EPA Region 5 Records Ctr.
311782

FINAL REPORT

REMEDIAL INVESTIGATION REPORT

ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

VOLUME 12 OF 12
BASELINE ECOLOGICAL RISK ASSESSMENT

Prepared for

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1414 West Hamilton Avenue
Eau Claire, WI 54701

August 31, 2007

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APPENDIX I

FINAL REPORT

BASELINE ECOLOGICAL RISK ASSESSMENT - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

VOLUME I: MAIN REPORT

Prepared for

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A Baseline Ecological Risk Assessment (BERA) was conducted to describe the likelihood, nature and severity of adverse effects to ecological receptors resulting from their exposure to contaminants at the Ashland/NSP Lakefront Superfund Site (Site) under current conditions.

This BERA supports the Ashland/NSP Lakefront Superfund Site Remedial Investigation/Feasibility Study (RI/FS) being conducted under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601, et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CRF Part 300. It supplements two other ecological risk assessments that have been conducted for this Site. In 1998, SEH completed an Ecological Risk Assessment (ERA) of the contaminated sediments adjacent to Kreher Park (SEH 1998). A supplemental ERA was performed in 2001 (SEH 2002) during which additional sediment toxicity testing was conducted to provide information for determining clean up goals for the sediments.

The scope of work conducted as part of the RI studies for this BERA was approved by USEPA on December 7, 2004. The approved scope of work resulted from extensive discussions with various stakeholders and Natural Resource Trustees, including:

- National Oceanographic and Atmospheric Administration (NOAA),
- Wisconsin Department of Natural Resources (WDNR),
- Red Cliff Band of Lake Superior Chippewa Indians, and
- Bad River Band of Lake Superior Chippewa Indians.

This BERA was prepared following USEPA Guidance including, *Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final.* (USEPA 1997).

The Site consists of property owned by Northern States Power Company, a Wisconsin corporation [d.b.a. Xcel Energy, a subsidiary of Xcel Energy Inc. ("NSPW")], a portion of Kreher Park, and sediments in an offshore area adjacent to Kreher Park[1]. Based on current data, the impacted area of Kreher Park consists of a flat terrace adjacent to the Chequamegon Bay shoreline. The surface elevation of the park varies approximately 10 feet, from 601 feet above mean sea level (MSL), to about 610 feet above MSL at the base of the bluff overlooking the park. The bluff rises to an elevation of about 640 feet above MSL, which corresponds to the approximate elevation of the NSPW property.

The lake elevation fluctuates about two feet, from 601 to 603 feet above MSL. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the marina occupies the west end of the property, while a miniature golf facility formerly occupied the east end of the site. The former City of Ashland waste water treatment plant (WWTP) and

[1] Reference to this portion of the Site as Kreher Park developed over the course of this project. Kreher Park consists of a swimming beach, a boat landing, an RV park and adjoining open space east of Prentice Avenue, lying to the east of the subject study area of the Site. For purposes of this report and to be consistent with past reports, the portion of the Site to the west of Prentice Avenue, east of Ellis Avenue and north of the NSPW property is referred to as the "Kreher Park Area" or simply Kreher Park.

associated structures front the bay inlet on the north side of the property. The impacted area of Kreher Park occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National railroad to the south, Ellis Avenue and the marina extension of Ellis Avenue to the west, and Chequamegon Bay to the north.

The offshore area with impacted sediments is located in a small bay created by the Prentice Avenue jetty and marina extensions previously described. For the most part, contaminated sediments are confined within this small bay by the northern edge of the line between the Prentice Avenue jetty and the marina extension. The impacted sediments consist of lake bottom sand and silts, and are overlain by a layer of wood chips, likely originating from former lumbering operations. Based upon MGP operation history there is no evidence that the wood in the bay is a result of purifier box waste from the MGP. The chips layer varies in thickness from 0 to seven feet, with an average thickness of nine inches and overlay approximately 95% of the sediment that is potentially affected by contamination. Based on current data, the entire area of potentially affected sediments encompasses approximately ten acres.

As part of this RI, a number of investigations were conducted whose results were used, along with historical information, to support this BERA. All of the historical and current data were used for screening for contaminants of potential concern (COPCs). Investigations conducted during this RI to support the BERA included:

1) Surface soil samples collected in the vicinity of Kreher Park (See RI report URS 2006a);
2) Sediment samples collected as part of the supplemental sediment sampling and Sediment Quality Triad (Triad) investigations;
3) Sediment toxicity testing;
4) Benthic macroinvertebrate community studies;
5) Collection of fish tissue;
6) Surface water collection; and
7) Characterization of wetlands and terrestrial habitats.

The details of these investigations are in the reports appended to this BERA or in reports submitted separately to USEPA.

Problem Formulation

The initial step of the BERA was to screen all data, including all historical data, relating to level of Site-related contaminants against conservative generic guidelines and benchmarks for soil, sediment and surface water quality. These benchmarks included Wisconsin's Consensus-Based Sediment Quality Guidelines (WDNR 2003), USEPA Region V's Ecological Screening Levels (ESLs) and USEPA Ecological Soil Screening Levels (ECO-SSLs) as well as other similar benchmarks.

Based upon this screening a number of contaminants of concern (COPCs) were identified (Table ES-1).

Table ES-1. List of COPCs by Medium Based on Maximum Detected Concentration.

Surface Water	Sediment	Soil
None	Total polycyclic aromatic hydrocarbons (PAHs)	Total PAHs
	Dibenzofuran	Benzene
	m-Cresol	Antimony
	o-Cresol	Barium
	p-Cresol	Cadmium
	1,2,4-Trimethylbenzene	Chromium
	1,3,5-Trimethylbenzene	Copper
	Benzene	Lead
	Ethylbenzene	Manganese
	Toluene	Mercury
	Total Xylenes	Selenium
	Antimony	Silver
	Barium	Thallium*
	Cadmium	Zinc
	Copper	Cyanide
	Iron	
	Lead	
	Manganese	
	Mercury	
	Nickel	
	Selenium	
	Silver	
	Thallium	
	Vanadium	
	Zinc	
	Cyanide*	

* Eliminated as a COPC based on frequency of detection (<5%)

As part of the Problem Formulation, an overall risk management goal was developed as the basis for evaluating risk at the Site:

> **Maintenance (or provision) of soil, sediment and water quality as well as food source, and habitat conditions capable of supporting a "functioning ecosystem" for the aquatic and terrestrial plant and animal populations (including individuals of protected species) inhabiting or utilizing the Ashland/NSP Lakefront Superfund Site area.**

Assessment endpoints were developed based upon this risk management goal.

After development of a conceptual site model describing:

- The source of contamination;
- Release and transport mechanisms;
- Contact point and exposure media;
- Routes of entry; and
- Key receptors.

Assessment endpoints, risk questions and measurement endpoints were selected as the basis for the BERA. These are summarized in the following table (Table ES-2).

Table ES-2. Endpoints and Risk Questions.		
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
Benthic macroinvertebrate community	Are concentrations of contaminants in the sediments at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Determine the levels of soot, coal, coke and slag, which may moderate the bioavailability of PAHs in the sediment. • Determine the levels of acid volatile sulfides (AVS) and simultaneously extractable divalent metals (SEM) in the sediment. • Compare concentrations of metals measured in Site sediment to WDNR (2003) sediment quality guidelines for threshold and probable effects. • Evaluate, quantitatively or qualitatively the bioavailability of sediment associated COPCs using SEM:AVS or Equilibrium Partitioning approach. • Compare concentrations of PAHs that accumulated in worm tissues in the bioaccumulation bioassay to the No Effects Body Residue (NEBR) that is associated with narcosis caused by PAHs and volatile organic compounds (VOCs). Use this as a model for predicting risk at the Site. • Using sediment toxicity bioassays, determine which sediments at the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared to sediments in reference areas. • Determine on the basis of benthic macroinvertebrate sampling and analysis where benthic communities inhabiting sediments in waterbodies in and adjacent to the Site are impaired when compared to benthic communities inhabiting reference area sediment.

Table ES-2. Endpoints and Risk Questions.

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
Fish community	Are concentrations of contaminants in sediments and surface waters at the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	• Determine the concentrations of Site-related contaminants in Site surface water. • Determine the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site. • Compare tissue levels of PAHs and estimated VOCs in wild fish caught at the Site to the NEBR. • Using sediment bioassays, determine whether areas on and adjacent to the Site have elevated toxicity compared to sediment from reference areas to surrogates for juvenile resident fish species. • Compare the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site to levels in fish from reference areas. (This assessment endpoint will be used only qualitatively as an indicator of exposure).
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Through food chain models for the black duck using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to toxicity reference values (TRVs) associated with adverse effects, including reproductive impairment.
Omnivorous birds	Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the red-winged blackbird using soil to vegetation and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including

Table ES-2. Endpoints and Risk Questions.

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
		reproductive impairment.
Insectivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the tree swallow using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to individual ospreys or to the piscivorous avian community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Determine the concentrations of Site-related contaminants in fish caught in and adjacent to the Site. • Through food chain models for the double-crested cormorant and the osprey using actual levels of Site-related contaminants measured in fish in and adjacent to the Site, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Omnivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the white-footed mouse using soil to plant and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Table ES-2. Endpoints and Risk Questions.		
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
Insectivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the big brown bat using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?	• Determine the concentrations of Site-related contaminants in fish caught in the Site area. • Through food chain models using actual levels of Site-related contaminants measured in fish, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects.

Based upon these risk questions and endpoints a number of Receptors of Concern (ROCs) were selected (Table ES-3).

Table ES-3. Receptors of Concern

ROC Category	ROC	Habitat
Aquatic Habitat		
Benthic macroinvertebrate community	Generic	Littoral portions of Chequamegon Bay
Fish Community	Generic	Littoral portions of Chequamegon Bay
Omnivorous birds	Black Duck	Littoral portions of Chequamegon Bay
Insectivorous birds	Tree swallow	Upland and riparian
Piscivorous birds	Double-crested cormorant Osprey (State endangered)	Littoral portions of Chequamegon Bay
Insectivorous mammals	Big brown bat	Upland and riparian
Piscivorous mammals	Mink	Upland and riparian
Terrestrial Habitat		
Omnivorous birds	Red-winged blackbird	Upland and riparian
Omnivorous mammals	White-footed mouse	Upland and riparian

Effects Analysis

The Effects Analysis consisted of an evaluation of available toxicity or other effects information that could be used to relate the exposure estimates to a level of adverse effects. Stressor-response (i.e., effects) data that were used to evaluate ecological risks in this BERA were of three types: (1) literature-derived toxicity data, (2) site-specific ambient media toxicity tests (e.g. sediment toxicity tests), and (3) site-specific biological community surveys.

The focus of the majority of the effort for this BERA was on aquatic portions of the Site. For the evaluation of Site sediment, all three lines of evidence were integrated into a Sediment Quality Triad approach (Triad) (Long and Chapman 1985; Chapman et al. 1987). The Triad evaluates sediment quality by integrating spatially and temporally matched sediment chemistry, biological, and toxicological information. Benthic invertebrate community analysis and sediment toxicity testing provided site-specific information regarding potential ecological effects of exposure of ecological receptors to COPCs in the Site sediment. These additional lines of evidence supplement traditional bulk sediment chemistry data to provide a more relevant, site-specific assessment of risks.

The evaluation of bulk sediment chemistry data involved comparison of Site sediment chemistry data to effects levels published by WDNR (2003), derived from relevant studies reported in published literature, or from studies performed for this BERA. Site-specific sediment toxicity tests were conducted with aquatic receptors that are representative surrogates for those living on

the Site and the results of this testing provided information on potential toxic effects that were observed in Site relevant organisms exposed to Site sediment. Site-specific surveys of benthic macroinvertebrate community also were conducted for the Site. In addition to these three lines of evidence that focus primarily on the benthic environment at the Site, surface water quality data and fish tissue data were collected from Site waters.

For upland portions of the Site, only two lines of evidence were used in this BERA. One was the comparison of bulk soil chemistry to soil quality benchmarks used as generic criteria, e.g., the soil ECO-SSLs (USEPA 2005a) or derived from relevant studies reported in published literature. The second was the comparison of doses accumulated through the food chain that terrestrial and aquatic prey-dependent wildlife (i.e., birds and mammals) may feed upon. These doses were compared to TRVs derived from the primary scientific literature.

The result of the ecological effects analysis was a range of TRVs that were compared with the dose estimates (birds and mammals) or toxicological benchmarks that were compared with estimated exposure point concentrations (EPCs) (benthic invertebrates and fish) to estimate potential risks in this Risk Characterization.

Exposure Analysis

In the exposure analysis, the relationship between receptors at the Site and potential stressors (chemical, biological, or physical entities that may result in adverse effects to one or more receptors or groups of receptors) were evaluated. Exposure point calculations (EPCs) used to estimate exposure were calculated as the mean and 95% upper confidence limit of the mean concentration (UCL_{95}) of the exposure medium. EPCs calculated for surface water, sediment, soil, or tissue residues were based directly upon the levels of contaminants in these media.

Exposure estimates for birds and mammals were calculated using food chain models. Simplified food chain models were developed to calculate average daily doses (ADDs) of COPCs that selected receptor groups experience through exposure to surface water, sediment, and surface soil at the Site. The ADD represents the dose of a chemical that a receptor may ingest if it foraged within designated exposure units. ADDs for wildlife receptors are calculated using (1) EPCs for prey and media developed for each, (2) COPC-specific bioaccumulation factors or bioaccumulation models for dietary items, and (3) receptor-specific exposure parameters and food chain model assumptions, (e.g., diet composition, foraging area, amount of incidental soil or sediment ingested, etc.).

Risk Characterization

Risk Characterization was the final phase of the BERA. In the Risk Characterization the information from the effects and exposure analyses was used to determine a probability of adverse effects to ROCs and discuss the strengths, weaknesses, and assumptions in the BERA. Risk estimates (or Hazard Quotients) were developed for each assessment endpoint based upon comparison of site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels (generic criteria, benchmarks and TRVs) for the various ROCs. Finally risk was characterized for each assessment endpoint by integrating the risk estimate with the results of other lines of evidence, if available.

The results of the risk characterization indicated that there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site. Two lines of evidence, bulk sediment chemistry and sediment toxicity testing, indicated that some impairment at the community level was possible. Effects observed from field surveys of the existing benthic community indicated effects that were less dramatic than those demonstrated in the laboratory toxicity studies, but interpretation of the field survey data is made very difficult by a high degree of variability and lack of comparability between reference and site stations.

However, the fact that hydrocarbons are sporadically released from the Site sediment during some high energy meteorological events or when disturbed by other activities indicates the potential for impact to the benthic community that may not have been fully measured by the benthic community studies conducted to support the RI. While there is no evidence that effects from these releases will lead to impairment of populations and communities of these receptors inhabiting the waters of Chequamegon Bay, it remains a source of uncertainty. It is possible that the presence of this continuing source of site related contaminants may sporadically impair the healthy functioning of the aquatic community in the Site area.

In addition, if normal lake front activities, i.e., wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI/FS studies.

The BERA concludes that the potential for adverse effects to ecological receptors other than benthic macroinvertebrates was not sufficient to result in significant adverse alterations to populations and communities of these ecological receptors.

The following table (Table ES-4) summarizes the results of the BERA.

ES-4. Conclusions of the Baseline Ecological Risk Assessment.

Assessment Endpoint	Risk Question	Conclusion of BERA
Benthic macroinvertebrate community	Are concentrations of contaminants in the sediments in Chequamegon Bay adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	Based upon two lines of evidence (risk estimates and sediment bioassays), there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site although these impacts were not documented at a community level by a focused benthic community investigation. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the benthic macroinvertebrate community is

ES-4. Conclusions of the Baseline Ecological Risk Assessment.

Assessment Endpoint	Risk Question	Conclusion of BERA
		exposed to them should be addressed in the Feasibility Study.
Fish community	Are concentrations of contaminants in sediments and surface waters of waterbodies in and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	There is no unacceptable risk to the fish community utilizing the Site. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the fish community is exposed to them should be addressed in the Feasibility Study.
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	There is no unacceptable risk to the omnivorous aquatic bird community utilizing the Site. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the omnivorous aquatic bird community is exposed to them should be addressed in the Feasibility Study.
Omnivorous birds	Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?	There is no unacceptable risk to omnivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Insectivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?	There is no unacceptable risk to insectivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Piscivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to individual ospreys or to the piscivorous avian community?	There is no unacceptable risk to piscivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Omnivorous mammals	Are dietary exposure levels of Site-related contaminants	There is no unacceptable risk to omnivorous mammals utilizing the

ES-4. Conclusions of the Baseline Ecological Risk Assessment.

Assessment Endpoint	Risk Question	Conclusion of BERA
	sufficient to cause adverse alterations to the omnivorous mammal community?	Site. This exposure pathway does not require consideration in the Feasibility Study.
Insectivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous mammal community?	There is no unacceptable risk to insectivorous mammals utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Piscivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?	There is no unacceptable risk to piscivorous mammals utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.

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Appendix G Data Quality Objectives (DQOs)
Appendix H Toxicological Reference Values and Benchmarks
Appendix I Exposure and Risk Estimates

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS[2]

µg/g	Micrograms per gram (parts per million)
µg/kg	Micrograms per kilogram (parts per billion)
µg/L	Micrograms per liter (parts per billion)
$\mu W/cm^2$	Microwatt per square centimeter
ACR	Acute to chronic ratio
ADD	Average daily dose
Ag	Silver
AH	Aromatic hydrocarbons
ANCOVA	Analysis of covariance
AOI	Area of interest
ARARs	Applicable or relevant and appropriate requirements
As	Arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area use factor
AVS	Acid volatile sulfides
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BaP	Benzo(a)pyrene
BERA	Baseline Ecological Risk Assessment
BSAF	Biota sediment accumulation factors
BTEX	Benzene, toluene, ethylbenzene, and xylene
BW	Body weight
CBR	Critical body residue
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	Chemical of concern
COPC	Chemical of Potential Concern
CS	Contaminated sand
CSM	Conceptual Site Model
Cu	Copper
CW	Contaminated wood
DBH	Diameter breast height
DNA	Deoxyribonucleic acid
DOC	Dissolved organic carbon
DQO	Data Quality Objective
ECOSAR	Ecological Structure Activity Relationships
ECO-SSL	Ecological Screening Level
EC_{20}	Effective concentration – 20 percent response
EC_{50}	Effective concentration – 50 percent response
ED_{20}	Effective dose – 20 percent response
ED_{50}	Effective dose – 50 percent response

[2] This list includes acronyms, abbreviations, and definitions used in the BERA text and appendices.

USEPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERED	Environmental Residue Effects Database
ER-L	Effects range-low
ER-M	Effects range-median
ESA	Endangered Species Act
ESL	Ecological Screening Level
ETO	Ephemeroptera, trichoptera, odonata
FS	Feasibility Study
GPS	Global Positioning System
ha	Hectare
Hg	Mercury
HHRA	Human health risk assessment
HMW-PAHs	High molecular weight polycyclic aromatic hydrocarbons
HOMO	Highest occupied molecular orbit
HQ	Hazard Quotient
IR	Ingestion rate
Kow	Octanol-water partition coefficient
LMW-PAHs	Low molecular weight polycyclic aromatic hydrocarbons
LOAEC	Lowest observed adverse effect concentration
LOAEL	Lowest observed adverse effects level
LOEC	Lowest observed effects concentration
LSRI	Lake Superior Research Institute
LUMO	Lowest unoccupied molecular orbit
MD	Maryland
MDR	Minimum daily requirement
mg/kg	Milligrams per kilogram (parts per million)
mg/kg/d	Milligrams per kilogram per day
mg/kg BW/d	Milligrams per kilogram body weight per day
mg/L	Milligrams per Liter (parts per million)
MGP	Manufactured gas plant
MI	Michigan
MSL	Mean sea level
NA	Not applicable
NC	Not calculated
NCP	National Contingency Plan
NE	Not established
NEBR	No effect body residue
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No observed adverse effect concentration
NOAEL	No observed adverse effects level
NOC-PAH	PAH concentration normalized to organic carbon
NOEC	No observed effects concentration
NOEL	No observed effects level

NRDA	Natural Resource Damage Assessment
NRWQC	National Recommended Water Quality Criteria
NSP	Northern States Power
NWI	National Wetland Inventory
OC	Organic carbon
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCBs	Polychlorinated biphenyls
PEC	Probable effects concentration
PER	Photoenzymatic repair
POM	Particulate organic matter
ppm	Parts per million
ppb	Parts per billion
PRG	Preliminary Remedial Goal
QA	Quality assurance
QAPP	Quality assurance project plan
QSARs	Quantitative structure-activity relationships
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROC	Receptor of concern
SLERA	Screening Level Risk Assessment
SEM	Simultaneously extractable metals
SMDP	Scientific Management Decision Point
SQUIRT	NOAA Screening Quick Reference Table
SQT	Sediment Quality Triad
SVOC	Semivolatile organic compound
SW	Surface Water
T&E	Threatened and endangered
TEC	Threshold effect concentration
TEL	Threshold Effects Level
TLM	Target Lipid Model
TOC	Total organic carbon
TPAH	Total polycyclic aromatic hydrocarbons
TRV	Toxicity Reference Value
TU	Toxic unit
UCL	Upper Confidence Limit
UPL	Upper Prediction Limit
USACE	U.S. Army Corp. of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	Ultraviolet light
UVA	Ultraviolet light (340-400 nm)
UVB	Ultraviolet light (280-320 nm)
UVC	Ultraviolet light (200-280 nm)

VOC	Volatile organic compound
WCMP	Wisconsin Coastal Management Program
WDNR	Wisconsin Department of Natural Resources
WI	Wisconsin
WPBCO	Weathered Prudhoe Bay crude oil
WWTP	Waste water treatment plant
Zn	Zinc

1.1 OBJECTIVE AND SCOPE

The objective of this baseline ecological risk assessment (BERA) is to describe the likelihood, nature and severity of adverse effects to ecological receptors, both plants and animals, resulting from their exposure to contaminants at the Ashland/NSP Lakefront Superfund Site (Site) under current conditions.

The BERA has been prepared to support the Ashland/NSP Lakefront Superfund Site Remedial Investigation/Feasibility Study (RI/FS) being conducted under the regulatory framework of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601, et seq. and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 CRF Part 300.

This BERA supplements two other ecological risk assessments that have been conducted for this Site. In 1998, SEH completed an Ecological Risk Assessment (ERA) of the contaminated sediments adjacent to Kreher Park (SEH 1998). A supplemental ERA was performed in 2001 (SEH 2002) during which additional sediment toxicity testing was conducted to provide information for determining clean-up goals for the sediments.

The scope of work conducted as part of the RI studies for this BERA was approved by USEPA on December 7, 2004. The approved scope of work resulted from extensive discussions with various stakeholders and Natural Resource Trustees, including:

- National Oceanographic and Atmospheric Administration (NOAA),
- Wisconsin Department of Natural Resources (WDNR),
- Red Cliff Band of Lake Superior Chippewa Indian Tribe, and
- Bad River Band of Lake Superior Chippewa Indian Tribe.

In addition U.S. Fish and Wildlife Service reviewed the scope of work before it was implemented.

1.2 GUIDANCE

The guidance that was followed in preparation of this BERA includes:

- Ecological Risk Assessment for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final. Environmental Response Team, Edison, NJ. (USEPA 1997);
- Guidance for the Data Quality Objective Process (USEPA 2000);
- Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites. OSWER Directive 9285.6-08 (USEPA 2002a); and,
- Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. USEPA-540-R-05-012. OSWER 9355.0-85. (USEPA 2005b).

1.3 REPORT ORGANIZATION

The BERA is organized as follows:

Section 2.0 – Site History and Description

This section includes a description of the site and a brief summary of the historical operations.

Section 3.0 – Baseline Problem Formulation

This section includes the elements of Problem Formulation: refinement of contaminants of potential concern (COPCs); description of regional ecosystems and human communities; presentation of conceptual site models (CSM); identification of receptors of concern (ROCs); development of risk questions/hypotheses and assessment endpoints, lines of evidence and measurement endpoints.

Section 4.0 – Step 4: Study Design and Data Quality Objective Process

This section establishes the study design and data quality objectives of the BERA. In this section, the conceptual site model is completed and measurement endpoints are identified to evaluate the assessment endpoints established in Section 3.0.

Section 5.0 – Analysis

This section includes the exposure and effects analysis for the BERA.

Section 6.0 – Risk Characterization

The risk estimate and risk description are presented in this section.

Section 7.0 – Summary and Implications for Risk Management

The conclusions of he BERA are summarized in this section

Section 8.0 – References

2.1 SITE DESCRIPTION [EXCERPTED FROM THE RI/FS WORKPLAN (URS 2005)]

The Site consists of property owned by Northern States Power Company, a Wisconsin corporation (d.b.a. Xcel Energy, a subsidiary of Xcel Energy Inc. ("NSPW") a portion of Kreher Park, and sediments in an offshore area adjacent to Kreher Park. The Site is located in S 33, T 48 N, R 4W in Ashland County, Wisconsin, shown on Figure 2-1. Existing site features showing the boundary of the site are shown on Figure 2-2.

Based on current data, the impacted area of Kreher Park consists of a flat terrace adjacent to the Chequamegon Bay shoreline. The surface elevation of the park varies approximately 10 feet, from 601 feet above MSL, to about 610 feet above MSL at the base of the bluff overlooking the park. The bluff rises to an elevation of about 640 feet above MSL, which corresponds to the approximate elevation of the NSPW property. The lake elevation fluctuates about two feet, from 601 to 603 feet above MSL. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the marina occupies the west end of the property, while a miniature golf facility formerly occupied the east end of the site. The former City of Ashland waste water treatment plant (WWTP) and associated structures front the bay inlet on the north side of the property. The impacted area of Kreher Park occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National Railroad to the south, Ellis Avenue and the marina extension of Ellis Avenue to the west, and Chequamegon Bay to the north.

The offshore area with impacted sediments is located in a small bay created by the Prentice Avenue jetty and marina extensions previously described. For the most part, contaminated sediments are confined within this small bay by the northern edge of the line between the Prentice Avenue jetty and the marina extension (Figure 2-3). The affected sediments consist of lake bottom sand and silts, and are overlain by a layer of wood chips, likely originating from former lumbering operations. The chips layer varies in thickness from 0 to seven feet, with an average thickness of nine inches and overlay approximately 95% of the sediment that is impacted. Based on current data, the entire area of impacted sediments encompasses approximately ten acres.

2.2 SITE HISTORY [EXCERPTED FROM THE RI/FS WORKPLAN (URS 2005)]

Historically, Chequamegon Bay has been utilized as a vital transportation route for the shipment of various materials to and from Ashland including iron ore, lumber, pulp and coal. During the late 19th and early 20th centuries, Ashland was one of the busiest ports on the Great Lakes. In recent times, the shipping volume through the bay has declined because of the decline in the mining, smelting and lumber industries in the region.

The Kreher Park area is reclaimed land of which the south boundary defined the original lake shoreline. Beginning in the mid to late 1800's, this area was filled with a variety of materials including slab wood, concrete, demolition debris, municipal and industrial wastes and earthen fill that created the land now occupied by the park. The filled area was used for lumbering and sawmill activities which occurred during the deforestation of the northern portion of Wisconsin around the turn of the century. Timber was also cut in various places in the area, including the Apostle Islands and the Arrowhead region of Minnesota, and the logs rafted into the Ashland

area where they were floated awaiting processing. The large amount of wood "mulch"[3] in aquatic portions of the Site provides testimony to the log rafting that occurred here. The extensive amount of bark mulch-sized wood particles and small wood chips found on and in the sediment today likely originated from the constant working of the logs in the log rafts as well as, perhaps, the disposal of wood debris from the saw mill operation. Based on the MGP operation there is no evidence supporting that wood in the bay is a result of purifier box waste from the MGP.

In addition to the lumbering operations, the Site area has also been used as:

- A "dump" for solid waste, fly ash, and dredge spoils by property owners, residents, and the United States Army Corps of Engineers;
- The City of Ashland Waste Water Treatment Plant;
- A manufactured gas plant; and
- Secondary wood processing plants including possible wood treatment and shingle manufacturing.

Since the mid-1980's a full service marina has also operated at the foot of Ellis Avenue.

2.3 PHYSICAL SETTING [EXCERPTED FROM THE RI/FS WORKPLAN (URS 2005)]

The Site is located at the top of a ravine on the shore of Chequamegon Bay. Regional surface water drainage flows to the north through Fish Creek and several small unnamed creeks and swales into Chequamegon Bay. Surface water at the Site flows either to the City of Ashland storm sewer system, or discharges directly to Chequamegon Bay.

Soils in the Ashland area generally consist of surficial deposits underlain by red clay and silt deposits of the Miller Creek Formation. Geology of the upper bluff area in the vicinity of the former ravine consists of earthen fill materials, with clay soils of the Miller Creek Formation on the flanks of the former ravine. The ravine fill unit consists of silty clay fill material mixed with ash, cinders, slag, and fragments of bricks, concrete, glass, wood, and other solid waste.

Offshore geology consists of a discontinuous layer of submerged wood mulch on the lake bottom underlain by variably fine to medium grained sediments. Silts and clays of the Miller Creek Formation underlie the sediments.

2.3.1 Climate

The regional climate of the Ashland area is mid-continental, being highly influenced by adjacent Lake Superior. The average daily high varies from 19.1 F° during January to 79.2 F° during July. Total annual precipitation averages nearly 33 inches. The highest precipitation levels occur during the summer months, although the total annual snowfall averages nearly 100 inches. The

[3] The term wood mulch probably best describes the conditions of most wood debris and wood waste found overlying the surface sediment. Most of it is ground up pieces or bark and twigs not unlike bark mulch. In addition to the wood mulch there is a variety of other wood waste including logs, shingles and other manufacturing wood waste, branches, and twigs.

average first frost occurs in mid-September and the average last frost does not occur until the end of May. Chequamegon Bay is generally ice-bound between December and April.

2.3.2 Population and Land Use

The population of the City of Ashland is 8,620 based on the 2000 census results. Residents are served by the city's municipal water supply, which is provided from Chequamegon Bay surface water from an area about one mile northeast of the Site.

3.1 SCOPE OF BASELINE PROBLEM FORMULATION

Problem formulation is the systematic planning process that identifies the factors to be addressed in a BERA and consists of several activities, including:

- Refinement of the preliminary list of chemicals of potential concern (COPCs) at the site [(i.e., those that were identified during the screening level ecological risk assessment (Section 3.6)];
- Development of management goals and objectives that provide an explicit statement of the desired condition of the valued entity being protected (Section 3.9);
- Identification of assessment endpoints (Section 3.11),
- Review and refinement of the information relating to the fate and transport of COPCs, potential exposure pathways, and the information on receptors potentially at risk (Sections 3.10);
- Development of a conceptual model with risk questions that the risk assessment will address (Sections 3.10);
- Identification of lines of evidence and measurement endpoints to address the risk hypotheses (Sections 3.11 and 4.1).

3.2 RESULTS OF PREVIOUS ECOLOGICAL RISK ASSESSMENTS CONDUCTED FOR THE ASHLAND/NSP LAKEFRONT SUPERFUND SITE

In 1998, SEH completed an Ecological Risk Assessment (ERA) of the contaminated sediments adjacent to Kreher Park (SEH 1998). The 1998 ERA concluded that there is evidence that some sediments at the Site were contaminated to the degree that they were harmful to benthic organisms living in them.

Several lines of evidence were used in the 1998 investigation including:

1) a literature search conducted to select relevant sediment effects benchmarks for evaluation of Site data and to identify ecological effects documented at other sites with similar contaminants and exposures;
2) sediment and surface water samples collected, analyzed, and compared to sediment and surface water effects benchmarks for the contaminants identified;
3) collection of fish for analysis of tissue chemical concentrations;
4) a limited survey conducted of the benthic community at contaminated and reference locations; and
5) a series of laboratory bioassays conducted to characterize the effects of short term exposure to contaminated and reference sediment samples.

A supplemental ERA was performed in 2001 (SEH 2002) during which additional sediment toxicity testing was conducted to provide information for determining clean-up goals for the sediments.

The following sections summarize the various lines of evidence used and the conclusions of these two preliminary ecological risk assessments.

3.2.1 Sediment and Surface Water Chemical Data Evaluation

Sediment chemical data from the Site were compared to several sets of effects levels for both dry weight units (µg/g) and normalized-to-organic-carbon (NOC) units (µg/gOC). Semi-volatile (SVOC) and volatile organic compounds (VOC) sediment benchmarks were exceeded for several chemicals at several locations in the shallow bioactive zone sediments (0-15 cm) and deeper sediments. Based on this comparison, the report concluded there was a high probability of adverse effects to aquatic life from the contaminated sediments.

No contaminants were detected in twelve unfiltered surface water samples collected on January 14 and 15, 1998. However, in one unfiltered water column sample collected during a period on May 14, 1998, when wave heights were estimated to be between 60 and 90 cm,[4] benzo(a)anthracene and benzo(a)pyrene exceeded secondary chronic and acute water quality criteria values, respectively. No VOCs exceeded water quality criteria in that sample. It is unknown whether the contaminants in this sample were adsorbed onto suspended particulates or in a dissolved state. However, it is likely they were bound to suspended particles because more water soluble PAHs that are much more abundant in the Site sediments, were not detected.

3.2.2 Fish Tissue Study

A study was conducted to evaluate levels of PAHs in fish caught at the Site and to evaluate the condition of the fish at the Site. Results from this study indicated that there was no evidence of external deformities in the fish. Of 27 fish collected on May 18, 1998, October 14, 1998 and May 28, 1999, fewer than 50% had measurable levels of any PAHs, either low molecular weight (LMW) or high molecular weight (HMW) in their tissues (Correspondence from Henry Nehls-Lowe to Jamie Dunn, et al., January 12, 2000). No fish collected had measurable amounts of high molecular weight PAHs in their tissues. The PAHs detected were low molecular weight PAHs including naphthalene, acenaphthene, anthracene, fluorene, and phenanthrene. Total PAH concentrations ranged as high as 483 µg/kg in the whole fish samples.

3.2.3 Benthic Community Evaluation

A limited benthic community survey was conducted in 1998 (SEH 1998). Four stations were sampled, two contaminated stations (one in sand, the other in wood debris) and two reference stations (one in sand, the other in wood debris) (Table 3-1). Benthic community survey results were evaluated for richness, abundance and relative indices. Graphical analyses indicated that the two contaminated stations and the reference wood station were degraded compared to the reference sand station.

[4] It is likely that estimate was based upon crest to trough height rather than wave height compared to lake surface.

Table 3-1. Benthic Community and Bioassay Stations Used in 1998 SEH Study

Total PAH Concentration	Contaminated Wood	Contaminated Sand	Reference Wood	Reference Sand
µg/g	370.2	1.5	6.5	0.4
µg PAH/g OC (NOC)	21776.5	583.6	114.8	92.2

3.2.4 Bioassays

Bioassays were conducted in 1998 on several sediment samples collected from the same two contaminated wood and sand stations and two reference wood and sand stations (SEH 1998). These were the same two stations where the benthic community samples were collected. Bulk sediment toxicity tests were conducted on the following benthic species: *Hyalella azteca, Chironomous dilutus* (formerly *C. tentans*), and *Lumbriculus variegatus*. Sediment elutriate preparations from these sites were also used in tests on *Pimephales promelas* and *Daphnia magna*. The results of these tests generally showed that growth and survival of test organisms decreased as the HA-28 NOC toxic units[5] increased.

Supplemental bioassay toxicity studies were conducted in 2001 using *H. azteca, C. dilutus*, and *P. promelas* exposed to bulk sediments collected from four contaminated stations and two reference stations (SEH 2002). Parallel tests were conducted utilizing a dilution methodology in which various proportions of sediments from impacted sites were mixed with sediments from reference sites to obtain a range of exposure concentrations.

The results of the 2001 sediment bioassay testing is summarized in Table 3-2. In some instances control and reference station survival was less than test acceptance criteria. These results are discussed further in Section 5.

Test results were evaluated for effects on survival and growth, and graphically compared to PAH toxic units. Statistically significant differences in survival and/or growth between each sample were documented. The SEH report concluded that toxic effects appeared to correlate well to the magnitude of toxic units. SEH concluded that results from both the bulk sediment dilution tests and the sediment elutriate dilution tests supported the exposure concentration/effects characterization.

[5] The Toxic Unit (TU) approach compares the dry weight or Normalized to Organic Carbon (NOC) concentrations of the contaminant, in this case total PAHs, to the Effects Range-Median (ERM) value for total PAHs in a 28 day bioassay with *Hyalella azteca* (HA). Thus a concentration of total PAHs equal to the HA-28 ERM value would be one toxic unit.

Table 3-2. Summary of 2001 SEH Sediment Bioassays for Sandy Stations (as reported).

Test*	No Observed Adverse Effects Concentration (NOEC)		Lowest Observed Adverse Effects Concentration (LOEC) = reduced growth or mortality > 20%	
	Total PAHs µg/g	Total PAHs (NOC) µgPAHs/g OC	Total PAHs µg/g	Total PAHs (NOC) µgPAHs/g OC
CT-10	16.2	735	79.9	3996
PP-7	79.9	3996	249.4	9978
HA-28	249.4	9978	823.1	4842
HA-28 w/UV	16.2	735	79.9	3996

*CT-10 = 10 day *Chironomous dilutus* bioassay

PP-7 = 7 day *Pimephales promelas* bioassay

HA-28 = 28 day *Hyalella azteca* bioassay

HA-28 w/UV = 28 day *Hyalella azteca* bioassay under UV light

SEH also reported that comparison of phototoxic PAH concentrations at the Site to reference levels in the literature indicated the potential for phototoxic effects at the Site. Phototoxicity studies using UV light were performed in 1998 and 2001 in conjunction with standard toxicity test organisms exposed to bulk sediment or sediment elutriate samples collected from the Site. While there was no documentation of how well the UV regime during the bioassay compared to what ecological receptors would be exposed to at the Site, SEH concluded that under the conditions in which the bioassay was conducted there was evidence of enhanced phototoxicity effects for benthic organisms, zooplankton, and fish larvae.

3.2.5 Risk Characterization

SEH concluded from these various lines of evidence that a strong potential exists for ecological risks from exposure to contaminated sediments in the bioactive zone and contaminated surface water over this zone. The lines of evidence they used to support this conclusion included: 1) PAH concentrations in sediments exceeding several sediment effects benchmarks; 2) evidence from field studies of benthic community impairment in the contaminated areas; 3) results of standard and photo-enhanced bioassay tests that indicated that the likelihood of ecological effects increase with exposure to increased contaminant concentrations in sediments and surface waters over the sediments; 4) the exceedances of secondary acute and chronic water quality criteria in one surface water sample collected during heavy wave action, based on field sampling and elutriate studies; 5) sediment concentrations of PAHs similar to those at other sites where bioaccumulation and mutagenic effects have been observed in fish; and 6) evidence of low molecular weight PAHs in some fish tissues collected from the Site.

The risk characterization also concluded that levels of PAHs in subsurface sediments are higher than in the bioactive zone and that future disturbance and exposure of the deeper contaminated sediments to the sediment-water interface and water column by either natural (e.g., storms, ice scouring) or uncontrolled anthropogenic (e.g., boat prop wash, shoreline maintenance) forces could potentially release contaminants from subsurface sediments and transport them from the Site.

The 2001 ERA (SEH 2002) also proposed Preliminary Remediation Goals (PRGs) for the contaminated substrates present (wood chips and sand) that were based on the results of these lines of evidence.

3.2.6 Contaminants of Potential Concern

SEH (1998) screened data on contaminants found in sediment samples collected in 1996 against several sediment quality benchmarks, including those developed by the Ontario Ministry of the Environment (Persaud 1993) and Long and Morgan (1991). Concentrations of most PAHs, as well as total PAHs, and some VOCs exceeded screening values. Metals found in this sampling campaign did not exceed guideline values at any location (SEH 2003); cyanide exceeded a sediment quality guideline in one location.

Further sampling in 2001 detected phenolic compounds in a few samples although these were not specifically screened against sediment quality benchmarks.

SEH (2003) reported additional screening was conducted for contaminants associated with surface sediments collected during 2003. In addition to exceeding sediment quality benchmarks for PAHs and some VOCs (primarily benzene, toluene, ethylbenzene, and xylenes [BTEX]), it was concluded that copper, lead, mercury, zinc and cyanide also exceeded some sediment quality benchmarks. SEH (2003) concluded that COPCs for the RI studies should include VOCs, SVOCs and copper, lead, mercury, zinc, and cyanide.

No screening of contaminants in other media was conducted in these previous risk assessments.

As part of this BERA, all media were re-screened to select COPCs (See Section 3.4).

3.3 SUMMARY OF STUDIES CONDUCTED FOR THE REMEDIAL INVESTIGATION

As part of this RI, a number of investigations were conducted and the results were used, along with historical information, to support this BERA. All of the historical and current data were used as discussed below to screening for COPCs (Appendix A). Investigations conducted during this RI included:

1) Surface soil samples collected in the vicinity of Kreher Park (See RI report URS 2006a);
2) Sediment samples collected as part of the supplemental sediment sampling and sediment quality triad investigations (Appendix B);
3) Sediment toxicity testing (Appendix B);
4) Benthic macroinvertebrate community studies (Appendix B);
5) Collection of fish tissue (Appendix C);

6) Surface water collection (Appendix D); and

7) Characterization of wetlands and terrestrial habitats (Appendix E).

The details of these investigations are in the reports appended to this BERA or in other reports submitted separately to USEPA as cited above.

3.4 NATURE AND EXTENT OF CONTAMINATION

The Site has been the subject of numerous investigations. Previous investigations have identified contamination at Kreher Park and in near shore sediments. Contaminated near shore sediments are located within the inlets created by the jetty and marina extension as discussed in Section 2.1.

3.5 SCREENING OF CONTAMINANTS OF POTENTIAL CONCERN

As the first task in the Baseline Problem Formulation, data for all media, including all historical data, were screened to select COPCs. Screening was conducted using the following benchmarks using the maximum concentration measured:

- **Sediment:** Contaminants in sediment were screened using Wisconsin's sediment quality guidelines (WDNR 2003). If benchmarks for Site contaminants were not available from WDNR the following were used, in order of precedence: USEPA Region V Ecological Screening Levels (ESLs) (USEPA 2003a), TLM=Target Lipid Model (DiToro and McGrath 2000), T50 =Logistic model point estimate of T50 concentrations (concentration at which 50% of samples are predicted to be toxic; Field et al. 2002), NOAA Screening Quick Reference Table (SQuiRT- http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html), and other available sources.
- **Surface Water:** Region V ESLs (USEPA 2003a) were used as the primary source of screening criteria. If ESLs were not available, then the following criteria were used, in order of precedence: ORNL Tier II values, USEPA Region IV Water Quality Standards and structure-activity relationships using chronic values for fish (ECOSAR).
- **Soil:** USEPA Ecological Soil Screening Levels (ECO-SSLs) (USEPA 2003b; 2005a) were the primary screening criteria for evaluating soils. If ECO-SSLs were not available, then the following criteria were used, in order of precedence: Region V ESLs (USEPA 2003a) and other available sources.

Because USEPA advises that some chemicals that also function as nutrients, (e.g., calcium, magnesium, sodium and potassium) typically pose no ecological risk when present at relatively low concentrations that allow them to function in this manner, these chemicals were not screened.

If any PAH exceeded its individual screening criterion, PAHs as a group were retained as COPCs because it was considered that the mode of action is similar for all PAHs and their toxicity additive (See Section 5).

A summary of media specific screening criteria used to re-screen contaminants detected in Site samples are provided in Table 3-3, Table 3-4 and Table 3-5.

Table 3-3. Screening Criteria Selected for the Re-Screening of COPCs in Surface Water.

Analyte	Criteria (µg/L)	Source[1]
VOCs		
1,2,4-Trimethylbenzene	438	ECOSAR ChV (fish)
1,3,5-Trimethylbenzene	438	ECOSAR ChV (fish)
Benzene	11.4	Region V ESL
Ethybenzene	14	Region V ESL
Sec-Butylbenzene	263	ECOSAR ChV (fish)
Styrene	32	Region V ESL
Toluene	253	Region V ESL
Total Xylenes	27	Region V ESL (sum of isomers)
PAHs		
1-Methylnaphthalene	433	ECOSAR ChV (fish)
1-Methlyphenanthrene	56	ECOSAR ChV (fish)
2,3,5-Trimethylnaphthalene	58	ECOSAR ChV (fish)
2,6-Dimethylnaphthalene	161	ECOSAR ChV (fish)
2-Methylnaphthalene	433	ECOSAR ChV (fish)
Acenaphthene	38	Region V ESL
Acenaphthylene	4840	Region V ESL
Anthracene	0.035	Region V ESL
Benzo(a)anthracene	0.025	Region V ESL
Benzo(a)pyrene	0.014	Region V ESL
Benzo(b)fluoranthene	0.42	Reg IV WQS
Benzo(e)pyrene	0.014	same as B(a)P
Benzo(g,h,i)perylene	7.64	Region V ESL
Benzo(k)fluoranthene	0.14	Reg IV WQS
Biphenyl	14	OSWER Tier II
Chrysene	0.07	Reg IV WQS
Dibenz(a,h,)anthracene	0.04	Reg IV WQS
Fluoranthene	1.9	Region V ESL
Fluorene	19	Region V ESL
Indeno(1,2,3-cd)pyrene	4.31	Region V ESL
Naphthalene	13	Region V ESL
Perylene	0.006	ECOSAR ChV (fish)
Phenanthrene	3.6	Region V ESL
Pyrene	0.3	Region V ESL

Notes:

1, Region V ESL, USEPA Region V Ecological Screening Levels
Region IV WQS, USEPA Region IV Water Management Division Screening List
ECOSAR, Structure-activity relationships using chronic values for fish

Table 3-4. Screening Criteria Selected for the Re-Screening of COPCs in Sediment.

Analyte	Units	Criteria			Source[1]
		TEC	MEC	PEC	
VOCs					
1,2,4-Trimethylbenzene	µg/kg OC	1147			TLM[2]
1,3,5-Trimethylbenzene	µg/kg OC	1147			TLM[2]
Benzene	µg/kg dw @ 1%OC	57	83.5	110	WDNR 2003
Ethybenzene	µg/kg	175			Region V ESL
Sec-Butylbenzene	µg/kg dw @ 1%OC	25	37.5	50	WDNR 2003
Styrene	µg/kg OC	254			Region V ESL
Toluene	µg/kg dw @ 1%OC	890	1345	1800	WDNR 2003
Total Xylenes	µg/kg dw @ 1%OC	25	37.5	50	WDNR 2003
PAHs					
1-Methylnaphthalene	µg/kg		94.00		T50
1-Methylphenanthrene	µg/kg		112		T50
2,3,5-Trimethylnaphthalene	µg/kg OC	988.0			TLM[3]
2,6-Dimethylnaphthalene	µg/kg		133.0		T50
2-Methylnaphthalene	µg/kg		120.0	240.0	BC
Acenaphthene	µg/kg dw @ 1%OC	6.7	48.0	89.0	WDNR 2003
Acenaphthylene	µg/kg dw @ 1%OC	5.9	67.0	128.0	WDNR 2003
Anthracene	µg/kg dw @ 1%OC	57.2	451.0	845.0	WDNR 2003
Benzo(a)anthracene	µg/kg dw @ 1%OC	108.0	579.0	1050.0	WDNR 2003
Benzo(a)pyrene	µg/kg dw @ 1%OC	150.0	800.0	1450.0	WDNR 2003
Benzo(b)fluoranthene	µg/kg dw @ 1%OC	240.0	6820.0	13400.0	WDNR 2003
Benzo(e)pyrene	µg/kg dw @ 1%OC	150.0	800.0	1450.0	WDNR 2003
Benzo(g,h,i)perylene	µg/kg dw @ 1%OC	170.0	1685.0	3200.0	WDNR 2003
Benzo(k)fluoranthene	µg/kg dw @ 1%OC	240.0	6820.0	13400.0	WDNR 2003
Biphenyl	µg/kg		73.0		T50
Chrysene	µg/kg dw @ 1%OC	166.0	728.0	1290.0	WDNR 2003
Dibenz(a,h,)anthracene	µg/kg dw @ 1%OC	33.0	84.0	135.0	WDNR 2003
Fluoranthene	µg/kg dw @ 1%OC	423.0	1327.0	2230.0	WDNR 2003
Fluorene	µg/kg dw @ 1%OC	77.4	307.0	536.0	WDNR 2003
Indeno(1,2,3-cd)pyrene	µg/kg dw @ 1%OC	200.0	1700.0	3200.0	WDNR 2003
Naphthalene	µg/kg dw @ 1%OC	176.0	369.0	561.0	WDNR 2003
Perylene	µg/kg OC	812.0			TLM[3]
Phenanthrene	µg/kg dw @ 1%OC	204.0	687.0	1170.0	WDNR 2003
Pyrene	µg/kg dw @ 1%OC	195.0	858.0	1520.0	WDNR 2003
Total PAHs	µg/kg dw @ 1%OC	1610.0	12205.0	22800.0	WDNR 2003
Other SVOCs					
Cresols, m- & p-	µg/kg	52.4			Region V ESL
Cresol, o-	µg/kg	55.4			Region V ESL
Dibenzofuran	µg/kg dw @ 1%OC	150.0	365.0	580.0	WDNR 2003
Phenol	µg/kg dw @ 1%OC	4200.0	8100.0	12000.0	WDNR 2003
Metals					
Aluminum	µg/g	25500.0			SQuiRT
Antimony	µg/g	2.0	13.5	25.0	WDNR 2003
Arsenic	µg/g	9.8	21.4	33.0	WDNR 2003
Barium	µg/g	48.0			OR
Beryllium	µg/g	122.0			OR
Cadmium	µg/g	1.0	3.0	5.0	WDNR 2003
Chromium	µg/g	43.0	76.5	110.0	WDNR 2003
Cobalt	µg/g	43.4			Region V ESL
Copper	µg/g	32.0	91.0	150.0	WDNR 2003
Iron	µg/g	20000.0	30000.0	40000.0	WDNR 2003
Lead	µg/g	36.0	83.0	130.0	WDNR 2003
Manganese	µg/g	460.0	780.0	1100.0	WDNR 2003
Mercury	µg/g	0.2	0.6	1.1	WDNR 2003
Nickel	µg/g	23.0	36.0	49.0	WDNR 2003
Selenium	µg/g	1.0			SQuiRT
Silver	µg/g	1.6		2.2	WDNR 2003
Thallium	µg/g	0.7			OR
Vanadium	µg/g	57.0			SQuiRT
Zinc	µg/g	120.0	290.0	460.0	WDNR 2003
Cyanides	µg/g	0.1			Region V ESL

Notes:

1. WDNR 2003, Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application Interim Guidance (WDNR 2003)
   Region V ESL, USEPA Region V Ecological Screening Levels
   TLM, Target Lipid Model (DiToro and McGrath 2000-See text)
   T50, Logistic model point estimate of T50 concentrations (concentration at which 50% of samples are predicted to be toxic; Field et al . 2002).
   SQuiRT, NOAA. Screening Quick Reference Tables
   BC, Critria for Managing Contaminated Sediment in British Columbia. MWLAP. 2004.
   OR, Oregon DEQ Level 2 Screening Level Values
2. Critical body residue (CBR) VOCs is 6.94 umol/g lipid
3. Critical body residue (CBR) for PAHs is 3.79 umol/g lipid

Table 3-5. Screening Criteria Selected for the Re-Screening of COPCs in Soil.

Analyte	Criteria[1]	Source[2]
VOCs (µg/kg)		
1,2,4-Trimethylbenzene	NE	
1,3,5-Trimethylbenzene	NE	
Benzene	255	Region V ESL
Ethybenzene	5160	Region V ESL
Sec-Butylbenzene	NE	
Styrene	4690	ORNL 1997
Toluene	5450	Region V ESL
Total Xylenes	10000	Region V ESL
PAHs (µg/kg)		
1-Methylnaphthalene	NE	
1-Methlyphenanthrene	NE	
2,3,5-Trimethylnaphthalene	NE	
2,6-Dimethylnaphthalene	NE	
2-Methylnaphthalene	NE	
Acenaphthene	682000	Region V ESL
Acenaphthylene	682000	Region V ESL
Anthracene	1480000	Region V ESL
Benzo(a)anthracene	5210	Region V ESL
Benzo(a)pyrene	1520	Region V ESL
Benzo(b)fluoranthene	59800	Region V ESL
Benzo(e)pyrene	1520	BaP surrogate
Benzo(g,h,i)perylene	119000	Region V ESL
Benzo(k)fluoranthene	148000	Region V ESL
Biphenyl	60000	ORNL 1997
Chrysene	4730	Region V ESL
Dibenz(a,h,)anthracene	18400	Region V ESL
Fluoranthene	122000	Region V ESL
Fluorene	122000	Region V ESL
Indeno(1,2,3-cd)pyrene	109000	Region V ESL
Naphthalene	99.4	Region V ESL
Perylene	NE	
Phenanthrene	45700	Region V ESL
Pyrene	78500	Region V ESL
Total PAHs	NE	
Other SVOCs (µg/kg)		
Cresols, M & P	7950.00	Region V ESL
Cresol,O	40400.0	Region V ESL
Dibenzofuran	NE	
Phenol	120000.0	Region V ESL
Metals (µg/g)		
Aluminum	NE	USEPA 2005
Antimony	0.27	USEPA 2005
Arsenic	18.0	USEPA 2005
Barium	330.0	USEPA 2005
Beryllium	21.0	USEPA 2005
Cadmium	0.36	USEPA 2005
Chromium	26.0	USEPA 2005
Cobalt	13.0	USEPA 2005
Copper	54.0	USEPA 2003b
Iron	NE	USEPA 2005
Lead	11.0	USEPA 2005
Manganese	152.0	USEPA 2003b
Mercury	0.1	Region V ESL
Nickel	48.0	USEPA 2003b
Selenium	0.028	USEPA 2003b
Silver	4.0	Region V ESL
Thallium	0.057	Region V ESL
Vanadium	78.0	USEPA 2005
Zinc	120.0	USEPA 2003b
Cyanides	1.3	Region V ESL

Notes:
1, NE= Not Established
2, Region V ESL, USEPA Region 5 Ecological Screening Levels (USEPA 2003a)
USEPA 2005, Ecological soil screening levels (ECO-SSLs).
USEPA 2003b, Draft Ecological Soil Screening Levels (ECO-SSLs)
ORNL 1997, Oak Ridge National Laboratory (Efroymson et al. 1997).

The results of this re-screening is presented in Appendix A and summarized in Table 3-6. These chemicals were retained for further analysis in the BERA.

Table 3-6. List of COPCs by Medium Based upon the Maximum Detected Concentration.

Surface Water	Sediment	Soil
None	Total PAHs	Total PAHs
	Dibenzofuran	Benzene
	m-Cresol	Antimony
	o-Cresol	Barium
	p-Cresol	Cadmium
	1,2,4-Trimethylbenzene	Chromium
	1,3,5-Trimethylbenzene	Copper
	Benzene	Lead
	Ethylbenzene	Manganese
	Toluene	Mercury
	Total Xylenes	Selenium
	Antimony	Silver
	Arsenic	Thallium*
	Barium	Zinc
	Cadmium	Cyanide
	Copper	
	Iron	
	Lead	
	Manganese	
	Mercury	
	Nickel	
	Selenium	
	Silver	
	Thallium	
	Vanadium	
	Zinc	
	Cyanide*	

* Eliminated as a COPC based upon frequency of detection (<5%).

3.6 REFINEMENT OF CONTAMINANTS OF CONCERN

This initial list of COPCs was reviewed to determine whether any COPCs could be eliminated based upon relatively infrequent, less than 5%, detection. Cyanide was eliminated as a sediment COPC and thallium was eliminated as a soil COPC based upon this criterion.

3.7 OTHER STRESSORS OF POTENTIAL CONCERN

In addition to contaminants that may be related to the MGP that operated on the Site there were several other historical operations that used the Site. The following is a preliminary list of activities that have resulted in physical and chemical alterations to the habitat that are not directly related to MGP contaminant releases:

1) City-owned parcels of the lakefront were created during the late 1880s through the latter part of the 1980s by the uncontrolled placement of wood wastes, soil, sand, and industrial and municipal demolition waste material into Chequamegon Bay;
2) Sawdust and wood waste from a series of sawmills that operated on the Ashland site from the early 1880s until about the mid-1930s were dispersed by natural forces, rain, flooding, storms and ice throughout Chequamegon Bay;
3) Log rafting and timber loading led to bark and wood waste accumulating to depths of many feet in various places in Chequamegon Bay;
4) Releases of chemicals from wood wastes and releases from secondary wood processing facilities including shingle victories and possible wood treatment operations; and
5) Discharges of chemicals from the construction, expansion and operation of the Ashland WWTP.

These other sources and physical alterations of Site habitat may have some of the same effects as Site contaminants. While it may not be possible to differentiate the effects of these other stressors relative to the effects from Site contaminants it should be understood that they are potentially contributing stressors. This is particularly true of the physical alterations to the nearshore aquatic habitat resulting from the presence of wood "mulch" and wood waste overlaying the sediments.

As reported by SEH (1998b), wood waste is found throughout the Ashland site in thickness averaging about 0.26 meters (~ eight inches) and ranging from 0-2 meters, "the wood chip layer extends from the Ashland Harbor shoreline out to the harbor mouth (approximately 270 m) and is deepest at the east end of the harbor (up to 2.1 m), rapidly declining to a thickness of between 15 and 24 cm [six-eight inches] over the majority of the remainder of the harbor." Further observations made during the RI sampling by underwater video and side scan sonar (URS 2006a) have provided more information about this wood "mulch" and based upon this information approximately 95% of the substrate in the Site area is covered by wood "mulch" and wood waste.

In addition to the potential direct effects to habitat quality from all of this wood covering the bottom, there are also indirect effects that may include release of excess nitrogen (which may exist in the form of ammonia, nitrate and/or nitrite), phosphorous (in the form of phosphate) and sulfides. The presence of wood mulch on top of the sediment bed can also increase biological

oxygen demand and materially affect the dissolved oxygen levels at the sediment-water interface and at shallow depths within the sediment. Both the presence of excess nutrients, soluble organics and changes to dissolved oxygen can cause changes to the environment for both benthos and fish and may limit their presence in certain areas. Other physical changes related to changes in lake level, storms and sediment deposition dynamics also potentially can modify the characteristics of the aquatic environment and thus exert an effect on aquatic receptors.

The former Ashland WWTP operated at the site of the former sawmill (at the end of Prentice Avenue), adjacent to the highest levels of sediment contaminants, until approximately 1990. It is likely that the construction and operation of the WWTP resulted in various chemicals, including metals and SVOCs, being discharged into waters now included within the Site boundary.

3.8 ENVIRONMENTAL SETTING

3.8.1 Aquatic Habitat Description

The littoral areas of Chequamegon Bay within the Site boundaries have a relatively smooth and gradually sloping bottom to depths of around 10 feet deep. As reported by SEH (2002), "although the harbor area is open to Lake Superior, the limnology is more comparable to a warm water lake than the pelagic, oligotrophic zone typical of [deeper areas of] Lake Superior." The lake bottom in the Site area is primarily sandy substrate although, as described above, it is mostly covered by variable depth layers of wood debris, tree branches, wood slabs, lumber and logs. The presence of this wood has significant implications for the structure of the benthic community, including emergent plants, periphyton infauna and epifauna. The planktonic and fish community is probably somewhat less affected by the presence of the wood.

3.8.1.1 Aquatic Plants

No study of the aquatic plant community in the Site waters has been conducted. Observations made during the RI sampling suggest it is neither extensive nor diverse. Some limited submerged vegetation was observed and recorded by underwater video. The presence of the wood "mulch" and the fact that the smaller particles of wood are likely mobile, moving in response to wave action, precludes the proliferation of emergent vegetation or periphyton species that would typically live in this type of habitat.

3.8.1.2 Aquatic Animals

The benthos was the only group of animals that utilize this aquatic habitat that was studied during this RI and earlier studies conducted to support the ecological risk assessment (SEH 1998). The results of the benthic community study conducted as part of the RI indicate that the benthic community in the Site area is largely dominated by oligochaetes, molluscs, chironomids and crustaceans (Appendix B). The dominant taxa were chironomids which made up an average 32.6% (maximum 84 to 91% in the five replicate samples from Sand Reference Station SQT12) of the abundance in each sample. In all, 58 taxa of chironomids were identified. The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa*), oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai*), amphipods (including *Gammarus*

fasciatus), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals (Appendix B). Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

For characterization of the fish community we have to rely on studies conducted by USGS over the years of 1973 to 1996 (Hoff and Bronte 1998). These studies as well as observations by WDNR have produced a list of about 49 species likely to utilize waters in or near the Site for spawning, rearing or feeding (See Table 6 in SEH 2002). Of these, the USGS concluded that about seven species are more likely to utilize the shallow Site waters: smallmouth bass, logperch, mimic shiner, silver redhorse, black bullhead, johnny darter and spottail shiner. Based upon observations made during the RI fish tissue sampling, the list of those species frequenting the Site waters should be amended to include rock bass, walleye, common carp, shorthead redhorse, longnose sucker, white sucker, brown bullhead, rainbow smelt, and trout-perch. To a lesser extent, northern pike, green sunfish, pumpkinseed, yellow perch and juvenile coho salmon have also been observed in the Site waters.

Although SEH (1998, 2002) mentions that either zooplankton or phytoplankton surveys were conducted in the 1970's to support a dredging project, no data on plankton are presented in their two reports and a search for other descriptions of the plankton community found in Ashland Harbor was not productive.

3.8.2 Upland Habitat Description

On June 15, 2005, a characterization of terrestrial and wetland habitats on the Site was conducted. The results of that characterization are reported in Appendix E and summarized in the following sections.

3.8.2.1 Terrestrial Habitat Description

There are five main habitat types on the upland portion of the Site. These include wooded/shrub, open field, developed/lawn, wetland and lake edge. The Canadian National Railroad runs parallel to the bluff, approximately 30 feet lakeward of the bluff. Vegetation between the tracks and the bluff is a 30- to 50-year-old strip of woodland consisting of green ash, oak, boxelder and cottonwood. Downslope vegetation parallels the railroad tracks for the most part, and consists of 10- to 20-year-old boxelder and shrubs such as raspberry, dogwood, willow, honeysuckle, red elderberry, green ash, and grape. The entire wood/shrub area is approximately 1.55 acres in size.

The open field between the wooded area and Chequamegon Bay is approximately 1 acre and consists primarily of open field made up of brome, thistle, dandelion and timothy. This area is traversed by a lawn area that contains some park amenities, such as picnic tables and benches. The marina parking lot on the western edge of the site is gravel. There is one small wetland area located east of the parking lot, near the border of the wooded/shrub and open field areas.

North of Marina Drive consists of primarily lawn, which gives way to the sandy/rocky shore edge. There is another shrub area approximately 2.07 acres in size located to the east/northeast of the former wastewater treatment plant. Lake edge habitat consists of a fairly narrow strip of sand

and rocks along Chequamegon Bay in some areas, with lawn vegetation going all the way to the water's edge in others.

The developed/lawn areas would typically be home to songbirds, squirrels, rabbits, and other small rodents that are adapted to an urban setting. The lakeshore typically provides habitat for a wide range of birds and mammals, however, in the immediate Site area, lakeshore habitat is limited due to the location of the marina (high boat traffic area) and shoreline development (riprap).

3.8.2.2 Wetland Habitat Description

No wetlands on the Site were identified on National Wetland Inventory or Wisconsin Wetlands Inventory maps. There is no soil survey data for the project site, as most of the Site consists of dredge and fill material deposited in the 1900s. Field observations resulted in the identification and delineation of one wetland area, using the U.S. Army Corps of Engineers (USACE) Wetlands Delineation Manual (Appendix E).

The wetland is located east of the Ellis Avenue Marina parking lot, along the edge of the wooded/shrub area. A small part of the wetland is south of the railroad tracks and this is connected to the remainder of the wetland to the north of the railroad tracks by a culvert. This wetland is approximately 0.24 acre in size with a majority (90%) of the wetland consisting of the area north of the railroad tracks. Dominant plant species included reed canary grass *(Phalaris arundinacea)*, stinging nettle *(Urtica dioica)*, sandbar willow *(Salix interior)* and Canada thistle *(Cirsium arvense)*. All but the thistle are considered wetland species. Depth to saturated soil was approximately six inches and hydric, clayey soils were present. The wetland appears to be receiving water through a seep south of the tracks. It runs through a small ditch on the south side of the tracks passing through a culvert and flowing into the north basin. The basin is primarily a wet meadow wetland with a fringe of sandbar willow. It had a drain tile beneath the wetland, though now that drain tile has been exposed and broken allowing water to freely flow to the north toward Lake Superior. The wetland boundary was determined by presence of vegetation and hydric soils.

A functional values assessment was completed for this wetland based upon USACE protocols. The wetland scored low in significance for Floral Diversity, Wildlife Habitat, Fishery Habitat, Groundwater and Aesthetics/Recreation/Education. The wetland does provide a high function for Water Quality Protection from upslope runoff and provides moderate flood/stormwater attenuation function. Documentation of this assessment is also included in Appendix E.

3.8.2.3 Wetland and Terrestrial Plants and Animals

Common plants and animals either observed or expected to utilize the wetland and terrestrial habitats on the Site are summarized in Table 3-7. See Appendix E for details on what was actually observed and what was assumed to be there based upon regional species lists and habitat types.

Table 3-7. Wildlife Species Observed or Expected to Utilize Site Upland or Terrestrial Habitats.

Common Name	Scientific Name	Site Habitat
Gray catbird	*Dumetella carolinensis*	Shrub/wooded
Common crow	*Corvus brachyrhynchos*	Developed
House sparrow	*Passer domesticus*	Developed
American robin	*Turdus migratorius*	Wooded
Brown-headed cowbird	*Molothrus ater*	Wooded
Herring gull	*Larus argentatus*	Lake edge
Cedar waxwing	*Bombycilla cedrorum*	Wooded
Common starling	*Sturnus vulgaris*	Developed
Ovenbird	*Seiurus aurocapillus*	Wooded
Red-winged blackbird	*Agelaius phoeniceus*	Open field and Wetland
Pigeon	*Columba fasciata*	Developed
Mourning dove	*Zenaida macroura*	Developed
Chipmunk	*Tamias minimus*	Developed
Woodchuck	*Marmota monax*	Developed

3.8.2.4 Special Status Species

Rare, endangered, or threatened species of plants and animals are treated more conservatively than more common plants and animals in risk assessments. Therefore, it was important to ascertain if any of these species exist at or near the Site. Letters requesting information on rare, threatened and endangered species were sent to the U.S. Fish and Wildlife Service (USFWS) and Wisconsin Department of Natural Resources (WDNR) on July 29, 2005. The USFWS maintains a list of federally-protected species, while the WDNR maintains a list of state-protected species. These agencies are responsible for identifying and enforcing necessary mitigation measures should any species potentially be affected by a proposed project.

The WDNR concluded that there are 7 known occurrences of rare species or natural communities within an approximate 2-mile radius around the project site and within five miles for aquatic species. The species listed includes two birds, one diving beetle and four plants.

The birds were the merlin (*Falco columbarius*) and the common tern (*Sterna hirundo*), which were the only species found near the project area. Neither bird species has habitat within the project area and further surveys or protocols for these species are not necessary. The diving beetle is recorded in Bay City Creek, which will not be impacted by this project. The plants are all wetland species and were not in the project site or adjoining properties.

The USFWS provided a list of species that are known to occur within Ashland County, but indicated that no federally-listed species or critical habitat is known to occur in the project site or within a 2-mile radius.

3.9 RISK MANAGEMENT GOAL

As defined by USEPA (2001a), "a *risk management goal* is a general statement of the desired condition or direction of preference for the entity to be protected.

The following risk management goal is proposed:

> **Maintenance (or provision) of soil, sediment and water quality as well as food source, and habitat conditions capable of supporting a "functioning ecosystem" for the aquatic and terrestrial plant and animal populations (including individuals of protected species) inhabiting or utilizing the Ashland/NSP Waterfront Superfund Site area.**

The proposed assessment endpoints presented in Section 3.10 were developed based upon this risk management goal.

3.10 CONCEPTUAL SITE MODEL

3.10.1 Contaminant Fate and Transport

Available information provided in prior reports was reviewed to evaluate the potential fate and transport mechanisms that may result in complete exposure pathways. The evaluation focused on identifying whether the following primary components of a complete exposure pathway were present in the AOIs:

- Source of contamination;
- Release and transport mechanism;
- Contact point and exposure media;
- Routes of entry; and,
- Key receptors.

Each of these components is discussed below.

3.10.2 Source of Contamination

As discussed in Section 2.1 various industries have operated on the Site. In addition to the lumbering operations, the Site area has also been used as:

- A "dump" for solid waste, fly ash, and dredge spoils by property owners, residents, and the United States Army Corps of Engineers;
- The City of Ashland WWTP;
- A manufactured gas plant; and
- Secondary wood processing plants including possible wood treatment and shingle manufacturing.

These operations have resulted in both chemical and physical alterations of the Site area, particularly in aquatic portions of the Site.

3.10.3 Release and Transport Mechanisms

One or more of the following release and transport mechanisms potentially may affect the concentration and spatial distribution of COPCs at and around the Site:

- Dissolution and leaching into groundwater underlying the Site;
- Migration of dissolved COPCs in groundwater to sediment and surface water in Chequamegon Bay, and its attenuation by dilution/dispersion, sorption and biodegradation;
- Suspension and windblown transport of COPCs adsorbed to particles in ambient air;
- Transport of COPCs adsorbed to soil particles via surface water runoff;
- Backfilling of soils, wood waste and construction debris; and
- Trophic transfer of COPCs that are incorporated in the aquatic and terrestrial food chains.

The potential for COPCs to be released and transported from the sources to points of contact with ecological receptors depends on their physicochemical properties, ambient concentrations, and their spatial distribution. Surface water runoff and groundwater infiltration are of particular importance to soluble species of contaminants and less important to hydrophobic organic compounds. Hydrophobic compounds, if any, are likely more of an issue in soil, sediment, and food/prey exposure media.

3.10.4 Contact Point and Exposure Media

The potential contact points for ecological receptors are identified below:

- Surface water, surface soil and food/prey in terrestrial habitats; and
- Surface water, sediment and food/prey in aquatic and wetland habitat.

Each of these contact points and their respective exposure media will be addressed in the BERA.

3.10.5 Routes of Entry

The potential routes of entry for ecological receptors are:

- Direct contact: dermal and/or gill absorption;
- Ingestion; and,
- Inhalation.

Adequate ecotoxicity information is available in the scientific literature to address ecological risks associated with the direct contact and ingestion routes of entry. Complete exposure pathways that include these routes are evaluated in this BERA. Available scientific information is not adequate to evaluate complete exposure pathways for inhalation, and this route will represent an uncertainty in the BERA, although exposure of Site ecological receptors to volatile chemicals is considered to be a minor potential issue at this Site.

3.10.6 Toxicology of COPCs

PAHs are the primary COPC that will be addressed in this BERA. PAHs are a diverse class of organic compounds that include about one hundred individual substances containing two or more fused benzene, or aromatic, rings. Low molecular weight (LMW) PAHs have fewer than four rings, while high molecular weight (HMW) PAHs have four or more rings. The LMW PAHs include acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, 2-methylnaphthalene, and phenanthrene. The HMW PAHs include benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenz(a,h)anthracene, fluoranthene, and pyrene.

PAHs are usually present in the environment in complex mixtures of hundreds or even thousands of related compounds (Neff et al. 2005). They may originate from three sources: fossil fuels (petrogenic PAHs), burning of organic matter (pyrogenic PAHs) and transformation of natural organic precursors by diagenic processes (biogenic PAHs).

The behavior of PAHs in the aquatic environment depends on a number of chemical-specific and site-specific factors. The physicochemical properties of PAHs tend to determine their fate in aquatic systems. The PAHs with high aqueous solubilities are less tightly bound to sediments and may be found in surface water. PAHs with lower aqueous solubilities are usually incorporated into the bed sediment, but may be found in surface waters if they are bound to suspended particulates of benthic origin.

While in the water column either in association with colloidal material or suspended particulates, the fate of PAHs tends to be governed by physical hydrodynamic factors, (e.g. advective transport). While in the water column PAHs may be transported to other areas, biodegrade, evaporate, photochemically degrade or may be consumed by water column biota.

Release of some materials such as tar or creosote, which contain a number of PAH compounds, into an aquatic environment can lead to relatively quick incorporation into the sediment milieu. Once in the sediment bed release of LMW PAHs into the overlying water column is possible although the primary fate is biodegradation and biotransformation by benthic organisms (USEPA 1980 as cited by Eisler 2000). The rate of these biodegradation processes vary substantially depending upon the molecular weight of the PAHs and the presence of microbial communities in the sediments. In the absence of penetrating radiation and oxygen (beneath the immediate surface layers) degradation rates are typically slow. As a result, at most historical PAH waste sites, PAHs are found distributed relatively deeply in the sediment column since the rate of sediment deposition exceeds PAH degradation rates.

The presence of PAHs in aquatic ecosystems pose a number of potential risks to aquatic organisms. At sufficiently elevated levels waterborne PAHs can be lethal to water column receptors and long-term exposure to sublethal levels of PAHs in the sediment have been shown to affect survival, growth and reproduction of benthic organisms. USEPA (2002) has recently provided guidance for evaluating the effects of mixtures of PAHs in sediment on benthic organisms. It is based upon equilibrium partitioning (i.e., estimating the bioavailability of PAHs in sediment pore water using equilibrium theory) and a common narcotic mode of action for mixtures of PAHs and other nonionic organic chemicals.

However, USEPA (2002a) acknowledges that this approach could potentially overestimate the bioavailable fraction of PAHs in sediment pore water if there are PAHs in the sediment associated with soot, coke, slag, tar and coal. As recent research into the bioavailability of PAHs

in sediment has demonstrated, PAHs associated with these forms of pyrogenic carbonaceous material have very low bioavailability (Accardi-dey and Gschwend 2003; Burgess 2004; Ghosh et al. 2003, Rust et al. 2004). Other authors have shown that the longer PAHs are in contact with organic carbon even from ordinary detritus, the less bioavailable they become.

Other aspects of the fate and transport as well as potential toxicology of PAHs and the other COPCs is discussed in Section 5 (Effects Analysis).

3.10.7 Ecosystems Potentially at Risk

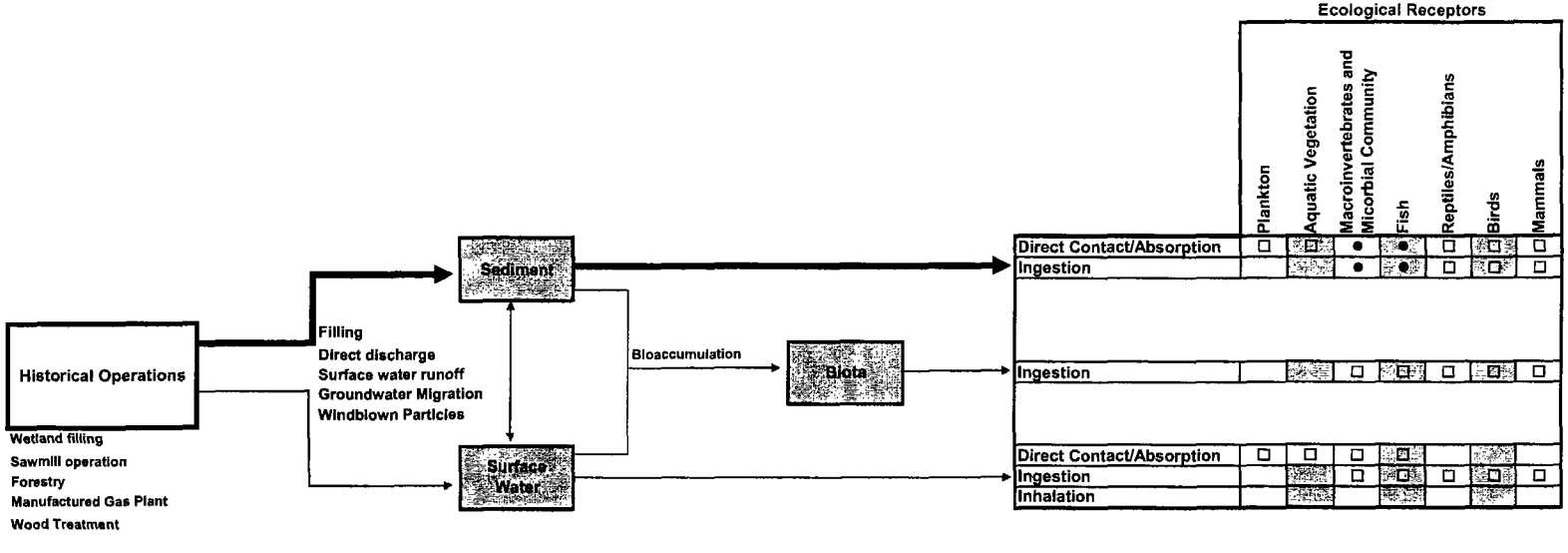
This BERA focuses on the aquatic ecosystem in the Site. The majority of the upland portion of the Site is developed for industrial or residential use or open fields. Not much area within the Site boundaries is undisturbed and the area is managed and used without regard to wildlife habitat. However, as directed by USEPA, the BERA will address potential risk to exclusively terrestrial receptors.

3.10.8 Exposure Pathways

The potential routes of exposure are the means by which chemicals are transferred from a contaminated medium to ecological receptors. The routes by which ecological receptors may be exposed to COPCs in the Site area include:

- Periphyton – direct contact with sediment and surface water;
- Benthic macroinvertebrates – ingestion and direct contact with sediment or surface water;
- Fish – ingestion and direct contact with sediment and surface water;
- Terrestrial plants – direct contact with soil or sediment;
- Soil community – ingestion and direct contact with soil or sediment;
- Amphibians – ingestion and direct contact with surface water and soil or sediment;
- Reptiles – ingestion and direct contact with surface water and soil and sediment; and
- Birds and mammals – ingestion of soil or sediment, surface water, and food.

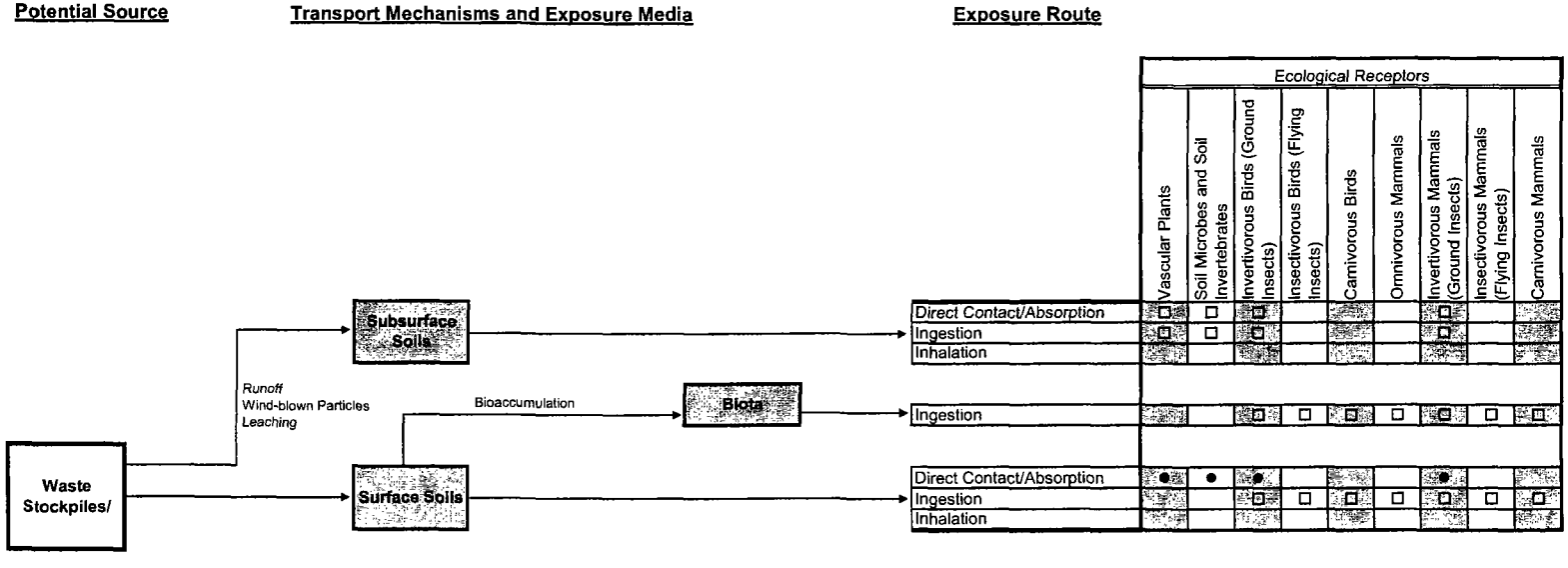
These potential exposure pathways are illustrated in the Conceptual Site Model (CSM) Figures 3-1 and 3-2. Some exposure pathways have been combined with others or cannot be quantitatively evaluated because of a lack of available information for the exposure evaluation. These will be considered uncertainties in this BERA. Examples of these potential exposure pathways include dermal and inhalation exposures for birds and mammals. Although these pathways are not quantitatively evaluated they are considered relatively minor exposure pathways relative to other exposure pathways.



NOTE:
● = Potentially Important Exposure Pathway
□ = Minor Exposure Pathway
Blank = Incomplete Exposure Pathway

FIGURE 3-1

CONCEPTUAL SITE MODEL
AQUATIC EXPOSURE PATHWAYS
Ashland Lakefront Site
Ashland, Wisconsin



NOTE:

NOTE:

● = Potentially Important Exposure Pathway

□ = Minor Exposure Pathway

Blank = Incomplete Exposure Pathway

FIGURE 3-2
SITE CONCEPTUAL MODEL
TERRESTRIAL PATHWAYS
Ashland Lakefront Superfund Site
Ashland, Wisconsin

The following exposure pathways will not be quantitatively evaluated for the following reasons (Table 3-8):

Table 3-8. Exposure Pathways Not Quantitatively Evaluated.

Potential Exposure Pathway	Reason for not Evaluating Quantitatively
Direct contact of periphyton, fish and amphibians with sediment.	Surface water is the primary exposure pathway (no COPC were identified in surface water) and there is inadequate information to quantitatively evaluate direct contact with sediment.
Aquatic invertebrates and fish: Exposure to chemicals through food chain transfer.	Although this is a complete exposure pathway, there is inadequate information to quantitatively evaluate. The evaluation of fish will integrate any food chain transfer taking place at lower trophic levels.
Terrestrial invertebrates: Exposure to chemicals through food chain transfer.	Inadequate information exists to quantitatively evaluate. The evaluation of small mammals and birds will integrate any food chain transfer taking place at lower trophic levels.
Birds and mammals: Exposure to chemicals through dermal adsorption.	Inadequate information exists to quantitatively evaluate. The fur-covered skin of mammals and the feathers of birds limit the direct dermal uptake of chemicals from the environment and this pathway will not be evaluated. Preening and grooming behaviors, however, contribute to the incidental ingestion of soil or sediment, and are included as part of the incidental ingestion exposure pathway.
Birds and mammals: Exposure to chemicals through inhalation.	Inadequate information exists to quantitatively evaluate. It is doubtful that there is sufficient volatilization of sediment-or soil-associated chemicals to result in a threat to bird and mammal receptors. This will be discussed as an uncertainty.

3.11 ASSESSMENT ENDPOINTS, RISK QUESTIONS, MEASUREMENT ENDPOINTS

This section will present specific assessment endpoints as well as associated risk questions and measurement endpoints. Although measurement endpoints are typically introduced in Step 4 of the ERAGS process during the Study Design and Data Quality Objective Process, they are discussed in this section to emphasize the relationship between the assessment endpoints, risk questions, and measurement endpoints.

Assessment endpoints are explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes (USEPA 1998). The criteria for selection of assessment endpoints include ecological relevance, susceptibility (exposure plus sensitivity), and relevance to management goals.

Risk questions are questions about the relationships among assessment endpoints and their predicted responses when exposed to contaminants. The risk questions should be based on the assessment endpoints and provide a basis for developing the study design (Step 4) and for evaluating the results of the site investigation in the analysis phase (Step 6) and during risk characterization (Step 7) (USEPA 1997).

A measurement endpoint is a measurable ecological characteristic that is related to the assessment endpoint and is a measure of biological effects (e.g., mortality, reproduction, growth) (USEPA 1997). Measurement endpoints are frequently numerical expressions of observations (e.g., toxicity test results, community diversity measures) that can be compared statistically to a control or reference site to detect adverse responses to a site contaminant.

A line of evidence is, "information derived from different sources or by different techniques that can be used to describe and interpret risk estimates" (USEPA 1998). USEPA (1997) concluded that, in general, there are four possible lines of evidence that can be used to test these risk questions and hypotheses:

1) Comparing estimated or measured exposure levels of contaminants with levels of the contaminants that are known to cause adverse effects to receptors associated with the assessment endpoints;
2) Comparing laboratory bioassays of media from the subject site with artificial media or media from a reference site;
3) Comparing in situ toxicity tests at the subject site with in situ toxicity tests at a reference site; and
4) Comparing observed effects in receptors associated with the subject site with similar receptors at a reference site. This could include population and community studies, for instance.

Each of these lines of evidence can incorporate one or more measurement endpoints that describe the change in the assessment endpoint in response to exposure to a stressor, in this case, a COPC. Lines of evidence proposed for use in this baseline ecological risk assessment include:

Exposure Levels: Concentration Values in Environmental Media

This approach is essentially a predictive line of evidence. By comparing levels of contaminants measured in site media, (e.g., soil, sediment and surface water), or in organisms, (e.g., contaminant levels in fish and invertebrate tissue or in prey ingested by wildlife) to toxicological information from the literature, one can predict the likely response of site-specific ROCs. Uncertainty associated with this approach relates to the differences between the site-specific exposure and the conditions of the study from which the toxicological information was obtained.

Site-Specific Toxicity Data: Laboratory Bioassays

This line of evidence generally uses tests of receptor response to site media, e.g. sediment, soil or water column toxicity bioassays. This approach is often more relevant than the literature in understanding the responses of site receptors to contaminants. However, since site-specific exposure conditions cannot be exactly replicated, nor do test organisms necessarily react to a stressor similar to site receptors, there is some uncertainty associated with this approach.

Direct Observations of Receptor Populations

Direct observations on presence, composition, condition and behavior of receptor populations and communities at the site of interest can also be a fairly direct line of evidence for evaluating the extent of site-related impacts on ecological receptors. The inherent variability in natural populations, however, inevitably introduces uncertainty into interpretation of this line of evidence. Therefore, it is critical that analysis of this line of evidence be sufficiently sensitive to distinguish differences between site and reference populations or communities that may be related to the stressors being evaluated from differences in these populations or communities that are only due to natural variability.

3.11.1 Assessment Endpoints

Nine assessment endpoints have been identified for this BERA. Individual effects level endpoints were selected for protected species; community effects level endpoints were selected for other species. Assessment endpoints are discussed in the following sections.

3.11.2 Aquatic Ecosystem

3.11.2.1 Assessment Endpoint #1: Viability and Function of Benthic Macroinvertebrate Community

The benthic macroinvertebrate community was selected as an assessment endpoint due to its role in energy flow and materials cycling, its potential for exposure to contaminants, and its potential role as a food source for higher trophic level organisms. This assessment endpoint will consider whether the sediment quality at the Site is adequate to support a benthic invertebrate community composition and diversity that is within the range of natural variability of benthic communities in nearby lake habitats in the region and to provide suitable forage for indigenous fish and wildlife species.

Risk Question:

Are concentrations of contaminants in the sediments at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site sediment.
- Determine the levels of soot, coal, coke and slag which may moderate the bioavailability of PAHs in the sediment.
- Compare concentrations of metals measured in Site sediment to WDNR (2003) sediment quality guidelines for TEC and PEC.
- Determine the levels SEM:AVS in the sediment. This is a measure of the bioavailability of divalent metals in sediment.
- Evaluate, quantitatively or qualitatively, the bioavailability of sediment associated COPCs using SEM:AVS or Equilibrium Partitioning approach.
- Compare the concentrations of PAHs that accumulated in worm tissues in the bioaccumulation bioassay to the no effect body residue (NEBR) that is associated with narcosis caused by PAHs and VOCs. Since all PAHs are assumed to act through the same mechanism of toxicity, the sum of all of the accumulated PAHs and VOCs is compared to the NEBR.
- Using sediment toxicity bioassays, determine which sediments at the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared to sediments in reference areas.
- Determine on the basis of benthic macroinvertebrate sampling and analysis where benthic communities inhabiting sediments in waterbodies at the Site are impaired when compared to benthic communities inhabiting reference area sediment.

3.11.2.2 Assessment Endpoint #2: Viability and Function of Fish Community

The fish community was selected as an assessment endpoint because of its significant role in lake energy flow, nutrient cycling and organic matter accumulation and because fish are an important food resource for higher trophic level species. This assessment endpoint will consider whether the sediment and surface water quality in aquatic potions of the Site are adequate to support a fish community composition and diversity that is within the range of natural variability of fish communities in Chequamegon Bay and to provide suitable forage for indigenous fish and wildlife species.

Risk Question:

Are concentrations of contaminants in sediments and surface waters of waterbodies at the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site surface water.
- Determine the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site.
- Compare concentrations of Site-related contaminants measured in Site surface water with toxicological benchmarks that have been associated with adverse effects to fish.
- Compare tissue levels of PAHs and estimated VOCs in wild fish caught at the Site to the NEBR.
- Using sediment bioassays, determine whether areas on and adjacent to the Site have elevated toxicity compared to sediment from reference areas to surrogates for juvenile resident fish species.
- Compare the concentrations of Site-related contaminants in tissue from fish caught at the Site to levels in fish from reference areas. (This assessment endpoint will be used only qualitatively as an indicator of exposure).

3.11.2.3 Assessment Endpoint #3: Viability and Function of Omnivorous Aquatic Bird Community

Omnivorous aquatic birds were selected as an assessment endpoint because they have an important role in energy transfer from the aquatic to the terrestrial ecosystem. Consumers of both aquatic plants and animals, they, in turn, provide an important food source for higher trophic levels. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity of omnivorous aquatic birds that is within the range of natural variability of omnivorous aquatic bird communities in other habitats in Lake Superior of this region.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?

Selected Receptor: Black Duck (*Anas rubripes*):

Black ducks are common at Site and breed in this part of Wisconsin. This bird's diet consists mainly of plant food (seeds, vegetative parts of aquatic plants and crop plants) and small aquatic animals including aquatic insects, molluscs, crustaceans and amphibians. They feed by grazing, probing, dabbling or upending in shallow water; occasionally they dive.

The feeding behavior of black duck, such as pulling up vegetation rooted in sediments, could result in exposure to Site-related contaminants in the sediment. They are small relative to other aquatic omnivorous birds such as geese and swans, and so have higher ingestion rates per unit body weight, yielding more conservative estimates of risk. Additional information on the life history of the black duck is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site sediment.
- Through food chain models for the black duck using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment. Restricting the model to a diet benthic invertebrates conservatively overestimates the dose expected when black ducks also ingest plant matter.

3.11.3 Terrestrial and Wetland Ecosystem

3.11.3.1 Assessment Endpoints #4 through #9: Viability and Function of the Terrestrial Vertebrate Community

The terrestrial vertebrate community is comprised of a variety of species that perform various roles within the terrestrial ecosystem. These roles include energy flow and organic matter production. Terrestrial vertebrates also serve as a link between the aquatic and terrestrial ecosystems on the Site.

Assessment Endpoint #4: Viability and Function of the Omnivorous Avian Community

Omnivorous birds were selected as an assessment endpoint because they consume plant and animal tissue from several different tropic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals. This assessment endpoint will consider whether surface water and soil quality is adequate to support a community composition and diversity of omnivorous birds that is within the range of natural variability of omnivorous bird communities in other terrestrial habitats in the region.

Risk Question:

Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?

Selected Receptor: Red-winged blackbird (*Agelaius phoeniceus*):

The red-winged blackbird is a seasonal resident of the Site area and feeds in both wetland and riparian areas. It feeds primarily on insects and weed seeds. Additional information on the life history of the red-winged blackbird is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site soils.
- Through food chain models for the red-winged blackbird using soil-to-vegetation and soil-to-invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Assessment Endpoint #5: Viability and Function of the Insectivorous Avian Community

Insectivorous birds were selected as an assessment endpoint because they consume insects from several different tropic levels and thus have an important role in energy transfer from insect tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity of insectivorous birds that is within the range of natural variability of insectivorous bird communities in other terrestrial habitats in the region.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?

Selected Receptor: Tree swallow (*Tacycineta bicolor*):

The tree swallow is a seasonal resident of the Site area and feeds primarily on flying insects in terrestrial, wetland and riparian areas. Many of these have been seen in the Site area during hatches of aquatic insects. Additional information on the life history of the tree swallow is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site sediments
- Through food chain models for the tree swallow using sediment-to-emergent aquatic insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Assessment Endpoint #6: Viability and Function of the Piscivorous Avian Community

Piscivorous birds have been selected as an assessment endpoint because they eat primarily fish and thus serve as an important pathway for nutrients and energy from the aquatic to the terrestrial ecosystem. They are also usually the highest trophic level in the food chain and would thus be potentially vulnerable to any contaminants that would bioaccumulate. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity of piscivorous birds that is within the range of natural variability of piscivorous bird communities in other terrestrial habitats in the region.

Risk Questions:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous avian community?

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse effects, including reproductive impairment, to individual ospreys.

Selected Receptors: Double-Crested Cormorant *(Phalacrocorax auritus)* and osprey *(Pandion haliaetus)*:

The cormorant is a seasonal resident of the Site area and breeds locally. It is expected to feed primarily on small fish (4-8") as well as occasionally on amphibians. The osprey is a listed species (State threatened) that is expected to feed on small to medium sized fish (<12"). While the osprey has not been documented to use the Site, it is used as a representative species to provide a conservative exposure scenario for a listed piscivore. Additional information on the life history of the both species is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site sediments.
- Determine the concentrations of Site-related contaminants in fish caught in and adjacent to the Site.
- Through food chain models for the cormorant and osprey using actual levels of Site-related contaminants measured in fish, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Assessment Endpoint #7: Viability and Function of the Omnivorous Mammal Community

Omnivorous mammals were selected as an assessment endpoint because they consume plant and animal tissue from several different trophic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity that is within the range of natural variability of omnivorous mammal communities in other disturbed terrestrial habitats in the region.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?

Selected Receptor: White-footed mouse *(Peromyscus leucopus)*:

The white-footed mouse is likely an abundant and permanent resident of the Site area and feed on seeds, berries, nuts and insects. Additional information on the life history of the white-footed mouse is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site soils.
- Through food chain models for the white-footed mouse using soil to plant and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Assessment Endpoint #8: Viability and Function of the Insectivorous Mammal Community

Insectivorous mammals were selected as an assessment endpoint because they consume insects from several different trophic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity of insectivorous mammals that is within the range of natural variability of insectivorous mammal communities in other terrestrial habitats in the region.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous community.

Selected Receptor: Big Brown Bat (*Eptesius fuscus*)

The big brown bat likely feeds in the vicinity of the Site. This bat is larger than the little brown bat and is a widespread species in North America. It roosts in colonies in tree hollows, wall spaces, and buildings. It is tolerant of cold conditions and may overwinter in walls and attics. It also hibernates in caves, abandoned mines, and sometimes in buildings. It feeds on a several types of flying insects. Additional information on the life history of the big brown bat is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in Site soils.
- Through food chain models for the small-footed bat using soil to insect and sediment to emergent aquatic insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Assessment Endpoint #9: Viability and Function of the Piscivorous Mammal Community

Piscivorous mammals have been selected as an assessment endpoint because they eat primarily fish and thus serve as an important pathway for nutrients and energy from the aquatic to the terrestrial ecosystem. They are usually the highest trophic level in the food chain and would thus be potentially vulnerable to any contaminants that would bioaccumulate. This assessment endpoint will consider whether surface water and sediment quality is adequate to support a community composition and diversity of piscivorous mammals that is within the range of natural variability of piscivorous mammal communities in other terrestrial habitats in the region

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?

Selected Receptor: Mink (*Mustela vison*):

The mink is a permanent resident of the Site area where it feeds both on aquatic and terrestrial prey, the proportions depending upon the season. Although it is likely to be rare in the Site area because of the developed and disturbed nature of the habitat, the mink is used as an ROC because of its sensitivity and the availability of toxicological information. Additional information on the life history of the mink is found in Appendix F.

Measurement Endpoints (Exposure and Effects):

- Determine the concentrations of Site-related contaminants in fish caught in the Site area.
- Through food chain models using actual levels of Site-related contaminants measured in fish, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects.

3.11.4 Receptors of Concern

A BERA cannot specifically evaluate the potential for adverse effects to every plant, animal, and microbial species that may be present and potentially exposed in the Site area. As a result, receptors that are representative of high ecological or societal value, those believed to be representative of broader groups of organisms, or those potentially most exposed to Site contaminants were selected as "receptors of concern (ROC)" for evaluation in the BERA.

Each ROC was selected to reflect an assessment endpoint considering their trophic category and particular feeding behaviors (e.g., fish-eating birds versus insect-eating birds) that would represent different modes of exposure to COPCs. Consequently, the species that were chosen for evaluation may represent several similarly exposed species in the area.

The following criteria were used to select potential receptors:

- The receptor does or could use habitats that are present around the Site;
- The receptor is important to either the structure or function of the ecosystem;
- The receptor is statutorily protected (i.e., threatened or endangered species, migratory birds) or is otherwise highly valued by society (i.e., species of cultural importance);
- The receptor is reflective and representative of the assessment endpoints for the Site area; and,
- The receptor is known to be either sensitive or highly exposed to COPCs around the Site.

The soil invertebrate community was not selected as a ROC because the terrestrial portion of the Site is largely a developed urban area.

The species selected as ROCs are summarized by habitat type, and assessment endpoint level in Table 3-9. Life history profiles for each of the representative species are presented in Appendix F.

Table 3-9. Receptors of Concern.		
ROC Category	**ROC**	**Habitat**
Aquatic Habitat		
Benthic macroinvertebrate community	Generic	Littoral portions of Chequamegon Bay
Fish Community	Generic	Littoral portions of Chequamegon Bay
Omnivorous birds	Black Duck	Littoral portions of Chequamegon Bay
Insectivorous birds	Tree swallow	Upland and riparian
Piscivorous birds	Double-crested cormorant Osprey (State endangered)	Littoral portions of Chequamegon Bay
Insectivorous mammals	Big brown bat	Upland and riparian
Piscivorous mammals	Mink	Upland and riparian
Terrestrial Habitat		
Omnivorous birds	Red-winged blackbird	Upland and riparian
Omnivorous mammals	White-footed mouse	Upland and riparian

As indicated in USEPA (1997), "Step 4 of the ecological risk assessment establishes the measurement endpoints [...], completing the conceptual model begun [earlier]. Step 4 also establishes the study design [...] and data quality objectives based upon statistical considerations." In this section of the Baseline Problem Formulation, the measurement endpoints, which were introduced in the last Section, are summarized and used to evaluate the assessment endpoints from Step 3 proposed.

4.1 PROPOSED MEASUREMENT ENDPOINTS AND DECISION CRITERIA

The measurement endpoints that will be used in this BERA are summarized in Table 4-1 with associated decision criteria. Data Quality Objectives for each assessment and measurement endpoint are discussed further in Section 4.2.

Table 4-1. Endpoints and Risk Questions.

Assessment Endpoint	Risk Question	Measurement Endpoint(s) (Exposure and Effects)
Benthic macroinvertebrate community	Are concentrations of contaminants at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Determine the levels of TOC, soot, coal, coke and slag which may moderate the bioavailability of PAHs in the sediment. • Determine the levels of AVS:SEM in the sediment. • Compare concentrations of metals measured in Site sediment to WDNR (2003) sediment quality guidelines for TEC and PEC. • Evaluate, quantitatively or qualitatively, the bioavailability of sediment associated COPCs using SEM:AVS or Equilibrium Partitioning approach. • Compare concentrations of PAHs that accumulated in worm tissues in the bioaccumulation bioassay to the NEBR that is associated with narcosis caused by PAHs and VOCs. Use this as a model for predicting risk at the Site. • Using sediment toxicity bioassays, determine which sediments in and adjacent to the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared

Table 4-1. Endpoints and Risk Questions.		
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
		to sediments in reference areas. • Determine on the basis of benthic macroinvertebrate sampling and analysis where benthic communities inhabiting sediments in waterbodies in and adjacent to the Site are impaired when compared to benthic communities inhabiting reference area sediment.
Fish community	Are concentrations of contaminants in sediments and surface waters of waterbodies at the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	• Determine the concentrations of Site-related contaminants in Site surface water. • Determine the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site. • Compare tissue levels of PAHs and estimated VOCs in wild fish caught at the Site to the NEBR. • Using sediment bioassays, determine whether areas on and adjacent to the Site have elevated toxicity compared to sediment from reference areas to surrogates for juvenile resident fish species. • Compare the concentrations of Site-related contaminants in tissue from fish caught in and adjacent to the Site to levels in fish from reference areas. (This assessment endpoint will be used only qualitatively as an indicator of exposure).
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	• Determine the concentrations of Site-related contaminants in Site sediment. • Through food chain models for the black duck using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Table 4-1. Endpoints and Risk Questions.		
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
Omnivorous birds	Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the red-winged blackbird using soil to vegetation and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the tree swallow using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to individual ospreys or to the piscivorous avian community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Determine the concentrations of Site-related contaminants in fish caught in and adjacent to the Site. • Through food chain models for the double-crested cormorant and the osprey using actual levels of Site-related contaminants measured in fish in and adjacent to the Site, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.

Table 4-1. Endpoints and Risk Questions.		
Assessment Endpoint	**Risk Question**	**Measurement Endpoint(s) (Exposure and Effects)**
Omnivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site soils. • Through food chain models for the white-footed mouse using soil to plant and soil to invertebrate bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Insectivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous mammal community?	• Determine the concentrations of Site-related contaminants in Site sediments. • Through food chain models for the big brown bat using sediment to emergent insect bioaccumulation factors, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects, including reproductive impairment.
Piscivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?	• Determine the concentrations of Site-related contaminants in fish caught in the Site area. • Through food chain models using actual levels of Site-related contaminants measured in fish, estimate the ingestion of Site-related contaminants and compare it to TRVs associated with adverse effects.

4.2 DATA QUALITY OBJECTIVES

4.2.1 The Data Quality Objectives (DQO) Process

The data quality objectives (DQO) process is described in USEPA guidance as "a seven-step planning approach to develop sampling designs for data collection activities that support decision making. This process uses systematic planning and statistical hypothesis testing to differentiate between two or more clearly defined alternatives". It is recommended by USEPA in RI/FS guidance (USEPA 1988) and ecological risk assessment guidance (USEPA 1997; 1998). The USEPA developed the DQO process "...as the Agency's recommended planning process when

environmental data are used to select between two opposing conditions." A summary of the seven steps involved in the DQO process is presented in Table 4-2 below (from USEPA 2000)

Table 4-2.The Data Quality Objective Process.

DQO Step	Activity
Step 1. State the problem.	Define the problem; identify the planning team; examine budget and schedule.
Step 2. Identify the decision.	State decision; identify study questions; define alternative actions.
Step 3. Identify inputs to the decision.	Identify information needed for the decision (information sources, basis for Action Level, sampling/analysis method.)
Step 4. Define the boundaries of the study.	Specify sample characteristics; define spatial/temporal limits, units of decision making.
Step 5. Develop decision rule.	Define statistical parameter (mean, median); specify Action Level; develop logic for action.
Step 6. Specify tolerable limits on decision errors.	Set acceptable limits for decision errors relative to consequences (health effects, costs).
Step 7. Optimize the design for obtaining data.	Select resource-effective sampling and analysis plan that meets the performance criteria.

The goals of the DQO process are to:

- Clarify the study objective and define the most appropriate types of data to collect;
- Determine the most appropriate field conditions under which to collect the data; and,
- Specify acceptable levels of decision errors that will be used as the basis for establishing the quantity and quality of data needed to support risk management decisions.

4.2.2 Site Data Quality Objectives

DQOs have been prepared to ensure that data proposed for use in the risk assessment would be of sufficient quality, appropriate for the intended uses, and useful in meeting RI/FS objectives. The overall quality assurance (QA) objective of the project is to ensure that field and laboratory data collected during the RI has been precise, accurate, representative, comparable, and complete. Specific procedures for obtaining these QA objectives are presented in the Quality

Assurance Project Plans (QAPP) that accompanied the RI Work Plan and amendments. DQOs for the Site have included the following:

- Utilization of laboratory procedures and the appropriate analytical support (i.e. data validation) for identifying contamination consistent with the levels for remedial action objectives identified in the National Contingency Plan (NCP);
- Identification of the vertical and lateral extent of sediment, soil, surface water and groundwater contamination in the Site area;
- Utilization of historic and RI-generated site data to interpret geologic and hydrogeologic conditions with respect to evaluating contaminant migration pathways and the fate and transport of contaminants;
- Generation of laboratory data with appropriate detection limits to compare to media specific cleanup standards and to assess attainment of risk-based criteria;
- Utilization of historic and RI-generated data necessary to perform human health and ecological risk assessments;
- Utilization of historic and RI-generated data necessary to develop site-specific cleanup standards protective of human health and the environment; and
- Utilization of historic and RI-generated data for the evaluation of potential remedial alternatives that will achieve site-specific cleanup standards protective of human health and the environment.

A detailed discussion of these DQOs is presented in the Quality Assurance Project Plan (QAPP) that has accompanied the RI/FS work plan. Specific aspects of DQOs for the studies used to support this BERA are summarized in Appendix G, Tables 1-6.

4.2.3 Weight of Evidence Evaluation

As discussed in USEPA (1997),

> "Confidence in the conclusions of a risk assessment may be increased by using several lines of evidence to interpret and compare risk estimates. These lines of evidence may be derived from different sources or by different techniques relevant to adverse effects on the assessment end points, such as quotient estimates, modeling results, or field observational studies. There are three principal categories of factors for risk assessors to consider when evaluating lines of evidence: (1) adequacy and quality of data, (2) degree and type of uncertainty associated with the evidence, and (3) relationship of the evidence to the risk assessment questions [...]. Data quality directly influences how confident risk assessors can be in the results of a study and conclusions they may draw from it. Specific concerns to consider for individual lines of evidence include whether the experimental design was appropriate for the questions posed in a particular study and whether data quality objectives were clear and adhered to. An evaluation of the scientific understanding of natural variability in the attributes of the ecological entities under consideration is important in determining whether there were sufficient data to satisfy the analyses chosen and to determine if the analyses were sufficiently sensitive and robust to identify stressor caused perturbations. Directly related to data quality issues is the evaluation of the relative uncertainties of each line of evidence [...]."

Weighting of evidence should be used for two purposes:

1) Weighting of the value of the various measures or studies that are used to support a line of evidence, e.g., deciding which toxicological study is the most relevant in deriving a toxicological benchmark for use at a specific site; and,
2) Weighting of relative value of each line of evidence in determining what estimate of risk is most likely for site receptors given the results from that line of evidence.

The process of weighing various measures and studies or the relative value of each line of evidence may consider such factors as:

1) Relevance of the study to the assessment endpoint;
2) Strength of the exposure-response relationship;
3) Appropriateness of the study temporal scope;
4) Appropriateness of the study spatial scope;
5) Quantity of data; and,
6) Quality of data.

The lines of evidence used in this BERA will be accorded the following weight of evidence [numbered according to relative significance, with 1) having greater weight than 3)]:

1) Comparison of observed effects in the receptor group community characteristics in waterbodies in and adjacent to the Site to receptor group community characteristics from reference areas;
2) The results of bioassays conducted using standardized toxicity tests with sediments in and adjacent to the Site and surrogate test organisms;
3) Comparison of site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels [(toxicological benchmarks and TRVs][6] for the various ROCs.

Not all lines of evidence are necessarily used for each receptor group but when multiple lines of evidence are used the highest weight, i.e. the most important, should be accorded the results of site-specific studies. For instance, if there are conflicting results from the various lines of evidence, results from site-specific studies, e.g., from sediment bioassays using sediment from the Site or comparison of the tissue residue levels of organisms collected at the Site to tissue residue levels from similar species in reference areas, should be deemed more reliable for evaluating potential risk, then comparison to TRVs for surrogate species. To the extent that additional lines of evidence are used for any of the assessment endpoints, it is recommended that a process be employed to reach consensus on the relative weight of evidence for these lines. As an example, if adequate information is available, the Triad approach offers the benefit of precedent in interpreting multiple lines of evidence relating to sediment quality.

[6] In this risk assessment the term "Toxicological Reference Value" will be used for effects levels for birds and mammals, while "toxicological benchmark" will be used for effects levels for other receptors.

For those lines of evidence where Hazard Quotients (HQs) were calculated, the risk questions presented in Section 3.9.1 and Table 4-1 will be answered in the affirmative if the hazard quotient was greater than one.

During the analysis phase, an evaluation of ecological and chemical data is conducted to determine the potential for ecological exposure and adverse effects. The management goals and objectives, assessment endpoints, and measures of effect, as well as the ecological CSM developed during problem formulation help focus this analysis. The analysis consists of two components: (1) effects analysis and (2) exposure analysis. These two components are used to evaluate the relationships between receptors, potential exposures, and potential effects. The results of these evaluations provide the information necessary to estimate potential risks to the representative species.

5.1 EFFECTS ANALYSIS

The Effects Analysis consists of an evaluation of available toxicity or other effects information that can be used to relate the exposure estimates to a level of adverse effects. Stressor-response (i.e., effects) data that are used to evaluate ecological risks in this BERA are of three types: (1) literature-derived toxicity data, (2) site-specific ambient media toxicity tests (e.g. sediment toxicity tests), and (3) site-specific biological community surveys.

The focus of majority of the effort for this BERA was on aquatic portions of the Site. For the evaluation of Site sediment all three lines of evidence were integrated into a Sediment Quality Triad (Triad) (Long and Chapman 1985; Chapman et al. 1987). The Triad evaluates sediment quality by integrating spatially and temporally matched sediment chemistry, biological, and toxicological information. Benthic invertebrate community analysis and sediment toxicity testing provide site-specific information regarding potential ecological effects of exposure of ecological receptors to COPCs in the Site sediment. These additional lines of evidence supplement traditional bulk sediment chemistry data to provide a more relevant, site-specific assessment of risks.

The evaluation of bulk sediment chemistry data involves comparison of Site sediment chemistry data to effects levels derived from relevant studies reported in published literature or performed for this BERA. These data may also be represented as generic criteria or guidelines that have been developed from toxicity data, e.g., National Recommended Water Quality Criteria (NRWQC). Toxicity data developed for use in this BERA are summarized in this Section and the details are presented in Appendix H. Site-specific sediment toxicity tests also have been conducted with aquatic receptors that are representative surrogates for those living on the Site. This testing provides information on potential toxic effects that were observed in Site relevant organisms exposed to Site sediment. The results of the sediment toxicity testing done for this Site are summarized in this section and Site-specific sediment toxicity test reports are presented in Appendix B. Site-specific surveys of benthic macroinvertebrate community also were conducted for the Site. A summary of this investigation is presented in this section and Appendix B provides further details.

In addition to these three lines of evidence for aquatic portions of the Site, surface water quality data and fish tissue data were collected from Site waters.

For upland portions of the Site only two lines of evidence were used in this BERA. One was the comparison of bulk soil chemistry to soil quality benchmarks used as generic criteria, e.g., the soil ECO-SSLs (USEPA 2005a) or derived from relevant studies reported in published literature. The second is the comparison of doses accumulated through the food chain that terrestrial and

aquatic prey-dependent wildlife (i.e., birds and mammals) may feed upon. These doses were compared to toxicity reference values derived from the primary scientific literature.

The result of this ecological effects analysis is a range of TRVs that will be compared with the dose estimates (birds and mammals) or toxicological benchmarks that will be compared with estimated exposure point concentrations (EPCs) (benthic invertebrates and fish) to estimate potential risks in this risk characterization.

5.1.1 Site Contaminants of Concern

While the primary Site COPCs are derived from tar related to historical industrial operations at the Site, there are other COPCs whose origin is uncertain. Tars contain a number of non-toxic and potentially toxic chemicals. By far the greatest percentage of tar components are non-toxic because they are not water soluble or bioaccessible. The toxicity of tars is due largely to the aromatic hydrocarbons and, to a lesser degree, the short-chain alkanes, phenols, and other components such as cyanide and ammonia. The tar related COPCs for this Site include VOCs, principally BTEX, and SVOCs, principally PAHs. Of these, the PAHs are considered the most potentially bioaccessible and toxic. Therefore, PAHs are considered the major source of toxicity at the Site and are the focus of this ecological risk assessment.

As discussed in Section 3.6 in addition to tar associated COPCs, the levels of some other chemicals were higher than the screening values for sediment and soil quality and also will be addressed in this Effects Analysis. These included barium, copper, selenium and thallium in sediment and antimony, cadmium, lead, manganese, mercury, selenium and zinc in soil. No COPCs were identified in surface water samples.

These other COPCs likely originated from the various industrial operations that occurred on this Site (See Section 2.2) or may have originated in the backfill.

Based upon comments by USEPA, screening to determine COPCs was conducted based upon comparison of the maximum detected concentration to the screening criteria. However, USEPA also indicated that use of the UCL_{95} was appropriate for quantifying intake and characterizing risks. Section 5.2 provides a list of the COPCs for which TRVs will be developed in this section.

5.1.1.1 Tar Related Compounds

Tar is a complex mixture of hydrocarbons which may be divided into at least four operationally-defined major categories:

1) Aromatics;
2) Saturates;
3) Resins; and
4) Asphaltenes.

Aromatic hydrocarbons (AHs) are compounds sharing the cyclic unsaturated bonds (π bonds) found in benzene. AHs are further characterized according to the number of benzyl rings (e.g., naphthalenes are di-aromatic, anthracene is tri-aromatic, and pyrene is tetra-aromatic). Aromatics may also be classified as mono- –(i.e., often called VOCs) and poly (polycyclic)

aromatic (PAHs). PAHs are further subdivided into low molecular weight (LMW) or high molecular weight (HMW) PAHs. VOCs are volatile and relatively water-soluble, but are also relatively non-toxic to aquatic organisms. The LMW PAHs are less water-soluble and bioaccessible[7] than VOCs, but are more toxic. HMW PAHs are even less water-soluble and bioaccessible but are potentially the most toxic members of this group of tar compounds. In tars, the aromatic hydrocarbons mostly belong to the benzene, naphthalene, anthracene, and phenanthrene series. Naphthalene, a LMW PAH, is often the largest single component of unrefined, un-weathered, tar, with concentrations of between 7 and 12%. Although PAHs are mostly comprised of carbon and hydrogen atoms, sulfur, oxygen, and nitrogen may substitute for carbon to form heterocycles. VOCs usually comprise a small portion of the total aromatics of tars and this portion decreases as tar environmentally "weathers" with age due to their volatility and leaching by water. VOCs made up about 3% of the total AHs in some Site sediments. In soil, VOCs were less than 2% of the total AHs.

Saturates are non-polar aliphatics comprised of straight-chain, branched, and cycloalkanes (naphthenes) hydrocarbons. Short-chain alkanes are highly water-soluble saturates but are also highly volatile and non-persistent. The paraffins (waxes) are long, straight-chain alkanes that are very water-insoluble.

Resins are operationally defined as the portion of tar that is insoluble in propane, but soluble in pentane or heptane. Resins are polar molecules often containing heteroatoms, atoms other than carbon in the structure of a heterocyclic compound. Resins are structurally similar to asphaltenes but have lower molecular weight. Resins are also insoluble in water.

Asphaltenes are very HMW aromatics that are operationally defined as the fraction of tar that precipitates in pentane, hexane or heptane, but not in toluene or benzene. Asphaltenes contain the largest number of heteroatoms and organometallic constituents. The molecular weights of asphaltenes are difficult to assess, but are believed to range fro 500 to 2,000 g/mole. Asphaltenes are insoluble in water.

Besides the hydrocarbons, tars may include about 2% of the simpler phenols, the best known of which is carbolic acid. The phenols are highly soluble in water. Trace minerals found in the coal (arsenic, chromium, lead, etc.), as well as cyanides, sulfur, and ammonia are other potentially toxic components of tars. The actual composition of the individual tar components is highly dependent on the coal source, method used to make the coal gas, and the degree of exposure to oxidizing conditions (i.e., weathering).

5.1.1.2 PAHs in Site Sediments

As discussed in Section 2.0 contamination in Site sediments is mainly confined to a sediment layer extending a few hundred feet from the shoreline. This contaminated sediment layer is thickest near the shoreline, typically 3 to 4 ft, and tapers off in the offshore direction. The areas

[7]Bioaccessibility refers to the portion of the diet that is desorbed from the food or soil and is dissolved in the stomach or gut contents. For a chemical to be bioavailable it has to be both bioaccessible and assimilated across the gut epithelium. Therefore, the bioaccessible portion is a conservative estimate of the bioavailable portion. Because of precedent the term bioavailability will be used as the inclusive term for both elements of bioavailability in the following discussion.

with the highest levels of contamination tend to mimic the shape of the shoreline. Layers of wood mulch are sometimes found overlying or within the contaminated sediment layer. The wood mulch layer varies in thickness from 0 to 6 ft, averaging about 9 inches across the Site. It is estimated that approximately 25,000 cubic yards of wood mulch are found in the nearshore area, and most of this overlies the sediment bed (URS 2006b). Native sediments underlying the wood mulch layer consist of interbedded layers of sand, silty sand, silt and silty clay. The highest concentrations of VOCs and PAHs were detected in sediment samples collected in the area south of a line between the former WWTP and the marina, an area north of the former WWTP, and in the area between the former WWTP and the boat launch. The highest concentrations are found at sediment depths between 0 and 6 ft (URS 2001).

Newfields (2005) conducted a forensic analysis of the soils and sediments from the Site. They concluded that sediments at stations closer to shore had a composition of PAHs similar to that found in soils at the Tar Dump. The hydrocarbon composition at stations further offshore was more similar to regional background sediments and soils at Kreher Park. Both samples also contained modern organics and degraded vegetative debris. Higher concentrations of PAHs and soot were also found at the stations closer to shore.

As discussed further below, the presence of wood mulch and soot modify the bioavailability and bioaccessibility and, therefore, the toxicity of PAHs.

Bioavailability of PAHs in Sediments

In order to make contact with or enter an organism, chemicals must be bioaccessible. The bioaccessibility of PAHs is governed by the balance between their affinity for like substances, such as organic carbon or dense non aqueous phase liquid (DNAPL), and their aversion to unlike substances, such as water. This affinity is most frequently described as the octanol-water partition coefficient, or Kow. HMW PAHs also have a relatively high Kow, while LMW PAHs have a relatively low Kow. The most commonly measured organic carbon sources to which PAH bioaccessibility is correlated are total organic carbon (TOC) in the bulk sediment (and soil) and dissolved organic carbon (DOC) in the sediment or soil porewater. As the concentration of TOC and/or DOC increases, the bioaccessibility of PAHs decreases, although this is more important for HMW than LMW PAHs. At the Site, the most obvious form of organic matter is wood mulch, and, as discussed later, areas of wood mulch have been associated with lower levels of toxicity in sediment bioassays at the Site.

In addition to wood mulch another source of organic carbon in site sediments is soot. Soot made up as much as 10% of the sediment at some of the sediment stations (Table 5, Newfields 2005). When hydrocarbons are exposed to high temperatures, but without sufficient oxygen to allow complete combustion, they polymerize to form soot. Because soot is composed of hydrocarbons, PAHs are attracted and tightly bound to soot. Studies have shown that binding to soot is tighter than to TOC (Lamoureux and Brownawell 2004) which results in lower bioaccessibility than predicted by equilibrium partitioning (Accardi-Dey and Gschwend 2003; Sunderlin et al. 2004; Rust et al. 2004). The other potential organic carbon source in sediments at the Site is coal and coal dust from various sources in the vicinity of the Site. However, based upon petrologic analysis of site sediments other than Station SQT8, where coke and coal made up 6% of the sediments, coal (or coke) was not found in any quantity in Site sediments (Newfields 2005).

Effects of Weathering on the Bioavailability of PAHs

When tars are exposed to sunlight and water their composition is changed. Contact with water removes the more water-soluble LMW PAHs by dissolution and photo-oxidation changes the PAHs to other, more water-soluble forms such as acids, alcohols, ketones, aldehydes and quinones (Ehrhardt and Burns 1993). In both cases, these water-soluble products are diluted in the surrounding water and only very low concentrations have ever been measured. Weathering is likely to be a very important factor influencing potential toxicity because LMW PAHs and other water-soluble components volatilize or leach from sediments. The remaining tar products will, therefore, be relatively enriched in HMW PAHs and water-insoluble components. As discussed below, there is a large difference in the toxicity of LMW and HMW PAHs.

Photo-oxidation occurs due to short wave length UVA (320-400 nm) and UVB (280-320 nm) light. Photo-oxidation preferentially depletes alkyl-substituted PAHs and heterocyclic PAHs (Ehrhardt et al. 1992). Some of these oxidation products may be more toxic than the parent compounds. However, because only a small fraction of the total volume of tar is weathered, the concentration of the oxidation products is small. In fact, Ali et al. (1995) reported that under controlled laboratory conditions, only 12% of phenanthrene was found as photoproducts after 7-hrs exposure to intense UV light. Furthermore, in sediments contaminated with crude oil, Ehrhardt and Burns (1993) reported photo-oxidation products in water samples, but not in sediments because the products were water-soluble and leached from the sediments. Furthermore, despite the heavily weathered condition of these sediments, the concentrations of these products in infaunal benthic invertebrates were lower than those of the parent compounds. Because only the LMW PAHs are water-soluble and bioaccessible, the composition of parent PAHs in infaunal benthic invertebrates is biased towards the lighter fraction. Further degradation follows since the water-soluble products are readily consumed by microbes as a carbon source.

5.1.2 Mechanisms of Toxicity of PAHs to Aquatic Organisms

It is generally accepted that PAHs cause toxicity to aquatic organisms primarily by narcosis (DiToro et al. 2000; Swartz et al. 1995; Russom et al. 1997; Barron 2000; McGrath et al. 2004). Narcosis is a nonspecific, reversible, disruption of neural activity (i.e., anaesthesia).

There are currently two theories about how narcosis works. The "critical volume theory" involves the disruption of nervous conductance caused by changes in the nerve cell membrane lipid composition due to the accumulation of toxicant molecules. The "protein binding theory" involves the interaction of toxicant molecules with specific receptors in or on the nerve cell. In either case, a certain constant molar volume of narcotic chemicals must be reached in order to cause the effect. For instance, several small molecules that occupy the space of a single large molecule will cause the same degree of narcosis. This has been shown in studies by Protic and Sabljic (1989) and Mortimer and Connell (1995) using various non-polar organic chemicals. Furthermore, since AHs exhibit the same quantitative structure-activity relationships (QSARs) between toxicity and the potential for uptake of other classical non-polar narcotics, and because the toxicity of PAHs and VOCs is additive on a molar basis (Landrum et al. 1991), it can be assumed that all PAHs and VOCs are also narcotics.

However, narcosis may not be the sole cause of toxicity to certain fish species. This is because, although all fish can detoxify PAHs through metabolism, certain fish may metabolize certain PAHs to metabolites that can cause cancer in the fish. Cancer does not occur in aquatic invertebrates, either because their life times are too short for cancer to develop, or because they do not produce these metabolites. However, as discussed below, the field data for PAHs as the cause for cancer in fish is controversial because there are numerous carcinogens in the aquatic environment and only certain species appear to be susceptible. Therefore, it is important to understand the metabolism of PAHs by fish, and the relative rates of detoxification vs. the formation of carcinogenic metabolites. This subject is discussed more extensively in the following sections.

PAH Metabolism by Aquatic Organisms

Once PAHs are dissolved in water they are subject to metabolism both within microbes and within higher organisms. Within most higher animals, PAHs are metabolized by the cytochrome P450-dependent (CYP1A1) Phase 1 enzyme system to products that are more water-soluble and may have much more specific mechanisms of toxicity than narcosis. The degree of metabolism depends in large part on phylogeny, with more advanced animals being more capable of metabolism than less advanced animals. Because the metabolites produced are more water-soluble, they are more easily released from the body than the parent compound (active excretion plus passive diffusion).

However, it is not clear that metabolism of PAHs is uniformly beneficial, since certain metabolites appear to be more toxic than the parent. Since metabolic capacity is lower in animals such as invertebrates and fish than in mammals, there appears to be a trade-off between the creation of a small mass of more toxic metabolites, and the high mass of the less toxic parent compound. For instance, Landrum and Scavia (1982) reported that the amphipod, *Hyalella azteca*, metabolized only about 2.1% of an anthracene body burden per hour, and Landrum (1988) and Landrum et al. (1994) reported no metabolism of a series of PAHs by the amphipod, *Diporeia spp.* (formerly *Pontoporeia hoyi*). Since very few or no toxic metabolites are formed, any adverse effects must be due to narcosis in these organisms.

On the other hand, in higher animals, where metabolism is faster, more toxic metabolites are produced at a higher rate and these have been associated with oxidative damage (i.e., free radicals) and carcinogenesis.

Even in animals that form more toxic metabolites, these may be further metabolized and detoxified by the Phase II system of epoxide hydrolases and glutathione S-transferases. In fact, even under acute exposure conditions, PAHs are generally not detected in fish tissue, unless in the presence of a continuing source of LMW PAHS to the water column or items in the fish diet, and exposure can only be shown by the measurement of conjugated metabolites in the bile. The uptake of PAHs by fish is determined by the affinity of PAHs for lipids in fish tissues and this affinity increases as Kow increases. Therefore, if PAHs are bioavailable for uptake to fish, i.e. in the water column and diet, HMW PAHs are theoretically more likely to be accumulated than LMW PAHs in fish tissue. However, since the uptake is relatively slow, PAHs are frequently not detected because the rate of metabolism equals that of uptake. Furthermore, fish metabolize HMW PAHs with greater efficiency than LMW PAHs.

Exposure of fish to sublethal concentrations of PAHs can activate the CYP1A1 gene so that PAHs are more rapidly metabolized. This phenomenon is called induction. Induction results in an increase in tolerance such that fish can survive concentrations of PAHs that are toxic to PAH-naïve fish. For instance, Diamond et al. (1995) reported that fathead minnows exposed to a sublethal level of fluoranthene increased their tolerance to PAHs by 30%. This is good evidence that the primary mechanism of toxicity of PAHs is narcosis rather than oxidative damage and that any metabolites produced are less toxic than the parent. As a result of induction, wild fish chronically exposed to sublethal levels of PAHs in the field would be expected to be more tolerant of PAH exposure than naïve fish tested in the laboratory.

The metabolism of PAHs not only produces metabolites, but also free radicals that can react directly with biological molecules. Such free radicals can cause cellular injury when they react with proteins or lipids or can be detoxified when they react with antioxidants such as ascorbate or carotenes. This antioxidant system is normally capable of detoxifying radicals created by normal metabolism and some degree of toxicant-induced radical generation Over time resistant animals appear to be selected under such exposure conditions such that populations remain stable. However, under high exposure conditions both the Phase I and Phase II systems can be overwhelmed.

Even when the Phase I, Phase II, and antioxidant systems perform perfectly, some PAH metabolites could potentially react with cellular components to cause sublethal adverse effects. These effects range from individual cell swelling (cytomegaly), to cell death (necrosis). Certain HMW PAHs that contain a "Bay" region may be metabolized to highly reactive epoxide intermediates capable of binding to DNA and causing mutations. These mutations occur at oncogenes, such as the Ki-*ras* oncogene[8]. Under normal conditions, these mutated cells are recognized by the cellular immune system and killed, but some of these cells escape detection and may go on to replicate themselves. Cell replication is stimulated when cell injury is present, and when PAHs cause cell injury they may stimulate the replication of normal as well as "transformed" cells. Over time, the replication of genetically transformed cells may result in cancer.

However, malignant cancer is a disease that requires an accumulation of genetic alterations. Most tumor cells are genetically unstable, as manifested by the genomic heterogeneity between cells within a tumor. This genetic instability may accelerate tumor progression by promoting mutations that convey a growth advantage. The increase in mutation frequency in cancer cells may be explained by the inactivation of genes involved in maintaining the integrity of the genome. These include the p53 tumor suppressor gene, the mismatch repair genes, and genes involved in controlling replication during mitosis. Oncogenes are expressed in tumors from fish (Goodwin and Grizzle 1994), but no corresponding point mutations, at least in the Ki-*ras* oncogene, have been found (Peck-Miller et al. 1998. During periods of stress and old age, when the immune system is sub-optimal, the incidence of tumors is increased. Chemical stress from many different sources may suppress the tumor suppressor gene P53. Thus, old, immune

[8]Oncogenes are genes that have sequences that are susceptible to mutation and are frequently found to be modified in cancer cells. Ki-ras is a particular sequence that is similar to that found in retroviruses and is found in cancer cells.

suppressed fish and PAH-exposed fish have both been shown to have elevated levels of liver tumors.

Certain naturally occurring chemicals also reduce cancer incidence in fish. Reddy et al. (1999) showed that chlorophyllin reduced the incidence of carcinogenesis in rainbow trout that were fed dibenzo[a,l]pyrene, and that this effect was not simply due to a reduction in bioaccessibility through complexation.

In summary, fish possess multiple levels of detoxifying mechanisms, and detoxification is the major fate for PAHs. The field data for PAHs as the cause for cancer in fish is controversial because there are numerous carcinogens in the aquatic environment and only certain species appear to be susceptible. Cancer is not an endpoint for invertebrates since they neither produce carcinogenic metabolites or live long enough to develop cancer.

Relative Metabolite Yield in Fish

The cytochrome P-450 system in fish is primarily a detoxification system, and most of the metabolites formed from PAHs are less toxic than the original parent compound. Although the focus of much of the research into the metabolism of PAHs is on negative effects including carcinogenesis due to some metabolites, few studies have reported the relative yield of PAH detoxified metabolites relative to the potentially carcinogenic metabolites. However, the fact that PAH metabolites are routinely measured in bile but are non-detectable in liver and flesh suggests that most PAHs are efficiently metabolized, conjugated, and excreted as non-toxic compounds. Balk et al. (1984) exposed pike larvae to [^{3}H]BaP in the diet and in the water. When fed, the pike initially (1.3 days) accumulated benzo(a)pyrene (BaP) in the liver and kidney, but by day three the liver, gall bladder, intestine and rectum continued to concentrate radioactivity. By day 21, the liver and kidney radioactivity had decreased. When exposed in the water, the gills and skin initially accumulated BaP, but the liver, bile duct, kidney and bladder were also labelled between 12-h and 3 days. Between 3 and 21-days, the intestine and rectum became labelled, presumably as the result of biliary excretion. The gall bladder contained over 50% of the radiolabel between day 1 and day 8.5. The highest percentage reached by the liver was 18% on day 14 and this was reduced to 4.8% by day 23. At day 23, the gall bladder accounted for 28% and the intestine 38%. This indicates that BaP was metabolized and excreted into the bile and urine, and that, at most, <5% could have remained bound to the liver tissue. The virtual absence of radiolabel from adipose tissues shows that only PAH metabolites were available for distribution to the other tissues. This shows that most parent PAH was cleared from the body and that very little remained to cause adverse effects.

Studies with wild fish have also shown that the majority of metabolic products of PAHs are benign. Among wild freshwater fish, Baumann et al. (1996) have shown that brown bullhead appear to be the most sensitive to chemically-induced carcinogenesis. Steward et al. (1990) evaluated the distribution and composition of BaP administered to brown bullhead. They reported that the highest concentrations of BaP were found in the bile and consisted of 10% unmetabolized BaP, and 81% water-soluble metabolites which are excreted. The potentially genotoxic metabolite BP-7.8-dihydrodiol accounted for only 3% of the total radioactivity in the bile. In addition, the results from the brown bullhead cannot be extrapolated to other species of freshwater fish. Willett et al. (2000) reported that both brown bullhead and channel catfish produce more non-toxic BaP-diones than the proximal carcinogenic 7,8-dihydrodiols.

Furthermore, the channel catfish clears PAHs more rapidly than brown bullhead and does not produce mutagenic PAH metabolites. This is due to channel catfish having greater activities of the Phase II detoxification enzymes and being able to detoxify and eliminate PAHs more efficiently than brown bullhead.

Similar in-depth studies are not available for salmonids, perhaps because this class of fishes are relatively primitive and may not produce the yield of metabolites necessary for analysis. When trout were exposed to between 1.2 and 4.0 µg BaP/L for 30-days, no hepatic DNA adducts were formed (Potter et al. 1994) and when BaP was administered by i.p., only 2.38% of the administered dose was recovered as hepatic DNA adducts (Schnitz and O'Connor 1992). Presumably, the remaining 97.6% did not form metabolites that bind to DNA. From these studies it appears that the brown bullhead studies represent the worst case for carcinogenesis in freshwater fish and the characteristics of this species should not be generalized to the other species that frequent the Site.

In summary, although carcinogenic metabolites may be formed by certain fish species, detoxification is the more likely fate for PAHs.

Evidence for PAH-Induced Carcinogenesis in Fish

Whether or not the mechanisms discussed above are a significant source of biological effects in the environment is still open to question. Although numerous studies have produced tumors in fish in the laboratory, few controlled few studies have produced tumors using PAHs, and none were identified that used environmentally-relevant concentrations.

Hawkins et al. (1990) exposed Japanese medaka and guppies to 30-250 µg BaP and or 7,12-dimethylbenzo(a) anthracene/L and reported liver tumors. However, these concentrations were only obtained by using dimethylforamide as a solvent to achieve adequate aqueous solubility. Hendricks et al. (1985) fed rainbow trout a diet containing 1000 µg BaP/kg for 18-months and reported liver tumors.

Although carcinogenesis has been produced in several species of fish in the laboratory, it has only been reported in some species of bottom-feeding in the wild. Even within an apparently similar feeding guild (fish with the same feeding ecology), large interspecies differences have been described. For instance, Malins et al. (1987) showed that within the same creosote-impacted harbor, two marine species of bottom-dwelling flatfish have drastically different incidences of liver tumor. English sole had a hepatic carcinoma incidence of 45% while starry flounder had an incidence of <1%. Similarly, there are numerous reports of hepatic of tumors in brown bullhead, but none in the closely related channel catfish. Furthermore, tumors have never been found in wild salmonids even though they can be induced in the laboratory (Hendricks et al. 1985).

Baumann and Harshbarger (1995) reported sediment and whole body PAH concentrations and incidences of hepatic lesions, including hepatocarcinoma, in brown bullhead at an industrial site in Ohio. In 1982, the sediment PAH[9] concentration was 381 mg PAH/kg, the whole fish

[9] Total PAH concentrations are dependent on the number of PAHs analysed. In 1982, only 11 PAHs were analysed, while 44 PAHs were analysed in 2000.

concentration was 0.48 mg PAH/kg (wet weight), and the incidence of cancer was between 31.2 and 41.1%, depending on age class. When sediment concentrations decreased to 4.3 mg PAH/kg, cancer incidence decreased to between 2.1 and 10%, again, depending on age class. Pinkney et al. (2004) reported liver tumors in between 50 and 68% of brown bullhead in the Anacostia River (MD) where the different surveys have reported mean sediment PAH concentrations of 26.8, 77.3, and 249 mg/kg. Although these concentrations of PAHs are lower than those studied by Baumann and Harshbarger (1995), the percentage of bullhead in the Anacostia with hepatic tumors is greater than the highest reported incidence in the Great Lakes.

This high variability of effects of PAHs on fish may be because PAHs are not the only, or the most potent, organic chemicals in sediments capable of causing carcinogenesis. High incidences of liver tumors have also been found in areas where low concentrations of PAHs were found in the sediments. Barron et al. (2000) reported an increased incidence of hepatic tumors in walleye from Green Bay, WI, but attributed these lesions to the presence of PCBs in sediments. Mikaelian et al. (2002) also reported hepatic tumors in whitefish that were associated with PCBs, chlorobenzenes and pesticides, but not PAHs. Black et al. (1982) reported nearly 100% hepatocarcinoma in sauger and 5-10% hepatocarcinomas in walleye from Torch Lake and Keweenaw Waterway, MI, where copper was the only contaminant identified. The high incidence of hepatic parasitism in sauger also may have contributed to the high levels of tumors because liver injury stimulates cell replication of both normal and transformed cells. High incidences of epidermal hyperplasia and dermal sarcomas found in walleye in Oneida Lake were shown to be caused by retroviruses. It is possible that the common denominator in all of these studies is not the presence of reactive metabolites, but the generation of reactive oxygen free radicals (Greenberg 2005), generated by reactions to PAHs, PCBs, lipids, metals, or cellular reactions to parasites i.e., leukocytes).

5.1.2.1 Phototoxicity of PAHs in the Aquatic Environment

Ultraviolet Light

There is a body of literature, based largely on laboratory experiments, that indicates that some PAHs when incorporated into the bodies of aquatic organisms, can become more toxic to the organism when the organisms are exposed to ultraviolet light (UV). UV light is the highest energy light reaching the Earth's surface. UV light is a normal component of sunlight, but it is invisible to the human eye. UV light has been divided into three subunits according to their wavelengths, UVA (320-400 nm), UVB (280-320 nm) and UVC (200-280 nm). About 90% of the total UV sunlight reaching the earth is UVA and the rest is UVB. Many atmospheric gases (i.e., ozone) and aerosols (i.e., water) selectively absorb UVB and reduce its penetration to the earth's surface. UVC is completely absorbed and does not reach the Earth. Of the wavelengths reaching the earth's surface, UVB is the most dangerous to aquatic life.

UVB and UVA penetrate surface waters to a depth that varies with site-specific absorbing capacity. The UV penetration can vary from a few centimeters to tens of meters depending on water transparency and time of year. However, the UVB portion of the spectra is absorbed to a greater extent than the UVA portion, even in pure water. This results in a reduction of the most damaging UV energy reaching aquatic organisms under natural conditions.

As the sun rises and sets the angle of the sun and the spectra of wavelengths that reach the earth's surface also changes. This is due to the longer light path through atmospheric ozone and particulates during the morning and evening, and, within water bodies, the back-scattering of light from reflective surfaces. As a result, to accurately reproduce the effects of UV light in the laboratory it is essential to record changes in the UV spectrum from dawn to dusk and to integrate the area under the curve in terms of energy.

Biological Effects of UVB Light

As discussed above, UV light is divided into UVA, UVB, and UVC. However, it is thought that UVB, or near UVB wavelengths, because of their higher energy relative to UVA or UVC, can directly cause the most adverse effects on organisms. The primary target of UV injury is generally considered to be DNA, but other studies have cited effects on external organs such as gills as other important targets. Most studies have reported that although UVA is more abundant, it is UVB that is responsible for cellular injury. For instance, Williamson et al. (2001) reported that 320 nm (UVB) is 110-fold more damaging to *Daphnia magna* than that caused at 370 nm (UVA).

A dose of UV light is like any other toxicant in that the critical factors are the concentration and duration of exposure. In the case of UV light, the concentration is the exposure energy, commonly expressed as $\mu W/cm^2$. However, the toxicity of UV light has been assumed by many researchers to be governed by the reciprocity principle. The reciprocity principle states that a given total dose of radiation is independent of exposure duration. Therefore, the same effect is found for short, high-energy doses as for long, low-energy doses, so long as the dose (energy x duration) is the same. For organisms that do not have well-developed photoenzymatic repair (PER) mechanisms, reciprocity works as expected. However, for organisms with PER capacity, UV-induced toxicity acts like chemically-induced toxicity in that tolerance is a balance between the rate of injury and the rate of repair.

In both chemical and UVB-induced toxicity, the ability to repair injury can be overwhelmed by short-term high intensity exposures, even if the total exposure is equal to a long-term no effect exposure. The PER mechanism to repair DNA depends on the enzyme photolyase which reverses the cross-linking between adjacent DNA strands formed by UV energy. This reaction is of interest because it occurs only in the presence of UVA and visible light. This is one reason why laboratory experiments that do not replicate field conditions in terms of exposure spectra (i.e., UVA and visible light) and duration (i.e., 8-hours darkness) cannot be extrapolated to field conditions.

Modifying Factors and Adaptations to UV Light in the Aquatic Environment

In some clear lakes in North America, 99% of UVB reaches a depth of only 4 m while 99% of UVA reaches a depth of 10 m. However, in the water column of most lakes, dissolved (DOM) and particulate organic matter (POM) reduce UV penetration by absorbing the UV energy. DOM comprises a complex array of carbon containing compounds derived from the decomposition of dead organisms. Offshore, the major portion of POM is phytoplankton, but nearshore, where wave action keeps sediment suspended (i.e., turbidity), POM is dominated by plant matter that has not fully decomposed (i.e., detritus).

There are four major factors that affect UV light penetration in freshwater lakes: 1) chlorophyll α[10], 2) DOM, 3) suspended solids, and 4) pure water itself. Jerome and Bukata (1998) evaluated the relative absorbance of UV light in Lake Erie and Lake Waskesiu waters. They concluded that around 90% of UVA and UVB is absorbed by the combination of chlorophyll α and DOM. However, at the shortest UVB wavelengths, between 76 and 86% of UVB is absorbed by DOM while absorption by chlorophyll α is comparable to that of pure water. On the other hand, in the near visible UVA range chlorophyll α is the dominant factor. Based upon these data it appears that DOM concentration is the most important factor controlling UVB light-dependent toxicity in the aquatic environment.

Animal behavior also plays a significant role in photoxicity. Because UV light energy is capable of damaging the structure of DNA in organisms, most organisms have developed mechanisms to avoid UV light. The two most basic mechanisms are photoprotection and photoavoidance. The most obvious mechanism of photoprotection is the presence of pigmentation on the dorsal surface of all aquatic species except those that live below the level of light penetration. Persaud and Yan (2005) reported that UV tolerance and pigmentation increased with age in larvae of the midge *Chaoborus punctipennis*, and Bell et al. (2004) reported that adult midges, *Chironomus dilutus*, were much less sensitive to UV light than larvae. McNamara and Hill (1999) reported that prosobranch snails are relatively insensitive to UVB; *Elimia clavaeformis* was not affected by UVB doses that killed midges, and small *Physa gyrina* were more sensitive than larger specimens of the same genus. These results show that pigmentation and relatively thick shells convey UVB tolerance.

For many species exposure to 280-400 nm UV and shorter wavelength visible light (400-440 nm) triggers avoidance, or negative phototaxis. Negative phototaxis is a form of photoavoidance that is commonly observed in phytoplankton, zooplankton, fish and amphibians. These organisms come near the water surface only during the morning and evening when light levels are low. These UV-sensitive organisms avoid depths at which damaging wavelengths are present but seek out cover (i.e., "light niches") or depths where beneficial wavelengths for photorepair and UV vision are present. Many invertebrates also respond directly to UV light, while others merely respond to light. For instance, when natural pigmentation is not sufficient to protect from light, burrowing and cryptic behavior are the most common responses of benthic invertebrates. Not surprisingly, Bell et al. (2004) reported that midge larvae exposed to UV light in sediment were much less sensitive than when exposed in water only.

In addition, freshwater macroinvertebrates that normally inhabit or feed on the tops or sides of rocks, such as mayflies, caddisflies and blackflies, also avoid UV light. Kiffney et al. (1997) showed that such species exhibit increased drift to more shaded areas when exposed to increased UVB. Donohue and Schindler (1998) reported that blackfly larvae density was 161-168-fold lower in UV-exposed channels than in shaded channels. Hatch and Burton (1999) reported that, in the laboratory, *Hyalella azteca* avoided UV light by hiding under leaf litter when available. Other benthic organisms such as the chironomid, *Chaoborus*, can detect long wavelength UVA, but cannot detect (and avoid) short wavelength UVA or UVB (Persaud et al. 2003). Presumably, these organisms adapt by other mechanisms and avoidance is not important to these organisms in

[10] Chlorophyll a is used as a surrogate measure of phytoplankton abundance or POM.

the wild. Kelly et al. (2000) reported that benthic invertebrate population patterns are altered by both UV light and the concentrations of DOM that absorb UV light.

The ability to perceive UVB light appears to be best developed in pelagic organisms, and organisms such as daphnids and copepods appear to be able to detect and avoid UVB light (Smith and Baylor 1953; Stortz and Paul 1998; Barcelo and Calkins 1978; Leech and Williamson 2001). Fish are also negatively phototactic to UV light, and the spawning depth of perch (Williamson et al. 1997) and the nesting depth of sunfish (Gutierrez-Rodriguez and Williamson 1999), is deeper in high UV lakes compared to low UV lakes.

Not surprisingly, behavioral responses to UV-light are related to UV tolerance. Leech and Williamson (2000) reported that organisms inhabiting the surface waters of a lake in Pennsylvania were more tolerant of UV light than those inhabiting deeper waters during the day. Many fish species, such as sunfish and perch, possess UV photoreceptors as larvae but lose them with maturity and pigmentation. This loss of photoreception coincides with a habitat shift from the surface waters to deeper waters in addition to a change in diet from small to large zooplankton and/or fish (Lowe et al. 1993; Browman et al. 1993).

Photoactivation of PAHs

As discussed previously a number of recent laboratory studies have shown that the presence of UVA as well as UVB light increases the toxicity of PAHs. This increase in toxicity theoretically may occur via two different mechanisms, photosensitization or photomodification. In photosensitization, internalized PAHs directly absorb a photon that elevates the ground-state to an excited triplet state (^{3}PAH). This ^{3}PAH reacts with another PAH or water molecule to generate the PAH free radical or water free radical. These can react directly with biological ligands to cause toxicity. Photomodification reactions are similar but proceed externally and generate oxidation products from PAHs, such as quinones[11], in the aqueous medium. Both parent and product PAHs can enter the organism, and certain endogenous molecules (i.e., quenchers), such as ascorbic acid and carotenes, can deactivate the $^1O_2$ free radicals. Interestingly, although certain quinones may be theoretically more toxic than their parent molecules, DeGraeve et al. (1980) reported that hydroquinone was rapidly oxidized to *p*-benzoquinone and that the latter was degraded so rapidly to less toxic compounds that they could not estimate a chronic LC50 in fish.

Only certain PAHs can be photoactivated to release free radicals because the ability of a molecule to undergo these reactions is dependent upon its absorbance spectra. The absorbance spectra of a molecule can be expressed as the magnitude of difference between the energy required to elevate an electron from the highest occupied molecular orbital (HOMO) to the lowest unoccupied molecular orbital (LUMO), the so-called HOMO-LUMO gap. PAHs that undergo photosensitization are characterized by a HOMO-LUMO gap in the range of 7.24 to 7.68 eV. This group includes anthracene, benzo(a)pyrene, dibenzo(a,h)anthracene, pyrene, benzo(a)anthracene, benzo(e)pyrene, acridine, benzo(k)fluoranthene, fluoranthene, perylene, and benzo(g,h,i)perylene (Mekenyan et al. 1994). The required energy to excite PAHs to the LUMO can be produced by either UVB or UVA, depending on the specific PAH. This is important

[11] Quinones are only one of up to 30 photoproducts that have been identified.

because UVA penetrates to much greater depths than UVB and, as discussed above, it is not clear that all organisms are able to detect and avoid UVA.

Different PAHs react to UV light in different ways. Krylov et al. (1997) reported that of 16 PAHs tested, nine were more likely to be photomodified to more water-soluble products while seven were more likely to form directly reactive free radicals. For instance, anthracene, benzo(a)anthracene, and phenanthrene form quinones through photomodification, while fluoranthene produces free radicals through photosensitization. However, Barron et al. (2003) and Little et al. (2000) reported only photosensitization reactions with fish exposed to water-soluble fractions of crude and refined petroleum oils. Diamond et al. (2000) showed that under identical UVA exposure conditions, the spectral characteristics of individual PAHs could be used to predict their biological effects. Therefore, photomodification, while toxicologically interesting, may be environmentally irrelevant except that it increases the rate of PAH degradation and limits uptake by creating more water soluble compounds.

In an external medium, PAHs are degraded by UV light to more water-soluble compounds. McConkey et al. (2002) reported that naphthalene is photomodified by natural sunlight to 1-naphthol, coumarin and possibly two hydroxyquinones. They also cited mammalian studies for evidence that 1-naphthol is more toxic than naphthalene. However, Boese et al. (1998) found no difference in the toxicity of naphthalene to amphipods before and after UV irradiation. This may be due to the relatively low yield of 1-naphthol created under bioassays conditions versus the high yield created by McConkey el al. (2002) in their efforts to create photoproducts in detectable amounts. Certainly, under field conditions where the parent compound is present in toxic concentrations, photomodification products would be present in lower concentrations. Another possible explanation is that 1-naphthol is not taken up as efficiently as naphthalene. Regardless, there is no evidence that naphthalene or alkylnaphthalenes, undergo photosensitization reactions.

Nevertheless, photomodified PAHs may play an important role in the degradation of other PAHs. For instance, 1-naphthol is a photoactivator for other aromatic compounds that do not absorb UV light, such as alkylbenzenes (Payne and Phillips 1985). Multiple photooxidation products of alkylbenzenes have been detected in surface waters (Ehrhardt and Burns 1990). UV light not only affects the concentrations of PAHs, but their composition as well. Ehrhardt et al. (1992) reported that alkyl-substituted benzenes and PAHs and heterocyclic PAHs are preferentially degraded to ketones and aldehydes in surface waters. Aldehydes are effective cross-linking agents that could cause adverse effects on aquatic organisms, but they are also less lipophilic and less likely to be accumulated by the organism. It is not known if these compounds are more or less toxic to aquatic organisms, but DOM is also photo-degraded to aldehydes and ketones (Mopper and Stanhovec 1986) and microbes in the water column readily consume these photoproducts. The same degradation and metabolism would be expected of photomodified PAHs.

Because photosensitized PAHs are only effective when released inside the body, only bioaccessible PAHs can cause toxicity through this mechanism. The bioavailability[12] of PAHs is governed by their aqueous and lipid solubility, and these in turn are governed by the compound-

[12] Bioavailability refers to a bioaccessible compound that can be taken up across biological membranes. Not all bioaccessible compounds are bioavailable.

specific octanol-water partition coefficient (Kow). However, not all of the routinely measured PAH body burden is internal and bioavailable to cause phototoxicity. Bell et al. (2004) reported that the exuviae (the exoskeleton shed by the pupa when molting to the adult stage) of chironomids contained higher concentrations of fluoranthene than the whole body tissue, and that emerging adults contained seven-times less fluoranthene than 4th instar larvae.

The ability to create photosensitivity using UV light under laboratory conditions does not necessarily mean that toxicity will occur under natural conditions. Since PAHs must be exposed to UV light in order to be photoactivated, it is not surprising that, although photomodified PAHs have been reported in surface waters, they have not been found in sediments (Ehrhardt and Burns 1993) where they are not exposed to UV light. Similarly, although PAHs are photosensitized and cause toxicity when exposed in the water column, thin layers of sediment protect benthic invertebrates from photosensitization (Ahrens and Hickey 2005). Boese et al. (1998) also reported that the compounds with the lowest water solubilities (i.e. HMW PAHs) were the least phototoxic in sediment bioassays because these compounds were bound to organic matter and not available for uptake. Therefore, the ability to create photosensitity under laboratory conditions does not necessarily mean that toxicity will occur under natural conditions.

In addition, UV light also increases the sensitivity of organisms to stressors other than PAHs. For instance, UV light increases the toxicity of arsenic to *Ceriodaphina dubia* (Hansen et al. 2002), probably as a simple additive stress or through inhibition by arsenic of intrinsic DNA and/or protein repair mechanisms. Retene, a natural product found in wood chips and common near pulp mills, is also photosensitized and causes enhanced toxicity (Hakkinen et al. 2003). In field samples it may be difficult to separate the effects of UV light and PAHs from those of the multiple environmental contaminants inevitably present.

Relevance of Phototoxicity of PAHs to the Natural Environment

The effect of UV light on PAH-induced toxicity is an area of current academic research that is poorly understood and may not be relevant to the natural environment. McDonald and Chapman (2002) have discussed a number of factors in the photo-toxicity literature that call into question the relevance of the UV studies that have been conducted. For instance, laboratory bioassays do not mimic natural conditions because different wavelengths have different intensities during the day as the angle of the sun to the water surface changes and spectral changes alter phototoxicity. These conditions are not faithfully duplicated in the laboratory. Laboratory studies also do not include the dissolved organic matter and suspended solids that reduce PAH bioaccessibility. McDonald and Chapman (2002) summarized that "To date there have been no studies that clearly and directly implicate PAH phototoxicity with adverse ecological effects in field populations" and referring to the association between UV light and toxicity in the laboratory, "This likelihood has been unrealistically increased in all published studies of PAH phototoxicity".

This perspective is supported by remarks by Swartz et al. (1997) who concluded that photo-activation of PAHs "may be toxicologically correct but ecologically irrelevant because infaunal burrowing amphipods...are rarely, if ever, exposed to UV radiation". Likewise, as mentioned previously, Hatch and Burton (1999) found that *Hyalella azteca* avoided UV light by hiding under leaf matter when provided the opportunity, and Diamond et al. (cited in McDonald and

Chapman 2002 as in preparation) noted that "in nature these organisms are protected by extensive water column attenuation, shading, and are strongly thigmotactic".

Were the effects levels of PAHs and UV light found in the laboratory indicative of those found in the field, McDonald and Chapman (2002) concluded that "large areas of shallow aquatic environments should be depauperate, yet this is not the case." This would be particularly true of commercial waterways, urban estuaries, marinas, and receiving water of surface runoff. Yet this is not true.

For the reasons discussed in this section, endpoints based upon bioassays under UV light will only be considered as an uncertainty in this BERA.

5.1.2.2 Effects of PAHs to Benthic Invertebrates

As discussed in Section 3.11.1, four lines of evidence were used to evaluate the potential effects of Site related PAHs in sediment. These included:

1) Comparison of bulk sediment chemistry concentrations to WDNR sediment quality guidelines;
2) Levels of PAHs and VOCs in *Lumbriculus variegatus* tissue compared to a no observed effect body residue (NEBR) developed using the target lipid model (TLM) [DiToro et al. (2000)];
3) Sediment bioassays; and
4) A benthic macroinvertebrate community investigation.

Bulk Sediment Chemistry

The maximum concentrations of chemicals in sediment were first compared to the WDNR sediment quality guidelines (WDNR 2003) or, where these guidelines were not available, other benchmarks listed in Table 3-4. Contaminants that exceeded these values were then further evaluated as described below.

Tissue Residues of PAHs and VOCs in Benthic Invertebrates

As previously discussed, numerous studies have shown that PAHs exert toxicity on aquatic organisms via narcosis. Narcotics act by occupying a certain set volume within neural membranes. As a result, a number of small narcotic molecules that occupy the same molar volume as one large narcotic molecule causes the same degree of narcosis. This means that the toxicity of multiple narcotic chemicals can be estimated by the sum of their molar volumes. This is called the critical body residue (CBR). Numerous studies have also shown that the CBR in body lipids provides a better estimate of the toxic concentrations than either sediment or water benchmarks. This is because the concentration in body lipids accounts for both bioaccessibility and bioavailability.

The Target Lipid Model of DiToro et al. (2000) was used to evaluate the toxicity of PAHs and VOCs in benthic invertebrates as well as fish. The TLM combines the CBR concept with

equilibrium partitioning (EqP) to calculate the no effect body residue (NEBR). The TLM method is described below.

DiToro and McGrath (2000) compiled the available acute toxicity data (i.e., aqueous LC50s) for 33 species of aquatic organisms exposed to 156 narcotic chemicals. The authors then used EqP to calculate the residue of each chemical in the animal body lipid. EqP results from the propensity of nonpolar organic chemicals to avoid water and seek other organic compounds, such as body lipids. Then, using the same method used by U.S. EPA to develop water quality criteria, they rank ordered the LC50 data and selected the lowest 5th percentile tissue residue (the residue that causes no effects on 95% of all species tested) as the CBR. This CBR, 35.3 µmol/g lipid, is the body residue that will cause 50% lethality in an estimated 5% of aquatic organisms. In order to estimate the chronic no effect body residue (NEBR), they divided the CBR by an acute-to-chronic ratio (ACR, 5.09) that was derived from acute and chronic toxicity data for 20 chemicals and six species. This means that the no effect concentration is approximately 5-fold lower than the LC_{50} concentration. Dividing the CBR by 5.09 results in a NEBR of 6.94 µmol/g lipid.

However, DiToro et al. (2000) realized that different categories of organic chemicals cause narcosis at different CBRs. Therefore, they divided the available toxicity into six different categories, one of which was PAHs. Compared to the overall (baseline) NEBR of 6.94 µmol/g lipid, PAHs are approximately twice as toxic. Therefore, the NEBR for PAHs was modified by a factor of 0.546. The resulting NEBR for PAHs is 3.79 µmol/g lipid. The NEBR for VOCs is no different from the baseline NEBR, 6.94 µmol/g lipid (McGrath et al. 2005).

As discussed greater detail below and in Appendix B, 28-d sediment bioaccumulation tests were conducted with the aquatic oligochaete worm, *Lumbriculus variegatus*. The results of this bioassay were used as the basis for modeling the uptake of contaminants from Site sediment by Site benthic macroinvertebrates. The predicted tissue concentrations in Site macroinvertebrates were then compared to the NEBR for PAHs. Section 5.1.2.3 will discuss how this benchmark was also compared to the actual tissue concentrations in wild fish collected at the Site.

Site-specific Sediment Bioassays

The third line of evidence for evaluating the potential toxicity of sediments was through conduct of site-specific bioassays. Bioassays were conducted with the sensitive benthic invertebrates *Hyalella azteca* (amphipod) and *Chironomus dilutus* (midge). The results of these bioassays are presented in more detail in Appendix B (Attachment 2: Sediment Bioassays).

Exposure of laboratory organisms to Site sediments in the laboratory was used to determine the levels of sediment contaminants that were associated with adverse effects to laboratory animals. Because these sediments contain all of the Site COPCs, the results of these tests represent the cumulative toxicity of all of the COPCs, not just the PAHs. However, of the COPCs measured in sediments PAHs were, by far, the most widespread and had the highest level of any COPC. Therefore the focus of this discussion will be on the potential effects of PAH.

The following summarizes the results of toxicity tests using Site sediment that were conducted in 2005-2006. Details of these tests are provided in Appendix B: Attachment 2.

Hyalella azteca

There was significant mortality to *H. azteca*, generally the most sensitive organism used in sediment bioassays, in all of the Reference Sand sediments collected in 2005-2006. Furthermore the mortality was consistent in four different Reference Sand stations collected from four different locations in Chequamegon Bay and at two different times four months apart. In addition, this mortality was observed during three different bioassays with *H. azteca* during three different bioassays conducted months apart. This strongly suggests that there were unmeasured variables that affected the outcome of the bioassays and that not all of these adverse effects were attributable to Site-related contaminants (Appendix B: Attachment 2).

When compared to silica sand control treatments in 2005-2006, only Site sediment SQT1 and SQT7 showed significant and consistent mortality under normal laboratory light conditions. Based upon the results of the *H. azteca* bioassays a no effect concentration (NOEC) of 4536 µg PAH/gOC (20.9 µg PAH/g; 0.46%OC) and a low effects concentration (LOEC) of 6084 µg PAH/gOC (22.5 µg PAH/g; 0.37 %OC) was indicated (Table 5-1).

SEH (2001) reported a slightly higher NOEC for *H. azteca,* 9,978 µg PAH/gOC (249.4 µg/g; 2.5%OC), and a LOEC of 14,396 µg PAH/gOC[13] (823.1 µg/g; 5.7%OC) (Table 5-2).

Table 5-1. Results for Sediment Bioassays 2005-2006.

Summary of Normal Light Bioassay Results with Three Species for URS 2005-2006				
Organism	NOEC		LOEC	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	20.9	4,536	22.5	6,084
P. promelas	22.5	6,084	166.9	36,291
C. dilutus	NA	NA	NA	NA

Table 5-2. Results for Sediment Bioassays 2001.

Summary of Normal Light Bioassay Results with Three Species Conducted for SEH 2001				
Organism	NOEC[1]		LOEC[1]	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	249.4	9,978	823.1	4842 or 14396[2]
P. promelas	79.9	3,996	249.4	9978
C. tentans	16.2	735	79.9	3996

1) SEH reports that the NOEC and LOEC are for lowest of either mortality or growth endpoints (reduced growth or mortality > 20%

2) The first value is suspect due to apparent problems with TOC analyses. The second vaue assumes that the true TOC lies between adjacent higher and lower values.

[13] This value has been corrected from the original report. See discussion in Appendix B: Attachment 2.

Chironomus dilutus

Low survival with *C. dilutus* at all 6 reference stations during the 2005-2006 bioassays made evaluation of Site sediment inconclusive. The failure of chironomid larvae bioassay to settle could have been due to sediment avoidance related to either chemical or physical reasons (Appendix B: Attachment 2).

SEH (2002) reported a NOEC of 735 µg PAH/gOC (16.2 µg PAH/g; 2.2%OC) for *C. dilutus* in sandy sediments (Table 5-2). The LOEC of 3,996 µg PAH/gOC (79.9 µg PAH/g; 2.0%OC) resulted in only 10% survival difference from the control (71.5 vs. 82.5%), or 90% of the control value.

Bioassays were also conducted with the fathead minnow, *Pimephales promelas.* The results of these tests are treated below in Section 5.1.2.3 (Effects of PAHs on Fish).

Proposed NOECs and LOECs based upon all bioassay studies are summarized in Table 5-3. See Appendix B: Attachment 2 for a discussion.

Table 5-3. Proposed NOECs and LOECs Based Upon Bioassay Results for 2001 and 2005-2006.

Proposed NOECs and LOECs Considering both the 2001 and 2005-6 Bioassays.		
	NOEC	LOEC
Organism	**Total PAHs ug/gOC**	**Total PAHs ug/gOC**
H. azteca	4536	6084
P. promelas	5040	23135
C. tentans	735	3996
3 Species Average=	3437	11072

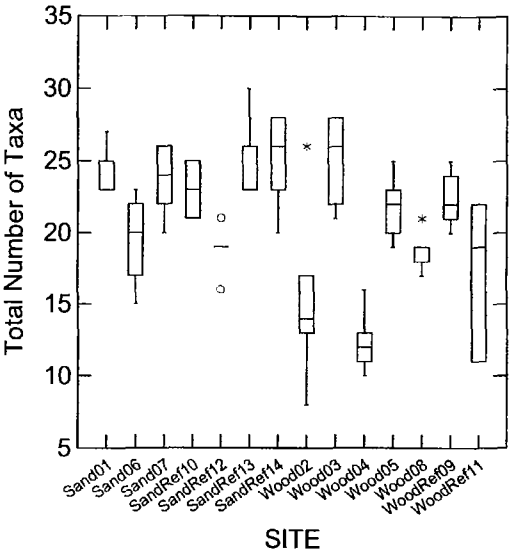
Site-specific Benthic Macroinvertebrate Studies

Lastly, a benthic community investigation was conducted to evaluate whether the presence of contaminants in Site sediment resulted in any changes to benthic community structure relative to reference stations. The results of this investigation are presented in more detail in Appendix B: Attachment 3.

Taxa richness was variable amongst stations with number of taxa at each station ranging from 8 to 30 (average = 20.9). The total number of unique taxa for all stations was 133. With the exception of two stations, Site Wood SQT2[14] and Site Wood SQT4, there was no substantial difference in the average number of taxa across all station replicates (Figure 5-1).

[14] SQT is a station designator meaning sediment quality triad.

Figure 5-1.Number of Taxa at Triad Stations.



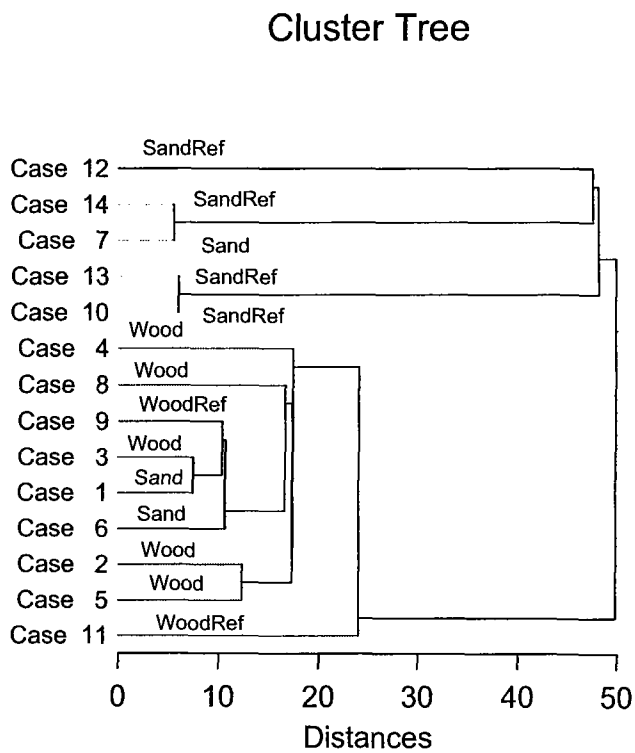
The dominant taxa were chironomids which made up an average 32.6% (maximum 84 to 91% in the five replicate samples from Sand Reference SQT12) of the abundance in each sample. In all, 58 taxa of chironomids were identified (Figure 1 in Appendix B: Attachment 3). The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa),* oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai),* amphipods (including *Gammarus fasciatus*), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals. Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

Very few patterns in the distribution of the taxa were discerned and only two appeared to be possibly related to the levels of PAHs (either total PAHs (TPAH) or total carbon normalized PAHs (NOC-PAH) (Figure 2 in Appendix B: Attachment 3). The epibenthic isopod, *C. racovitzai,* was more abundant at Site Wood stations, than at Reference Wood, Reference Sand or Site Sand Stations. The unionid snail, *A. limnosa,* also an epibenthic species, was absent from all of the Site Wood Stations but was present at Reference Sand, Site Sand and Reference Wood stations. Its exclusion from the Site Wood stations may be due to a combination of PAH levels and/or wood mulch substrate. Other than that example there did not seem to be a consistent pattern in the distribution of dominant taxa. *M. speciosa* was abundant at Reference Sand Stations SQT 13 and SQT14, but it was even more abundant at Site Sand Station SQT 7, a station where NOC-PAH ranged from 1014 to 62,900 µg/gOC. Likewise tubificids were abundant at Reference Sand Stations SQT10, SQT13 and SQT 14 but were also abundant at Site Sand Station SQT7. Mayflies (Ephemeroptera) were abundant at Reference Sand Stations SQT13 and SQT14, but were also abundant at several Site Sand stations (Appendix B: Attachment 3).

Review of the box and whisker plots indicated that there was substantial variation amongst replicate samples for most variables, including PAH levels, organism density and all benthic community metrics, at most of the stations. Examination of these plots did not indicate any obvious relationships with the levels of PAH (either as TPAH or NOC-PAH) (Appendix B: Attachment 3).

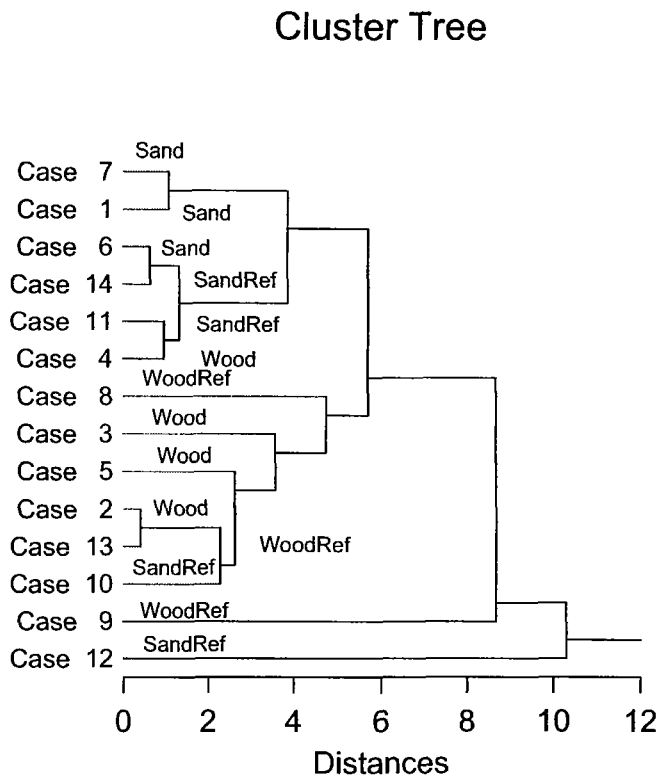
Results of the cluster analysis indicated few stations of the same substrate category were similar (Figure 5-2). Site Sand Station SQT1 was very similar to Site Sand Station SQT7 when the proportion of tolerant, facultative and intolerant taxa was considered (Figure 5-3). These two stations are both sand substrate, are adjacent to one another, and have the highest levels of NOC-PAHs. However, when clusters were based upon other metrics such as functional grouping (Figure 5-1) SQT7 was very similar to some of the Reference Sand stations such as SQT14 and quite different from SQT1. Three of the Site Wood Stations (SQT4, SQT8 and SQT2) were similar based upon percent functional groups. Based upon other metrics, however, Site Wood stations were very similar to Reference Wood stations.

Figure 5-2. Cluster Diagram Based Upon All Biological Metrics.



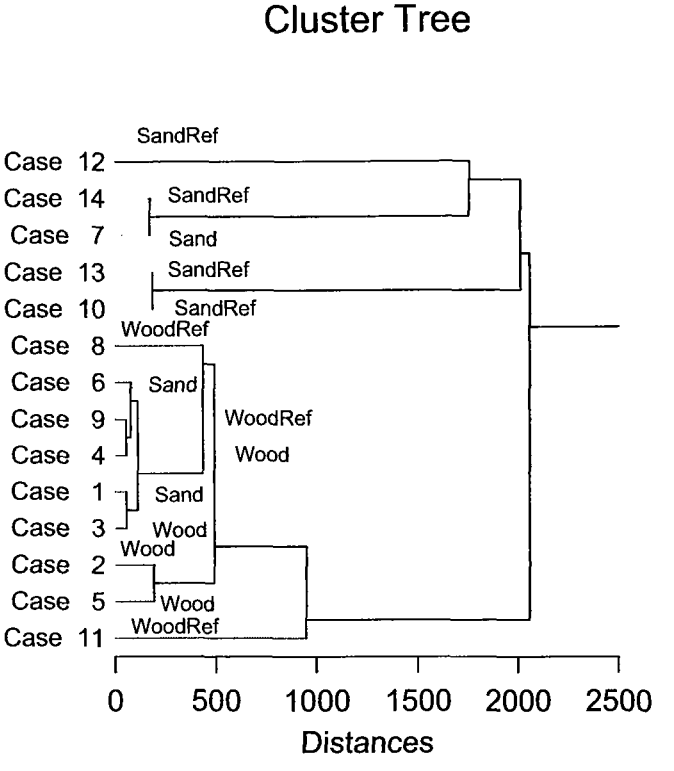
"Case" Number on Cluster Trees is the same as SQT Station Number.

Figure 5-3. Cluster Diagram Based Upon Percent Relative Tolerance.



"Case" Number on Cluster Trees is the same as SQT Station Number.

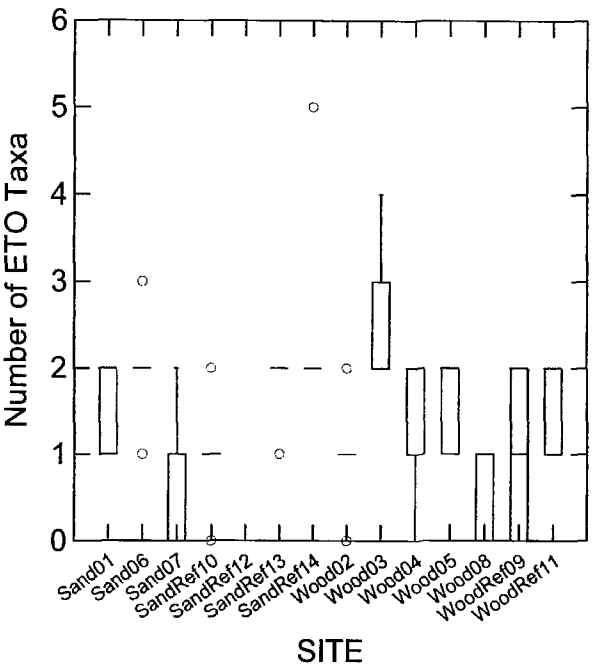
Figure 5-4. Cluster Diagram Based Upon Percent Functional Groups.



"Case" Number on Cluster Trees is the same as SQT Station Number.

Statistical analyses were conducted to evaluate whether contaminants in the sediment explained any of the differences observed in the benthic community structure. The results of the analysis of covariance (ANCOVA) indicated few significant relationships between the benthic community metrics and the level of PAHs, either as TPAH or NOC-PAH. In fact, with the exception of two metrics, the number of Ephemeroptera, Trichoptera, Odonata (ETO) taxa and the ratio of ETO/ ETO + chironomid abundance, all significant relationships indicated that as TPAH or NOC-PAH increased, the biological metric increased. These results suggest that the putatively most sensitive taxa, Ephemeroptera, Trichoptera, Odonata are negatively affected by increasing levels of NOC-PAHs. The negative relationship of the ratio of ETO/ETO+chironomid abundance to NOC-PAH levels suggest that the number of chironomids are positively related to NOC-PAHs, i.e., the chironomid abundance increased as NOC-PAH levels increased. However the paucity of ETO taxa at each station (0 to 4 taxa) indicates that not much weight should be placed upon the negative relationship between ETO taxa and levels of NOC-PAHs (Figure 5-5).

Figure 5-5. Number of ETO Taxa at Triad Stations.



The nature of the substrate and grain size had a much greater influence on benthic community metrics than did the level of PAHs. Based upon the step-wise regression and the one-way ANOVA, grain size and substrate type were significant explanatory factors for the variation in the benthic community. For most of the benthic community variables the finer grain sizes were associated with lower values.

The overall results suggest that PAH levels (whether TPAH or NOC-PAH) are playing only a minor role in structuring communities, overshadowed by other substrate effects (e.g., grain size and whether the substrate category was wood or sand). Perhaps this is not surprising as it was expected that a benthic community inhabiting an area with a wood mulch substrate would differ from that inhabiting a sand substrate. It has also been well-established in benthic ecology that grain size and substrate type is often a significant explanatory factor of differences in benthic community structure.

Summary of Lines of Evidence for Benthic Invertebrates – Sediment Quality Triad

In summary, bulk sediment chemistry suggests that compared to WDNR sediment quality guideline (WDNR 2003) there should be a no effects threshold between 1.6 and 22.8 µg/g in sediment with 1% organic carbon (@1%OC). The results of the sediment bioassays conducted in 2001 and 2005-2006 indicate that the no effects threshold for benthic invertebrates such as *H. azteca* in the range of 4500 to 10,000 µg PAH/gOC. These levels are equivalent to 45 to 100 µg/g @1%OC. For benthic invertebrates like *C. dilutus* a no effects level is predicted at about 735 µg PAH/gOC (or 7.35 µg/g @1%OC).

No significant effects appear to be manifested at the benthic community level of organization even in areas where PAH levels from benthic samples were in the range of 40,000 to 80,000 µg PAH/gOC (400 to 800 µg/g@1%OC) at individual Triad stations samples (Appendix B: Attachment 1). However, there was tremendous variability and resultant uncertainty associated with both the site samples and reference samples collected in the benthic macroinvertebrate community investigation.

5.1.2.3 Effects of PAHs on Fish

Surface water Chemistry

The potential toxicity of surface waters at the Site was evaluated in three different manners. Maximum concentrations of chemicals were first compared to the Region V ESLs (USEPA 2003a) or equivalent criteria as discussed in Section 3-5 (Table 3-3). No chemicals exceeded these values.

Two further lines of evidence are also presented. The first entailed the collection and analysis of wild fish from the Site and the second relied on bioassays conducted with early life stage *Pimephales promelas* (fathead minnow). The fish tissue PAH, VOC and lipid data were treated as described above for *L. variegatus*, using the NEBR. The results of these bioassays are presented in Appendix B and summarized here.

Tissue Residues of PAHs in Wild Fish

The bioaccumulation of PAHs in three species of wild fish was measured for two purposes. First, as discussed above, using the TLM of DiToro et al. (2000) the body residues of PAHs were used to evaluate risk to the fish community. Secondly, the body residues were used in the food chain model to calculate the doses to wildlife that ingest fish (Section 5.2).

Whole small-mouth bass, brown bullhead and smelt were caught from the Site and the concentrations of PAHs in the whole body were measured. Using the same methodology as described for the worm bioassay, the lipid-normalized concentrations of VOCs was also estimated. The resulting PAHs were compared to the baseline NEBR of 3.79 µmol/g lipid for PAHs (DiToro et al. 2000). None of the fish collected contained a concentration of PAHs or VOCs greater than the NEBR.

Site-Specific Sediment Bioassay

As expected for a receptor that does not normally contact the sediment, fathead minnow larvae were relatively insensitive to PAHs in bulk sediments, with no mortality reported at 36,291 µg PAH/gOC (166. 9 µg PAH/g; 0.46%OC) in 2005-2006 (Table 5-1). There was a significant growth effect at that concentration however and that value was considered as a LOEC. The NOEC for this bioassay is 6,084 µg PAH/gOC (22.5 µg PAH/g; 0.37%OC). However, the NOEC in 2001 was 3,996 µg PAH/gOC (79.9 µg PAH/g; 2.0%OC) in 2001 (Table 5-2). The average of these two NOECs (5,040 µg PAH/gOC) is proposed as the NOEC and the average of the two LOECs, 23,135 µg PAH/gOC (22.5 µg PAH/g; 3.6%OC) is proposed as the LOEC (Appendix B: Attachment 2 and (Table 5-3).

5.1.3 Effects of PAHs on Wildlife

As discussed above, tars are composed of four major categories of compounds, aromatics, saturates (alkanes, paraffins), resins, and asphaltenes. However, as with aquatic organisms, not all of these components are toxic to terrestrial organisms. Because toxicological studies have been conducted with small mammals as surrogates for humans, there is much more toxicological data for mammals than for birds. In mammals, LMW and HMW PAHs and short-chain alkanes may cause toxicity, but neither resins nor asphaltenes are toxic. A few studies have also shown that these compounds are non-toxic to birds. In wild mammals, both LMW and HMW PAHs can cause toxicity, but because they are volatile, the VOCs such as benzene and the alkylbenzenes, are unlikely to get into the food chain unless there is an ongoing source. As a result, most laboratory toxicity data for VOCs has focused on inhalation in confined spaces, but oral ingestion studies have been conducted on mammals with BTEX compounds. No literature concerning the toxicity of VOCs to birds was identified. However, only burrowing species could reasonably be expected to be exposed to potentially toxic concentrations if there were VOCs in soil. However VOCS were not identified as COPCs for soil; therefore, with regard to ecological exposure pathways, most studies have focused on the PAHs. Therefore, with regard to ecological exposure pathways, most studies have focused on the PAHs. Furthermore, in this BERA,

The two major exposure pathways for wildlife are the diet and soil or sediment that is incidentally ingested during feeding, grooming, or preening. The composition of the PAHs in these pathways is very different. Both HMW and LMW PAHs may be acquired through incidental soil ingestion, but PAHs do not accumulate in small mammals or birds (US EPA. 2005) and Site-specific fish tissue data reveal only LMW PAHs. Therefore, TRVs for HMW and LMW PAHs are relevant for incidental soil or sediment ingestion while only TRVs for LMW PAHs are relevant for the diet.

5.1.3.1 Birds

The PAHs that have been detected in fish samples from the Site reflects the composition expected from the more water-soluble fraction of site sediments. Nearly all PAHs detected in fish tissues from the Site were LMW PAHs. (Appendix C). Therefore, it is assumed that LMW PAHs are the dominant form that would be ingested by piscivorous bird species. On the other hand, worms from the bioaccumulation study, which will be used as surrogates for invertivorous wildlife, contained HMW, as well as LMW PAHs. The avian toxicity studies evaluated for both LMW and HMW PAHs are discussed below.

Toxicity studies that reflect the composition of PAHs found in fish tissues were selected for evaluation to derive representative TRVs. Only one chronic study evaluated the toxicity of LMW PAHs on birds. The following describes the bioassays and their results.

The best quantitative chronic study is that conducted by Patton and Dieter (1980). These authors fed mallard ducks an artificial mixture of 400 or 4000 mg PAHs/kg diet for 7 months, and reported no mortality or symptoms of toxicity in any of these tests when compared to control animals. Patton and Dieter (1980) reported the relative composition of the PAH mixture used in the study, but not the individual concentrations of percentages. However, the authors stated that the compounds were present at concentrations that were equimolar to that found in South

Louisiana crude oil. The mixture also contained ethylbenzene, two sulfur heterocycles, and 2,6-dimethylquinone. Since only one of the ten aromatics was a monoaromatic (VOC), it was assumed that the mixture was representative of a LMW PAH mixture.

Patton and Dieter (1980) reported no growth or survival responses related to the LMW mixture; however, an adaptive physiological response to mallards ingesting 4000 mg PAHs in their diet was observed. Ingestion of 4000 mg PAHs caused an increase in liver weight, hepatic blood flow, and indocyanine green clearance rate (a marker of liver function). No plasma enzyme markers of organ injury were elevated above control values. The increase in liver size, blood flow and dye clearance rate indicated that the ducks had adapted to the contaminated diet. Exposure to 400 mg PAHs/kg diet resulted in little physiological and no biochemical response.

Given that no effects on growth or survival were observed, the dose calculated from the dietary concentration of 4000 mg PAH / kg is considered a NOAEL dose. The designation of this dose as a NOAEL is consistent with USEPA guidance, which does not consider a physiological response an adverse effect in its derivation of ECO-SSL values. However, at the direction of USEPA in its comments on the draft BERA, an additional conservative NOAEL is calculated based on the dietary concentration of 400 mg PAH / kg.

The ducks in Patton and Dieter (1980) weighed about 1300 g. Using the allometric dry weight food ingestion rate for galliformes (Nagy 2001) results in a food ingestion rate of 0.04 kg/kg BW/day. Diets containing 400 or 4000 mg PAHs/kg result in the following NOAEL doses:

$$NOAEL = 4000\ mgPAH/kg\ x\ 0.04\ kg/kg\ BW/day$$
$$= 161\ mg\ PAH/kg\ BW/day$$

$$NOAEL = 400\ mgPAH/kg\ x\ 0.04\ kg/kg\ BW/day$$
$$= 16.1\ mg\ PAH/kg\ BW/day$$

Because worms from the bioaccumulation study conducted to support this BERA contained HMW PAHs, a chronic study that evaluated the potential toxicity of these compounds was also evaluated. Only one study was found. Stubblefield et al. (1995) fed 5-day old mallard ducklings 0, 200, 2,000, or 20,000 mg/kg BW/day weathered Prudhoe Bay crude oil (WPBCO) for 20-weeks and reported no adverse effects on reproduction; ducklings did not avoid WPBCO. While Stubblefield et al. (1995) did find reduced eggshell thickness and changes in plasma electrolytes, they also reported that there were no adverse effects on the ability of parental birds to produce viable embryos, the rate of hatch success, or the survival and fitness of the resulting chicks. Therefore, eggshell thinning is considered a physiological and not a reproductive effect. Consistent with USEPA guidance for deriving ECO-SSLs, physiological responses are not considered adverse effects in calculating TRVs.

Stubblefield et al. (1995) reported a final body weight of 1250 g and a food ingestion rate of 132.5 g/bird/day. Based upon a dietary concentration of 20,000 mg/kg BW/day, the NOAEL for HMW PAHs is:

$$NOAEL = \frac{20{,}000\ mg/kg\ food\ x\ 0.1325\ kg/day}{1.25\ kg\ BW}$$
$$= 2120\ mg\ HMW\ PAH/kg\ BW/day$$

Since the diet usually comprises the majority of the total exposure in wildlife, the lower of these TRVs, those from the Patton study, 16.1 and 161 mg PAH/kg BW/day, will be used in this BERA as the avian TRVs for PAHs (Table 5-4). This is conservative because the sum of all PAHs will be compared to the lower TRV for LMW PAHs.

5.1.3.2 Mammals

Fish-eating mammals, such as the mink, may also be exposed to PAHs in their diet at the Site. Since the PAHs in the fish collected from the Site were largely LMW PAHs, and the largest component of the LMW PAHs at the Site is naphthalene, this compound was selected to represent all LMW PAHs. Two studies of naphthalene were evaluated, one a chronic study, and the other an early life stage study. Shopp et al. (1984) fed mice 5.3, 53, or 133 mg naphthalene/kg BW/day for 90-days and reported no adverse effect on body weight or survival. Female, but not male, mice exhibited increased spleen weight at the highest dose. The authors concluded that naphthalene doses up to ¼ the LD50 caused no biologically-relevant effects. Therefore, the NOAEL from this study was 133 mg LMW PAH/kg BW/day.

Plasterer et al. (1985) administered naphthalene to CD-1 mice for eight days starting on the seventh day of gestation and reported an LD50 of 354 mg/kg BW and an LC0 of 250 mg/kg BW/day. The 250 mg naphthalene caused a significant decrease in dam body weight and 300 mg/kg BW/day caused a 15% decrease in maternal survival. The latter dose caused no significant decrease in the reproductive index, but reduced the average number of pups. Since there was not a concomitant decrease in dead pups, this was likely due to an increased number of embryonic resorptions. The pups that were delivered were normal and healthy. No adverse effects on either generation were found at 125 mg naphthalene/kg BW/day.

The geometric mean of these two early life-stage no effect doses (133 and 125 mg naphthalene/kg BW/day) was selected as the NOAEL for mammals exposed to LMW PAHs through the diet (Table 5-5).

$$TRV_{NOAEL} = 129\ mg\ LMW\ PAH/kg\ BW/day$$

Based upon the bioaccumulation tests with *L. variegatus*, were mink to ingest benthic invertebrates, they might also be exposed to HMW PAHs. Therefore, three studies with HMW PAHs were evaluated. Springer et al. (1989) reported that administration of 740 mg tar/kg BW/day to rats during days 12 to 14 of gestation had no adverse effects on the number of live births, but was associated with a significant increase in early mortality in pups and in dams. Therefore, this study was not considered further for the NOAEL.

Culp et al. (1998) fed female B6C3F1 mice 0, 0.01, 0.03, 0.1, 0.3, 0.6, and 1% tar for 2-years and reported a decrease in body weight at doses of 1,364 and 2,000 mg/kg BW/day, but not at 628 mg tar/kg BW/day. However, in a simultaneous study with a different tar containing elevated levels of BaP, they reported a 20% weight loss at doses of 333 to 346 mg tar/kg BW/day. The differences in these effects on body weight is likely due to differences in the

component mixtures of these different fresh tars and the age of initial exposure. The authors attributed their weight losses to food avoidance, rather than toxicity. Laboratory mice normally live less than 2-years and older wild mice live less than 1 year (U.S. EPA 1993) or are culled by predation. Therefore, this study was not considered further for the NOAEL.

Weyand et al. (1995) administered 0.05, 0.25, or 0.5% MGP residue, a type of tar formed as a by-product of coal gasification, to B6C3F1 mice for 185-days and reported no adverse effects on survival, growth, development, hematology, histopathology, clinical chemistry, or reproduction at a dose of 462 mg/kg BW/day.

Since the objective of ecological risk assessments is protection of animal populations and mice are reproductively mature at 6- to 8-weeks, the 185-d no effect doses of Weyand et al. (1995) were selected as a conservative NOAEL for small mammals ingesting HMW PAHs (Table 5-5). Therefore:

$$TRV_{NOAEL} = 462\ mg\ HMW\ PAH / kg\ BW / day$$

For the purposes of this BERA, only the lower TRV for LMW PAHs was used for mammals (Table 5-5). This is conservative because the sum of all PAHs will be compared to the lower TRV for LMW PAHs.

5.1.4 Effects From Other Contaminants of Concern

In addition to PAHs, VOCs and several metals were higher than the screening values for sediment and soil quality. VOCs included dibenzofuran, m, o and p-cresol, and the BTEX compounds in sediment. Metals included barium, copper, selenium and thallium in sediment and antimony, cadmium, lead, manganese, mercury, selenium and zinc in soil. In addition, one PAH, dibenzofuran, exceeded screening levels.

5.1.4.1 Benthic Invertebrates

No benchmarks were derived for metals in sediment. However, the results of SEM:AVS analysis were used to evaluate the bioavailability of any divalent metals in the sediment. Since metals make up such a minor portion of COPCs in the sediment WDNR Sediment Quality Guidelines (WDNR 2003) were used for risk estimates from these metals. As discussed in Section 5.1.2.2, VOCs were evaluated along with PAHs by comparing the NEBR to estimated body burdens in the bioassay worms.

5.1.4.2 Fish

As discussed in Section 5.1.2.3 VOCs were evaluated along with PAHs by comparing the NEBR to estimated body burdens in wild fish collected at the Site. Metals in surface water or fish tissue were not measured. Not only do metals make up such a minor portion of COPCs in the sediment, but use of BSAFs to estimate fish metals levels is an unreliable way to evaluate the potential for adverse effects. This is because different species of fish have different mineral requirements and contain different levels of metals, naturally, and because the sediment-to-fish exposure pathway is poorly understood. Most studies have shown that the major exposure pathway for fish to metals is through the dissolved ions present in the water column. Some other

studies have shown that metals can be accumulated through the diet, but these studies have identified risks from this pathway only at mine sites where metals are the major contaminants and both invertebrate and sediment levels are far higher than at the Site. Since there were no exceedances of screening benchmarks for metals in surface water, there is little reason to believe that metals would be elevated significantly above normal levels in Site fish.

5.1.4.3 Birds

The following TRVs were derived for metals and summarized in Table 5-4. No TRVs for VOCs were derived because no adequate studies were identified. Avian exposure to VOCs is considered an uncertainty in the assessment.

Antimony

No avian ECO-SSLs have been proposed because there is no toxicity data for birds exposed to antimony. Therefore, no TRVs are proposed for antimony for birds for this risk assessment.

Barium

No avian ECO-SSL has been proposed. Based on work by Johnson et al. (1960), Sample et al. (1996) calculated a NOAEL of 208.3 and a LOAEL of 416.5 mg Ba/kg BW/day.

NOAEL = 208.3 mg Ba/kg BW/day

LOAEL = 416.5 mg Ba/kg BW/day

Cadmium

At the direction of USEPA, avian TRVs for cadmium were based on reproduction and growth endpoints from studies used to derive the ECO-SSLs (USEPA 2005a). The NOAEL (1.47 mg Cd/kg BW/day) was based on the geometric mean of NOAELs for growth and reproduction from these studies. The LOAEL (6.3 mg Cd/kg BW/day) was based on the geometric mean of LOAELs for growth and reproduction (USEPA 2005a).

NOAEL = 1.47 mg Cd/kg BW/day

LOAEL = 6.3 mg Cd/kg BW/day

Copper

The avian NOAEL for copper was based on the geometric mean of NOAEL endpoints from growth and reproduction studies used to derive the ECO-SSL for copper (18.4 mg Cu/kg BW/day; USEPA 2005a). The LOAEL was based on the geometric mean of LOAEL endpoints (growth and reproduction endpoints) from the ECO-SSL (34.8 mg Cu/kg BW/day)

NOAEL = 18.4 mg Cu/kg BW/day

LOAEL = 34.8 mg Cu/kg BW/day

Lead

At the direction of USEPA, studies of lead effects on growth and reproduction in birds evaluated in the development of ECO-SSLs were the basis for lead TRVs in the BERA. The NOAEL was based on the geometric mean of reproduction and growth NOAEL endpoints from these studies (10.9 mg Pb/kg BW/day); the LOAEL was based on the geometric mean of LOAEL endpoints (44.6 mg Pb/kg BW/day).

NOAEL = 10.9 mg Pb/kg BW/day

LOAEL = 44.6 mg Pb/kg BW/day

Manganese

Based on work by Laskey and Edens (1985), Sample et al. (1996) from ORNL calculated a NOAEL of 977 mg Mn/kg BW/day. Applying the NOAEL-LOAEL uncertainty factor of 5 (Lewis et al. 1990), this is a NOAEL of 4,885 mg Mn/kg BW/day.

NOAEL = 977 mg Mn/kg BW/day

LOAEL = 4885 mg Mn/kg BW/day

Mercury

Only one study for inorganic mercury that used a reproductive endpoint is available. Hill and Schaffer (1976) fed Japanese quail a dose of 0.45 mg Hg/kg BW/day for 1 year that included the reproductive cycle and found no adverse effects on egg production, fertility, or hatchability of the eggs produced. The LOAEL from this study was 0.91 mg Hg/kg BW/day.

NOAEL = 0.45 mg Hg/kg BW/day

LOAEL = 0.91 mg Hg/kg BW/day

Selenium

The avian TRV (NOAEL=0.4 mg/kg BW/day and LOAEL=0.8 mg/kg BW/day) for birds exposed to selenium is based on a series of studies by Heinz and others on mallard ducks. The form of selenium tested is selenomethionine (SeM), a product of microbial metabolism, rather than either selenate or selenite. Heinz et al. (1989) reported that adult mallards suffered reduced reproductive success when fed a diet containing 8 mg SeM/kg, but that no effects were found at 4 mg SeM/kg. The resulting NOAELs and LOAELs were calculated by Sample et al. (1996) as 0.4 and 0.8 mg SeM/kg BW/day, respectively. Similar sensitivities have been shown for chickens, quail, and pheasants. These TRVs will be used for the black duck.

NOAEL = 0.4 mg Se/kg BW/day

LOAEL = 0.8 mg Se/kg BW/day

However, there appears to be good evidence that SeM effects on Anseriformes (such as the black duck) and Galliformes (chicken-like birds) may not be representative of insectivorous species such as the tree swallow.

The following information describes the adjustments to the mallard TRV that will be applied to the food chain models to compensate for differences in species sensitivity between mallard ducks and the tree swallow.

Reproductive success is generally considered one of the most sensitive measurement endpoints for studies of potential adverse effects to receptor populations. Studies have shown that the selenium content of eggs is the best estimator of reproductive success in a variety of bird species (Fairbrother et al. 1999; Adams et al. 2003). Heinz et al. (1987; 1989) showed that the effects threshold concentration for mallard eggs is about 3 mg Se/kg dry weight. However, both laboratory and field studies have shown that black-crowned night heron, screech owl, and American kestrel accumulate egg selenium concentrations much greater than 3 mg Se/kg dry weight without adverse effects on reproduction. Furthermore, field studies have shown much higher egg selenium concentrations have no adverse effects on reproductive success in American dipper, spotted sandpiper (Harding et al. 2005), loggerhead shrike, Northern harrier (Santolo and Yamamoto 1999), and barn swallow (King et al. 1994). These studies considered together suggest that the TRV for carnivorous birds should be adjusted upwards. Probably the most relevant study for the tree swallow is that conducted with barn swallows. King et al. (1994) reported no adverse effects on reproduction with barn swallow eggs containing up to 12 mg Se/kg egg. If it is assumed that the barn swallow and tree swallow are equally sensitive, and that swallows are a good representative of an insectivorous bird feeding on emergent insects, the difference in apparent toxicity thresholds (the NOAEL) between mallard and tree swallow can be estimated as:

$$NOAEL_{swallow} = NOAEL_{mallard}\ x \left[\frac{NOEC_{swallow\ egg}}{NOEC_{mallard\ egg}}\right] = 0.4\ x \frac{12}{3} = 1.6\ mg\ Se/kg\ BW/day.$$

In this BERA a factor of 5 has been applied to convert a NOAEL to a LOAEL (Section 5.1.31) when a LOAEL is not available. However for this conversion we can use the same relationship between the NOAEL and LOAEL as was found in the Heinz et al. (1989) study. Assuming the same relationship holds for effect concentrations (i.e., the LOAEL is twice the NOAEL), the swallow LOAEL would be 3.2 mg Se/kg BW/day.

Thallium

No avian toxicity data for thallium was found.

Zinc

Four studies were evaluated. The NOAEL selected for zinc is based on the minimum daily requirement (MDR) for laying hens (NAS 1994). NAS reported that the MDR is 44.4 mg Zn/kg diet at 90% dry weight. In order to obtain this concentration in plants at 100% dry weight the soil-to-plant uptake equation of Efroymson et al. (2001) was used. The soil concentration that provides the MDR is 54 mg Zn/kg, which is slightly lower than the estimated arithmetic mean

soil zinc concentration of 60 mg Zn/kg for the conterminous United States (Shacklette and Boerngen 1984). Applying the soil- to-worm uptake equation for zinc (Sample et al. 1999) and the allometric ingestion rate for the robin (Nagy 2001) results in a dose of 54.4 mg Zn/kg BW/day. This was assumed to be a conservative estimation of the NOAEL. The LOAEL was taken from a study by Stahl et al. (1990). These authors fed 48, 228, or 2028 mg Zn/kg food to adult leghorn chickens for 44 weeks and found a slight decrease (i.e., LOAEL) in hatchability at 131 mg Zn/kg BW/day.

NOAEL = 54.4 mg Zn/kg BW/day

LOAEL = 131 mg Zn/kg BW/day

The other studies reviewed resulted in reported NOAELs that result in unfeasible soil concentrations (Stahl et al. 1990; Jackson et al. 1986) and examined shorter exposure durations (Gasaway and Buss 1972).

Table 5-4. Summary of Avian Toxicity Reference Values (TRVs).

Analytes	Avian Receptors			
	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source
Metals				
Antimony	NA	NA	--	--
Barium	208.3	416.5	1-d old chicks	Johnson et al. 1960
Cadmium	1.47	6.3	Geometric Mean	USEPA 2005a
Copper	18.4	34.8	Geometric Mean	USEPA 2005a
Lead	10.9	44.6	Geometric Mean	USEPA 2005a
Manganese	977	4885	1-d old Japanese quail	Laskey and Edens 1985
Mercury	0.45	0.91	Japanese quail	Hill and Schaffer 1976
Selenium	0.4	0.8	Mallard[c]	Heinz et al. 1989
Thallium	NA	NA	--	--
Zinc	54.4	131	Chicken	Stahl et al. 1990
Organic Compounds				
Total PAHs & VOCs	16.1 / 161	NA	mallard	Patton and Dieter 1980
Benzene	NA	NA	--	--
Ethylbenzene	NA	NA	--	--
Toluene	NA	NA	--	--
Xylenes (total)	NA	NA	--	--
m & p-cresols	NA	NA	--	--
o-cresol	NA	NA	--	--
Trimethylbenzenes (total)	NA	NA	--	--

Notes:

a, NOAEL is no observable adverse effects level.

b, LOAEL is low observable adverse effects level.

c, Mallard-based TRV is multplied by correction factors of 4.0 for tree swallow.

d, Lower TRV for p-cresol selected as a conservative TRV for m & p-cresols.

-- Appropriate data are not available from published literature to derive NOAEL and LOAEL values.

NA, Toxicity Reference Value not available.

5.1.4.4 Mammals

The following TRVs were derived for metals and summarized in Table 5-5.

Antimony

The geometric mean of NOAEL values reported for reproduction and growth endpoints in the studies used to derive the ECO-SSL (13.3 mg Sb/kg BW/day) was used as the mammalian NOAEL for antimony. The geometric mean of the limited number of LOAEL values available from ECO-SSL studies (2.8 mg Sb/kg BW/day) was lower than the geometric mean of NOAEL values. Given the incongruous LOAEL endpoints based on a limited dataset, no LOAEL was estimated for mammals exposed to antimony.

NOAEL = 13.3 mg Sb/kg BW/day

Barium

At the direction of USEPA, the mammalian NOAEL for barium is based on the geometric mean of NOAEL endpoints from reproduction and growth studies used to derive ECO-SSLs (51.8 mg Ba/kg BW/day; USEPA 2005a). The geometric mean of LOAEL endpoints for reproduction and growth from the ECO-SSL (82.7 mg Ba/kg BW/day) is presented as the LOAEL.

NOAEL = 51.8 mg Ba/kg BW/day

LOAEL = 82.7 mg Ba/kg BW/day

Cadmium

USEPA (2005a) evaluated studies of cadmium effects on reproduction and growth in mammals in the development of ECO-SSLs. The geometric mean NOAEL from these studies was 0.77 mg Cd kg BW/day and, as directed by USEPA, represents the NOAEL for the BERA; the geometric mean of LOAEL endpoints from these studies is 6.9 mg Cd/kg BW/day and represents the LOAEL for the BERA.

NOAEL = 0.77 mg Cd/kg BW/day

LOAEL = 6.9 mg Cd/kg BW/day

Copper

Mammalian TRVs for copper were based on growth and reproduction studies used to derive ECO-SSLs (USEPA 2005a). The NOAEL was based on the geometric mean of NOAELs from these studies (23.7 mg Cu/kg BW/day); the LOAEL was based on the geometric mean of LOAEL endpoints (82.7 mg Cu/kg BW/day).

NOAEL = 23.7 mg Cu/kg BW/day

LOAEL = 82.7 mg Cu/kg BW/day

Lead

The mammalian NOAEL for lead (40.7 mg Pb/kg BW/day) was calculated as the geometric mean of growth and reproduction NOAEL from studies used to derive ECO-SSLs (USEPA 2005a). The LOAEL (182.4 mg Pb/kg BW/day) was calculated as the geometric mean of LOAEL endpoints for reproduction and growth from studies evaluated in the development of ECO-SSLs.

NOAEL = 40.7 mg Pb/kg BW/day

LOAEL = 182.4 mg Pb/kg BW/day

Manganese

Based on work by Laskey et al. (1982), Sample et al. (1996) from ORNL calculated a mammalian NOAEL of 88 and a LOAEL of 284 mg Mn/kg BW/day.

NOAEL = 88 mg Mn/kg BW/day

LOAEL = 284 mg Mn/kg BW/day

Mercury

Three studies were evaluated. The NOAEL selected for mercury is based on results from a study by Revis et al. (1989). Revis et al. (1989) reported a 20-month NOAEL of 13.2 mg Hg/kg BW/day for lethality that included 6-month estrous-cycle assessment on reproduction in mice exposed to mercuric chloride. This is proposed as the NOAEL. No LOAEL was available from the Revis et al. (1989) study, but in another study Fitzhugh et al. (1950) reported a 2-year LOAEL of 56 mg Hg/kg BW/day for growth in rats exposed to mercuric chloride. This is proposed as the LOAEL. The third study reviewed was one by Aulerich et al. (1974), which examined only a single, lower, no effect dose for a shorter time period.

NOAEL = 13.2mg Hg/kg BW/day

LOAEL = 56 mg Hg/kg BW/day

Selenium

Three chronic-term studies with reproductive endpoints were evaluated. The NOAEL selected was based on the study by Rosenfeld and Beath (1954). Other studies used only a single dose and did not produce a NOAEL (Schroeder and Mitchener 1971), or used a shorter exposure duration and did not measure reproductive success (NTP 1994).

Rosenfeld and Beath (1954) exposed pregnant rats to 0.21, 0.35, or 1.05 mg Se/kg BW/day (as potassium selenate in drinking water) and reported no adverse effects on the number of normal litters at 0.35 mg/kg BW/day in the first generation. Therefore:

NOAEL = 0.35 mg Se/kg BW/day

LOAEL = 1.05 mg Se/kg BW/day

Thallium

Four studies were available and all were evaluated. The NOAEL selected for thallium is based on a study by U.S. EPA (1986) and used by IRIS as the NOAEL for the protection of human health. Other studies were of shorter duration at a single dose level (Formigli et al. 1986), evaluated only mortality (Downs et al. 1960) or mortality and neural histology (Manzo et al. 1983).

U.S. EPA (1986) exposed rats to thallium sulfate at doses of 0, 0.008, 0.04, or 0.20 mg Tl/kg BW/day for 90-days and reported no adverse effects on body weight, organ weight, hematology or clinical chemistry, food consumption of histopathologic lesions at the highest dose tested (the only adverse effect found was alopecia or hair loss). Since rats reproduce with 8-10 weeks of birth, this is a chronic NOAEL for ecological receptors. The LOAEL was estimated by multiplying the NOAEL by 5 (Lewis et al. (1990).

NOAEL = 0.2 mg Tl/kg BW/day

LOAEL = 1.0 mg Tl/kg BW/day

Zinc

Four studies were evaluated. The NOAEL selected for zinc is based on results reported by Schlicker and Cox (1968), and Aulerich et al. (1991). Schlicker and Cox (1968) fed rats zinc oxide for 16-days during gestation and found no adverse effects on mating, fertilization, implantation, and fetal development at 160 mg Zn/kg BW/day. The LOAEL from this study was 320 mg Zn/kg BW/day. However, in another study with mink, Aulerich et al. (1991) reported that concentrations of 0, 500, 1000, or 1500 mg Zn/kg food caused no adverse effects on body weight, food consumption, haematological parameters, or histological lesions in the pancreas, liver, or kidney after 144-days. For mink the highest concentration in this study (1500 mg Zn/kg food is equivalent to a NOAEL of 205 mg Zn/kg BW/day.

Since the NOAEL from the Schlicker and Cox (1968) is lower this will be used along with the LOAEL from the same study.

NOAEL = 160 mg Zn/kg BW/day

LOAEL = 320 mg Zn/kg BW/day

Other studies reached similar NOAEL conclusions (Ketcheson et al. 1969; Maita et al. 1981, Aughey et al. 1977) but did not provide LOAEL values.

VOCs

Benzene

Three toxicity studies examining reproduction and development were evaluated. The NOAEL was based on a study by Nawrot and Staples (1979).

Nawrot and Staples (1979 exposed mice by gavage to 0.3, 0.5, or 1 ml benzene/kg BW/day from days 6 to 12 of gestation. Adverse effects on maternal mortality, and embryonic resorption were found at the lowest concentration. Therefore, the LOAEL is:

0.3 ml benzene/kg BW^{-day} x 0.8787 g/ml x 1000 mg/g = 264 mg benzene/kg BW/day.

This LOAEL was converted to a NOAEL by applying an extrapolation factor of 5. Therefore, the NOAEL for ingestion of benzene is:

NOAEL = 264 mg benzene/kg BW/day divided by 5

= 52.8 mg benzene/kg BW/day

The other studies evaluated a single higher effect dose of 1000 mg benzene/kg BW/day (Exxon 1986), or evaluated endpoints that are not related to population stability and provided no study protocol, few study details, and no statistical analyses (Wolf et al. 1956).

m, o, and p-Cresol

ATSDR (1992) summarized the available data concerning the toxicity of cresols to mammals. The lowest NOAELs having implications for animal population stability were:

m-cresol

ATSDR (1992) cited BRCC (1988) as reporting a NOAEL for rabbits exposed during days 6 to 15 of gestation. The rabbit NOAEL for development and reproduction is 100 mg m-cresol/kg BW/day. This is the lowest NOAEL reported.

NOAEL = 100 mg m-cresol/kg BW/day

o-cresol

ATSDR (1992) cited Hornshaw et al. (1986) 6-month feeding studies with mink and reports a NOAEL of 105 mg o-cresol/kg BW/day. Sample et al. (1996) cite the same study, but calculated a NOAEL of 219 mg o-cresol/kg BW/day. The lower estimate was selected as the NOAEL for this BERA. Other studies with o-cresol were found in ATSDR (1992), but the mink values were the lowest and mink is a Site-specific receptor.

NOAEL = 105 mg o-cresol/kg BW

p-cresol

ATSDR (1992) cited MBA (1988) as reporting that a dose of 50 mg p-cresol/kg BW/day caused nephropathy in rats after 13-weeks of dietary exposure. This is the lowest value reported in ATSDR (1992). Therefore, the NOAEL for ingestion of p-cresol is:

NOAEL = 50 mg p-cresol/kg BW/day divided by 5

= 10 mg p-cresol/kg BW/day

Ethylbenzene

Three studies of ethylbenzene toxicity were evaluated. The NOAEL was based on the study by Wolf et al. (1956). Wolf et al. (1956) exposed rats to 13.6, 136, 408, or 680 mg ethylbenzene/kg BW/day by gavage 5-days/week for 182 days. No effects on liver or kidney weight and no histological changes were found at 136 mg ethylbenzene/kg BW/day. This NOAEL was converted to a 7 day per week NOAEL by multiplying by 5/7:

$$\text{NOAEL} = 136 \text{ mg ethylbenzene/kg BW}^{-\text{day}} \times 5/7\text{-days}$$

$$= 97 \text{ mg ethylbenzene/kg BW/day.}$$

Other studies examined higher lethal doses (Smyth et al. 1962) or fewer doses with no statistical analyses (Ungvary 1986).

Toluene

Eight studies of toluene effects on reproductive or developmental endpoints were evaluated. The NOAEL was based on the study by Nawrot and Staples (1979).

Nawrot and Staples (1979) exposed mice to toluene to 0.3, 0.5, or 1.0 ml toluene three-times per day for 10 days between days 6 and 15 of gestation. They found increased mortality at the lowest concentration tested. Therefore, the LOAEL is:

$$0.3 \text{ ml toluene/kg BW}^{-\text{day}} \times 3 \text{ doses/day} \times 0.866 \text{ g/ml} = 779 \text{ mg toluene/kg BW/day.}$$

This was converted to a NOAEL by dividing by 5. This results in a NOAEL for ingestion of benzene of:

$$\text{NOAEL} = 779 \text{ mg toluene/kg BW/day divided by } 5$$

$$= 156 \text{ mg toluene/kg BW/day.}$$

Other studies reported higher NOAELs (Smith 1983; Seidenberg et al. 1982; NTP 1990) or LC50s only (Kimura et al. 1971; Smyth et al. 1969; Withey and Hall 1975; Wolf et al. 1956).

Trimethylbenzenes

No adequate studies of the toxicity of trimethylbenzenes (TMB) were found in the literature. USEPA (1994) reported only one study of the oral toxicity of trimethylbenzenes. They reported that rats given 1,2,4-trimethylbenzene at a dose of 0.5 g/kg BW/day five days a week for four weeks died and that one rat given 0.2 g/kg BW/day died. No other data were provided. When queried for trimethylbenzene, the USEPA database IRIS (2003) provides an oral RfD based on an NTP (1986) study of xylenes. The NTP study exposed F344/N rats and B6C3F1 mice to xylenes (60% m-xylene, 13.6% p-xylene, 9.1% o-xylene, and 17% ethylbenzene) by gavage 5-days per week for 103 weeks. The NOAEL for rats, upon which the RfD was calculated is 250 mg/kg BW/day and the LOAEL is 500 mg/kg BW/day. There were no effects on mice except for hyperactivity following the daily gavage administration. The NOAEL and LOAEL for mice were 500 and 1000 mg/kg BW/day, respectively (IRIS 2003).

In the BERA, the more conservative of the two endpoints from NTP (1986) will be used to represent the TRVs for trimethylbenzene:

NOAEL= 250 mg TMB/kg BW/day

LOAEL= 500 mg TMB/kg BW/day

Xylene

Three studies of the effect of xylenes ingestion were evaluated. The NOAEL for ingestion of xylenes was taken from the study by NTP (1986).

NTP (1986) exposed rats and mice to 250, 500, or 1000 mg xylenes by gavage, 5 days per week for 13 and 103 weeks. They reported no adverse effects on histological change in reproductive organs of rats and mice, respectively, at doses of 500 and 1000 mg xylenes/kg BW/day. This NOAEL was converted to a 7 day per week NOAEL by multiplying by 5/7:

NOAEL = 500 mg xylenes/kg BW/day x 5/7

= 357 mg xylenes/kg BW/day.

Other studies reported NOAELs at lower doses (Seidenberg et al. 1986; Marks et al. 1982).

Table 5-5. Summary of Mammalian Toxicity Reference Values (TRVs).

Analytes	Mammalian Receptors			
	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source
Metals				
Antimony	13.3	NA	Geometric Mean	USEPA 2005a
Barium	51.8	82.7	Geometric Mean	USEPA 2005a
Cadmium	0.77	6.9	Geometric Mean	USEPA 2005a
Copper	23.7	82.7	Geometric Mean	USEPA 2005a
Lead	40.7	182.4	Geometric Mean	USEPA 2005a
Manganese	88	284	rat	Laskey et al. 1982
Mercury	13.2	56	mouse/rat	Revis et al. 1989 (NOAEL); Fitzhugh et al. 1950 (LOAEL)
Selenium	0.35	1.05	rat	Rosenfeld and Beath 1954
Thallium	0.2	1	rat	USEPA 1996
Zinc	160	320	rat	Schlicker and Cox 1968
Organic Compounds				
Total PAHs & VOCs	129	NA	rat	Shopp et al 1984; Plasterer et al 1985
Benzene	52.8	264	mouse	Nawrot and Staples 1979
Ethylbenzene	97	NA	rat	Wolf et al 1956
Toluene	156	779	mouse	Nawrot and Staples 1979
Xylenes (total)	357	NA	rat	NTP 1986
m & p-cresols	10	NA	rat	MBA 1988[d]
o-cresol	21	NA	mink	MBA 1988
Trimethylbenzenes (total)	250	500	rat	IRIS 2003

Notes:
a, NOAEL is no observable adverse effects level.
b, LOAEL is low observable adverse effects level.
c, Mallard-based TRV is multplied by correction factors of 4.0 for tree swallow.
d, Lower TRV for p-cresol selected as a conservative TRV for m & p-cresols.
-- Appropriate data are not available from published literature to derive NOAEL and LOAEL values.
NA, Toxicity Reference Value not available.

5.2 EXPOSURE ANALYSIS

In the exposure analysis the relationship between receptors at the Site and COPCs are evaluated. The information necessary to estimate exposure is described in this section, including an overview of the various sources, the spatial and temporal distribution of chemical stressors, and the methods through which different types of exposure are estimated for each receptor group.

5.2.1 Calculation of Exposure Point Concentrations

EPCs used to estimate exposure were calculated as the UCL_{95}. Since calculation of the UCL_{95} is dependent on the underlying distribution of sample data the distribution was tested for normality using ProUCL (USEPA 2004). For normally distributed datasets (α=0.05), the UCL_{95} was calculated based on the Student's t-distribution (USEPA 2000):

$$UCL_{95} = X + t_{a,n-1} SD / \sqrt{n}$$

where:

UCL_{95} = 95 percent confidence limit of the arithmetic mean

X = arithmetic mean concentration of the data (non-detections estimated as 50 percent of the method detection limit)

SD = standard deviation of the data (non-detections estimated as 50 percent of the method detection limit)

$t_{\alpha n-1}$ = Student's t-statistic at $\alpha = 0.05$

n = sample size

Constituents with non-normal distributions were calculated using a bootstrap or jackknife resampling procedure. The major advantage of these methods is they can provide a robust approximation of the UCL without having to make assumptions regarding an underlying distribution to the data (EPA 1997). Either of these methods can be used; however, the Jackknife method tends to be more robust and more conservative (and thus preferred) on datasets with fewer samples (e.g., sample sizes less than 15). When analysis with ProUCL indicated that the underlying distribution was not normal, the Standard Bootstrap UCL_{95} was used. If the Standard Bootstrap was not available then the Jackknife UCL_{95} was used.

Bootstrapping is a nonparametric statistical technique that draws repeated random samples of size n with replacement from the original set of data. A sample mean is calculated with each replacement, resulting in a new population of sample means. In this assessment, standard bootstrapping techniques were used to produce a new population of 1000 sample means. The central limit theorem states that arithmetic means obtained from independent, random samples drawn from the same population will be approximately normally distributed, regardless of the distribution of the sampled population, if the sample size is large (USEPA 2002). Therefore, the principals of the Student's t-distribution may be applied to the bootstrap estimates of the mean to calculate a UCL_{95} based on normally distributed data:

$$UCL_{95} = X_r + SD_r \times 1.645$$

where:

UCL_{95}	= 95 percent confidence limit of the arithmetic mean
X_r	= mean of bootstrapped estimates of the mean
SD_r	= standard deviation of the bootstrapped estimates
1.645	= Student's t-statistic for degrees of freedom greater than 120 at α equal to 0.05

For the jackknife mean and standard error are calculated as follows:

Step 1: *n* pseudovalues (ϕ) are first calculated by leaving out each of the observations i in turn:

$$\phi = (n \times \overline{X}) - [(n-1) \times \overline{X}_{i-1}]$$

Step 2: The jackknifed estimate of the mean is then:

$$\Phi = \sum(\phi) \div n$$

Step 3: The standard error of the mean is calculated as:

$$SE_{mean} = \sqrt{\sum(\phi_i - \Phi)^2 / [n \bullet (n-1)]}$$

Step 4: The upper confidence limit of the jackknifed mean is calculated as:

$$UCL_{\alpha} = \Phi + t_{1-\alpha,n-1} \bullet SE_{mean}$$

EPCs calculated for sediment and soil exposure media are presented for terrestrial and aquatic exposure areas in Appendix I.

Because the UCL_{95} of the data represents a reasonable maximum exposure for ecological receptors the UCL_{95} was then compared to the screening criteria. This has the effect of eliminating extreme but unrepresentative environmental concentrations. Table 5-6 summarizes those COPCs whose UCL_{95} exceeded the screening criteria.

Table 5-6. List of Site Contaminants Whose EPC based upon the 95%UCL Exceeds the Screening Criteria.

Surface Water	Sediment	Soil
None	Total PAHs	Total PAHs
	Dibenzofuran	Antimony
	m-Cresol	Cadmium
	o-Cresol	Lead
	p-Cresol	Manganese
	1,2,4-Trimethylbenzene	Mercury
	1,3,5-Trimethylbenzene	Selenium
	Benzene	Zinc
	Ethylbenzene	
	Toluene	
	Total Xylenes	
	Barium	
	Copper	
	Selenium	
	Thallium	

5.2.2 Exposure Estimation for Birds and Mammals

Exposure estimates for birds and mammals were calculated using food chain models. Simplified food chain models were developed to calculate average daily doses (ADDs) of COPCs that selected receptor groups experience through exposure to sediment and surface soil at the Site.[15] The ADD represents the dose of a chemical that a receptor may ingest if it foraged exclusively within the boundaries of the Site. ADDs for wildlife receptors are calculated using (1) exposure-point concentrations for prey and media, and (2) receptor-specific exposure parameters and food chain model assumptions (Appendix F). These ADDs can then be compared to toxicity reference values (TRVs), which represent no observable adverse effects levels (NOAELs) or lowest observable adverse effects levels (LOAELs). Appendix F provides a detailed description of the calculation of ADDs, including the derivation of exposure parameters, biota accumulation factors (BAFs), biota-sediment accumulation factors (BSAFs), and bioavailability adjustments. For all receptors an area use factor (AUF) of 100% is used to calculate the ADD for each of the modelled receptors. This is a very conservative assumption for wildlife receptors that have significantly larger foraging areas than the approximately 10 acre Site.

[15] Exposure through surface water was not considered in the wildlife models because no COPCs were detected in surface water samples.

The simplified food chain model considers the primary routes of exposure to wildlife receptors: the direct ingestion of prey and the incidental ingestion of soil or sediment. There were only occasional low level detections of benzene, ethylbenzene, toluene and naphthalene in the filtered fraction of Site surface water and none of these detections exceeded screening criteria. No other VOCs or PAHs were detected. For this reason the surface water exposure pathway will not be used in the wildlife models.

Chemical concentrations in prey are expressed as a function of the chemical concentrations in sediment, or soil, using BAFs for terrestrial prey items and BSAFs for aquatic prey items. Other important parameters in the model include, receptor body weight, and food ingestion rates.

The total dose (ADD_{total}) experienced by each selected receptor is the sum of the doses obtained from the three primary routes of exposure:

$$ADD_{total} = ADD_{diet} + ADD_{substrate}$$

In the model, the total dose from each route of exposure is calculated individually as follows:

Dietary Dose:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (C_{food} \times DF_i)}{BW}$$

where:

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)

IR_{diet} = Ingestion rate of food (kg food ingested per day, dry weight)

C_{food} = Concentration of COPCs in food item *i* (mg COPC/kg food item, dry weight); Determined using direct measurements of tissue concentrations or estimated using bioaccumulation factors (BAFs) or biota-sediment accumulation factors (BSAFs) (See Section 5.2.3).

DF_i = Dietary fraction of food item *i* (proportion of food type in the diet)

BW = Body weight of the receptor, wet weight (kg)

Substrate Dose:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate}}{BW}$$

$ADD_{substrate}$ = Dose of COPC obtained from soil or sediment (mg COPC/kg receptor body weight-day)

IR_s = Incidental Ingestion Rate of soil (kg substrate ingested per day, dry weight)

$C_{substrate}$ = Mean or UCL_{95} COPC concentration in substrate (mg COPC/kg substrate, dry weight)

BW = Body weight of the receptor, wet weight (kg)

The receptor dose of COPCs from diet, and incidental substrate ingestion is modeled using dry weight parameters. To avoid introducing unnecessary uncertainty into the model by converting parameters from dry weight to wet weight based on approximate moisture contents of dietary items, model parameters for food ingestion rates, substrate ingestion rates, and substrate-to-biota accumulation rates also are expressed on a dry weight basis.

5.2.3 Estimates of Dietary Exposure Point Concentrations for Wildlife

The concentration of Site COPCs in prey consumed eaten by wildlife was estimated in one of three manners:

1) Tissue concentrations of organisms (wild fish) actually collected on Site;
2) Tissue concentrations of the invertebrate benthic worm, *L. variegatus*, that resulted from the bioaccumulation bioassay; or
3) Using literature based BAFs and BSAFs and applying it to levels of COPCs in soil or sediment to estimate levels of COPCs expected in wildlife prey.

During the RI, tissue concentrations were measured in two categories of prey: fish and benthic invertebrates. Fish were collected in Site water at two different times and levels of COPCS were quantified in species representative of likely wildlife prey: smelt, brown bullhead and smallmouth bass. Appendix C describes this investigation and summarizes the data resulting from it. Estimates of tissue concentrations of benthic invertebrates were developed from the *L. variegatus* bioaccumulation study. It was assumed that under the test conditions, this soft-bodied infaunal oligochaete would provide a very conservative estimate of COPCs in benthic invertebrates and thus maximize the dose to wildlife feeding on aquatic invertebrates. Appendix B describes the bioaccumulation study and summarizes the data resulting the investigation. The fish and worm data were used to estimate a UCL_{95} body burden concentration in these species (Appendix I) that is used in the wildlife dose rate modeling (Appendix F).

5.2.3.1 Doses for Wildlife from Benthic Invertebrates and Fish

From Benthic Invertebrates

Doses to invertivorous wildlife, i.e., tree swallow, big brown bat, and black duck[16] were calculated using concentrations of PAHs measured in the freshwater benthic worm, *L. variegatus*, chronically exposed to Site sediments in the laboratory. BSAFs for PAHs were calculated as the ratio of the lipid normalized concentrations of PAHs in *L. variegatus* to the organic carbon normalized concentrations of PAHs in the bioassay sediments. Normalized[17] BSAFs for 23 individual PAHs evaluated in the 17 samples included in the 28-day *L. variegatus* bioaccumulation study (Table 5-7). These BSAFs were then used to estimate the Site-wide

[16] For the purposes of the BERA, it was assumed that the black duck feeds exclusively on benthic macroinvertebrates

[17] 'Normalized BSAFs' refers to BSAFs normalized by the geometric mean lipid fraction of *L. variegatus* and the geometric mean organic carbon fraction in the test sediment from the 28-day bioaccumulation study.

UCL_{95} concentration of benthic invertebrates inhabiting the Site. This was accomplished in two steps as follows.

1) Site-wide BSAFs were calculated for each individual PAH compound from the bioaccumulation study stations using the normalized BSAFs based on the UCL_{95} concentration of sediment organic carbon calculated for the Site area and the geometric mean lipid concentration measured in the bioaccumulation study. Site-wide BSAFs were calculated for each compound as follows:

$$BSAF_{Site-Wide} = BSAF_{norm} \times f_{lipid} \div f_{oc}$$

where: $BSAF_{Site-Wide}$ = BSAF based on Site-wide fraction of sediment organic carbon and geometric mean estimated lipid fraction in the worms ;

$BSAF_{norm}$ = Normalized BSAF for each individual PAH compound (kg sediment organic carbon / kg lipid);

f_{lipid} = Fraction of lipids (0.0785, geometric mean calculated for *L. variegatus* on a dry weight basis); and

f_{oc} = Site-wide fraction of sediment organic carbon (0.1857, UCL_{95} calculated from sediment samples in the Site area).

2) Concentrations of PAHs in Site-wide prey were estimated by multiplying the Site-wide BSAF by the Site-wide UCL_{95} sediment concentration:

$$C_p = BSAF_{Site-Wide} \times C_s$$

where: C_p = Estimated concentration of PAHs in prey (mg PAH/kg prey, dry weight)

$BSAF_{Site-wide}$ = BSAF based on Site-wide fraction of sediment organic carbon and estimated lipid fraction in benthic invertebrates; and

C_s = Concentration of PAH in sediment (mg PAH/kg sediment, dry weight)

The 28-day *L. variegatus* bioaccumulation study did not analyze the concentrations of dibenzofuran or the VOCs that were identified as COPCs in the BERA: benzene, m, p and o-cresols, ethylbenzene, toluene, and total xylenes. In addition, since biphenyl was analyzed in fish, but not in worms, it was felt that the concentration of that compound should also be estimated. The normalized BSAF developed for acenaphthene from the *L. variegatus* bioaccumulation study was used to estimate concentrations of dibenzofuran and biphenyl in benthic invertebrate tissue due to similar log K_{ow}s and molecular weights between compounds. The normalized BSAF for naphthalene was used as a conservative surrogate to estimate concentrations of VOCs in benthic invertebrates based on the assumption that VOCs do not bioaccumulate at a greater rate than naphthalene (Table 5-7, Roubal et al. 1977).

Table 5-7. Estimation of BSAFs Based on 28-day *L. variegatus* Bioaccumulation Study

Compound	Log K_{ow}	Normalized BSAFs (kg sediment organic carbon / kg lipid)			
		Minimum	Geometric Mean	UCL_{95}	Maximum
1-Methylnaphthalene	3.84	0.01	1.01	4.09	9.26
1-Methylphenanthrene	5.04	2.40	9.31	38.2	124.78
2,3,5-Trimethylnaphthalene	4.86	0.91	6.80	18.23	49.42
2,6-Dimethylnaphthalene	4.37	0.14	2.96	8.33	25.87
2-Methylnaphthalene	3.86	0.01	1.43	5.72	19.17
Acenaphthene	4.01	0.07	1.27	4.37	13.80
Acenaphthylene	3.22	0.46	3.44	10.49	33.36
Anthracene	4.53	0.47	3.02	10.29	27.36
Benzo(a)anthracene	6.71	1.70	6.38	23.07	66.60
Benzo(a)pyrene	6.11	0.55	3.31	12.15	40.86
Benzo(b)fluoranthene	6.27	0.93	5.63	23.18	64.01
Benzo(e)pyrene	6.14	2.26	7.31	24.59	73.04
Benzo(g,h,i)perylene	6.51	0.66	2.71	8.45	22.87
Benzo(k)fluoranthene	6.29	2.35	9.01	27.62	86.32
Chrysene	5.71	2.45	7.32	25.52	80.35
Dibenzo(a,h)anthracene	6.71	1.64	7.69	22.15	56.19
Fluoranthene	5.08	1.84	7.18	28.08	88.26
Fluorene	4.21	0.17	2.42	7.95	26.69
Indeno(1,2,3-cd)pyrene	6.72	0.28	1.95	6.69	18.69
Naphthalene	3.36	0.02	3.12	12.51	42.97
Perylene	6.14	1.65	7.01	12.49	34.56
Phenanthrene	4.57	1.34	6.87	20.42	64.80
Pyrene	4.92	2.34	7.45	37.31	106.96

Concentrations of organic compounds in benthic invertebrates estimated based on BSAFs and the UCL_{95} sediment concentrations that are used in the food chain models are presented in Appendix I, Table I-3. Exhibit 5.1 provides a sample calculation of the naphthalene concentration estimated in benthic invertebrates based on the UCL_{95} sediment concentration and BSAF. This tissue concentration substantially exceeds those measured in the lab because the bioaccumulation bioassay was not conducted using sediments from SQT1 and SQT7, which had the highest levels of PAHs on a carbon normalized basis. It is likely that applying this BSAFs to the much greater Site concentrations is very conservative.

Exhibit 5.1: Calculations of Site-wide Benthic Invertebrate Tissue Concentrations Using Biota to Sediment Accumulation Factors (BSAFs)

The concentration of naphthalene in benthic invertebrate tissue was estimated based on the BSAF determined in the 28-day *L. variegatus* bioaccumulation study and the UCL_{95} naphthalene concentration measured in sediments at the Site. The ratios of the naphthalene concentration measured in *L. variegatus* to the concentration of naphthalene measured in bioassay sediment were calculated for each of the 17 samples evaluated in the *L. variegatus* bioaccumulation study. The calculated ratios were normalized by the sediment organic carbon content (geometric mean of organic carbon measured in bioassay samples) and *L. variegatus* lipid content (geometric mean of lipid content measured in bioassay samples); the resulting values are hereafter referred to as normalized BSAFs. The geometric mean of the 17 normalized BSAFs calculated for naphthalene in the bioaccumulation samples (3.12 kg sediment organic carbon/kg lipid) was used to estimate naphthalene concentrations in benthic invertebrates at the entire Site. The geometric mean of normalized BSAFs calculated for other organic compounds are presented in Table 5-7.

The geometric mean of the normalized BSAFs for naphthalene (3.12 kg sediment organic carbon/kg lipid) derived under laboratory conditions was corrected to account for differences in sediment organic carbon content at the Site. A Site-wide BSAF was calculated using the UCL_{95} sediment organic carbon fraction (0.1857) and geometric mean lipid fraction measured in *L. variegatus* (0.0785, dry weight), as follows:

$$BSAF_{Site-Wide} = BSAF_{norm} \times f_{lipid} \div f_{oc}$$

$$BSAF_{Site-Wide} = 3.12\,(kg\,OC / kg\,lipid) \times 0.0785\,(kg\,lipid / kg\,tissue, dry\,weight) \div 0.1857\,(kg\,OC / kg\,sediment, dry\,weight)$$

$$BSAF_{Site-Wide} = 1.32\,(kg\,sediment, dry\,weight / kg\,tissue, dry\,weight)$$

The Site-wide BSAF was then multiplied directly by the measured concentration of naphthalene in sediment (UCL_{95} concentration for the Site) to estimate the Site-wide naphthalene concentrations in benthic invertebrate tissue (C_p, on a dry weight basis):

$$C_p\,(mg\,naphthalene / kg\,tissue, dry\,weight) = BSAF_{Site-Wide} \times C_s$$

$$C_p = 1.32\,(kg\,sediment, dry\,weight / kg\,tissue, dry\,weight) \times 107.47\,(mg\,naphthalene / kg\,sediment, dry\,weight)$$

$$C_p = 28.378\,(mg\,naphthalene / kg\,tissue, dry\,weight)$$

Estimated benthic invertebrate tissue concentrations calculated based on BSAFs and UCL_{95} sediment concentrations are presented in Appendix I, Table I-3.

The preceding example calculates the estimated naphthalene concentration in benthic invertebrates on a dry weight basis for use in the food chain models. However, this approach was also used to estimate benthic invertebrate body burdens as lipid-normalized molar concentrations (wet weight) for comparisons with the NEBR developed in Section 5.1. The lipid-normalized molar concentration (μmol/g lipid) for naphthalene was calculated as the lipid-normalized concentration divided by the molecular weight of naphthalene ($MW_{naphthalene}$):

$$C_p\,(\mu mol/g\,lipid) = \left(\frac{3.12\,(kg\,OC/kg\,lipid \times 107.47\,(mg\,naphthalene/kg\,sediment,\,dry\,weight)}{0.1857\,(kg\,OC/kg\,sediment)}\right) \div 128.19\,(g/mol)$$

$$C_p\,(\mu mol/g\,lipid) = 1807.54\,(mg\,naphthalene/kg\,lipid) \div 128.19\,(g/mol)$$

$$C_p\,(\mu mol/g\,lipid) = 1807.54\,(\mu g\,naphthalene/g\,lipid) \div 128.19\,(g/mol)$$

$$C_p\,(\mu mol/g\,lipid) = 14.1\,(\mu mol/g\,lipid)$$

Estimated lipid-normalized molar concentrations of PAHs and VOCs in benthic invertebrate tissues calculated based on UCL_{95} sediment concentrations and BSAFs are presented in Section 5.2.4 (Table 5-14).

The normalized BSAFs estimated from the 28-day *L. variegatus* bioaccumulation study were compared two other sources of BSAFs, the TLM of DiToro et al. (2000) and the U.S. Army Corps of Engineers (USACE) Environmental Residue Effects Database (ERED). DiToro et al. (2000) rearranged the TLM to predict the BSAF for PAHs:

$$BSAF = \frac{[PAH]_{lipid}}{[PAH]_{organic\ carbon}} = Kow^{-0.38}$$

and concluded that BSAFs should be less than 1.0.Table 5-8). The ERED also contains BSAFs for *L. variegatus* exposed to PAHs (Table 5-9). The BSAFs range from 0.45 for benzo(a)pyrene to 6.8 for naphthalene.

BSAFs for PAH compounds derived from field-collected tissue studies and bioaccumulation studies using field sediments were compiled from the literature for comparison with the BSAFs derived from the *L. variegatus* bioaccumulation study (Table 5-10). A limited number of field-collected tissue studies were available in the literature. Brunson et al. (1998) compiled field tissue and sediment data for *L. variegatus* from sites in the upper Mississippi River and Saint Croix River. The mean BSAFs calculated from these field datasets are on the same order as the geometric mean BSAFs calculated from the *L. variegatus* bioaccumulation study conducted in the present study. However, BSAFs derived from field measurements of tissue of other invertebrates were generally an order of magnitude or more lower than the *L. variegatus* BSAFs calculated by Brunson et al. (1998) or the current study. Gewartz et al. (2000) evaluated bioaccumulation from field-collected tissue samples of mayflies, mussels, amphipods, and crayfish and reported BSAFs less than 1.0 for these invertebrates for all measured PAHs, except naphthalene. BSAFs for naphthalene ranged from 0.706 for crayfish to 1.451 for mayflies and mussels (Table 5-10).

A review of bioaccumulation studies using field-collected sediments indicates that BSAFs for invertebrates are generally below 1.0. BSAFs derived from bioaccumulation studies using field sediments ranged from 0.002 to 1.9 (Table 5-8). BSAFs greater than 1.0 were reported for phenanthrene in two studies and fluoranthene and pyrene in one study each. The range of BSAFs based on field-collected sediments from these studies is consistent with Kraaij et al. (2001) who reported BSAFs for a marine amphipod ranging from 0.25 to 1.7 from sediments collected from contaminated harbors in the Netherlands. Lamoureux and Brownawell (1999) also reported tPAH BSAFs less than 1.5 for *Yoldia* (Bivalva) exposed to sediments collected from New York Harbor. Tracey and Hansen (1996) reported a mean BSAF of 0.34 for PAHs calculated from 4,054 field and laboratory measurements of 27 species. Other studies also reported BSAFs less than 1.0 for PAH compounds (Maruya et al. 1997; Mitra et al. 2000).

Based on comparisons with normalized BSAFs calculated by DiToro and McGrath (200b), those compiled in ERED as well as other field studies, it was concluded that the normalized BSAFs calculated from the 28-day *L. variegates* bioaccumulation study provided very conservative estimations of PAH and VOC concentrations in benthic invertebrate tissue at the Site. For most compounds, the normalized BSAFs used in this study were an order of magnitude greater than those estimated by the TLM and the preponderance of invertebrate BSAFs for PAHs reported in the literature. Normalized BSAFs developed for the BERA also were greater than those compiled in ERED.

Table 5-8. Estimation of BSAFs using Target Lipid Model (DiToro et al. 2000).

Compound	Log K_{ow}	K_{ow}	Normalized BSAF (kg sediment organic carbon / kg lipid)
1-Methylnaphthalene	3.84	6918	0.715
1-Methylphenanthrene	5.04	109648	0.643
2,3,5-Trimethylnaphthalene	4.86	72444	0.654
2,6-Dimethylnaphthalene	4.37	23442	0.682
2-Methylnaphthalene	3.86	7244	0.713
Acenaphthene	4.01	10233	0.704
Acenaphthylene	3.22	1660	0.754
Anthracene	4.53	33884	0.673
Benzo(a)Anthracene	6.71	5128614	0.556
Benzo(a)Pyrene	6.11	1288250	0.586
Benzo(b)Fluoranthene	6.27	1862087	0.578
Benzo(e)Pyrene	6.14	1380384	0.584
Benzo(g,h,i)Perylene	6.51	3235937	0.566
Benzo(k)Fluoranthene	6.29	1949845	0.577
Biphenyl	4.17	14791	0.694
Chrysene	5.71	512861	0.607
Dibenzo(a,h)anthracene	6.71	5128614	0.556
Fluoranthene	5.08	120226	0.641
Fluorene	4.21	16218	0.692
Indeno(1,2,3-cd)Pyrene	6.72	5248075	0.555
Naphthalene	3.36	2291	0.745
Perylene	6.14	1380384	0.584
Phenanthrene	4.57	37154	0.670
Pyrene	4.92	83176	0.650

Table 5-9. BSAFs for *L. variegatus* from USACE ERED Database.

Analyte	Normalized BSAF (kg sediment organic carbon/kg lipid)
Benzo(a)pyrene	0.37
Benzo(a)pyrene	0.23
Benzo(a)pyrene	0.5
Benzo(a)pyrene	0.13
Benzo(a)pyrene	1
Benzo(a)pyrene	0.5
Benzo(a)pyrene	1.34
Geometric Mean:	0.45
Benzo(a)anthracene	0.97
Chrysene	1.5
Chrysene	1.1
Geometric Mean:	1.28
Fluoranthene	1.8
Fluoranthene	1.6
Geometric Mean:	1.70
Naphthalene	5.3
Naphthalene	8.8
Geometric Mean:	6.83
Perylene	2.2
Perylene	1
Geometric Mean:	1.48
Pyrene	2.3
Pyrene	2.2
Pyrene	0.52
Pyrene	0.29
Pyrene	0.74
Pyrene	0.29
Pyrene	1.34
Pyrene	0.66
Pyrene	2.03
Geometric Mean:	0.87
2-Methyl naphthalene	2.6
2-Methyl naphthalene	6.7
Geometric Mean:	4.17

Table 5-10. Biota-Sediment Accumulation Factors for PAHs Derived From Field Collected Tissue Studies and Bioaccumulation Studies Using Field-Collected Sediment.

PAH Compound	K_{ow}		Field-Collected Tissue Studies					Bioaccumulation Studies Using Field-Collected Sediment				
		Organism:	*Lumbriculus* (Oligochaete)	Mayfly	Dreissenia (Mussel)	Amphipods	Crayfish	*Ilyodrilus* (Oligochaete)	*Lumbriculus* (Oligochaete)	*Lumbriculus* (Oligochaete)	*Nereis* (Polychaete)	*Hinia* (Gastropoda)
		Reference:	Brunson et al. (1998)	Gewartz et al. (2000)	Gewartz et al. (2000)	Gewartz et al. (2000)	Gewartz et al. (2000)	Lu et al. (2006)	Van Hoof et al. (2001)	Ingersoll et al. (2006)	Cornelissen et al. (2006)	Cornelissen et al. (2006)
		Study Location:	Upper Mississippi River and Saint Croix River	Western Lake Erie	Western Lake Erie	Western Lake Erie	Western Lake Erie	Anacostic River	Little Scioto River, Ohio	Little Scioto River, Ohio	Three Harbors in Norway	Three Harbors in Norway
		PAH Pollution:	Relatively Low	Relatively Low	Relatively Low	Relatively Low	Relatively Low	Moderate	Downstream of Creosote Source	Contaminated	Contaminated	Contaminated
Naphthalene	3.36		8.8	1.451	1.451	1.137	0.706					
2-methyl naphthalene	3.86		6.7									
Fluorene	4.21			0.267	0.067	0.283	0.033		0.38	0.95		
Anthracene	4.53								0.33	0.89		
Phenanthrene	4.57			0.165	0.099	0.146	0.019	1.55	0.28	1.6		0.01
Pyrene	4.92		2.2	1.005	0.061	0.017	0.003	0.49	0.16	1.7	0.058 - 0.11	0.015 - 0.077
Fluoranthene	5.08		1.6	0.514	0.115	0.073	0.004		0.21	1.9	0.008 - 0.028	0.007 - 0.016
Chrysene/triphenylene	5.71		1.1	0.606	0.216	0.038	0.004	0.48	0.12	0.74	0.002	0.002
Benzo(a)pyrene	6.11			0.185	0.016	0.006	0.004	0.09	0.13	0.84	0.0042 - 0.011	0.006 - 0.008
Benzo(e)pyrene	6.14										0.024 - 0.06	0.011 - 0.052
Perylene	6.14		1.02								0.0029 - 0.01	0.006 - 0.012
Benzo(b)fluoranthene	6.27			0.043	0.099	0.004	0.003				0.0057 - 0.011	0.0057 - 0.007
Benzo(k)fluoranthene	6.29							0.11				
Benzo(g,h,i)perylene	6.51			0.131	0.025	0.006	0.004				0.0036 - 0.009	0.010 - 0.018
Benzo(a)anthracene	6.71		0.5	0.347	0.088	0.010	0.007					
Dibenzo(a,h)anthracene	6.71			0.198	0.243	0.027	0.018					
Indeno(g,h,i)perylene	6.72			0.277	0.053	0.008	0.005				0.0022 - 0.010	0.008 - 0.016

Note:
"PAH pollution" refers to the relative magnitude of PAH levels in the sediment

Because concentrations of metals in aquatic benthic invertebrates were not measured, they were estimated based on BSAFs or regression models developed or obtained from the literature. The BSAF for barium was estimated as the UCL_{95} BSAF calculated from co-located sediment and tissue data reported by Hamilton and Buhl (2003a and 2003b). Concentrations of copper were estimated as the 95 percent upper prediction limit (95UPL) of regression models developed by Bechtel (1998b). Concentrations of selenium in benthic invertebrates were based on a significant regression ($p < 0.001$) of sediment and benthic invertebrate concentrations of selenium developed from co-located sediment and tissue data reported by Hamilton and Buhl (2003a and 2003b). A weighted-average of thallium BSAFs reported in Borgmann et al. (1998) for the amphipod *H. azteca* was used to estimate concentrations of thallium in benthic invertebrates.

Swallows and bats feed on emergent aquatic insects, not the immature benthic forms. Bechtel (1998b) indicates that the regression model they developed based on depurated organisms was the best estimate of adult concentrations of copper. However, correction factors were applied to estimated aquatic life stage concentrations calculated for copper, selenium, and PAHs/VOCs to the estimated concentrations present in emergent insects. For selenium, a correction factor of 0.4 was applied to concentrations in aquatic stage invertebrates to estimate concentrations in emergent stage invertebrates. This correction factor was based on Reinfelder and Fisher (1994) who found that 59.2% of ^{75}Se that was found to be bound to the exoskeleton of copepods. Reinfelder and Fisher (1994) also cite Bertine and Goldberg (1972) who reported that 61% of the selenium in shrimp was due to exoskeleton binding. Since the exoskeletons of copepods, shrimp, and aquatic insects are composed of chitin, these findings are directly applicable to insects. Assuming a similar partitioning of selenium in aquatic insects (i.e. 59.2 to 61% associated with the exoskeleton in the final molt), approximately 40% of selenium found in aquatic stage invertebrates would remain in emergent invertebrates following molting.

A correction factor of 0.135 was applied to concentrations of PAHs/VOCs estimated for aquatic life stage invertebrates to estimate concentrations in emergent insects. Bell et al. (2004) exposed fourth-instar midge larvae to fluoranthene for 72 to 96-hr. and the emergent adults were collected in traps. Larvae, exuviae, and adults tissues were collected and analyzed for fluoranthene. The larvae exhibited a concentration-dependent uptake of fluoranthene and contained significantly greater concentrations of fluoranthene than the emergent adults. In three different exposure concentrations, the emergent adults contained 0.78, 1.29, and 13.5% of the larval fluoranthene concentration and the exuviae contained more fluoranthene than the emergent adult. The highest proportion of retained fluoranthene, 13.5% was applied to the *L. variegates* data to estimate the doses received by flying insectivores at the Site. For the remaining COPCs, concentrations estimated for aquatic life stages were used to conservatively estimate concentrations for emergent life stages.

From Fish

Doses to piscivorous wildlife, i.e., osprey, double-crested cormorant, and mink, were calculated based on site-specific tissue measurements and normalized BSAFs estimated from Site data. The UCL_{95} tissue concentration of the 24 PAHs measured from all fish collected at the site was used as the exposure point concentration for total PAH concentrations in fish tissue. Site-specific tissue measurements were not available for dibenzofuran and the VOCs identified as COPCs in the BERA: benzene, m, p and o-cresols, ethylbenzene, toluene, and total xylenes. The geometric

mean normalized BSAF for the 24 PAH compounds measured in fish tissue was calculated and the resultant normalized BSAF was used to calculate the concentrations of the unmeasured COPCs in fish tissue. This calculation was based on the UCL_{95} sediment concentrations of individual PAHs and the brown bullhead sample (W-3-4) containing the greatest concentrations of PAHs (Table 5-11). The geometric mean of normalized BSAFs calculated for the individual PAH compounds was 0.0146, which is an order of magnitude greater than other BSAFs that have been reported for PAHs in fish. Burkhard and Lukasewycz (2000), of U.S. EPA's National Health and Environmental Effects Research Laboratory, state that "an extensive but unsuccessful literature search was performed for field-measured bioaccumulation factors (BAFs) and biota-sediment accumulation factors (BSAFs) for polycyclic hydrocarbons (PAHs); no reported values were found for fish." The lack of BAFs and BSAFs for PAHs occurs in part because PAHs are metabolized by fish, resulting in very low or non detectable concentrations of the parent PAHs in fish tissues [Varanasi et al. 1989]. Using data from several studies Burkhard and Lukasewycz (2000) calculated BSAFs for phenanthrene (0.00011), fluoranthene (0.00016), pyrene (0.0071) benzo(a)pyrene (0.0054), and chrysene/triphenylene (0.00033).

The normalized BSAF calculated from the Site-wide fish tissue data was used to estimate fish tissue concentrations of dibenzofuran and the VOCs identified as COPCs by applying the Site-wide BSAF calculated for PAHs to Site-wide sediment concentrations of dibenzofuran and VOCs to estimate the concentrations of these unmeasured COPCs in fish tissue:

$$BSAF_{Site=Wide} = BSAF_{norm} \times f_{lipid} \div f_{oc}$$

$$C_p = BSAF_{Site-Wide} \times C_s$$

where:

$BSAF_{Site-Wide}$ = BSAF based on site-specific fraction of sediment organic carbon and measured lipid fraction in the fish ;

$BSAF_{norm}$ = Normalized BSAF for each individual PAH compound (kg sediment organic carbon / kg lipid);

f_{lipid} = Fraction of lipids (0.12, geometric mean calculated for fish measured at the site on a dry weight basis);

f_{oc} = Site-wide fraction of sediment organic carbon (0.1857, UCL_{95} concentration calculated from sediment samples in the site area).

C_p = Estimated concentration of PAHs in food/prey item (mg PAH/kg prey, dry weight); and

C_s = Concentration of PAH in sediment (mg PAH/kg sediment, dry weight)

Table 5-11. BSAF Calculated for Site Fish.

Compound	Sediment Concentration (ug/kg sediment OC)	Brown Bullhead Concentration (ug/kg lipid)	Normalized BSAF (kg sediment organic carbon/kg lipid)
1-Methylnaphthalene	18920	4166.7	0.2202
1-Methylphenanthrene	4202	541.7	0.1289
2,3,5-Trimethylnaphthalene	1928	541.7	0.2810
2,6-Dimethylnaphthalene	14233	1791.7	0.1259
2-Methylnaphthalene	295705	1375.0	0.0046
Acenaphthene	129733	4166.7	0.0321
Acenaphthylene	12269	541.7	0.0441
Anthracene	47707	1708.3	0.0358
Benzo(a)anthracene	26674	400.0	0.0150
Benzo(a)pyrene	21619	45.8	0.0021
Benzo(b)fluoranthene	12696	41.7	0.0033
Benzo(e)pyrene	5641	41.7	0.0074
Benzo(g,h,i)perylene	9313	179.2	0.0192
Benzo(k)fluoranthene	13434	41.7	0.0031
Biphenyl	6367	320.8	0.0504
Chrysene	24357	91.7	0.0038
Dibenzo(a,h)anthracene	5135	41.7	0.0081
Fluoranthene	53194	170.8	0.0032
Fluorene	57275	1208.3	0.0211
Indeno(1,2,3-cd)pyrene	8610	41.7	0.0048
Naphthalene	370582	2208.3	0.0060
Perylene	1435	41.7	0.0290
Phenanthrene	149411	258.3	0.0017
Pyrene	73452	408.3	0.0056
		Geometric Mean:	0.0146

In summary for both benthic invertebrates and fish, the sum of the measured and estimated PAHs and VOCs is the EPC concentration used for the relevant COPC as the dose term to wildlife.

5.2.3.2 *Doses for Wildlife from Soil Invertebrates*

The bioaccumulation factors for antimony, barium, cadmium, copper, lead, mercury, selenium, thallium, and zinc were taken from Sample et al. (1999) and Efroymson et al. (2001), or for manganese and thallium uptake into plants, from Baes et al. (1984). Bioaccumulation factors for plants, soil invertebrates and wildlife, potentially exposed to PAHs, were taken from U.S. EPA (2005).

5.2.4 Exposure Estimation for Benthic Invertebrates

The EPCs for metals for benthic macroinvertebrates are based upon mean and UCL_{95} concentration of total metals in sediment. Table 5-12 presents UCL_{95} statistics for estimated metal concentrations for COPCs in sediment collected from the Site. A description of the sediment sampling and summary of the sediment data can be found in Appendix B.

Table 5-12. Summary Statistics for Concentrations of Metal COPCs Measured in SiteSediment (mg/kg)

Constituent	Number of Samples	Number of Detections	Concentration (mg/kg)				
			Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	UCL95 Concentration	95% UCL Method
Barium	72	72	5.3	180	46.83	52.63	Student's-t
Copper	72	72	1.8	700	72.48	91.38	Standard Bootstrap
Selenium	72	21	0.83	16	1.63	1.99	Standard Bootstrap
Thallium	72	14	0.7	4.1	1.47	1.60	Standard Bootstrap

For organics, the EPCs were developed from tissue concentrations measured in the *L. variegatus* bioaccumulation study or estimated based on BSAFs derived from data obtained in the bioaccumulation study as described in Section 5.2.3.1. Estimated benthic invertebrate tissue concentrations used as EPCs in the food chain models are presented in Appendix I, Table I-3.

Measured or estimated concentrations of VOCs and PAHs were also compared to the NEBR developed from the target lipid model in Section 5.1. Body burdens of VOCs and PAHs measured in *L. variegatus* in the 17 samples from the bioaccumulation study are provided in Appendix B, Attachment 2, Table 3.1. Table 5-13 provides summary statistics for the total PAH and VOC concentrations measured during the bioaccumulation study.

Table 5-13. Summary Statistics for Total PAH and VOC[1] Concentrations Measured in *Lumbriculus. variegatus* and Site Fish (µmol/g lipid)

Species	Number of Samples	Total PAH & VOC Concentrations (µmol/g lipid)			
		Minimum Concentration	Maximum Concentration	Average Concentration	UCL95 Concentration
Lumbriculus variegatus	17	0.130	4.08	1.25	1.83
Combined Fish	23	0.008	0.136	0.040	0.051

Notes:
1, VOC concentrations estimated as 3.1% of total PAH concentration measured in *L. variegatus* (See Section 5.1.2.2)
2, 95% UCL = 95% Upper Confidence Limit
3, PAHs = Polycyclic Aromatic Hydrocarbons; VOCs = Volatile Organic Compounds
4, Combined Fish = combined data from bass, bullhead and smelt
5, Both datasets fit a gamma distribution; standard bootstrapping was used to calculate UCL95 concentrations

Estimated benthic invertebrate tissue concentrations calculated based on UCL_{95} sediment concentrations and BSAFs as described in Section 5.2.3.1 are presented in Table 5-14. The total PAH and VOC concentration estimated in benthic invertebrates (µmol/g lipid) was used as the EPC for Site-wide comparisons to the NEBR.

Table 5-14. Total PAH and VOC Concentrations Estimated in Benthic Invertebrates (µmol/g lipid) Based on Geometric Mean BSAFs and UCL_{95} Sediment Concentrations.

Analyte	Molecular Weight (g/mol)	UCL_{95} Sediment Concentration (mg/kg, dry weight)	UCL_{95} NOC-PAH (mg PAH/kg OC)[a]	Normalized BSAF (kg OC/kg lipid)[b]	Lipid Normalized Molar Concentration (µmol/g lipid)[c]
PAHs					
Total PAHs & VOCs[d]		408.2	2198		47.0
PAHs:					
1-Methylnaphthalene	142.20	5.49	29.55	1.01	0.21
1-Methylphenanthrene	192.26	1.22	6.56	9.31	0.32
2,3,5-Trimethylnaphthalene	170.26	0.56	3.01	6.80	0.12
2,6-Dimethylnaphthalene	156.23	4.13	22.23	2.96	0.42
2-Methylnaphthalene	142.20	85.75	461.79	1.43	4.63
Acenaphthene	154.21	37.62	202.60	1.27	1.67
Acenaphthylene	152.20	3.56	19.16	3.44	0.43
Anthracene	178.20	13.84	74.50	3.02	1.26
Benzo(a)anthracene	228.29	7.74	41.66	6.38	1.16
Benzo(a)pyrene	252.31	6.27	33.76	3.31	0.44
Benzo(b)fluoranthene	252.32	3.68	19.83	5.63	0.44
Benzo(e)pyrene	252.31	1.64	8.81	7.31	0.26
Benzo(g,h,i)perylene	276.34	2.70	14.54	2.71	0.14
Benzo(k)fluoranthene	252.32	3.90	20.98	9.01	0.75
Biphenyl	154.00	1.85	9.94	1.27[e]	0.08
Chrysene	228.29	7.06	38.04	7.32	1.22
Dibenzo(a,h)anthracene	278.35	1.49	8.02	7.69	0.22
Dibenzofuran	168.19	0.30	1.63	1.27[e]	0.01
Fluoranthene	202.26	15.43	83.07	7.18	2.95
Fluorene	166.20	16.61	89.44	2.42	1.30
Indeno(1,2,3-cd)pyrene	276.34	2.50	13.45	1.95	0.09
Naphthalene	128.19	107.47	578.72	3.12	14.10
Perylene	252.31	0.42	2.24	7.01	0.06
Phenanthrene	178.20	43.33	233.33	6.87	8.99
Pyrene	202.26	21.30	114.71	7.45	4.22
Total PAHs[f]		364.02	1960.25		45.52
VOCs:					
Benzene	78.11	0.54	2.91	3.12[g]	0.12
Toluene	92.14	1.57	8.45	3.12[g]	0.29
Ethylbenzene	106.17	2.32	12.52	3.12[g]	0.37
Xylenes (total)	318.50	4.37	23.51	3.12[g]	0.23
m & p-cresols	324.42	0.38	2.02	3.12[g]	0.02
o-cresol	108.14	0.06	0.34	3.12[g]	0.01
1,2,4-Trimethylbenzene	120.20	1.80	9.68	3.12[g]	0.25
1,3,5-Trimethylbenzene	120.20	1.30	7.00	3.12[g]	0.18
Trimethylbenzenes (total)					0.43

Notes:

a, NOC-PAH calculated based on the UCL95 fraction of sediment organic carbon (0.1857) measured in the Site area.

b, Normalized BSAF (kg OC / kg lipid) calculated based on the site-specific 28-day *Lumbriculus variegatus* bioaccumulation study. A normalized BSAF was calculated as the geometric mean of BSAFs for each individual PAH compound (BSAFs were normalized by lipid content [geometric mean of all organisms = 0.0157] and sediment organic carbon content [geometric mean of all samples = 0.1857]).

c, Molar concentration of PAHs in tissue calculated on a mass lipid basis (µmol PAH/g lipid) as follows:

$$C_{tissue} = NOC - PAH \times BSAF_{norm} \div MW$$

where: C_{tissue} = Molar concentration of PAHs in tissue on a mass lipid basis (µmol PAH/g lipid)
NOC-PAH = PAH concentration normalized to organic carbon (mg PAH/kg OC)
$BSAF_{norm}$ = Normalized BSAF (kg OC/kg lipid)
MW = Molecular weight of compound (g/mol)

d, Calculated as the sum of estimated concentrations for listed PAH and VOC compounds.

e, Normalized BSAF for acenaphthene used as a surrogate BSAF for biphenyl based on similar log K_{ow}.

f, Calculated as the sum of estimated concentrations for listed PAH compounds.

g, Normalized BSAF for naphthalene used as a surrogate for VOCs based on the assumption that VOCs are not accumulated at a greater rate than naphthalene (Roubal et al. 1977).

5.2.5 Exposure Estimation for Fish and Pelagic Receptors

There were no COPCs for surface water so no surface water EPCs for fish and pelagic receptors were estimated. Instead, the potential for adverse effects to fish was estimated by comparing the tissue concentrations of fish collected at the Site to NEBRs for fish developed using the target lipid model discussed in Section 5.1. Appendix C summarizes the fish tissue data that was used as the EPC. Table 5-13 presents the UCL_{95} of these data after conversion to µmol/g lipid.

6.1 INTRODUCTION

During Risk Characterization, information developed in the exposure analysis and effects analysis are integrated to estimate the likelihood of adverse effects to the assessment endpoints. Lastly a discussion of the uncertainty associated with each element of the BERA is provided as a context for the conclusions of the Risk Characterization.

The Risk Characterization quantifies potential risks associated with each combination of exposure and effects data. This approach develops risk estimates for receptors inhabiting or utilizing the Site by comparing the estimated EPCs or average dietary doses (ADDs, for birds and mammals) of COPCs (developed in Section 5.2) to a corresponding toxicity reference value or benchmark (Section 5.1). The HQ for each complete exposure pathway, that is, each combination of COPC, ROC, and exposure route, was calculated by dividing the EPC or ADD by the respective TRV or benchmark:

$$HQ = \frac{EPC \text{ or } ADD}{TRV}$$

The HQ provides an index that expresses the relationship between predicted exposure point concentrations (the EPCs or ADDs) and derived toxicological reference values or benchmarks. If the HQ is greater than one, it indicates that exposure might exceed a known "safe" (no-adverse-effect) concentration for the given receptor, COPC, and exposure pathway and that this particular pathway should be considered in greater depth. A HQ less than one indicates that adverse effects are extremely unlikely because of the inherent conservatism (protectiveness) built into the Exposure and Effects Characterizations, e.g., maximizing exposure potential coupled with protective TRVs or benchmarks.

In some cases in this BERA the HQ is supplemented with other lines of evidence, e.g., evaluation of site-specific toxicity tests and site-specific field surveys, which also provide a perspective on the potential for adverse effects to selected ecological receptors. Thus, for aquatic receptors like benthic invertebrates the results of sediment bioassays and community studies are used as separate lines of evidence to evaluate the potential for adverse effects. As indicated in Section 4.3, the lines of evidence used in this BERA are accorded the following weight of evidence [numbered according to relative significance, with 1) having greater weight than 3)]:

1) Comparison of observed effects in the receptor group community characteristics in waterbodies in and adjacent to the Site to receptor group community characteristics from reference areas;
2) The results of bioassays conducted using standardized toxicity tests with sediments in and adjacent to the Site and surrogate test organisms; and
3) Comparison of Site-specific media concentrations and/or estimated ingested contaminant dose estimates (the latter for wildlife) to effects levels (TRVs and benchmarks) for the various ROCs.

All risk estimates for mammals and birds in the following section are based upon the very conservative assumptions that all chemicals are 100% bioaccessible and bioavailable and that wildlife only feed on prey from the Site area. Obviously these are very conservative assumptions. The details of the calculation of HQs for wildlife are provided in Appendices F and I.

The Risk Characterization is presented by Assessment Endpoint so the results can be easily related back to the Problem Formulation (Section 3.11) and Table 4-1.

6.2 RISK CHARACTERIZATION BY ASSESSMENT ENDPOINT

6.2.1 Assessment Endpoint #1: Viability and Function of Benthic Macroinvertebrate Community

The benthic macroinvertebrate community was selected as an assessment endpoint due to its role in energy flow and materials cycling, its potential for exposure to contaminants, and its role as a food source for higher trophic level organisms.

Risk Question:

Are concentrations of contaminants in the sediments at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?

This endpoint was assessed using several measurement endpoints as part of four lines of evidence. Three of these lines of evidence make up the Sediment Quality Triad discussed in Section 3.3 and Appendix B.

1) Compare concentrations of metals measured in Site sediment to WDNR (2003) sediment quality guidelines for threshold effects concentration (TEC) and probable effect concentration (PEC).
2) Evaluate the bioavailability of sediment associated divalent metal COPCs using SEM:AVS equilibrium partitioning.
3) Evaluate the affect of soot and coal in the sediment on bioavailability of PAHs using equilibrium partitioning;
4) Compare concentrations of PAHs that accumulated in worm tissues in the bioaccumulation bioassay to the NEBR that is associated with narcosis caused by PAHs and VOCs. Use this as a model for uptake of sediment COPCs by benthic invertebrates at the Site.
5) Determine which sediments at the Site have elevated toxicity to surrogates for resident macroinvertebrate species compared to sediments in reference areas.
6) Determine where benthic communities inhabiting sediments in Site waters are impaired when compared to benthic communities inhabiting reference area sediment.

6.2.1.1 Measurement Endpoint 1): Comparison of Sediment COPCs to Benchmarks for Benthic Infauna

Barium, copper, selenium and thallium had hazard quotients greater than one based upon the WDNR (2003) sediment TEC. No metals exceeded the PEC.

Table 6-1. Hazard Quotients > 1 for Sediments Based upon the UCL_{95} and the TEC.

Metal	Hazard Quotient
Barium	1.1
Copper	2.9
Selenium	2.0
Thallium	2.3

6.2.1.2 Measurement Endpoint 2): Determine Bioavailability of Divalent Metals (Cadmium, Copper, Lead, Nickel and Zinc) Based Upon Equilibrium Partitioning to Acid Volatile Sulfides

Based upon SEM:AVS data copper, the only divalent metal whose HQ exceeded 1, is possibly bioavailable in Site sediments. The SEM:AVS ratio was less than one only at one station, SQT5, where copper exceeded the WDNR screening guidelines (Appendix B: Attachment 1). At the other stations where copper exceeded the WDNR screening guideline, AVS was not detected. These results don't necessarily indicate that the copper is bioavailable because organic carbon which was found at levels of 5 to 50% at Site stations (Appendix B: Attachment 1) can also act as a ligands which further reduces the bioavailability of divalent metals (Besser et al. 2003; Mahoney 1996).

6.2.1.3 Measurement Endpoint 3): Comparison of Benthic Worm Body Burden to No Effects Body Residue

Relative to the NEBR (3.79 µmol/g lipid), individual HQs from the bioaccumulation tests, ranged from 0.03 (SQT2) to 1.08 (SQT5), and the UCL95 of the benthic worm body residues (1.83 µmol/g lipid) resulted in an HQ < 1 (HQ=0.48) (see Appendix B, Attachment 2, Table 3.1).

Extrapolation of the Site-wide sediment PAH concentration to the Site-wide worm body residue (47.0 µmol/g lipid; Table 5-14) resulted in an HQ of 12.4. As explained above this is likely very conservative because it applies a BSAF calculated from much lower concentrations to the much higher Site sediment concentrations.

6.2.1.4 Measurement Endpoint 4): Results of Sediment Toxicity Testing

As discussed in Section 5.1.2.2, sediment toxicity test results indicated that there were significant effects in some bioassays including:

1) Significant mortality at SQT1 and SQT7 in the 28 day test *H. azteca* under laboratory light;

2) Significant mortality at SQT1 and the 50% dilution of SQT1 in the *H. azteca* 10 day test under laboratory light;

3) Mortality to all *L.variegatus* in SQT1 and SQT7 in the bioaccumulation screening test; and

4) The bioassays conducted under UV light indicated effects thresholds at lower concentrations of PAHs.

Derivation of preliminary remediation goals (PRGs) protective of the survival, growth, and reproduction of benthic invertebrate communities is described in the Remedial Action Objectives Technical Memorandum, provided as Appendix A to the RI.

6.2.1.5 Measurement Endpoint 4): Benthic Community Evaluation

Levels of PAHs in Site sediments did not consistently explain any variation in the benthic community, however, grain size and substrate type were significant explanatory factors. For most of the benthic community measures the finer grain sizes were associated with lower values (Appendix B). The overall results suggest that PAH levels (whether TPAH or NOC-PAH) are playing only a minor role in structuring communities, overshadowed by other substrate effects (e.g., grain size and whether the substrate category was wood or sand) (See Appendix B: Attachment 3 for full discussion).

Based upon these results, COPCs in Site sediments are not affecting the benthic community living there.

6.2.1.6 Benthic Community Risk Description

Of the various lines of evidence used to evaluate the benthic community the most weight is accorded to the results of community studies, the least weight is accorded to the comparison of Site COPC levels to effects levels from the literature.

Three lines of evidence, bulk sediment chemistry, sediment toxicity testing and estimated levels of COPCs in benthic invertebrate tissue, indicated a potential of impairment at the community level. This evidence included HQs greater than one for some metals and for PAHs as well as significant effects at some stations to test organisms in the sediment bioassays. The level of COPCs in the bioassay organism, *L. variegatus*, only exceeded the NEBR in two of the bioassay replicates and the HQ based upon the UCL_{95} of the bioassay replicates was less than one. However, the estimated levels of COPCs in site macroinvertebrates which were based upon BSAFs developed from the bioaccumulation study exceeded the NEBR (HQ=12.3).

In contrast, the benthic macroinvertebrate community investigation, the line of evidence that should be accorded the highest weight of evidence because it integrates the effects of contaminants and physical conditions experienced by the Site-specific organisms, indicated that the benthic macroinvertebrate community at the Site was not impaired relative to benthic communities in reference areas.

Considering all lines of evidence leads to the conclusion that elements of the benthic macroinvertebrate community at the Site are probably impacted, however, this impact is not manifested at the community level of organization. This could be due to a variety of factors such

as adaptation of the organisms that actually live in Site sediment or selection of species throughout Chequamegon Bay that are tolerant of a wide range of conditions. It could also be explained by the fact that the levels of PAHs in a six inch (15cm) deep sediment sample are not the exposure medium for the majority of the small benthic epifaunal and infaunal species that constitute the benthic community at the Site and in Chequamegon Bay. This is because these benthic organisms are primarily exposed to the top two to three inches. It is likely that the levels of Site chemicals in the top two to three inches is less than a composite sample of the top six inches.[18] If this is the situation, then comparing the levels of PAHs in the top six inches to the results of a grab sample that may have all the benthic organisms in the top two or three inches of the grab effectively separates cause (PAH level) from potential effect (impairment of benthic community).

Lastly, these results could reflect the fact that the species populations that make up benthic communities in Chequamegon Bay are limited by factors other than contaminants in the sediment. Any effects exerted at the individual level, as suggested by the bioassays, are overshadowed by limiting factors such as predation, niche availability (including substrate type and grain size) or food supply. The reproductive potential of these opportunistic benthic species is apparently sufficient to sustain a benthic community throughout Chequamegon Bay that is fairly similar but which may have small scale heterogeneity as the result of substrate characteristics. In this scenario, the levels of contaminants in the sediment would have no more influence on the benthic community than would a non-limiting variable.

Benthos outside the immediate Site area would not be affected by Site-related COPCs since they are not directly exposed to them at levels that would result in impairment too their health.

6.2.2 Assessment Endpoint #2: Viability and Function of Fish Community

The fish community was selected as an assessment endpoint because of its significant role in lake energy flow, nutrient cycling and organic matter accumulation and because fish are an important food resource for higher trophic level species.

Risk Question:

Are concentrations of contaminants in sediments and surface waters of waterbodies in and adjacent to the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?

This endpoint was assessed using three measurement endpoints.

1) Compare concentrations of Site-related contaminants measured in Site surface water to surface water quality benchmarks.
2) Compare tissue levels of PAHs and estimated VOCs in wild fish caught at the Site to the NEBR.
3) Determine where Site sediment has elevated toxicity to surrogates for resident fish species compared to sediment from reference areas.

[18] Note that the original RI/FS Work Plan recommended sampling only the top four inches (10cm).

6.2.2.1 Measurement Endpoint 1): Comparison of Surface Water COPCs to Surface Water Quality Benchmarks

No Site contaminants exceeded screening levels so there were no surface water COPCs.

6.2.2.2 Measurement Endpoint 2): Wild Fish Body Burdens to NEBRs

Comparison of the estimated UCL_{95} of wild fish collected at the Site (0.051 µmol/g lipid) to the NEBR for PAHs (3.79 µmol/g lipid) resulted in an HQ < 1 (HQ = 0.01).

6.2.2.3 Measurement Endpoint 3): Results of Sediment Toxicity Testing using P. promelas

Based upon the results of sediment bioassays there was significantly lower growth at SQT1. There was no mortality of these fish at any of the Triad stations tested in the bioassay under natural light.

Based upon the results of tests from both the 2001 (SEH 2002) and 2005-2006 bioassays with *P. promelas*, a sediment NOEC 40 to 60 µg/g PAHs@1%OC is proposed based upon the endpoints from both the 2001 (SEH 2002) and 2005-2006 bioassays with *P. promelas* (Appendix B: Attachment 2).

The bioassays conducted under UV light indicated effects thresholds at lower concentrations of PAHs.

6.2.2.4 Fish Community Risk Description

Based upon these three lines of evidence it is unlikely that fish utilizing the Site waters are significantly affected by Site COPCs. Although LMW PAHs (and perhaps VOCs) were accumulated to levels above reference conditions, they did not reach levels approaching the NEBR for PAHs. The bioassays using larval fish surrogates for Site fish experienced sublethal effects only at the highest concentrations of PAHs tested. No lethal effects were observed under laboratory light.

Fish outside the immediate Site area would not be affected by Site-related COPCs since they are not directly exposed to them at levels that would result in impairment to their health. Neither should fish outside the Site area be indirectly exposed to PAHs accumulated in fish which fed in the Site area since those accumulated PAHs rapidly be metabolized.

Based upon this evidence it is concluded that the fish community which utilizes the Site waters is within the range of natural variability of fish communities in other habitats in the region and is adequate to provide suitable forage for other indigenous fish and wildlife species.

6.2.3 Assessment Endpoint #3: Viability and Function of Omnivorous Aquatic Bird Community

Omnivorous aquatic birds were selected as an assessment endpoint because they have an important role in energy transfer from the aquatic to the terrestrial ecosystem. Consumers of both aquatic plants and animals, they, in turn, provide an important food source for higher trophic levels.

Risk Question:

Are dietary exposure levels of Site-related COPCs sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?

This endpoint will be assessed using one measurement endpoint.

1) Through food chain models for the black duck using sediment to benthic invertebrate bioaccumulation factors, estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.3.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for Omnivorous Aquatic Birds

The estimated dose of total PAHs and VOCs to black duck slightly exceeded the conservative NOAEL (16.1 mg /kg BW/day) resulting in an HQ of 1.9 (Appendix I, Table I-5). Comparison to a NOAEL for total PAHs and VOCs of 161 mg/kg BW/day resulted in an HQ substantially less than one. HQs were less than one for other COPCs based on NOAELs; HQs for all COPCs were less than one based on LOAELs.

6.2.3.2 Omnivorous Aquatic Bird Community Risk Description

It is unlikely that there are any unacceptable impacts to populations of omnivorous aquatic birds. Risk estimates were less than one based upon the NOAEL, with the exception of total PAHs and VOCs, which resulted in an HQ of 1.9 based the conservative NOAEL used at the direction of USEPA. Risk estimates based on an alternative NOAEL endpoint resulted in HQs substantially less than one. Furthermore, since there were no data for the approximately 30% of the black duck's diet that is made up of plants, due to the lack of contaminant data for submerged vegetation or reliable sediment to submerged plant bioaccumulation factors, it was conservatively assumed that the black duck consume 100% invertebrates. Thus, the model food chain for the black duck is conservative.

Based upon this evidence it is concluded that dietary exposure levels of Site-related contaminants are not sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community.

6.2.4 Assessment Endpoint #4: Viability and Function of the Omnivorous Terrestrial Bird Community

Terrestrial omnivorous birds were selected as an assessment endpoint because they consume plant and animal tissue from several different tropic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals.

Risk Question:

Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?

This endpoint will be assessed using one measurement endpoint.

1) Through food chain models for the red-winged blackbird using soil-to-vegetation and soil-to-invertebrate bioaccumulation factors estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.4.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for Omnivorous Birds

The estimated doses of cadmium, zinc, and total PAHs to red-winged blackbird slightly exceeded the NOAEL TRVs (Table 6-2). Comparison of the dose of total PAHs and VOCs to a NOAEL of 161 mg/kg BW/day resulted in an HQ substantially less than one (Appendix I; Table I-6). HQs based on NOAELs were less than one for all other COPCs. Estimated doses of all COPCs were lower than LOAEL doses.

Table 6-2. Risk Estimates for the Red-Winged Blackbird Based upon NOAEL for HQs>1.

COPC	Hazard Quotient
Cadmium	1.1
Zinc	1.2
Total PAHs	1.2[a] / <1[b]

Notes:
a, HQ based on conservative NOAEL of 16.1 mg/kg BW/day
b, HQ based on NOAEL of 161 mg/kg BW/day

6.2.4.2 Omnivorous Bird Community Risk Description

Dietary exposure levels of Site-related COPCs are not sufficient to cause adverse alterations to the omnivorous avian community. The HQ for zinc was based on the minimum (emphasis added) daily requirement of zinc for birds. It is unlikely that a dose slightly exceeding the MDR would exert a toxic effect on the omnivorous bird communities at the Site. The calculated dose of all COPCs also assumed continuous exposure (e.g., area use factor equal to one) of red-winged blackbird to the EPC calculated for the Site. Continuous exposure is unlikely and given HQs that are comparable or less than NOAEL doses, it is unlikely that even continuous exposure would result in adverse effects to the omnivorous bird community. As previously stated, estimated doses were lower than LOAELs for all COPCs. See Section 6.2.10 for a discussion of all terrestrial wildlife.

6.2.5 Assessment Endpoint #5: Viability and Function of the Insectivorous Bird Community

Insectivorous birds were selected as an assessment endpoint because they consume insects and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous avian community?

This endpoint will be assessed using one measurement endpoint.

1) Through food chain models for the tree swallow using sediment to emergent aquatic insect bioaccumulation factors, estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.5.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for Insectivorous Birds

The estimated dose of total PAHs and VOCs to tree swallow exceeded the conservative NOAEL (16.1 mg /kg BW/day) resulting in an HQ of 3.1 (Appendix I, Table I-7). However, comparison to the NOAEL of 161 mg/kg BW/day resulted in an HQ substantially less than one. HQs were less than one for other COPCs based on NOAELs; HQs for all COPCs were less than one based on LOAELs.

6.2.5.2 Insectivorous Bird Community Risk Description

Dietary exposure levels of Site-related COPCs are not sufficient to cause adverse alterations to the insectivorous avian community. The estimated dose of total PAHs and VOCs to tree swallow was substantially lower than the NOAEL dose of 161 mg/kg BW/day. Doses of all other Site-related COPCs did not exceed NOAEL doses. See Section 6.2.11 for a discussion of all aquatic dependent terrestrial wildlife.

6.2.6 Assessment Endpoint #6: Viability and Function of the Piscivorous Bird Community

Piscivorous birds have been selected as an assessment endpoint because they eat primarily fish and thus serve as an important pathway for nutrients and energy from the aquatic to the terrestrial ecosystem. They are also usually the highest trophic level in the food chain and would thus be potentially vulnerable to any contaminants that would bioaccumulate.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations, including reproductive impairment, to the piscivorous avian community or to individual ospreys?

This endpoint will be assessed using two measurement endpoints.

1) Through food chain models for the double-crested cormorant and osprey using actual levels of Site-related COPCs measured in fish, as well as sediment-to-fish bioaccumulation factors estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

Piscivorous birds were considered to forage in aquatic areas. Consumption of contaminated food (100% fish) exposure pathway was evaluated for both species.

6.2.6.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for the Double-Crested Cormorant

No HQ exceeded one for the cormorant (Appendix I; Table 8).

6.2.6.2 Measurement Endpoint 2): Comparison of Modeled Dietary Exposure Doses to Reference Doses for the Osprey

No HQ exceeded one for the osprey (Appendix I; Table 9).

6.2.6.3 Piscivorous Bird Community Risk Description

Dietary exposure levels of Site-related contaminants are not sufficient to cause adverse alterations to the piscivorous avian community. See Section 6.2.11 for a discussion of all aquatic dependent terrestrial wildlife.

6.2.7 Assessment Endpoint #7: Viability and Function of the Omnivorous Mammal Community

Omnivorous mammals were selected as an assessment endpoint because they consume plant and animal tissue from several different tropic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?

This endpoint will be assessed using two measurement endpoints.

1) Through food chain models for the white-footed mouse using soil-to-plant and soil-to-insect bioaccumulation factors estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.7.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for the White-footed Mouse

The estimated dose of cadmium to white-footed mouse slightly exceeded the NOAEL TRV used at the direction of USEPA (Appendix I; Table I-10). The dose of cadmium to white-footed mouse resulted in an HQ of 1.3 based on the NOAEL and was substantially lower than the LOAEL dose. HQs based on NOAELs were less than one for all other COPCs. Estimated doses of all COPCs were lower than LOAEL doses.

6.2.7.2 Omnivorous Mammal Community Risk Description

Dietary exposure levels of Site-related contaminants are not sufficient to cause adverse alterations to the omnivorous mammal community. The dose of cadmium to white-footed mouse

only slightly exceeded the NOAEL dose and was substantially lower than the LOAEL dose. See Section 6.2.10 for a discussion of all terrestrial wildlife.

6.2.8 Assessment Endpoint #8: Viability and Function of the Insectivorous Mammal Community

Insectivorous mammals were selected as an assessment endpoint because they consume insects from several different tropic levels and thus have an important role in energy transfer from plant tissue to animal tissue. They also serve as prey items for higher trophic levels, including both birds and mammals.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations, including reproductive impairment, to big brown bats?

This endpoint will be assessed using one measurement endpoint.

1) Through food chain models for the big brown bat using sediment-to-emergent aquatic insect bioaccumulation factors, estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.8.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for the Big Brown Bat

No HQs for the big brown bat exceeded one.

6.2.8.2 Insectivorous Mammal Community Risk Description

Dietary exposure levels of Site-related contaminants are not sufficient to cause adverse alterations to the insectivorous mammal community. See Section 6.2.11 for a discussion of all aquatic dependent terrestrial wildlife.

6.2.9 Assessment Endpoint #9: Viability and Function of the Piscivorous Mammal Community

Piscivorous mammals have been selected as an assessment endpoint because they eat primarily fish and thus serve as an important pathway for nutrients and energy from the aquatic to the terrestrial ecosystem. They are also are the usually the highest trophic level in the food chain and would thus be potentially vulnerable to any contaminants that would bioaccumulates.

Risk Question:

Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?

This endpoint will be assessed using one measurement endpoint.

1) Through food chain models for the mink using actual levels of Site-related COPCs measured in fish, as well as sediment-to-fish bioaccumulation factors, estimate the ingestion of Site-related COPCs and compare it to TRVs associated with adverse effects, including reproductive impairment.

6.2.9.1 Measurement Endpoint 1): Comparison of Modeled Dietary Exposure Doses to Reference Doses for the Mink

Piscivorous mammals were considered to forage in the wetland and lentic areas in riparian areas. Consumption of contaminated food (100% fish) exposure pathway was evaluated.

No HQs for the mink exceeded one.

6.2.9.2 Piscivorous Mammal Community Risk Description

Dietary exposure levels of Site-related contaminants are not sufficient to cause adverse alterations to the piscivorous mammal community. See Section 6.2.11 for a discussion of all aquatic dependent terrestrial wildlife.

6.2.10 Risk Description for Terrestrial Wildlife

Since HQs only slightly exceeded one (HQs < 1.3) for two terrestrial wildlife ROCs based on NOAEL TRVs, unacceptable alterations at the population or community level to any valued terrestrial receptors under current conditions are unlikely. Since an area use factor of one, meaning that it was assumed all wildlife foraged exclusively on the Site, was assumed even these results are very conservative.

6.2.11 Risk Description for Wildlife Dependent upon Aquatic Prey

Under current conditions, unacceptable alterations at the population or community level are unlikely for any valued wildlife dependent on aquatic prey. HQs only exceeded one (HQs < 3.1) based on a conservative NOAEL used at the direction of USEPA for two wildlife ROCs potentially exposed to total PAHs and VOCs. HQs based on alternative an NOAEL endpoint for total PAHs and VOCs resulted in HQs substantially less than one for all wildlife dependent on aquatic prey. Since the HQ for the osprey did not exceed one either, individual ospreys would not be unacceptably affected. Since an area use factor of one, meaning that it was assumed all wildlife forged exclusively on the Site, was assumed even these results are very conservative.

6.2.12 Terrestrial Ecosystem Functionality

The upland area of the Site is either urban or utilized for recreational purposes without regard to terrestrial receptors. Due to the virtual absence of any natural habitat in the upland area, it is unlikely that the area supports any populations of valued ecological receptors.

6.2.13 Aquatic Ecosystem Functionality

While there have been no Site-specific direct measurements of the functionality of aquatic ecosystem, the evaluation of the benthic invertebrate, fish and aquatic wildlife receptor

communities can provide an indirect measure of the potential for adverse effects to the aquatic ecosystem. These receptor groups are trophically and ecologically diverse and play a role in various aquatic ecosystem functions including nutrient cycling, energy flow, food production, etc.

Based upon the lines of evidence used in this risk assessment it was concluded that elements of the benthic macroinvertebrate community are potentially impaired in a portion of the Site area due to elevated levels of Site-related contaminants. This following evidence supports this conclusion:

1) Levels of Site-related PAHs and VOCs exceed WDNR benchmarks for sediment quality.
2) Levels of PAHs associated with unacceptable impacts to *H. azteca* in sediment bioassays were in the range of 45 to 100 µg/g @1%OC. Some of the near shore surface sediments exceed that concentration.
3) There was significant mortality at SQT1 and SQT7 in the *H. azteca* 28 day bioassay conducted under laboratory light;
4) There was significant mortality at SQT1 and the 50% dilution of SQT1 in the 10 day test conducted under laboratory light; and
5) There was mortality to all *L.variegatus* in SQT1 and SQT7 in the bioaccumulation screening test.
6) HQs for benthic invertebrates based upon tissue residues estimated from laboratory BSAFs and the UCL Site sediment concentrations exceeded one (HQ=12.3).

However it does not appear, based upon the lines of evidence used in this risk assessment, that populations or communities of other aquatic receptors, have experienced adverse alterations. This conclusion is supported by the following evidence from the BERA:

1) Levels of Site contaminants in fish tissue collected in the immediate Site area were below the NEBR.
2) Only the HQ for zinc slightly exceeded one for aquatic omnivorous birds.
3) HQs for aquatic dependent wildlife, including the tree swallow, big brown bat, double crested cormorant, osprey and mink who potentially feed on emergent aquatic insects or fish from Site waters were below one.

6.2.14 Potential for Adverse Effects to Ecological Receptors from Releases of Contaminants from Subsurface Sediments

Levels of Site-related hydrocarbons in subsurface sediments are sufficiently elevated in some near shore Site sediments that surface sheens occur following some high energy meteorological events or when sediments are otherwise physically disturbed. Regulators and local residents, as well as contractors who have sampled sediments at the Site have observed these sheens. The potential for these releases is primarily in shallower areas where sediments and wood mulch underlying surface sediments are apparently saturated with hydrocarbons. This results in a release of a sheen when the sediments are disturbed.

However, release of substantial quantities of these hydrocarbons is very unlikely. These sheens are typically the lighter fraction of Site hydrocarbons, i.e. short chain alkanes, VOCs and perhaps some LMW PAHs. Since HMW PAHs are too insoluble and/or are crystalline in nature they are probably not part of the sheens that are seen. While sheens are visually obvious the concentrations of the hydrocarbons in a sheen are not necessarily high. It only takes a concentration above the saturation level of these hydrocarbons to result in the free phase. As an example, a silvery sheen results from hydrocarbons when they are about 1/900,000 to 1/200,000 of an inch thick on the water, iridescence ranges from about 1/100,000 to 1/60,000 of an inch thick, dull iridescence with brown streaks about 50,000 to 10,000 inches thick (Wilkinson 1972). The following table (Table 6-3) is a rough guide to the relationship between the color of sheens and the estimated concentration of hydrocarbons.

Table 6-3. Relationship Between Sheen Color and Hydrocarbon Concentration.[1]

Appearance of Oil on Water	Concentrations in ppm
Barely visible	0.05
Silver sheen	0.1
First trace of color	0.2
Bright bands of color, iridescent	0.4
Colors tending to be dull	1.2
Colors fairly dark, rainbow tints	2.4
Brown or black	12
Brown / dark brown	120

1: After "Oil Spill Response in the Marine Environment" (Doerffer 1992)

In addition to surface sheens emanating from disturbed sediment, sediment samples collected in some areas of the Site, primarily in areas with the greatest PAH and VOC concentrations in sediment have a chemical odor indicating presence of hydrocarbons. However, the fact that the sediment has an odor does not necessarily imply there are significant levels of hydrocarbons in the sample. For instance the threshold level of commercial gasoline in water is around 5 µg/L with 10 µg/L giving a strong odor. The threshold odor concentration of commercial diesel in water is commonly accepted to be 100 ppb (SWRCB 1963).

Sediments that had this odor during the sediment sampling conducted as part of the RI studies had levels of hydrocarbons in the range of 10's to 100's of µg/g total PAHs plus VOCs. For instance, the sediments at several replicate sediment samples from SQT1 had a hydrocarbon odor and the highest concentration of PAHs was 1162 µg/g (average of all five replicates was about 440 µg/g). Total VOCs in the highest replicate from this SQT1 was about 3.5 µg/g (Appendix B: Attachment A).

Even hydrocarbons at the levels found in sediments at SQT1 would be rapidly diluted in the water column were they to be released from the sediments by waves or by a disturbance. As

documented in the surface water investigation conducted as part of these RI/FS studies hydrocarbons were virtually undetectable in surface water, even following high energy events.

Since there are not continual releases to the water column, as evidenced by the absence of sheens at all times and the absence of hydrocarbons in the water column, it is unlikely that pelagic receptors such as fish are directly exposed to harmful levels of Site COPCs and more likely that they acquire their body burden of PAHs through the food chain.

With the exception of major storms or disturbance in the shallow near shore zones by propeller wash or anchors, activities that are presently prohibited, releases of a sufficient quantity of hydrocarbons to acutely affect ecological receptors other than, perhaps, benthos that are on the bottom in the immediate area of the release are unlikely.

Although it is unlikely that sporadic releases of low levels of hydrocarbons from Site sediments will lead to impairment of populations and communities of ecological receptors inhabiting the waters of Chequamegon Bay, it remains a source of uncertainty. It is possible that the presence of this continuing source of site related contaminants may sporadically impair the healthy functioning of the aquatic community in the Site area.

In addition, if normal lake front activities, i.e, wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI studies.

6.3 UNCERTAINTY ANALYSIS

Uncertainties associated with any risk assessment have a number of components, including degree of success in meeting objectives, the range of conditions over which conclusions can be applied, and the certainty with which conclusions can be drawn (USEPA 1989a). The conclusions of a risk assessment are useful only when placed in perspective relative to the uncertainties associated with the evaluation. The purpose of this section is to provide that perspective.

6.3.1 Components of Uncertainty

Uncertainty in risk estimation has both qualitative and quantitative components. Qualitative uncertainty analyses are recommended by guidance, and contribute to the confidence with which risk assessment conclusions can be drawn and applied (USEPA 1989a; 1992a).

Uncertainty has two primary components: absence of knowledge and variability. Absence of knowledge of the quantity of sediment ingested by avian receptor which contributes to its ingested dose of COPCs is an example of the former. Variability refers to observed differences attributable to heterogeneity or diversity in a population or exposure parameter. A difference in COPC concentrations at different locations within a small area is an example of variability.

Variability in a risk estimate has a number of components, including parameter variability, calculation error and simplification, and the underlying reality of exposure assumptions and pathways (USEPA 1989b). It is important to understand that variability includes both real

variation (reflecting actual, mechanistic biological response ranges and variability in ecosystem conditions) and error. Thus, because biological systems are inherently uncertain and variable, some component of variability in risk estimation is due to a realistic reflection of ecological conditions, while another component is due to "error" or uncertainty introduced by the overall analytical process. "Error" is the component that can be minimized by additional information and knowledge, because this encompasses uncertainty that has been introduced by the assessment process. However, it is important to understand ecosystem variability because this represents an important component of the ecosystem within which risk management decisions must be made.

6.3.2 General Sources of Uncertainty

Uncertainties surrounding estimates of ecological risk are intrinsically greater than those associated with human health risk assessment, due to the multiplicity of potential receptor species, a general lack of knowledge regarding their life histories and behaviors (particularly with respect to utilization of the Site itself), and the unknowns of toxicological sensitivities among the receptor species. The toxicity benchmarks used in this assessment are intended to provide accurate benchmarks for judging potential exposures, but it is important to note that no one approach to benchmarks derivation is adequate for all sites and chemicals. The best methods currently available were used to evaluate the potential additive effects of the organic chemicals associated with the Site, but potential interactions between inorganic and organic chemicals is only based upon the results of the sediment bioassays that were performed. It is believed that these bioassays fully account for site-specific conditions that regulate chemical contact and bioavailability of these chemicals, but the disturbance and handling of the sediments undoubtedly results in greater exposure than occurs in undisturbed sediments. However, laboratory bioassays cannot reproduce any long-term flux from deep sediments to the biotic zone where benthic organisms live, or the significant influence of other factors resulting from historical use of the Site, such as log rafting and disposal of wood waste.

A qualitative description of many of the uncertainty and variability factors associated with the parameters used to estimate risks to ROCs in this risk assessment are provided in Table 6-4. These factors are generally applicable to both aquatic and terrestrial ecological risk assessments.

Table 6-4. General Factors Associated with Uncertainty and Variability in the Ecological Risk Assessment.		
Uncertainty/Variability Factor	**Direction of Uncertainty**	**Comment**
Use of conservative exposure point concentrations and doses	Will overestimate risk	The intent of using UCL_{95} exposure and dose concentrations is to be protective of biota and minimize effects of uncertainties that underestimate risks.
Point estimates of exposure concentrations of COPCs in environmental media	Tends to overestimate risks	Point estimates do not take into account bioavailability of chemicals or the likelihood of variable exposure concentrations resulting from highly variable spatial heterogeneity of sediment conditions.
Unavailability of toxicity benchmarks and reference values for some chemicals and exposure pathways	Will underestimate risk	Some site risks may be unquantifiable due to lack of TRVs or benchmarks.
Focus of risk assessment on chemicals analyzed and detected	Will underestimate risk	Chemicals not detected or not analyzed for may contribute to risks.
Extrapolation of laboratory data to field exposures	Generally overestimates risk	Receptors adapted to site conditions are likely not as sensitive as laboratory organisms.
Hazard Quotient calculation	May overestimate or underestimate risks	Direction of effect depends on accuracy with which TRVs or benchmarks describe the response of biota to chemicals.
Biota sampling locations	May overestimate or underestimate risks	Locations may not be representative of sites with either extremely elevated or low chemical concentrations.
Use of NOAELs as TRVs when possible instead of LOAELs	Will overestimate risks for most species. May underestimate risks for sensitive species.	The NOAEL is not associated with any effects and is often dependent on range of concentrations tested in laboratory studies. The highest true NOAEL may be higher than NOAEL used as a TRV.

Table 6-4. General Factors Associated with Uncertainty and Variability in the Ecological Risk Assessment.		
Uncertainty/Variability Factor	**Direction of Uncertainty**	**Comment**
Use of LOAEL-based TRVs	May underestimate risks for sensitive species; probably does not markedly overestimate risk for most individuals; uncertain for population-level effects.	LOAELs are more reliable than NOAELs and provide an indication of the dose–response function to aid in interpreting quotients.
Analytical chemistry variability	May overestimate or underestimate risks	Chemical analyses within 35% relative percent difference of each other may be equivalent.

Because the complexity of community and population dynamics, it is not currently possible to evaluate all possible exposures or effects. The information presented, while as complete and accurate as possible, may have missed long-term influences to the environmental chemistry of contaminants found at the Site. It also may have failed to address adaptation of natural communities to the unique site conditions. In addition, while ecological functional redundancies contributed by unevaluated species may provide resiliency against adverse effects at the community and ecosystem levels, more sensitive species may be present in other populations that have not been evaluated in the current studies. In either case, the studies presented are only representations of conditions as they exist at the Site, and it is virtually certain that not all of the underlying variability and stressor effects have been quantified. Therefore, it is important to recognize that (1) potentially large uncertainties exist regarding community and population health, but (2) these uncertainties most probably do not directionally bias conclusions.

Further, it is important to recognize that substantial differences exist between observations and conclusions made at the individual, population, and community levels of biological organization. For example, effects at the population or community levels resulting from the effects to only a few individuals may not be observable with the type of studies implemented. The ramifications of this also include an understanding that because the assessment level endpoints are protective of populations (not individuals), risks projected to cause loss of a few individuals, for example in bioassay studies, may not cause impacts that are important at the levels of assessment where risk management decisions are made, i.e. populations and communities.

The analysis performed for this assessment did not account for some Site-specific factors such as natural attenuation of COPCs over time, adaptive tolerance, adaptive reproductive potential, the small size of the affected area compared to the range of most species, and recruitment from similar adjoining areas, although many of these factors were implicit through measurement of the benthic macroinvertebrate communities. Such factors would tend to mitigate the degree and ecological significance of loss or impairment of a portion of ecological population(s) due to both

chemical and physical stressors in the area. As a result, the approach used in this assessment likely results in overestimation of risk.

6.3.3 Specific Sources of Uncertainty

Potential sources of uncertainty in this BERA are discussed in this section and summarized in Table 6-5.

Table 6-5. Specific Factors Associated with Uncertainty and Variability in the Ashland/Lakefront Baseline Ecological Risk Assessment.

Uncertainty/Variability Factor	Direction of Uncertainty	Comment
Adequate sampling	May overestimate or underestimate risks	Sampling is considered to be representative and adequate. It is unlikely any consistent bias exists. The RI Sampling plan was reviewed and approved by USEPA and WDNR and also reviewed by NOAA.
Choice of Receptors of Concern	May overestimate or underestimate risks	Both the number of and the type of ROCs are considered to adequate and representative. It is unlikely any consistent bias exists.
Use of surrogate species toxicological studies as the basis for benchmarks and TRVs	May overestimate or underestimate risks	Care was taken to select studies of the same or closely related species under the same conditions. It is unlikely there is any directional bias in these results.
Relative bioavailability not considered in derivation of wildlife TRVs	Will overestimate risks	Overestimation may be substantial.
Use of laboratory bioassays as the basis for bird and mammal TRVs	Will overestimate risk	Effects levels estimated from field data usually higher than those estimated in the laboratory. Homogenization of sediments results in previously unavailable contaminants becoming available. Exposures to UV light in the lab cannot duplicate natural UV exposure.
Site specific sediment bioassays	Generally overestimates risk	Receptors adapted to site conditions are likely not as sensitive as laboratory organisms. Disturbing sediment changes equilibrium.
Incremental effects of UV Light on benthic organisms and fish	Generally overestimates risks	While the effects of UV light on aquatic organisms have been demonstrated in the laboratory, there are a number factors, including time and space varying transparency of the

Table 6-5. Specific Factors Associated with Uncertainty and Variability in the Ashland/Lakefront Baseline Ecological Risk Assessment.		
Uncertainty/Variability Factor	**Direction of Uncertainty**	**Comment**
		water column and behavioral adaptations of organisms in the field to avoid UV light that can not be faithfully replicated in the laboratory.
Site specific community studies	May overestimate or underestimate risks	The high natural variability in populations and communities decreases confidence in attributing differences in community structure to only sediment contaminant levels. This uncertainty was addressed by rigorous sampling design and it is unlikely there is any directional bias in these results.
Using area use factor of one	Overestimates risk	An assumption of an area use factor of one assumes that wildlife forage exclusively in the impacted Site areas. However, the majority of receptors used as representative receptors in this risk assessment are mobile and have foraging ranges that exceed areas of the Site with elevated levels of contaminants.
Simplifying wildlife assumptions for diets	May overestimate or underestimate risks	Natural diets are much more complex than those assumed in wildlife models.
Use of bioaccumulation factors for metals in wildlife models	Likely overestimates risk	Much of the data used to develop bioaccumulation factors comes from laboratory studies which are limited with respect to modeling the site-specific bioavailability of contaminants.

6.3.3.1 Uncertainty Associated with Problem Formulation

The Problem Formulation outlines an approach for assessing risk to ecological receptors from exposure to surface water, sediment, and soil within and adjacent to the Ashland Lakefront Site. This approach follows USEPA guidance and was conducted with recommendations from both state and federal stakeholders, including USEPA, NOAA, and WDNR. Both USEPA and WDNR approved the scope of work upon which this BERA is based. The Problem Formulation was developed based on information obtained from various studies that have been conducted at the Site, both historical as well as these RI studies that were designed specifically to support the BERA. These studies decrease the uncertainty of the BERA conclusions by incorporating Site-specific information into the risk assessment process. However, some level of uncertainty remains inherent in the risk assessment process.

Data Quality and Representativeness

Insufficient sampling density or analyte lists may result in misrepresenting estimates of exposure to COPCs. Misrepresentation of exposure results in uncertainty and may lead to an overestimation or underestimation of risk. Additional data collection based on the data gap analysis as part of the RI Work Plan has substantially reduced this uncertainty. The surface water, sediment, fish tissue, benthic community data available for the Site and surrounding areas is considered to be sufficient to support the BERA. However, it is important to recognize that sampling was biased towards impacted areas and away from ambient background conditions.

Receptors of Concern

Because it is not feasible to evaluate every potential ecological receptor that may be exposed to contaminants in Site media, receptor groups and individuals that were believed to typify trophic categories were selected for evaluation. It is assumed that these ROCs are representative of the receptors on the Site that have ecological or societal value. There is some uncertainty associated with whether all ecological values present at the Site and surrounding areas will be adequately represented in the BERA. However, conducting aquatic and terrestrial habitat characterizations of the Site and communicating with relevant state and federal agencies responsible for the protection of ecological resources at the Site have reduced this uncertainty.

The Problem Formulation was developed based on the current knowledge of the ecological resources of the Site and exposure pathways from Site-related media to those ecological resources. It was developed with the frequent review and input of various federal and state regulatory and resource agencies including USEPA, WDNR and NOAA. Despite uncertainties inherent in the risk assessment process, the Problem Formulation outlines an appropriate approach to conducting the BERA agreed upon by all agency stakeholders.

6.3.3.2 Uncertainty Associated with Effects Analysis

Surrogate Species

Organisms used in the toxicological studies from which TRVs and benchmarks were derived were seldom the same species as those used in this risk assessment to estimate risk. To the extent the laboratory species are more or less sensitive then those used as ROCs in this risk assessment, the potential for adverse effects is under or over estimated.

Use of Laboratory Bioassays as the Basis for Bird and Mammal TRVs

The risk to bird and mammal populations may be overestimated if the results of laboratory bioassays are used as a proxy for what happens in the field. This is particularly true of the essential micronutrients, which are homeostatically regulated such as copper, selenium and zinc.

Relative Bioavailability

Relative bioavailability is the ratio of the absorption of a chemical from a site medium compared to the absorption that occurred in the study used to derive the relevant TRV. As a result of this factor, it is likely that exposure, and therefore, risk was over-predicted to all receptors. While

there is relative bioavailability data for mammals and birds exposed to some metals these are minor constituents at the Site and 100% bioavailability was assumed for both mammals and birds. Furthermore, there is no mammalian or avian data concerning the bioavailability of PAHs that are biologically incorporated into the diet (i.e., fish). Therefore, 100% bioavailability of PAHs was assumed. Bioavailability data of PAHs in soil, suggest that this assumption is conservative.

Probable Effects on Risk Evaluation of Not Compensating for Bioavailability, Bioaccessibility and Homeostasis

The toxicity tests upon which the avian and mammalian TRVs are based were conducted with COPCs or hydrocarbon mixtures that were added to the diets. Such amended diets may be representative of the exposures wildlife would have through the incidental ingestion of soil or sediment, but this exposure pathway is relatively small portion of the total exposure. For wildlife, the diet is the major portion of the total exposure and the composition of PAHs incorporated into the diet is likely very different from that in the PAH mixture in the environment. This is due to both solubility limitations in the abiotic media (i.e., surface water, or sediment pore water) and metabolism by the food chain items in the diet as well as in the intestine of the final receptor, prior to uptake into the animal. As a result, the doses to the wildlife receptors are likely overestimated.

Uncertainty Associated with Benthic Invertebrate Lines of Evidence

Site-specific Bioassays

Sediment bioassays were conducted as part of the aquatic studies used to assess risk to Site benthic macroinvertebrates. The results of these studies are used to supplement the risk estimates developed from comparing EPCs to benchmarks that may be associated with effects to aquatic organisms. However, these bioassays are imperfect abstractions of real life and may under or overestimate risk.

There are several sources of uncertainty in the bioassay studies including uncertainties associated with:

1) Bioassay duration;
2) Exposure of laboratory organisms to UV light; and
3) Failure of *C. dilutus* bioassay.

Specific details of these uncertainties are discussed in the bioassay report (Attachment 2 to Appendix B).

Because organisms used in the laboratory bioassays are likely to be more sensitive than adapted populations of organisms living at the Site the results of bioassays are likely to overestimate risk.

Since the objective of an ecological risk assessment is to assess the potential impact to biotic populations and communities (except for protected species), it is likely that the results of tests using a few individual organisms in an artificial environment will overestimate the potential for adverse effects to the population. A bioassay does not replicate either the environmental

heterogeneity present on the Site or duplicate the population dynamics, including compensatory mechanisms of the population. It also is important to note that nearly all organisms tested have shown the ability to increase their metabolism of PAHs in response to exposure, and that, under natural conditions, natural selection for tolerant organisms is operable. This natural selection does not occur in animals that are bred for bioassays and in fact, these organisms are isolated from nearly all natural stressors that would normally select for more robust organisms.

In summary it is likely that the results of the sediment bioassay overestimated risk to populations and communities of benthic macroinvertebrates.

Site-specific Bioaccumulation Study

Biota-sediment accumulation factors for benthic invertebrates were developed from the laboratory study using *L. variegatus*. The geometric means of BSAFs developed for individual PAHs from the bioaccumulation study were applied to Site-specific sediment concentrations to estimate the concentrations of PAHs in Site benthic invertebrates. Based upon these estimates, estimated tissue residues of PAHs in benthic invertebrate tissues resulted in an HQ greater than one (12.4). At the request of USEPA, concentrations in Site benthic invertebrates were estimated based on the UCL_{95} of BSAFs developed from the bioaccumulation study. Based on the UCL_{95} BSAFs, the estimated concentration of tPAH in benthic invertebrates was 176.6 µmol/g lipid, resulting in an HQ of 46.5 when compared with the NEBR of 3.79 µmol/g lipid (Table 6-6).

The laboratory-generated BSAFs from the *L. variegatus* study are several times greater than what has been measured in field studies or what is theoretically possible based upon the target lipid model (Di Toro et al. 2000). The BSAFs obtained with *L. variegatus* in the bioaccumulation study are site-specific only in that they were obtained using Site sediments. The bioavailability of PAHs in the *L. variegatus* bioaccumulation test is at least partly an artifact of the USEPA test procedures. When samples are composited for bioaccumulation tests (and bioassays) from the top 6 inches of site sediment, higher concentrations from deeper sediment depths are mixed with lower concentrations from the surface layers where most organisms live. This is important because Harkey et al. (1995) also showed that "uptake rate is primarily driven by the first few sampling points [i.e., first few days] during a bioaccumulation assay". This means that, until the overlying surface waters leach the PAHs from the surface layers, bioassay and bioaccumulation organisms are exposed to much higher concentrations than they would be in the field.

Higher bioaccumulation also occurs during tests with *L. variegatus* because they are not being fed for 28-d and lose weight and lipid content. However, lipid content is not necessarily lost in the same proportion as total weight. The worms analyzed at the beginning of the bioassay contained an average of 2.44% lipid and this decreased to 0.5% at one station and less than 2% at most stations

Table 6-6. Total PAH and VOC Concentrations Estimated in Benthic Invertebrates (µmol/g lipid) Based on UCL_{95} BSAFs and UCL_{95} Sediment Concentrations

Analyte	Molecular Weight (g/mol)	UCL_{95} Sediment Concentration (mg/kg, dry weight)	UCL_{95} NOC-PAH (mg PAH/kg OC)[a]	Normalized BSAF (kg OC/kg lipid)[b]	Lipid Normalized Molar Concentration (µmol/g lipid)[c]
PAHs					
Total PAHs & VOCs[d]		408.2	2198		176.6
PAHs:					
1-Methylnaphthalene	142.20	5.49	29.55	4.09	0.850
1-Methylphenanthrene	192.26	1.22	6.56	38.20	1.30
2,3,5-Trimethylnaphthalene	170.26	0.56	3.01	18.23	0.32
2,6-Dimethylnaphthalene	156.23	4.13	22.23	8.33	1.19
2-Methylnaphthalene	142.20	85.75	461.79	5.72	18.58
Acenaphthene	154.21	37.62	202.60	4.37	5.74
Acenaphthylene	152.20	3.56	19.16	10.49	1.32
Anthracene	178.20	13.84	74.50	10.29	4.30
Benzo(a)anthracene	228.29	7.74	41.66	23.07	4.21
Benzo(a)pyrene	252.31	6.27	33.76	12.15	1.63
Benzo(b)fluoranthene	252.32	3.68	19.83	23.18	1.82
Benzo(e)pyrene	252.31	1.64	8.81	24.59	0.86
Benzo(g,h,i)perylene	276.34	2.70	14.54	8.45	0.44
Benzo(k)fluoranthene	252.32	3.90	20.98	27.62	2.30
Biphenyl	154.00	1.85	9.94	4.37[e]	0.28
Chrysene	228.29	7.06	38.04	25.52	4.25
Dibenzo(a,h)anthracene	278.35	1.49	8.02	22.15	0.64
Dibenzofuran	168.19	0.30	1.63	4.37[e]	0.04
Fluoranthene	202.26	15.43	83.07	28.08	11.53
Fluorene	166.20	16.61	89.44	7.95	4.28
Indeno(1,2,3-cd)pyrene	276.34	2.50	13.45	6.69	0.33
Naphthalene	128.19	107.47	578.72	12.51	56.48
Perylene	252.31	0.42	2.24	12.49	0.11
Phenanthrene	178.20	43.33	233.33	20.42	26.74
Pyrene	202.26	21.30	114.71	37.31	21.16
Total PAHs[f]		364.02	1960.25		170.69
VOCs:					
Benzene	78.11	0.54	2.91	12.51[g]	0.47
Toluene	92.14	1.57	8.45	12.51[g]	1.15
Ethylbenzene	106.17	2.32	12.52	12.51[g]	1.47
Xylenes (total)	318.50	4.37	23.51	12.51[g]	0.92
m & p-cresols	324.42	0.38	2.02	12.51[g]	0.08
o-cresol	108.14	0.06	0.34	12.51[g]	0.04
1,2,4-Trimethylbenzene	120.2	1.80	9.68	12.51[g]	1.01
1,3,5-Trimethylbenzene	120.2	1.30	7.00	12.51[g]	0.73
Trimethylbenzenes (total)					1.74

Notes:

a, NOC-PAH calculated based on the UCL95 fraction of sediment organic carbon (0.1857) measured in the Site area.

b, Normalized BSAF (kg OC / kg lipid) calculated based on the site-specific 28-day *Lumbriculus variegatus* bioaccumulation study. A normalized BSAF was calculated as the UCL_{95} BSAFs for each individual PAH compound (BSAFs were normalized by lipid content [geometric mean of all organisms = 0.0157] and sediment organic carbon content [geometric mean of all samples = 0.1857]).

c, Molar concentration of PAHs in tissue calculated on a mass lipid basis (µmol PAH/g lipid) as follows:

$$C_{tissue} = NOC - PAH \times BSAF_{norm} \div MW$$

where: C_{tissue} = Molar concentration of PAHs in tissue on a mass lipid basis (µmol PAH/g lipid)
NOC-PAH = PAH concentration normalized to organic carbon (mg PAH/kg OC)
$BSAF_{norm}$ = Normalized BSAF (kg OC/kg lipid)
MW = Molecular weight of compound (g/mol)

d, Calculated as the sum of estimated concentrations for listed PAH and VOC compounds.

e, Normalized BSAF for acenaphthene used as a surrogate BSAF for biphenyl based on similar log K_{ow}.

f, Calculated as the sum of estimated concentrations for listed PAH compounds.

g, Normalized BSAF for naphthalene used as a surrogate for VOCs based on the assumption that VOCs are not accumulated at a greater rate than naphthalene (Roubal et al. 1977).

after 28-d. This alone causes an apparent increase in body residue although the relative concentration of PAHs in the lipid may not have changed.

Another possibility for the extraordinarily high bioaccumulation found in these worms is that the depuration period may have been insufficient for them to clear their gut contents. Harkey et al. (1995) report that only 2% of the body residue is released from worms during the 24-h depuration period. If the worms were narcotized, the active portion of depuration would presumably take even longer.

In summary the BSAFs calculated from the *L. variegatus* bioaccumulation study are greater than those typically observed in field studies, as reported in the literature (See Section 5.2.3). We believe therefore that estimates based on the geometric mean BSAFs from the bioaccumulation study provide a conservative estimate of tPAH concentrations in benthic invertebrate tissues for use in wildlife exposure models and direct comparisons with the NEBR. Given the already conservative nature of the BSAFs used in the BERA, calculating tissue concentrations based on the UCL_{95} of BSAFs introduces an additional level of uncertainty that likely overestimates risk.

Site-specific Benthic Macroinvertebrate Community Studies

Because the benchmarks used to evaluate ecological risk, except for protected species, are ultimately impacts to populations and communities of ecological receptors, field studies of natural populations and communities can therefore be the best line of evidence to evaluate impacts from contaminants at the Site. However, because of the inherent natural variability in populations and communities, unless there is a rigorous sampling design, it is difficult to attribute differences amongst Site stations and reference stations to the effects of Site contaminants and conversely to have confidence that the absence of a measured difference is indicative that Site contaminants are not having an effect.

As was explained in the RI/FS Work Plan (URS 2005), care was taken in benthic community studies conducted to support this BERA to get adequate replication of samples so that any differences amongst stations can be considered real and not just random variability. This sampling design included power analysis to ensure that levels of differences that were expected in the benthic community study could be differentiated with reasonable statistical confidence from random variation. However, there is uncertainty associated with the reference locations that produces questionable results and yields low power, including, but not limited to:

- The reference sand sites SQT10 and SQT12 exhibited "a strong odor of decaying organic matter" and "elevated levels of ammonia";
- The reference sand sites SQT10 and SQT12 exhibited <50% survival for *Hyalella azteca* 28 day sediment exposure toxicity test;
- The reference wood site SQT11 had no survival in several replicates of the *Lumbriculus* bioaccumulation study;

- The reference sand sites SQT13 and SQT 14 were collected in Fall 2005 versus Spring 2005, more than 3 months after the initial sample collection. Use of this data is questionable for comparison of population metrics due to expected seasonal variation in larval and emergent species; and

- Only three site locations appear to be "sand" sites, and none of the reference sand sites appear to be appropriate. Thus, the sample size for sand sediments does not appear meet the power requirements outlined in the RI/FS workplan

Uncertainty Associated with Fish Community Lines of Evidence

The results of Site-specific studies are believed to more accurately represent the potential for adverse effects to receptors inhabiting or utilizing the site and thus should be weighted higher than screening guideline values. However, neither the screening values nor the target Lipid Model indicated any risk to the fish community. While there was some mortality of juvenile fathead minnows in tests in 2001, no mortality was found in 2005-2006 bioassays. Furthermore, in both cases the fish were exposed predominately to highly contaminated sediments that had been mixed and as a result water column concentrations in the bioassay likely exceeded conditions in the field. It is likely therefore that bioassays conducted in the laboratory overestimate risk at the Site.

6.3.3.3 Uncertainty Associated with Exposure Analysis

The analytical database used to develop estimates of EPCs has inherent uncertainties. These include those uncertainties associated with spatial allocation of samples, laboratory error and statistical error. For example, because the primary objective of the sampling and analysis plan was to document the magnitude and extent of Site contaminants, sampling was generally concentrated in areas anticipated to have elevated concentrations. As a result estimates of exposure to contaminants for mobile ecological receptors are biased high. Also, the distribution of COPCs across aquatic and terrestrial portions of the site was assumed to coincide with receptor contact with environmental media. The degree to which this assumption is met is not quantifiable and the direction of bias (if any) cannot be identified.

Error due to lack of precision and inaccuracies in the laboratory is believed to be low since controls were in place to identify and quantify precision and accuracy. Likewise any inaccuracy in compiling summary statistics is believed to be low because of controls on the process. Both of these potential sources of error are without bias.

Area Use Factor

The receptors used as ROCs in this BERA are mobile and range beyond the boundaries of the Site while foraging or for other purposes, on a daily or seasonal basis. This risk assessment has assumed that all receptors have an area use factor of 100 percent, which means that they are continually exposed to maximum or upper estimates of the mean (UCL_{95}) COPC levels. This is a deterministic approach to estimating EPCs and is expected to bias the estimates of EPCs

upwards and result in an overestimate of risk to most receptors. This assumption also means that each receptor acquires 100% of its diet from the Site area. This assumption is very conservative, thus the estimates of risk based on these assumptions are useful for developing adequately protective remedial actions but cannot be considered as evidence of adverse effects.

There are available risk assessment methodologies such as estimating spatially weighted EPCs or conducting probabilistic modeling of exposure that could be employed to decrease the uncertainty and overestimation of potential risk. However, since HQs for wildlife were not above one, these approaches were not used.

Simplifying Assumptions for Wildlife Diets

In the wildlife dose rate modeling, simplifying assumptions were made about the diet of most wildlife species. It was assumed that all components within a particular category of diet had the same concentrations of COPCs.

Since the estimated COPC concentrations were calculated using conservative bioaccumulation factors the results are likely to overestimate risk. In addition to the conservative bioaccumulation factors, the assumption of a uniform concentration of COPCs in all species in a prey item category, e.g., invertebrates and mammals, ignores the substantial variability, both in types of prey and expected levels of COPCs.

No modeling of risks due to inorganic constituents was conducted for piscivorous wildlife. Inorganic constituents were not measured in fish or in surface waters. However, barium, copper, thallium, and selenium were considered COPCs for sediment. Barium, copper, and selenium were considered COPCs for wildlife because they exceeded their sediment screening benchmarks and could, theoretically, be accumulated up the food chain from fish into piscivores. Thallium was a COPC only because it was detected in sediment and there are no screening benchmarks for thallium. However, risks from these inorganic constituents were not evaluated for the following three reasons:

1) There is no scientifically valid method for directly relating the concentrations of metals in fish or invertebrates to sediment or surface water concentrations;
2) Both copper and selenium are essential micronutrients that are regulated by both mammals and birds according to their nutritional requirements; and
3) Neither copper nor selenium are COPCs that are known to have been associated with activities at the Site.

Use of Bioaccumulation Factors in Wildlife Modeling

Site-specific measurements of tissue concentrations are the best data to reduce uncertainty in estimating EPCs in dietary components. However, the collection of tissue for all dietary components requires killing animals and is not practical in most ecological risk assessments. Therefore, bioaccumulation factors or models must be applied and a level of uncertainty in estimated concentrations must be accepted. A discussion of this uncertainty is summarized below and provided in detail in Appendix F.

Bioaccumulation factors provide quantitative indicators of the tendency for a chemical to partition into biological organisms relative to the concentrations present in environmental exposure media. The complexity and limited Site-specific understanding of interactions controlling bioavailability of site contaminants lead to uncertainties in estimating the bioaccumulation of these contaminants from environmental media to biological organisms. Because bioaccumulation is generally non-linear, with accumulation decreasing with increasing media concentrations, estimates of prey concentrations based on regression models are less uncertain than estimates of prey concentrations based on constant accumulation factors. In this assessment, regression models were used when available to estimate COPC concentrations in terrestrial plants, soil invertebrates, and small mammals (Bechtel 1998a; Efroymson et al. 2001; USEPA 2005c; Bechtel 1998; Sample et al. 1998; Sample et al. 1999). Constant accumulation factors, used in the absence of appropriate regression models, likely overestimate bioaccumulation at higher media concentrations.

To the extent possible, estimates of the most important contaminants that are components of wildlife diets at the Site, PAHs, were derived directly from measured concentrations in wild fish, or bioassay invertebrates. Since the COPC concentrations were actually measured in fish from the Site the results are unlikely to over or underestimate risk for piscivores. Concentrations of biphenyl, dibenzofuran, and the VOCs identified as COPCs in sediment were estimated based on surrogate BSAFs calculated from the measured concentrations of wild fish and the bioassay invertebrates. Although the use of BSAFs to estimate tissue concentrations introduces more uncertainty than direct tissue measurements, it was determined that the calculated BSAFs were sufficiently conservative relative to BSAFs reported in the literature.

It is likely that BSAFs calculated from laboratory bioaccumulation studies result in an overestimate of risk. The artificial mixing of sediments, the small volume of overlying water in which to reach equilibrium, and the infrequent renewal of this water, assure that laboratory-exposed worms are exposed to greater concentrations of COPCs than occur at the Site. Furthermore, Schuler et al. (2003) have shown that *L. variegatus*, the test organism used in the site-specific bioaccumulation studies, accumulates PAHs to significantly higher concentrations than either *H. azteca* or *C. dilutus* exposed to the same PAH concentrations in both water and sediment. As discussed above, the inability to evaluate the bioavailability of the COPCs in the diet is also likely to lead to overestimation of risk.

Concentrations of invertebrate prey in the wildlife exposure models were calculated based on the geometric means of BSAFs developed for individual PAHs from the bioaccumulation study. At the request of USEPA, concentrations in benthic invertebrates at the Site were estimated based on the UCL_{95} of BSAFs developed from the bioaccumulation study to evaluate the uncertainty in estimating doses to invertivorous wildlife.

Wildlife exposure models based on doses calculated from UCL_{95} BSAFs are presented in Appendix I, Tables I-13 to I-16. The results of the models indicate HQs greater than one for black duck, depending on the NOAEL used as the basis for the HQ, and tree swallow (Table 6-7). Based on the conservative NOAEL for total PAHs and VOCs, doses to black duck and tree swallow based on the UCL_{95} BSAFs resulted in HQs of 6.8 and 11.6, respectively. Based on an alternative NOAEL endpoint, HQs were less than one for black duck and slightly exceeded one for tree swallow. HQs were less than one for the big brown bat using both methods of BSAF calculation and both NOAEL doses.

Table 6-7. Wildlife HQs for Total PAHs and VOCs Based on UCL_{95} BSAFs.

Receptor	NOAEL	
	16.1 mg/kg BW/day	161 mg/kg BW/day
Black Duck	6.8	<1
Tree Swallow	11.6	1.2

6.3.3.4 Uncertainty Associated with Risk Characterization

Hazard Quotients

The hazard quotient method is the simplest and most commonly used method to provide a risk estimate. The major regulatory advantage of the hazard quotient method is that since exposure estimations use the UCL_{95} of abiotic media concentrations, risk is undoubtedly overestimated in most cases. The major potential disadvantage comes from the single estimate of risk that results from a single TRV or benchmark. Since all species have not been tested, and since even different tests with the same organism frequently have different conclusions, it is possible that a given receptor will be more sensitive than the surrogate ROC selected for the TRV or benchmark, and that this will lead to an underestimation of the risk for that particular receptor. As explained above, conservative TRVs and benchmarks as well as EPCs have been used to protect against this possibility.

6.3.3.5 Summary

Because, for most factors considered in this risk assessment conservative estimates or assumptions were made, there is confidence that hazard quotients less than one indicate the potential of adverse effects for that COPC receptor exposure pathway is unlikely.

The results of the risk characterization indicated that there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site. Two lines of evidence, bulk sediment chemistry and sediment toxicity testing indicated the potential for impairment at the community level. Effects observed from field surveys of the existing benthic community indicated effects that were less dramatic than those demonstrated in the laboratory toxicity studies, but interpretation of the field survey data is made very difficult by a high degree of variability and lack of comparability between reference and site stations.

However, the fact that hydrocarbons are sporadically released from the Site sediment during some high energy meteorological events or when disturbed by other activity indicates the potential for impact to the benthic community may not have necessarily been fully measured by the benthic community studies conducted to support the RI. While there is no evidence that effects from these releases lead to adverse effects on populations and communities of these receptors inhabiting the waters of Chequamegon Bay, it remains a source of uncertainty. It is possible that the presence of this continuing source of site related contaminants may sporadically impair the healthy functioning of the aquatic community in the Site area.

In addition, if normal lake front activities, i.e, wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI/FS studies.

The BERA concluded that the potential for adverse effects to other ecological receptors was not sufficient to result in significant adverse alterations to populations and communities of ecological receptors.

The following table (Table 7-1) summarizes the results of the BERA.

Table 7-1. Conclusions of the Baseline Ecological Risk Assessment.

Assessment Endpoint	Risk Question	Conclusion of BERA
Benthic macroinvertebrate community	Are concentrations of contaminants in the sediments at the Site sufficiently elevated that they cause adverse alterations to the functioning of the benthic macroinvertebrate community?	Based upon two lines of evidence, there are potentially unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site although effects observed from field surveys of the existing benthic community indicated effects that were less dramatic than those demonstrated in the laboratory toxicity studies. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the benthic macroinvertebrate community is exposed to them should be addressed in the Feasibility Study.
Fish community	Are concentrations of contaminants at the Site sufficiently elevated that they cause adverse alterations to the functioning of the fish community?	There is no unacceptable risk to the fish community utilizing the Site. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the fish community is exposed to them should be addressed in the Feasibility Study.
Omnivorous aquatic bird community	Are dietary exposure levels of Site-related contaminants sufficiently elevated to cause adverse alterations to the omnivorous aquatic avian community?	There is no unacceptable risk to the omnivorous aquatic bird community utilizing the Site. However, the presence of contaminants in Site sediment that are sporadically released to the aquatic environment where the omnivorous aquatic bird community is exposed to them should be addressed in the Feasibility Study.
Omnivorous birds	Are dietary exposure levels of site-related contaminants sufficient to cause adverse alterations to the omnivorous avian community?	There is no unacceptable risk to omnivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Insectivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the	There is no unacceptable risk to insectivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.

Table 7-1. Conclusions of the Baseline Ecological Risk Assessment.

Assessment Endpoint	Risk Question	Conclusion of BERA
	insectivorous avian community?	
Piscivorous birds	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to individual ospreys or to the piscivorous avian community?	There is no unacceptable risk to piscivorous birds utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Omnivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the omnivorous mammal community?	There is no unacceptable risk to omnivorous mammals utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Insectivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the insectivorous mammal community?	There is no unacceptable risk to insectivorous mammals utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.
Piscivorous mammals	Are dietary exposure levels of Site-related contaminants sufficient to cause adverse alterations to the piscivorous mammal community?	There is no unacceptable risk to piscivorous mammals utilizing the Site. This exposure pathway does not require consideration in the Feasibility Study.

Accardi-Dey, A. and P. Gschwend. 2003. Reinterpreting literature sorption data considering both adsorption into organic carbon and adsorption onto black carbon. Env. Sci. Technol. 37: 99-106.

Adams, W., K. Brix, M. Edwards, L. Tear, D. DeForrest, and A. Fairbrother. 2003. Analysis of field and laboratory data to derive selenium toxicity thresholds for birds. Env. Toxicol. Chem. 22: 2020-2029.

Ahrens, M. and C. Hickey. 2005. UV-photoactivation of polycyclic aromatic hydrocarbons and the sensitivity of sediment-dwelling estuarine organisms, pp. 63-65. In: UV Radiation and Its Effects: an update 2002. Proc. Workshop

Ali, L. R. Mantoura, and S. Rowland. 1995. The dissolution and photodegradation of Kuwaiti crude oil in seawater. Part 2: A laboratory photodegradation apparatus and photodegradation kinetics of a model seawater soluble hydrocarbon (Phenanthrene). Mar. Env. Res. 40: 319-335.

ATSDR. 1992. Toxicological profile for cresols. Agency for Toxic Substances and Disease Registry. U.S. Public Health Service, Washington, D.C.

Aughey, E., L. Grant, B.L. Furman, and W.F. Dryden. 1977. The effects of oral zinc supplementation in the mouse. J. Comp. Pathol. 87:1-14. (Cited in USEPA, 1991a).

Aulerich, R.J., R.K. Ringer, and S. Iwamoto. 1974. Effects of dietary mercury on mink. Arch. Env. Contam. Toxicol. 2: 43-51.

Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano. 1982. Effects of supplementary copper on growth, reproductive performance and kit survival of standard dark mink and acute toxicity of copper on mink. Anim. Sci. 55: 337-343.

Aulerich R.J., S.J. Bursian, R.H. Poppenga, W.E. Braselton, and T.P. Mullaney. 1991. Toleration of high concentrations of dietary zinc by mink. J Vet Diagn Invest, 3: 232– 237.

Azar, A., H. Trochimowicz, and M. Maxfield. 1973. Review of lead studies in animals carried out at Haskell Laboratory: Two year feeding study and response hemorrhage study. pp. 199-210. In: Proc. Int. Symp. Env. Hlth. Aspects of Lead, Amsterdam, Netherlands. 2-6 October 1972.

Baes, C.F., R. Sharp, A. Sjoreen, and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp.

Bakalli, R.I., G.M. Pesti, W.L. Ragland, and V. Konjufca. 1995. Dietary copper in excess of nutritional requirement reduces plasma and breast muscle cholesterol in chickens. Poultry Sci. 74:360-365.

Balk, L., J. Meijer, J. DePierre, and L-E. Appelgren. 1984. The uptake and distribution of [^{3}H]benzo(a)pyrene in the northern pike (Esox lucius). Examinination by whole-body autoradiography and scintillation counting. Toxicol. Appl. Pharmacol. 74: 430-449.

Barcelo, J., and J. Calkins. 1978. Positioning of aquatic microorganisms in response to visible light and simulated UV-B irradiation. Photochem. Photobiol. 29: 75-83.

Barron, M., M. Anderson, D. Cacela, J., J. Lipton, S. the. D. Hinton, J. Zelikoff, J. Dikkeboom, D. Tillett, M. Holey, and N. Denslow. 2000. PCBs, liver lesions, and biomarker responses in adult walleye (Stizostedium vitreum) collected from Green Bay, Wisconsin. J. Great Lakes Res. 26: 250-271.

Barron, M., M. Carls, J. Short, and S. Rice. 2003. Photoenhanced toxicity of aqueous phase and chemically dispersed weathered Alaska crude oil to Pacific herring eggs and larvae. Env. Toxicol. Chem. 22: 650-660.

Baumann, P. and J. Harshbarger. 1995. Decline in liver neoplasms in wild brown bullhead catfish after coking plant closes and environmental PAHs plummet. Env. Hlth. Perspcs. 103: 168-170.

Baumann, P. I. Smith, and C. Metcalf. 1996. Linkages between chemical contaminants and tumors in benthic Great Lakes fish. J. Great lakes Res. 22: 131-152.

Bechtel Jacobs Company LLC. 1998a. Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation. Bechtel Jacobs Company LLC, Oak Ridge, TN. BJC/OR-112.

Bechtel Jacobs Company LLC. 1998b. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, TN. BJC/OR-133.

Bell, H., K. Liber, D. Call, and G. Ankley. 2004. Evaluation of bioaccumulation and photo-induced toxicity of fluoranthene in larval and adult life-stages of Chironomus tentans. Arch, Env. Contam. Toxicol. 47: 297-303.

Bertine, K. and E. Goldberg. 1972. Trace elements in clams, mussels, and shrimp. Limnol. Oceanogr. 17: 877-884.

Besser, J.M., W.G. Brumbaugh, T.W. May, and C.G. Ingersoll. 2003. Effects of organic amendments on the toxicity and bioavailability of cadmium and copper in spiked formulated sediments. Environmental Toxicology and Chemistry. 22 (3):805-815.

Black, J., E. Evans, J. Harshbarger, and R. Zeigel. 1982. Epizootic neoplasms in fishes from a lake polluted by copper mining wastes. J. Natl. Cancer Inst. 69: 915-926.

Boese, B., J. Lamberson, R. Swartz, R. Ozretich, and F. Cole. 1998. Photoinduced toxicity of PAHs and alkylated PAHs to a marine infaunal amphipod (Rhepoxinius abronius). Arch. Env. Contam. Toxicol. 34: 235-240.

Borgmann, U., V. Cheam, W. Norwood, and J. Lechner. 1998. Toxicity and bioaccumulation of thallium in Hyalella azteca, with comparison to other metals and prediction of environmental impact. Env. Pollut. 99: 105-114.

Boyden, R., V.R. Potter, and C.A. Elvehjem. 1938. Effect of feeding high levels of copper to albino rats. J. Nutr. 15: 397-402.

Browman, H., I. Novales-Flamarique, and C. Hawryshyn. 1993. Ultraviolet photoreception contributes to prey search behavior in two species of zooplanktivorus fishes. J. Exp. Biol. 186: 187-198.

BRRC. 1988. Developmental toxicity evaluation of o-, m-, or p-cresol administered by gavage to New Zealand white rabbits. Bushy Run Research Center. EPA/OTS S0517695.

Burgess R.M. 2004. Role of Black Carbon in the Partitioning and Bioavailability of Organic Pollutants. Environ. Toxicol. Chem. 23(11):2531-2533.

Burkhard, L.P. and M.T. Lukasewycz. 2000. Some Bioaccumulation Factors and Biota-Sediment Accumulation Factors for Polycyclic Aromatic Hydrocarbons in Lake Trout; Environmental Toxicology and Chemistry: Vol. 19, No. 5, pp. 1427–1429.

Brunson, E.L., Canfield, T.J., Dwyer, F.J., Ingersoll, C.G., and N.E. Kemble. 1998. Assessing the bioaccumulation of contaminants from sediments of the upper Mississippi River using field-collected oligochaetes and laboratory-exposed *Lumbriculus variegatus*. Archives of Environmental Contamination and Toxicology. 35: 191-201.

Cain B., L. Sileo, J.C. Franson, and J. Moore. 1983. Effects of dietary cadmium on mallard ducklings. Env. Res. 32: 286-297.

Camardese, M.B., D.J. Hoffman, L.J. LeCaptain, and G.W. Pendleton. 1990. Effects of arsenate on growth and physiology in mallard ducks. Environmental Toxicology and Chemistry. 9:785-95.

Chapman P.M., Dexter, R.N., and E.R. Long. 1987. Synoptic measures of sediment contamination, toxicity, and infaunal community composition (the Sediment Quality Triad) in San Francisco Bay. Mar. Ecol. Prog. Series 37:75-96

Cornelissen, G., Breedveld, G.D., Naes, K., Oen, A., and A. Ruus. 2006. Bioaccumulation of native polycyclic aromatic hydrocarbons from sediment by a polychaete and a gastropod: freely dissolved concentrations and activated carbon amendment. Environmental Toxicology and Chemistry. 25(9): 2349-2355.

Culp S, Gaylor D, Sheldon W, Goldstein L, Beland F (1998) A comparison of the tumors induced by coal tar and benzo[a]pyrene in a 2-year bioassay. Carcinogenesis 19:117–124.

Custer, T.W. and C. Bunck. 2000. Feeding flights of breeding double-crested cormorants at two Wisconsin colonies. J.Field Ornithol. 63(2):203-211.

DeGraaf, Richard M., Rudis, Deborah D.; 1986. New England wildlife: habitat, natural history, and distribution. General Technical Report NE-108. Broomall, PA: USDA, Forest Service, Northeastern Forest Experiment Station. 491 p

DeGraeve, G., D. Geiger, J. Meyer, and H. Bergman. 1980. Acute and embryo-larval toxicity of phenolic compounds to aquatic biota. Arch. Env. Contam. Toxicol. 9: 557-568.

Diamond, S., J. Oris, and S. Guttman. 1995. Adaptation to fluoranthene in a laboratory population of fathead minnows. Env. Toxicol. Chem. 14: 1393-1400.

Diamond, S., D. Mount, L. Burkhard, G. Ankley, E. Makten, and E. Leonard. 2000. Effect of irradiance spectra on the photoinduced toxicity of three polycyclic aromatic hydrocarbons. Env. Toxicol. Chem. 19: 1389-1396.

DiToro, D. and J. McGrath. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. II. Mixtures and sediments. Env. Toxicol. Chem. 19: 1970- 1982.

DiToro, D., J. McGrath, and D. Hansen. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Env. Toxicol. Chem. 19: 1951-1970.

Doerffer. J.W. 1992. Oil Spill Response in the Marine Environment. (Pergamon Press 1992 ISBN 0 08 041000 6) 2.

Donahue, W. and D. Schindler. 1998. Diel emigration and colonization responses of blackfly larvae (Diptera: Simulidae) to ultraviolet radiation. Freshwat. Biol. 40: 357-365.

Downs, W., J. Scott., L. Steadman, and E. Maynard. 1960. Acute and sub-acute toxicity studies of thallium compounds. Am. Ind. Hyg. J. 21: 399-406.

Draski, L.J., R.G. Burright, and P.J. Donovick. 1989. The influence of prenatal and/or postnatal exposure to lead on behavior of preweanling mice. Physiol Behav. 45: 711-715.

Edens, F.W., E. Benton, S.J. Bursian, and G.W. Morgan. 1976. Effect of dietary lead on reproductive performance in Japanese quail, Coturnix coturnix japonica. Toxicol. Appl. Pharmacol. 38: 307-314.

Edens, F.W. and J.D. Garlich. 1983. Lead-induced egg production decrease in leghorn and Japanese quail hens. Poult. Sci. 62: 1757-1763.

Efroymson, R.A., M.E, Will, and G.W. Suter II. 1997. Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Processes: 1997 Revision. Oak Ridge National Laboratory, Oak Ridge TN. ES/ER/TM-126/R2

Efroymson, R.A., B.E. Sample, and G.W. Suter. 2001. Uptake of inorganic chemicals from soil by plant leaves: Regressions of field data. Environmental Toxicology and Chemistry 20:2561-2571.

Eisler, R. 1987. Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: A synoptic review. Contaminant Hazard Review Report No. 11.

Erhardt, M. and K. Burns. 1990. Petroleum-derived dissolved organic compounds concentrated from inshore waters in Bermuda. J. Exp. Mar. Biol. Ecol. 138: 35-47.

Ehrhardt, M. and K. Burns. 1993. Hydrocarbons and related photo-oxidation products in Saudi Arabian Gulf coastal waters and hydrocarbons in underlying sediments and bioindicator bivalves. Mar. Pollut. Bull. 27: 187-197.

Ehrhardt, M., K. Burns, and M. Bicego. 1992. Sunlight-induced compositional alterations in the seawater-soluble fraction of a crude oil. Mar. Chem. 37: 53-64.

Exxon 1986. Initial Submission: Determination of maternal toxicity and fetal toxicity of benzene in rats following oral exposure (Final Report). EPA/OTS, Rep. # 88-9200010295.

Fairbrother, A., K. Brix, J. Toll, S. McKay, and W. Adams. 1999. Egg selenium concentrations as predictors of avian toxicity. Hum. Ecol. Risk Asses. 5: 1229-1253.

Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D.E. Smorong, and R. A. Lindskoog. 2002. Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environmental Toxicology and Chemistry. 21(9):1993-2005.

Fielden M, Wu Z, Sinal C, Hodgert J, Bend J, Hammond G, Zacharewski T (2000) Estrogen receptor- and aryl hydrocarbon receptor-mediated activities of a coal-tar creosote. Env. Toxicol. Chem. 19:1262–1271.

Fitzhugh, O.G, A.A. Nelson, E.P. Laug, and I.M. Kunze. 1950. Chronic oral toxicities of mercuric phenyl and mercuric salts. Arch. Ind. Hyg. Occup. Med. 2: 433-442.

Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, L Gottardi, and L. Manzo. 1986. Thallium-induced testicular toxicity in the rat. Env. Res. 40: 531-539.

Fowler, B.A., C.A. Kimmel, J.S. Woods, E.E. McConnell, and L.D. Grant . 1980. Chronic low-level lead toxicity in the rat. III. An integrated assessment of long-term toxicity with special reference to the kidney. Toxicol. Appl. Pharmacol. 56: 59-77.

Gasaway, W. and I. Bus. 1972. Zinc toxicity in the mallard duck. J. Wildlf. Manage. 36: 1107-1117.

Gewartz, S.B., Lazar, R., and G.D. Haffner. 2000. Comparison of polycyclic aromatic hydrocarbon and polychlorinated biphenyl dynamics in benthic invertebrates of Lake Erie, USA. Environmental Toxicology and Chemistry. 19(12): 2943-2950.

Ghosh U, Zimmerman JR, Luthy RG. 2003. PCB and PAH Speciation among Particle Types in Contaminated Harbor Sediments and Effects on PAH Bioavailability. Environ. Sc.i Technol. 37(10):2209-17.

Goodwin, A. and J. Grizzle. 1994. Oncogene expression in hepatic and biliary neoplasms of the fish Rivulus ocellatus marmoratus: correlation with histologic changes. Carcinogenesis 15: 1993-2002.

Grant, L.D., C.A. Kimmel, G.L. West, C.M. Martinez-Vargas, and J.L. Howard. 1980. Chronic low-level lead toxicity in the rat. II. Effects on postnatal physical and behavioral development. Toxicol. Appl. Pharmacol. 56: 42-58.

Greenberg, B. 2005. Project Summary, Univ. Guelph, Ontario, Canada. www.uoguelph.ca/cntc/research/risk/summaries.shtml.

Gutierrez-Rodriguez, C. and C.E. Williamson. 1999. Influence of solar ultraviolet radiation on early life-history stages of the bluegill sunfish, Lepomis macrochirus. Environmental Biology of Fishes. 55(3):307-319.

Hakkinen , J., E. Vehnianen, and A. oikari. 2003. Histopathological responses of newly hatched larvae of whitefish (Coregonus lavaretus s.l.) to UV-B induced toxicity of retene. Aquat. Toxicol. 63: 159-171.

Harkey, G., S. Driscoll, and P. Lamdrum. 1995. Bioavailability of polycyclic aromatic hydrocarbons from a historically contaminated sediment core. Env. Toxicol. Chem. 14: 1551-1560.

Hamilton, S.J. and K.J. Buhl. 2003a. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates, and fish from streams in southeaster Idaho near phosphate mining operations: September 2000. U.S. Geological Survey, Columbia Environmental Research Center.

Hamilton, S.J. and K.J. Buhl. 2003b. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates, and fish from streams in southeaster Idaho near phosphate mining operations: May 2001. U.S. Geological Survey, Columbia Environmental Research Center.

Hansen, L., J. Whitehead, and S. Anderson. 2002. Solar UV radiation enhances the toxicity of arsenic in Ceriodaphnia dubia. Ecotoxicol. 11: 279-287.

Harding, L., M. Graham, and D. Patton. 2005. Accumulation of selenium and lack of severe effects on productivity of American dippers (Cinclus mexicanus) and spotted sandpipers (Actitis macularia). Arch. Env. Contam. Toxicol. 48: 414-423.

Hatch, A. and G. Burton. 1999. Photo-enhanced toxicity of PAHs to Hyalella azteca and Chironomus tentans: effects of mixtures and behavior. Env. Pollut. 106: 157-167.

Hawkins, WQ., W. Walker, R. Overstreet, J. Lytle, and T. Lytle. 1990. Carcinogenic effects of river sediment extracts of some polycyclic aromatic hydrocarbons on the Japanese medaka and guppy in waterborne exposures. Sci. Tot. Env. 94: 155-167.

Hawthorne, S., D. Poppendieck, C. Grabanski, and R. Loehr. 2002. Comparing PAH availability from manufactured gas plant soils and sediments with chemical and biological tests. 1. PAH release during water desorption and supercritical carbon dioxide extraction. Env. Sci. Technol. 36: 4795-4803.

Hawthorne, S., D. Moller, and J. Krietinger. 2006. Measurement of total polycyclic aromatic hydrocarbon concentrations in sediments and toxic units used for estimating risk to benthic invertebrates at manufactured gas plant sites. Env. Toxicol. Chem. 25: 287-296.

Heinz, G.H., D.J. Hoffman, A.J. Krynitsky and D.M.G. Weller. 1987. Reproduction in mallards fed selenium. Env. Toxicol. Chem. 6: 423-432.

Heinz, G.H., D.J. Hoffman, and L.G. Gold. 1989. Impaired reproduction of mallards fed an organic form of selenium. J. Wliflf. Mangt. 53: 418-428.

Hendricks, J., T. Meyers, D. Shelton, J. Casteel, and G. Bailey. 1985. The hepatocarcinogenesis of benzo(a)pyrene by dietary exposure and intraperitioneal injection. J. Natl. cancer Inst. 74: 839-851.

Hill, E. and C. Schaffer. 1976. Sexual maturation and productivity of Japanese quail fed graded concentrations of mercuric chloride. Poult. Sci. 55: 1449-1459.

Hoffe, M.H. and C.R. Bronte. 1998. Population status and trends for economically and ecologically important fishes in Lake Superior, 1978-97. Lake Superior Committee Annual Meeting (Minutes). March 17-18, 1998. Great Lakes Fish. Comm.

Hornshaw, T., R. Aulerich, and R. Ringer. 1986. Toxicity of o-cresol to mink and European ferrets. Env. Toxicol. 5: 713-720.

Ingersoll, C.G., P.S. Haverland, E.L. Brunson, T.J. Canfield, F.J. Dwyer, C.E. Henke, N.E. Kemble, D.R. Mount, and R.G. Fox. 1996. Calculation and Evaluation of Sediment Effect Concentrations for the Amphipod Hyalella azteca and the Midge Chironomus riparius. Journal of Great Lakes Research 22(3):602-623.

Ingersoll, C.G., Brunson, E.L., Wang, N., Dwyer, F.J., Ankley, G.T., Mount, D.R., Huckins, J., Petty, J., and P.F. Landrum. 2003. Uptake and depuration of non-ionic organic constituents from sediment by the oligochaete, *Lumbriculus variegatus*. Env. Toxicol. Chem. 22: 872-885.

IRIS. 2003. Xylenes (CASRN 1330-20-7). Integrated Risk Information System. USEPA.

Jackson, N., S.W. Gibson, and M.H. Stevenson. 1986. Effects of short-and long-term feeding of zinc oxide-supplemented diets on mature, female domestic fowl with

Jensen, L.S. and D.V. Maurice. 1978. Effect of methionine on copper-induced growth depression and gizzard erosion. Poult. Sci. 57: 1530-1532.

Jerome, J.H. and R.P. Bukata. 1998. Tracking the propagation of solar ultraviolet radiation: dispersal of ultraviolet photons in inland waters. J. Great Lakes Res. 24(3):666-680.

Johnson, D., A. Merhring, and W. Titus. 1960. Tolerance of chickens for barium. Proc. Soc. Exp. Biol. Med. 104: 436-438.

Kelly, D., J. Clare, and M. Bothwell. 2000. Attenuation of solar ultraviolet radiation by dissolved organic matter alters benthic colonization patterns in streams. J. Am. Benth. Soc. 20: 96-108.

Kendall, R.J. and P.F. Scanlon. 1981. Histology and ultrastructure of kidney tissue from ringed turtle doves that ingested lead. J. Env. Toxicol. Oncol. 6: 85-96.

Kerr, K.B., J.W. Cavett, and O.L. Thompson. 1963. The toxicity of an organic arsenical, 3-nitro-4-hydroxy-phenylarsonic acid. I. Acute and subacute toxicity. Toxicol. Appl. Pharmacol. 5: 507-525.

Ketcheson, M.R., G.P. Barron, and D.H. Cox. 1969. Relationship of maternal dietary zinc during gestation and lactation to development and zinc, iron, and copper content of the postnatal rat. J. Nutr. 98:303-311

Kiffney, P. E. Little, and W. Clements. 1997. Influence of ultraviolet-B radiation on the drift response of stream macroinvertebrates. Freshwat. Biol. 37: 485-492.

Kimmel, C., L. Grant, C. Sloan, and B. Gladen. 1980. Chronic low-level lead toxicity in the rat. II. Maternal toxicity and perinatal effects. Toxicol. Appl. Pharmacol. 56: 28-41.

Kimura, E., D. Ebert, and P. Dodge. 1971. Acute toxicity and limits of solvent residue for sixteen solvents. Toxicol. Appl. Pharmacol. 19: 699-704.

King, K, T. Custer, and D. Weaver. 1994. Reproductive success of barn swallows nesting near a selenium-contaminated lake in east Texas, USA. Env. Pollut. 84: 53-58.

Kraaij, R., Ciarelli, S., Tolls, J., Kater, B., and A. Belfroid. 2001. Bioavailability of lab-contaminated and native polycyclic aromatic hydrocarbons to the amphipod *Corophium volutator* relates to chemical desorption. Env. Toxicol. Chem. 20: 1716-1724.

Krylov, S. X-D. Huang, L. Zeiler, D. Dixon, and B. Greengerg. 1997. Mechanistic quantitative structure-activity relationship model for the photoinduced toxicity of polycyclic aromatic hydrocarbons: I. Physical model based on chemical kinetics in a two-compartment system. Env. Toxicol. Chem. 16: 2283-2295.

Lamoureux, E. and B. Brownawell. 1999. Chemical and biological availability of sediment-sorbed hydrophobic organic contaminants. Env. Toxicol. Chem. 18: 1733-1741.

Lamoureux, E. and B. Brownawell. 2004. Influence of soot on hydrophobic organic contaminant desorption and assimilation efficiency. Env. Toxicol. Chem. 23: 2571-2577.

Landrum, P. and D. Scavia. 1982. Influence of sediment on anthracene uptake, depuration, and biotransformation by the amphipod Hyalella azteca. Can. J. Fish Aquat. Sci. 40: 298-305.

Landrum, P. 1988. Toxicokinetics of organic xenobiotics in the amphipod, Pontporeia hoyi: role of physiological and environmental variables. Aquat. Toxicol. 12: 245-271.

Landrum, P., B. Eadie, and W. Faust. 1991. Toxicokinetics and toxicity of a mixture of sediment-associated polycyclic aromatic hydrocarbons to the amphipod Diporeia sp. Env. Toxicol. Chem. 10: 35-46.

Landrum, P., W. Depuis, and J. Kukkonen. 1994. Toxicokinetics and toxicity of sediment-associated pyrene and phenanthrene in Diporeia spp.: Examination of equilibrium partitioning theory and residue-based effects for assessing hazard. Env. Toxicol. Chem. 13: 1769-1780.

Laskey, J., G. Rehnberg, J. Hein, and S. Carter. 1982. Effects of chronic manganese (Mn_3O_4) exposure on selected reproductive parameters in rats. J. Toxicol. Env. Hlth. 9: 677-687.

Laskey, J. and F. Edens. 1985. Effects of high-level manganese exposure on male behavior in the Japanese quail. Poult. Sci. 64: 579-584.

Leach, R.M., K.W. Wang, and D.E Baker. 1979. Cadmium and food chain: the effect of dietary cadmium on tissue composition in chick and laying hens. J. Nutr. 109(3): 437-443.

Lecyk, M. 1980. Toxicity of cupric sulfate in mice embryonic development. Zool. Pol. 28: 101-105.

Leech, D. and C. Williamson. 2000. Zooplankton behavioural responses to solar UV radiation vary within and among lakes. J. of Plankton Research. 27(5):461-471.

Leech, D. and C. Williamson. 2001. In situ exposure to solar UV radiation alters depth distribution of Daphnia. Limnol. Oceanogr. 46: 416-420.

Lewis et al. 1990. A new approach to deriving community exposure guidelines from "no-observed-effect levels". Reg. Toxicol. Pharmacol. 11: 314-330.

Little, E., L. Cleveland, R. Calfee, and M. Barron. 2000. Assessment of the photoenhanced toxicity of a weathered crude oil to the tidewater silverside. Env. Toxicol. Chem. 19: 926-932.

Llewellyn, G.C., E.A. Floyd, G.D. Hoke, L.B. Weekley, and T.D. Kimbrough. 1985. Influence of dietary aflatoxin, zinc, and copper on bone size, organ weight, and body weight in hamsters and rats. Bull. Env. Contam. Toxicol. 35: 149-156.

Long, E.R. and P.M. Chapman. 1985. A Sediment Quality Triad: Measures of sediment contamination, toxicity, and infaunal community composition in Puget Sound. Marine Pollution Bulletin. 16:405-415.

Long, E. R,. and L. G. Morgan 1991. The Potential for Biological Effects of Sediment-Sorbed Contaminants Tested in the National Status and Trends Program, NOAA Technical Memorandum NOS OMA 52, National Oceanic and Atmospheric Administration.

Longcore, J.R., D. G. McAuley, G.R. Hepp, and J.M. Rhymer. 2000. American Black Duck (Anas rubripes). In The Birds of North America, No. 481 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Lowe, E., W. McFarland, E. Mills, and D. Hunter. 1993. A chromatic action spectrum for planktonic predation by juvenile perch, Perca flavescens. Can. J. Zool. 71: 384-386.

Lu, X., Reible, D.D., J.W. Fleeger. 2006. Bioavailability of polycyclic aromatic hydrocarbons in field-contaminated Anacostia River (Washington, D.C.) sediment. Env. Toxicol. Chem. 25: 2869-2874.

Mahony, J., D. DiToro, A. Gonzales, M. Curto, M. Dilg, L. De Rosa, and L. Saprrow. 1996. Partitioning of metals to sediment organic carbon. Env. Toxicil. Chem. 15: 2187-2197.

Maita, K., M. Hirano, K. Mitsumori, K. Takahashi, and Y. Shirasu. 1981. Subacute toxicity with zinc sulfate in mice and rats. J. Pest. Sci. 6:327-336. (Cited in ATSDR, 1989).

Malins, D., B. McCain, M. Meyers, D. Brown, M. Krahn, W. roubal, H. Schiewe, J. Lndahl, and S-L Chan. 1987. Field and laboratory studies of the etiology of liver neoplasms in marine fish from Puget Sound. Env. Hlth. Persps. 71: 5-16.

Manzo, L. R. Scelsi, A. Moglia, P. Poggi, E. Alfonsi, R. Pietra, F. Mousty, and E. Sabbioni . 1983. Long-term toxicity of thallium in the rat, pp. 401-405. In: Chemical Toxicology and Clinical Chemistry of Metals. Acad. Press, London.

Marks, T., T. Ledoux, and J. Moore. 1982. Teratology of a commercial xylene mixture in the mouse. Toxicol. Env. Hlth. 9:97-105.

Maruya, K.A., Risebrough, R.W., and A.J. Horne. 1997. The bioaccumulation of polynuclear aromatic hydrocarbons by benthic invertebrates in an intertidal marsh. Environmental Toxicology and Chemistry, 16: 1087-1097.

Massie, H.R. and V.R. Aiello. 1984. Excessive intake of copper: Influence on longevity and cadmium accumulation in mice. Mech. Ageing Dev. 26: 195-203.

MBA. 1988. Subchronic toxicity of para-cresol in Sprague-Dawlry rats. Unpublished data submitted by Microbiological Associates to EPA.

McConkey, B. L. Hewitt, D. Dixon, and B. Greenberg. 2002. Natural sunlight induced photooxidation of naphthalene in aqueous solution. Wat. Air Soil Pollut. 136: 347-359.

McDonald, B. and P. Chapman. 2002. PAH phototoxicity- an ecologically irrelevant phenomenon? Mar. Pollut. Bull. 44: 1321-1326.

McGrath, J., T. Parkerton, and D. DiToro. 2004. Application of the narcosis target lipid model to algal toxicity and deriving predicted-no-effect concentrations. Env. Toxicol. Chem. 23: 2503-2517.

McGrath, J., T. Perkerton, F. Hellwger, and D. DiToro. 2005. Validation of the narcosis target lipid model for petroleum products: Gasoline as a test case. Env. Toxicol. Chem. 24: 2382-2394.

McNamara, A. and W. Hill. 1999 Effects of UV-B irradiance: comparison among grazers. J. N. Am. Benth. Soc. 18: 370-380.

Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus. 1960. The tolerance of growing chickens for dietary copper. Poult. Sci. 39: 713-719.

Mekenyan, O., G. Ankley, G. Veith, and D. Call. 1994. QSARs for photoinduced toxicity. I. Acute lethality of polycyclic aromatic hydrocarbons to Daphnia magna. Chemosphere 28: 567-582.

Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. University of Pittsburg Press. 408p.

Mikaelian, I., Y. DeLafontaine, J.C. Harshbarger, L.J. Lee, and D. Martineau. 2002. Health of Lake Whitefish (Coregonus clupeaformis) with elevated tissue levels of environmental contaminants. Environmental Toxicology and Chemistry. 21(3):532-541.

Mitra, S. Klerks, P.L., Bianchi, T.S., Means, J., and K.R. Carman. 2000. Effects of estuarine organic matter biogeochemistry on the bioaccumulation of PAHs by two epibenthic species. Estuaries, 23: 864-876.

Mopper, K. and W. Stanhovec. 1986. Sources and sinks of low molecular weight organic carbonyl compounds in seawater. Mar. Chem. 19: 305-321.

Mortimer, M. and D. Connell. 1995. Effect of exposure to chlorobenzenes on growth rates of the crab Portunus pelagicus (L). Env. Sci. Technol. 29: 1881-1886.

Mueller, J. P. Chapman, and P. Pritchard. 1989. Action of a fluoranthene-utilizing bacterial community on polycyclic aromatic hydrocarbon components of creosote. App. Env. Microbiol. 55: 3085-3090.

Murthy, R.C., S. Lal, D.K. Saxena, G.S. Shukla, M.M. Ali, and S.V. Chandra. 1981. Effect of manganese and copper interaction on behavior and biogenic amines in rats fed a 10% casein diet. Chem-Biol. Interact. 37: 299-308.

Nagy, K. 2001. Food requirements of wild animals: Predictive equations for free-living mammals, reptiles, and birds. Nutr. Absts. Revs. Series B 711R-12R.

NAS (National Academy of Sciences). 1994. Nutrient Requirements of Laboratory Animals. National Academy Press, N.Y.

Nawrot and Staples 1979. Embryofetal toxicity and teratogenicity of benzene and toluene in the mouse. Teratol. 19: 14A.

Neff, J.M., Stout, S.A., and Gunster, D.G. (2005) Ecological risk assessment of PAH in sediments: Identifying sources and ecological hazard.Integrated Environ. Assess. Management, 1(1): 22-33.

Neuhauser, E.F., Z.V. Cukic, M.R. Malecki, R.C. Loehr and P.R. Durkin. 1995. Bioconcentration and biokinetics of heavy metals in the earthworm. Environ. Pollut. 89:293–301.

Newfields. 2005. Environmental forensic investigation of tar residues at the Ashland Lakefront Site in Ashland, WI. Draft report. pp. 46.

NOAA. 1999. Screening Quick Reference Tables. National Oceanic and Atmospheric Administration. Hazmat Report 99-1. September 1999.

Norvell et al. 1975. Effects of feeding high levels of copper salts to broiler chickens. pgs. 457-463. In: Proc. 9th Ann. Conf. Trace Subs. Env. Hlth., Univ. Missouri.

NTP 1986. National Toxicology Program technical report on the toxicology and carcinogenesis studies of xylenes (mixed) (60% m-xylene, 14% p-xylene, 9% o-xylene, and 17% ethylbenzene) (CAS No. 1330-20-7) in F344/N rats and B6C3F1 mice (gavage studies). NIH. NTP TR 327, NIH Pub. No. 87-2583.

NTP. 1990. National Toxicology Program technical report series toxicology and carcinogenesis studies of toluene (CAS No. 108-88-3) in F344/N rats and 86C3F mice (gavage studies). Research Triangle Park, NIEHS, National Institutes of Health, Washington, D.C.

NTP. 1994. NTP technical report on toxicity studies of sodium selenate and sodium selenate administered in drinking water to F344/N rats and B6C3F1 mice. Toxicity report Series 38. NIH Publication 94-3387. Bethesda, MD

NTP (National Toxicology Program). 1996. Final report on reproductive toxicity of lead acetate trihydrate (CAS No. 6080-56-4) administered in drinking water to Sprague-Dawley rats. NIEHS, National Institutes of Health, Washington, D.C. RAC B94009.

Patton, J. and M. Dieter. 1980. Effect of petroleum hydrocarbons on hepatic function in the duck. Comp. Biochem. Physiol. 65C: 33-36.

Payne, J. and C. Phillips. 1985. Photochemistry of petroleum in water. Env. Sci. Technol. 19: 569-579.

Peck-Miller, K., M. Myers, and T. Collier. 1998. Complete cDNA sequence of the Ki-ras proto-oncogene in the liver of wild English sole (Pleuronectes vetulus) and mutation of hepatic neoplasms and other toxicopathic liver lesions. Mole. Carcinognesis 23: 207-216.

Persaud, D., R. Jaagumagi, and A. Hayton. 1993. Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario. ISBN 0-7729-9248-7. Standards Development Branch. Ontario Ministry of Environment and Energy. Toronto, Ontario. 27 pp.

Persaud, A., M. Arts, and N. Yan. 2003. Photoresponses of late instar Chaoborus punctipennis larvae to UVR. Aquat. Ecol. 37: 257-265.

Persaud, A. and N. Yan. 2005. Developmental differences and a test for reciprocity in the tolerance of Chaoborus punctipennis larvae to ultraviolet radiation. Can. J. Fish. Aquat. Sci. 62: 483-491.

Pinkney, A., J. Harshbarger, E. May, and W. Reichert. 2004. Tumor prevalence and biomarkers of exposure and response in brown bullhead (Ameiuris nebulosus) from the Anacostia River, Washington, CD, and Tuckhoe River, Maryland, USA. Env. Toxicol. Chem. 23: 638-647.

Plasterer, M., W. Bradshaw, G. Booth, R. Schuler, and B. Hardin. 1985. Developmental toxicity of nine selected compounds following prenatal exposure in the mouse: Naphthalene, p-nitrophenol, sodium selenite, dimethyl phthalate, ethylthiourea, and four glycol ether derivatives. Toxicol. Env. Hlth. 15: 25-38.

Pocino, M., L. Baute, and I. Malave. 1991. Influence of the oral administration of excess copper on the immune response. Fund. Appl. Toxicol. 16: 249-256.

Potter, D., T. Clarius, A. Wright, and W. Watson. 1994. Molecular dosimetry of DNA adducts in rainbow trout (Oncorhynchus mykiss) exposed to benzo(a)pyrene by different routes. Arch. Toxicol. 69: 1-7.

Protic, M. and A. Sabljic. 1989. Quantitative structure-activity relationships of acute toxicity of commercial chemicals on fathead minnows: effect of molecular size. Aquat. Toxicol. 14: 47-64.

Reddy, A., U. Harttig, M. Barth, W. Baird, M. Schimerlik, J. Hendricks, and G. Bailey. 1999. Inhibition of dibenzo[a/l]pyrene-induced multi-organ carcinogenesis by dietary chlorophyllin in rainbow trout. Carcinogenesis 20: 191901926.

Reinfelder, J. and N. Fisher. 1994. Retention of elements by juvenile fish (Menidia menidia, Menidia beryllina) from zooplankton prey. Limnol. Ocaeanogr. 39: 1783-1789.

Revis, N.W., T.R. Osborne, G. Holdsworth, and C. Hadden. 1989. Distribution of mercury species in soil from a mercury-contaminated site. Wat. Air Soil Pollut. 45: 105-113.

Robertson, R. J., B. J. Stutchbury, and R. R. Cohen. 1992. Tree swallow (Tachycineta bicolor). The Birds of North America, No. 11 (A. Poole and F. Gill, eds.). The Academy ofNatural Sciences, Philadelphia, and the American Ornithologists' Union, Washington,D.C.

Rosenfeld, I. and O. Beath. 1954. Effect of selenium on reproduction in rats. Proc. Soc. Exp. Biol. Med. 87: 295-297.

Roubal, W., T. Collier, and D. Malins. 1977. Accumulation and metabolism of carbon-14 labeled benzene, naphthalene, and anthracene by young coho salmon (Oncorhynchus kisutsh). Arch. Env. Contam. Toxicol. 5: 513-529.

Russom, C., S. Bradbury, S. Broderius, D. Hammermeister, and R. Drummond. 1997. Predicting modes of toxic action from chemical structure: acute toxicity in fathead minnow (Pimephales promelas). Env. Toxicol. Chem. 16: 948-967.

Rust, A., R. Burgess, A. McElroy, M. Cantwell, and B. Brownawell. 2004. Influence of soot carbon on bioaccumulation of sediment-bound aromatic hydrocarbons by marine benthic invertebrates: An interspecies comparison. Env. Toxicol. Chem. 23: 2594-2603.

SWRCB, Water Quality Criteria (2d ed. 1963) p. 230

Sample, B.E. and G.W. Suter. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. ES/ER/TN-125. Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B.E, D.M. Opresko, and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TM-86/R3.

Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998. Development and Validation of Bioaccumulation Models for Small Mammals. Oak Ridge National Laboratory, Oak Ridge, TN. ES/ER/TN-219.

Sample, B.E. and C.A. Arenal. 1999. Allometric models for interspecies extrapolation of wildlife toxicity data. Bull. Env. Contam. Toxicol. 62: 653-663.

Santolo, G., and J. Yamamoto. 1999. Selenium in blood of predatory birds from Kesterson Reservoir and other areas of California. J. Wildlf. Mangt. 63: 1273-1281.

Schlicker, S. and D. Cox. 1968. Maternal dietary zinc and development, and zinc, iron, and copper content of the rat fetus. J. Nutr. 95: 289-294.

Schnitz, A. and J. O'Connor. 1992. In Vivo DNA/RNA adduction of 7,8-dimethylbenz(a)anthracene (DMBA) and benzo(a)pyrene (BaP) in the liver of rainbow trout (Oncorhynchus mykiss). J. Env. Pathol. Toxicol. Oncol. 11: 229-233.

Schroeder, H.A. and M. Mitchener 1971. Toxic effects of trace elements on the reproduction of mice and rats. Arch. Env. Hlth. 23: 102-106.

Schuler, L.J. M. Wheeler, A. J. Bailer and M. J.Lydy. 2003: Toxicokinetics of sediment-sorbed benzo[a]pyrene and hexachlorobiphenyl using the freshwater invertebrates Hyallella azteca, Chironomus tentans, and Lumbriculus variegatus. Environmental Toxicology and Chemistry: Vol. 22, No. 2, pp. 439–449.

SEH. 1998. Ecological Risk Assessment. Problem Formulation. April 1998.

SEH. 2002. Ecological Risk Supplement. Ashland Lakefront Property – Contaminated Sediments. February 2002.

SEH. 2003. Remedial Investigation Work Plan: Ashland/NSP Lakefront Site, Ashland, WI. October 2003.

Seidenburg, J., D. Anderson, and R. Becker. 1986. Validation of an in vivo developmental toxicity screen in the mouse. Terat. Carcin. Mutagen. 6: 361-374.

Shacklette, H.T., and Boerngen, J.G., 1984, Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.

Shopp, G., K. White, M. Holsapple et al. 1984. Naphthalene toxicity in CD-1 mice: general toxicity and immunotoxicity. Fund. Appl. Toxicol. 4: 406-419.

Sibley, D.A. 2000. The Sibley guide to birds. New York: Alfred A Knopf. 544 p.

Smith, F. and E. Baylor. 1953. Color responses in the cladocera and their ecological significance. Am. Nat. 87: 49-55.

Smith, K. 1983. Determination of the reproductive effects in mice of nine selected chemicals. Bioassay Systems Inc. NIOSH Contract No. 210-81-6011. BSC Project Bo. 10867.

Smyth, H., C. Carpenter, and C. Weil. 1962. Range finding test toxicity data: List VI. Am. Ind. Hyg. Assoc. 23:

Smyth, H., C. Weil, and J. West. 1969. An exploration of joint action: twenty-seven industrial chemicals intubated in rats in all possible pairs. Toxicol. Appl. Pharmacol. 14: 340-347.

Springer D, Mann D, Dankovic D, Thomas B, Wright C, Mahlum D (1989) Influences of complex organic mixtures on tumor-initiating activity, DNA binding and adducts of benzo(a)pyrene. Carcinogenesis, 10:131–137.

Stahl, J., J. Gregor, and M. Cook. 1990. Breeding-hen and progeny performance when hens are fed excessive dietary zinc. Poult. Sci. 69: 259-263.

Stanley, T.R. Jr., J.W. Spann, G.J. Smith, and R. Roscoe. 1994. Main and interactive effects of arsenic and selenium on mallard reproduction and duckling growth and survival. Arch. Env. Contam. Toxicol. 26: 444-451.

Steward, A., C. Kandaswami, S. Chidambaram, C. Ziper, J. Rutkowski, and H. Sikka. 1990. Disposition and metabolic fate of benzo(a)pyrene in the brown bullhead. Env. Toxicol. Chem. 9: 1503-1512.

Storz, U. and R. Paul. 1998. Phototaxis in water fleas (Daphnia magna) is differentially influenced by visible and UV light. J. Comp. Physiol. A 183: 709-717.

Stubblefield, W., G. Hancock, H. Prince, and R. Ringer. 1995. Effects of naturally weathered Exxon Valdez crude oil on mallard reproduction. Env. Toxicol. Chem. 14: 1951-1960.

Sunderlin, B., E. Wiklind, G. Lithner, and O. Gustafsson. 2004. Evaluation of the role of black carbon in attenuating bioaccumulation of polycyclic aromatic hydrocarbons from field-contaminated sediments. Env. Toxicol. Chem. 23: 2611-2617.

Swartz , R., D. Schults, R. Ozretich, J. Lamberson, F. Cole, T. DeWitt, M. Redmond and S. Ferraro. 1995. ΣPAH: A model to predict the toxicity of field-collected marine sediment contaminated by polynuclear aromatic hydrocarbons. Env. Toxicol. Chem. 14: 1977-1987.

Swartz, R., S. Ferraro, J. Lamberson, et al. 1997. Photoactivation and toxicity of mixtures of polycyclic aromatic hydrocarbon compounds in marine sediment. Env. Toxicol. Chem. 16: 2151-2157.

Tracey, G.A., and D.J. Hansen. 1996. Use of biota-sediment accumulation factors to assess similarity of non-ionic organic chemical exposure to benthically-coupled organisms of differing trophic mode. Arch. Environ. Contam. Toxicol. 30: 467-475.

Underwood, E. 1956. Trace elements in human and animal nutrition. New York: Academic Press. Second edition, completely rewritten 1962. Third edition, revised and enlarged 1971. Fourth edition, revised, 1977.

Ungvary, G. 1986. Solvent effects on reproduction: Experimental toxicity. Prog. Clin. Biol. Res. 220:169-177.

URS 2001. Sediment Sample Results – NSP /Ashland Lakefront. June, 2001

URS 2005. Remedial Investigation Feasability Study (RI/FS). Work Plan. Ashland/NSP Lakefront Superfund Site. Ashland, Wisconsin.

URS 2006a Remedial Investigation Feasability Study Ashland/NSP Lakefront Superfund Site. Ashland, Wisconsin.

URS 2006b. Sediment Stability Assessment. Ashland/NSP Lakefront Superfund Site. Ashland, Wisconsin.

USEPA. (United States Environmental Protection Agency). 1986. Subchronic (90-day) toxicity of thallium sulfate in Sprague- Dawley rats. Office of Solid Waste, Washington, DC

USEPA 1988. Data Quality Objectives Process for Hazardous Waste Site Investigations EPA QA/G-4HW EPA/600/R-00/007.

USEPA. 1989a. Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual (Part A). Interim Final. EPA/540/1-89/002.

USEPA. 1989b. Risk Assessment Guidance for Superfund. Volume II. Environmental Evaluation Manual. Interim Final. EPA/540/1-89/001.

USEPA. 1992 Framework for ecological risk assessment. Washington, DC: Risk Assessment Forum, U.S. Environmental Protection Agency. EPA/630/R-92/001.

USEPA. 1993. Wildlife Exposure Factors Handbook, Vol. 1. EPA/600/R-93/187a.

USEPA. 1994. Chemical summary for 1,2,4-trimethylbenzene. EPA 749-F-94-022a.

USEPA. 1996. ECO Update: Ecotox Thresholds. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response. USEPA 540/F-95/038.

USEPA. 1997. Ecological Risk Assessment Guidance for Superfund (ERAGS): Process for designing and Conducting Ecological Risk Assessments. USEPA 540-R-97-006.

USEPA. 1998. Guidelines for Ecological Risk Assessment. USEPA/630/R-95/002F.

USEPA. 2000. Guidance for the Data Quality Objective Process

USEPA. 2001a. Planning for Ecological Risk Assessment: Developing Management Objectives.

USEPA. 2001b. The Role of Screening-Level Risk Assessments and Refining Contaminants of Concern in Baseline Ecological Risk Assessments. USEPA 540/F-01/014.

USEPA. 2002. Principles for Managing Contaminated Sediment Risks at Hazardous Waste Sites. OSWER Directive 9285.6-08.

USEPA. 2003a. Ecological Screening Levels (ESLs). U.S. Environmental Protection Agency, Region 5, August 2003.

USEPA. 2003b. Draft Ecological Soil Screening Levels (ECO-SSLs). In: Kapustka, L., W. Clements, L. Zicardi, P. Paquin, M. Sprenger, and D. Wall. 2004. Issue Paper on Ecological Effects of Metals. Submitted to U.S. EPA Risk Assessment Forum, Washington, DC.

USEPA. 2004. ProUCL Version 3.0 User's Guide. April 2004. U.S. Environmental Protection Agency. EPA/600/R04/079.

USEPA. 2005a. Ecological soil screening level (Eco-SSL) (various metals) guidance and documents. http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm

USEPA. 2005b. Contaminated Sediment Remediation Guidance for Hazardous Waste Sites. USEPA 540-R-05-012. OSWER 9355.0-85.

USEPA. 2005c. Guidance for Developing Ecological Soil Screening Levels, Attachment 4-1. Exposure factors and bioaccumulation models for derivation of wildlife Eco-SSLs. OSWER, Washington, D.C.

Van Hoof, P.L., Kukkonen, J., and P.F. Landrum. 2001. Impact of sediment manipulation on the bioaccumulation of polycyclic aromatic hydrocarbons from field-contaminated and laboratory-dosed sediments by an oligochaete. Environmental Toxicology and Chemistry. 20(8): 1752-1761.

Varanasi U, Stein JE and Nishimoto M. 1989. Biotransformation and disposition of polycyclic aromatic hydrocarbons (PAH) in fish. In: Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment (U Varanasi, Ed). CRC Press, Boca Raton, FL, pp. 94-149.

Weyand, E., Y. Chen, Y. Wu, A. Koganti, H. Dunsford, and L. Rodriguez. 1995. Differences in the tumorigenic activity of a pure hydrocarbon and a complex misture following ingestion: benzo(a)pyrene vs manufactured gas plant residue.

White, D.H. and M.T. Finley. 1978. Uptake and retention of dietary cadmium in mallard ducks. Env. Res. 17: 53-59.

White, D.H., M.T. Finley, and J.F. Ferrell. 1978. Histopathologic effects of dietary cadmium on kidneys and testes of mallard ducks. J. Toxicol. environ. Health, 4: 551-558.

Wilkinson, E.R. 1972. California offshore oil and gas seeps. Ca. Div. oil and Gas, Pub. TRO8, 11 p.

Willett, K., P. Gardinali, L. Lienesch, and R. DiGiulio. 2000. Comparative metabolism and excretion of benzo(a)pyrene in 2 species of Ictalurid catfish. Toxicol. Sci. 58: 68-76.

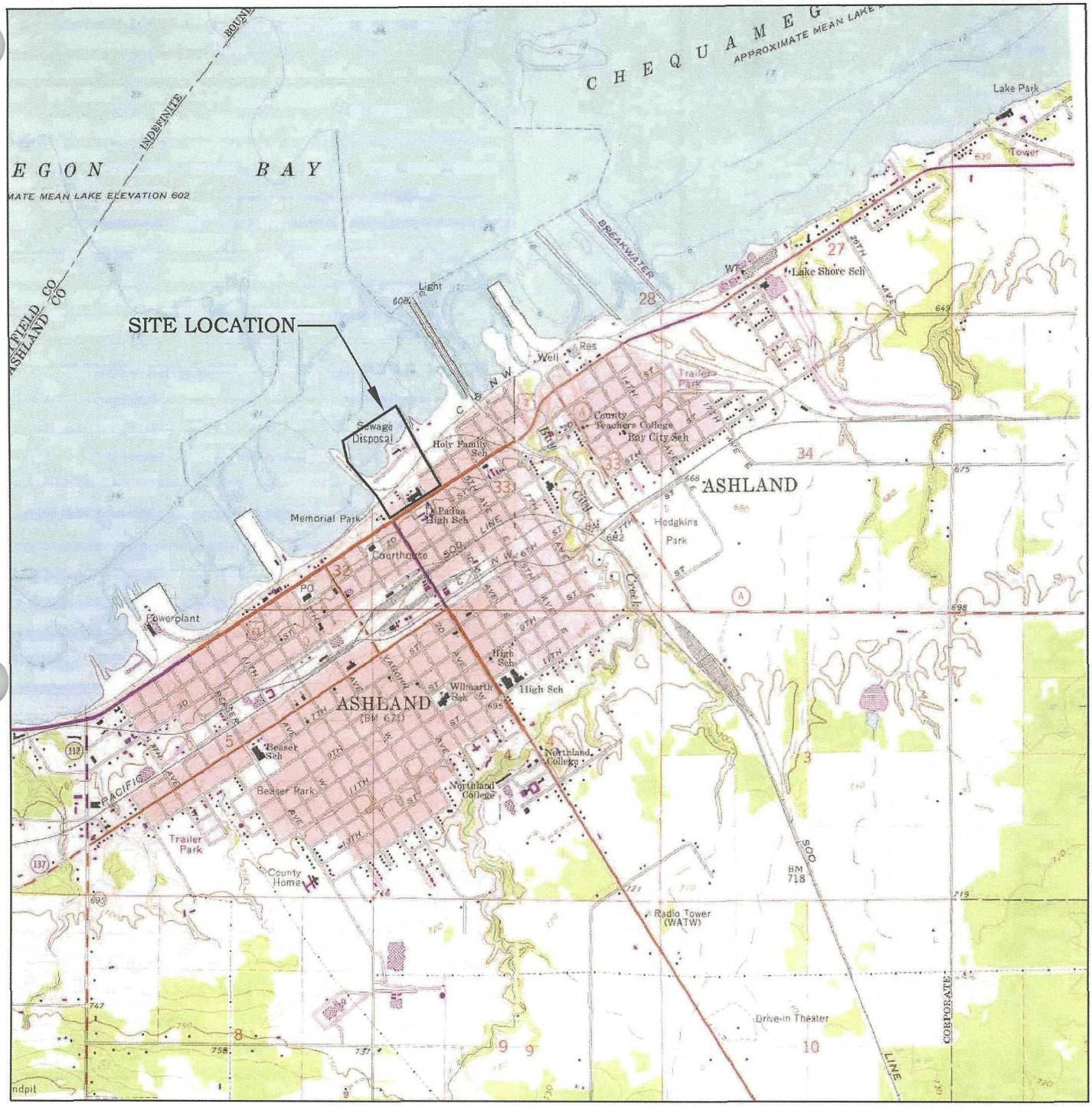
Williamson, C., P. Neale, H. Delange, and B. Hargraves. 2001. Beneficial and detrimental effects of UV radiation on aquatic organisms: implications of variation in spectral composition. Ecol. Applic. 11: 1843-1857.

Wisconsin Department Natural Resources (WDNR). 2003. Consensus-based Sediment Quality Guidelines. Recommendations for Use and Application: Interim Guidance. WT-723 2003.

Withey, R. and J. Hall 1975. The joint toxic action of perchloroethylene with benzene or toluene in rats. Toxicol. 4: 5-15.

Wolf, M., V. Rowe, and D. McCollister. 1956. Toxicological stiudies of certain alkylated benzenes and benzene. AMA. Arch. Ind. Hlth. 14: 387-398.

FIGURES



BASE MAP SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, ASHLAND, WISCONSIN, DATED 1964, PHOTOREVISED 1975.

QUADRANGLE LOCATION

NORTH

0 1320 2640 5280

SCALE IN FEET

PROJECT:	ASHLAND/NSP LAKEFRONT SITE ASHLAND, WISCONSIN
TITLE:	FIGURE 2–1 SITE LOCATION MAP

DRAWN BY: DDZ	SCALE: 1" = 2640'	PROJ. NO. 25688375
CHECKED BY: WSB	DATE: 31.JULY.2007	SHEET: 1 OF 3
APPROVED BY: DPT		

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414–831–4100

Legend

NPL Site Boundary

0 125 250 500 750 1,000 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: FIGURE 2-2
NPL SITE BOUNDARY

DRAWN BY: DDZ	SCALE: AS SHOWN	PROJ. NO. 25688375
CHECKED BY: WSB	DATE: 31.JULY.2007	SHEET: 2 OF 3
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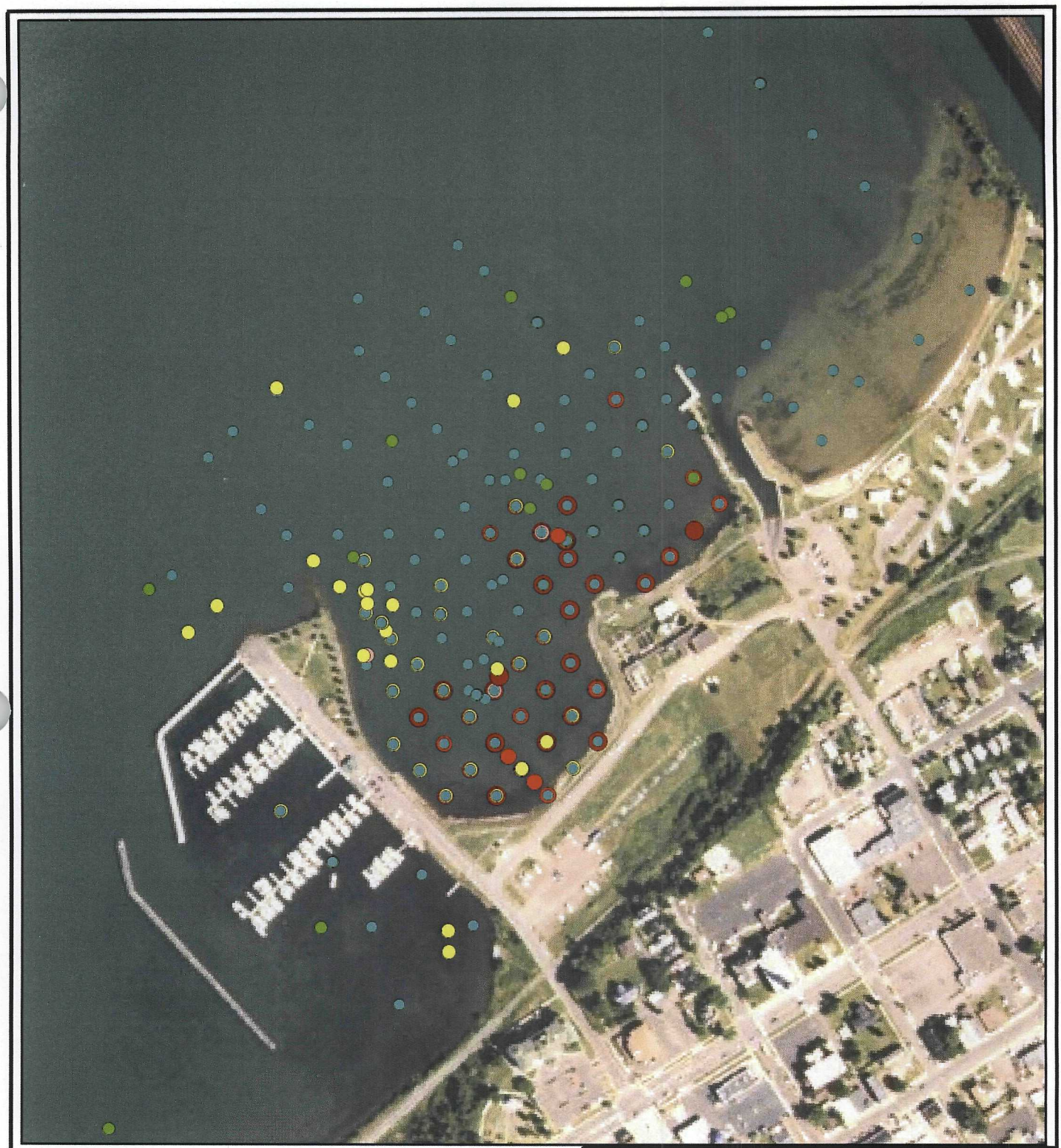

Legend

All Sed Results - Total PAH ppm

Total PAH ppm

- ND
- 1 - 5
- 6 - 10
- 11 - 100
- 101 - 200
- 201 - 1000
- >1000

0 125 250 500 750 1,000 Feet

PROJECT:
ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE:
FIGURE 2-3
AREA OF IMPACTED SEDIMENT

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FINAL REPORT

BASELINE ECOLOGICAL RISK ASSESSMENT - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

VOLUME II: APPENDICES A - I

Prepared for

Northern States Power Company - WI
1414 West Hamilton Avenue
Eau Claire, WI 54701

January 2007

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Milwaukee County Research Park
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Appendices A – I

Appendices

Appendix A Screening for Contaminants of Potential Concern

Appendix B Sediment Quality Triad Study

Appendix C Fish Tissue Investigation

Appendix D Surface Water Investigation

Appendix E Characterization Of Wetlands And Terrestrial Habitats

Appendix F Description of Food Web Modeling

Appendix G Data Quality Objectives (DQOs)

Appendix H Toxicological Reference Values and Benchmarks

Appendix I Exposure and Risk Estimates

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS[2]

µg/g	Micrograms per gram (parts per million)
µg/kg	Micrograms per kilogram (parts per billion)
µg/L	Micrograms per liter (parts per billion)
µW/cm^2	Microwatt per square centimeter
ACR	Acute to chronic ratio
ADD	Average daily dose
Ag	Silver
AH	Aromatic hydrocarbons
ANCOVA	Analysis of covariance
AOI	Area of interest
ARARs	Applicable or relevant and appropriate requirements
As	Arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area use factor
AVS	Acid volatile sulfides
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BaP	Benzo(a)pyrene
BERA	Baseline Ecological Risk Assessment
BSAF	Biota sediment accumulation factors
BTEX	Benzene, toluene, ethylbenzene, and xylene
BW	Body weight
CBR	Critical body residue
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	Chemical of concern
COPC	Chemical of Potential Concern
CS	Contaminated sand
CSM	Conceptual Site Model
Cu	Copper
CW	Contaminated wood
DBH	Diameter breast height
DNA	Deoxyribonucleic acid
DOC	Dissolved organic carbon
DQO	Data Quality Objective
ECOSAR	Ecological Structure Activity Relationships
ECO-SSL	Ecological Screening Level
EC_{20}	Effective concentration – 20 percent response
EC_{50}	Effective concentration – 50 percent response
ED_{20}	Effective dose – 20 percent response
ED_{50}	Effective dose – 50 percent response

[2] This list includes acronyms, abbreviations, and definitions used in the BERA text and appendices.

USEPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERED	Environmental Residue Effects Database
ER-L	Effects range-low
ER-M	Effects range-median
ESA	Endangered Species Act
ESL	Ecological Screening Level
ETO	Ephemeropter, trichoptera, odonata
FS	Feasibility Study
GPS	Global Positioning System
ha	Hectare
Hg	Mercury
HHRA	Human health risk assessment
HMW-PAHs	High molecular weight polycyclic aromatic hydrocarbons
HOMO	Highest occupied molecular orbit
HQ	Hazard Quotient
IR	Ingestion rate
Kow	Octanol-water partition coefficient
LMW-PAHs	Low molecular weight polycyclic aromatic hydrocarbons
LOAEC	Lowest observed adverse effect concentration
LOAEL	Lowest observed adverse effects level
LOEC	Lowest observed effects concentration
LSRI	Lake Superior Research Institute
LUMO	Lowest unoccupied molecular orbit
MD	Maryland
MDR	Minimum daily requirement
mg/kg	Milligrams per kilogram (parts per million)
mg/kg/d	Milligrams per kilogram per day
mg/kg BW/d	Milligrams per kilogram body weight per day
mg/L	Milligrams per Liter (parts per million)
MGP	Manufactured gas plant
MI	Michigan
MSL	Mean sea level
NA	Not applicable
NC	Not calculated
NCP	National Contingency Plan
NE	Not established
NEBR	No effect body residue
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No observed adverse effect concentration
NOAEL	No observed adverse effects level
NOC-PAH	PAH concentration normalized to organic carbon
NOEC	No observed effects concentration
NOEL	No observed effects level

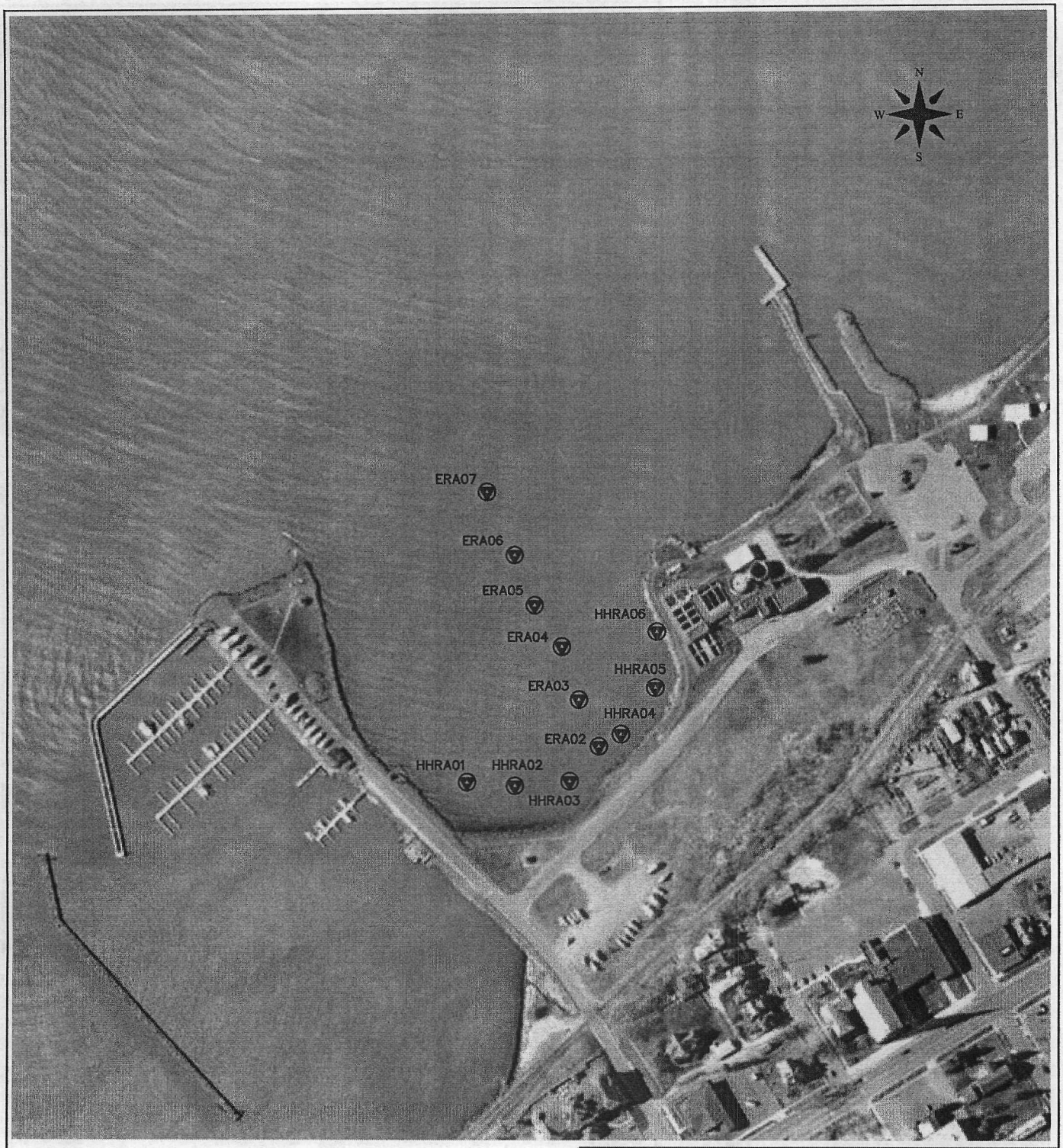
NRDA	Natural Resource Damage Assessment
NRWQC	National Recommended Water Quality Criteria
NSP	Northern States Power
NWI	National Wetland Inventory
OC	Organic carbon
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCBs	Polychlorinated biphenysl
PEC	Probable effects concentration
PER	Photoenzymatic repair
POM	Particulate organic matter
ppm	Parts per million
ppb	Parts per billion
PRG	Preliminary Remedial Goal
QA	Quality assurance
QAPP	Quality assurance project plan
QSARs	Quantitative structure-activity relationships
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROC	Receptor of concern
SLERA	Screening Level Risk Assessment
SEM	Simultaneously extractable metals
SMDP	Scientific Management Decision Point
SQUIRT	NOAA Screening Quick Reference Table
SQT	Sediment Quality Triad
SVOC	Semivolatile organic compound
SW	Surface Water
T&E	Threatened and endangered
TEC	Threshold effect concentration
TEL	Threshold Effects Level
TLM	Target Lipid Model
TOC	Total organic carbon
TPAH	Total polycyclic aromatic hydrocarbons
TRV	Toxicity Reference Value
TU	Toxic unit
UCL	Upper Confidence Limit
UPL	Upper Prediction Limit
USACE	U.S. Army Corp. of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	Ultraviolet light
UVA	Ultraviolet light (340-400 nm)
UVB	Ultraviolet light (280-320 nm)
UVC	Ultraviolet light (200-280 nm)

VOC	Volatile organic compound
WCMP	Wisconsin Coastal Management Program
WDNR	Wisconsin Department of Natural Resources
WI	Wisconsin
WPBCO	Weathered Prudhoe Bay crude oil
WWTP	Waste water treatment plant
Zn	Zinc

Appendix A
Contaminant Screening

Data for screening of contaminants in surface water was taken from stations sampled during the RI investigation (Figure A-1).

Data for screening of contaminants in sediment (Figure A-2) and soil (Figure A-3) was taken from historical data collection activities as well as data collected during the RI. For sediment, data from sampling depths 0-6" was used when available, however, if data from that depth interval was unavailable in areas of the Site, data from the depth interval 0-2' was used. Figure A-2 shows the depth intervals for each station.



LEGEND:

SURFACE WATER SAMPLE STATION

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SURFACE WATER SAMPLE STATIONS

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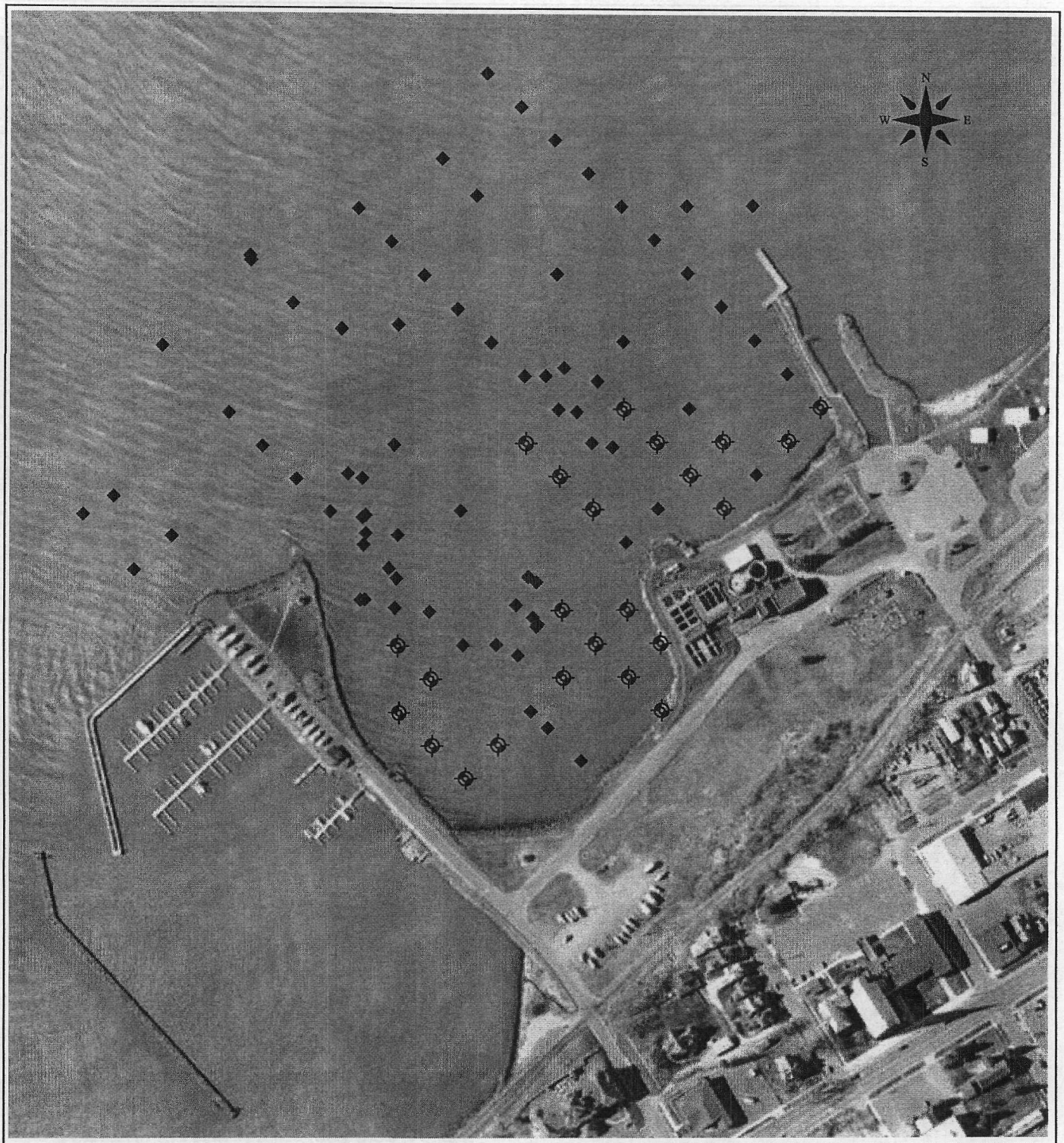

LEGEND:

SEDIMENT SAMPLE STATION

◆ SAMPLE DEPTH = 0–0.5'

⊕ SAMPLE DEPTH = 0–2'

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SEDIMENT SAMPLE STATIONS

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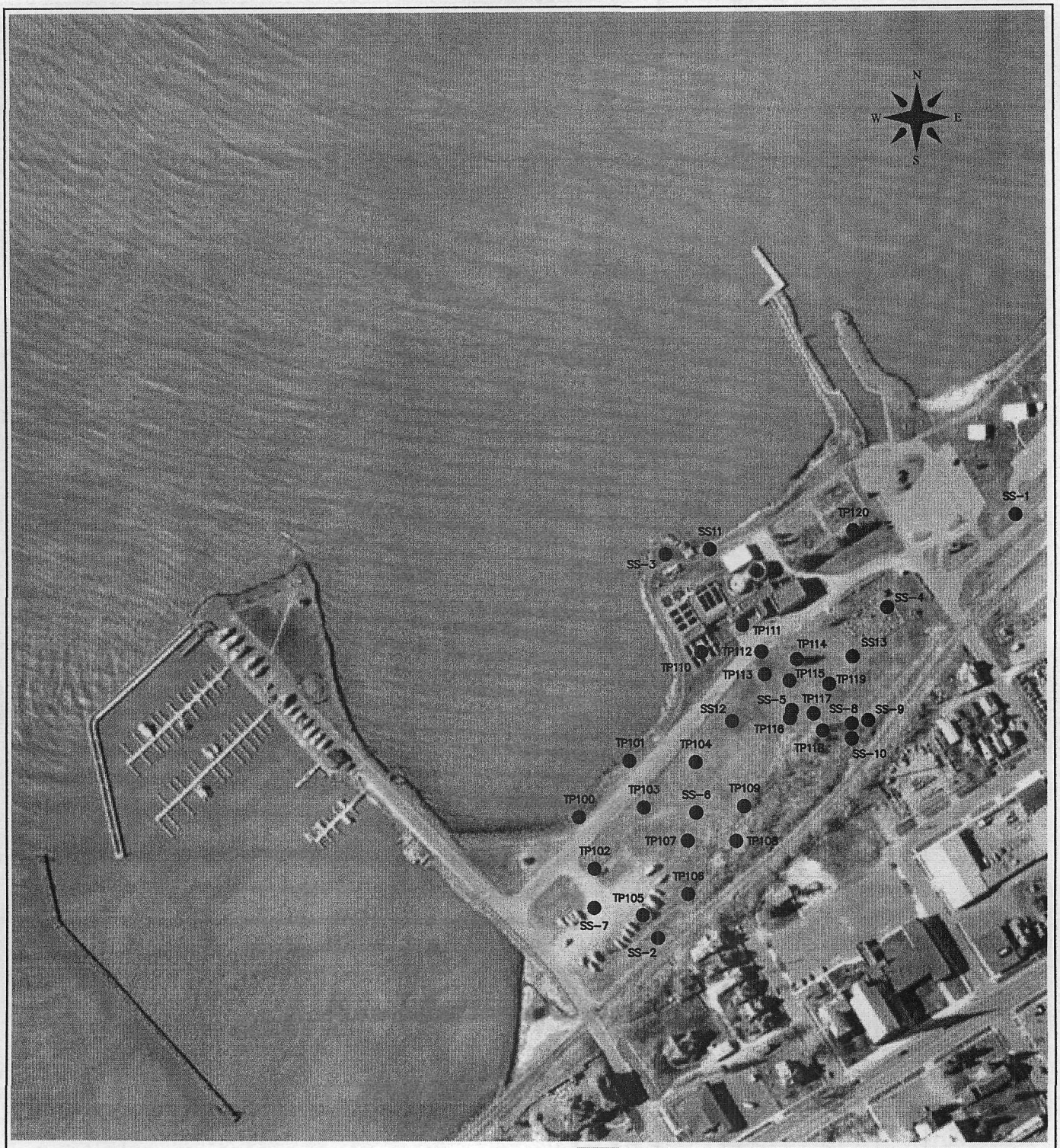

LEGEND:

● SOIL SAMPLE STATION

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SOIL SAMPLE STATIONS

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Table A-1
Surface Water Data Summary - Low Energy Event
Human Health Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Low Energy	VOC	Benzene	ug/L	6	2	33	0.26	0.28	0.14	non-parametric	Jackknife	0.22
Low Energy	VOC	Toluene	ug/L	6	4	67	0.26	0.34	0.25	normal	Student's-t	0.33
Low Energy	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	6	100	1.3	2.7	1.93	normal	Student's-t	2.31

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. 95% UCL = 95% Upper Confidence Limit
4. Table includes data from surface water sampling stations HHRA01, HHRA02, HHRA03, HHRA04, HHRA05 and HHRA06
5. Only consitutents detected at least once were evaluated
6. Data shown is for total fraction (unfiltered samples)
7. Low energy event sampling conducted in June 2005

Data Distribution and 95% UCL:

Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-2
Surface Water Data Summary - High Energy Event
Human Health Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
High Energy	VOC	1,2,4-Trimethylbenzene	ug/L	6	1	17	0.17	0.17	0.10	non-parametric	Jackknife	0.13
High Energy	VOC	Benzene	ug/L	6	5	83	0.15	0.74	0.27	gamma	Standard Bootstrap	0.42
High Energy	VOC	Ethylbenzene	ug/L	6	6	100	0.19	0.48	0.36	normal	Student's-t	0.44
High Energy	VOC	m & p-Xylenes	ug/L	6	2	33	0.39	0.44	0.26	non-parametric	Jackknife	0.36
High Energy	VOC	Toluene	ug/L	6	2	33	0.29	0.31	0.18	non-parametric	Jackknife	0.26
High Energy	PAH	1-Methylnaphthalene	ug/L	6	2	33	1.1	1.1	0.73	non-parametric	Jackknife	0.97
High Energy	PAH	2-Methylnaphthalene	ug/L	6	2	33	1.1	1.2	0.75	non-parametric	Jackknife	1.01
High Energy	PAH	Acenaphthene	ug/L	6	1	17	1.1	1.1	0.64	non-parametric	Jackknife	0.83
High Energy	PAH	Naphthalene	ug/L	6	5	83	1.1	1.8	1.38	normal	Student's-t	1.78
High Energy	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	5	83	0.63	2.1	1.06	normal	Student's-t	1.59

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. 95% UCL = 95% Upper Confidence Limit
4. COC = Constituent of Concern
5. Table includes data from surface water sampling stations HHRA01, HHRA02, HHRA03, HHRA04, HHRA05 and HHRA06
6. Only consitutents detected at least once were evaluated
7. Data shown is for total fraction (unfiltered samples)
8. High energy event sampling conducted in November 2005

Data Distribution and 95% UCL:

Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed,
the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-3
Surface Water Data Summary and Screening - Low Energy Event
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Sample Depth	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	HQ	COC Decision
Low Energy	Mid	VOC	Benzene	ug/L	6	2	33	0.15	0.35	0.13	non-parametric	Jackknife	0.22	11.4	3.07E-02	No
Low Energy	Mid	VOC	Toluene	ug/L	6	6	100	0.3	0.51	0.38	normal	Student's-t	0.44	253	2.02E-03	No
Low Energy	Mid	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	6	100	1.3	2.2	1.53	gamma	Jackknife	1.83	NE	NC	NA
Low Energy	Near Bottom	VOC	Benzene	ug/L	5	1	20	0.37	0.37	0.13	non-parametric	Jackknife	0.26	11.4	3.25E-02	No
Low Energy	Near Bottom	VOC	Toluene	ug/L	5	3	60	0.31	0.49	0.28	normal	Student's-t	0.44	253	1.94E-03	No
Low Energy	Near Bottom	OTHER	Dissolved Organic Carbon (DOC)	mg/L	5	5	100	1.1	1.8	1.48	normal	Student's-t	1.79	NE	NC	NA

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Table includes data from surface water sampling stations ERA02, ERA03, ERA04, ERA05, ERA06 and ERA07; dissolved fraction
10. Only detected consitutents were evaluated
11. Low energy event sampling conducted in June 2005
12. HQ calculated as follows: HQ = Maximum Detected Concentration/Criteria

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-4
Surface Water Data Summary and Screening - High Energy Event
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Sample Depth	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	HQ	COC Decision
High Energy	Mid	VOC	Benzene	ug/L	6	2	33	0.15	0.19	0.10	non-parametric	Jackknife	0.15	11.4	1.67E-02	No
High Energy	Mid	VOC	Ethylbenzene	ug/L	6	1	17	0.22	0.22	0.11	non-parametric	Jackknife	0.15	14	1.57E-02	No
High Energy	Mid	VOC	Toluene	ug/L	6	4	67	0.3	0.41	0.30	normal	Student's-t	0.39	253	1.62E-03	No
High Energy	Mid	PAH	Naphthalene	ug/L	6	2	33	1.6	2.2	1.00	non-parametric	Jackknife	1.59	13	1.69E-01	No
High Energy	Mid	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	3	50	1.8	2.2	1.14	non-parametric	Jackknife	1.92	NE	NC	NA
High Energy	Near Bottom	VOC	Benzene	ug/L	5	5	100	0.14	0.33	0.21	normal	Student's-t	0.29	11.4	2.89E-02	No
High Energy	Near Bottom	VOC	Ethylbenzene	ug/L	5	1	20	0.21	0.21	0.11	non-parametric	Jackknife	0.16	14	1.50E-02	No
High Energy	Near Bottom	VOC	Toluene	ug/L	5	4	80	0.27	0.57	0.42	normal	Student's-t	0.55	253	2.25E-03	No
High Energy	Near Bottom	PAH	Naphthalene	ug/L	5	2	40	1.1	2	0.95	lognormal	Jackknife	1.55	13	1.54E-01	No
High Energy	Near Bottom	OTHER	Dissolved Organic Carbon (DOC)	mg/L	5	4	80	0.75	2.6	1.58	normal	Student's-t	2.55	NE	NC	NA

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Table includes data from surface water sampling stations ERA02, ERA03, ERA04, ERA05, ERA06 and ERA07; dissolved fraction
10. Only detected consitutents were evaluated
11. High energy event sampling conducted in November 2005
12. HQ calculated as follows: HQ = Maximum Detected Concentration/Criteria

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-5
Sediment Data Summary and Screening (Carbon Adjusted Data)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	TEC	PEC	Source	HQ (Max Hit/TEC)	COC Decision	HQ (Max Hit/PEC)	COC Decision	HQ (95% UCL/TEC)	COC Decision	HQ (95% UCL/PEC)	COC Decision
Chequamegon Bay	CYANIDE	Cyanide	mg/kg	72	1	1	0.61	0.61	1.35	non-parametric	Standard Bootstrap	0.61	0.1	NE	Reg V	6.10E+00	Yes	NC	NA	6.10E+00	Yes	NC	NA
Chequamegon Bay	METALS	Aluminum	mg/kg	72	72	100	980	13000	3709.17	non-parametric	Standard Bootstrap	4373.99	25500	NE	SQuiRT	5.10E-01	No	NC	NA	1.72E-01	No	NC	NA
Chequamegon Bay	METALS	Antimony	mg/kg	72	22	31	1.45	4.2	1.68	non-parametric	Standard Bootstrap	1.82	2	25	WDNR 2003	2.10E+00	Yes	1.68E-01	No	9.12E-01	No	7.30E-02	No
Chequamegon Bay	METALS	Arsenic	mg/kg	72	61	85	1.4	30	4.20	non-parametric	Standard Bootstrap	4.91	9.8	33	WDNR 2003	1.06E+00	Yes	9.09E-01	No	5.01E-01	No	1.49E-01	No
Chequamegon Bay	METALS	Barium	mg/kg	72	72	100	5.9	180	46.83	normal	Student's-t	52.63	48	NE	OR	3.75E+00	Yes	NC	NA	1.10E+00	Yes	NC	NA
Chequamegon Bay	METALS	Beryllium	mg/kg	72	66	92	0.041	2.6	0.39	gamma	Standard Bootstrap	0.46	122	NE	OR	2.13E-02	No	NC	NA	3.75E-03	No	NC	NA
Chequamegon Bay	METALS	Cadmium	mg/kg	72	26	36	0.13	11	0.78	lognormal	Standard Bootstrap	0.63	0.99	5	WDNR 2003	1.11E+00	Yes	2.20E-01	No	6.36E-01	No	8.60E-02	No
Chequamegon Bay	METALS	Chromium	mg/kg	72	68	94	2	31	10.04	non-parametric	Standard Bootstrap	11.65	43	110	WDNR 2003	7.21E-01	No	2.82E-01	No	2.71E-01	No	1.06E-01	No
Chequamegon Bay	METALS	Chromium (III)	mg/kg	25	25	100	3	28	10.22	lognormal	Standard Bootstrap	12.57	43	110	WDNR 2003	6.51E-01	No	2.55E-01	No	2.92E-01	No	1.14E-01	No
Chequamegon Bay	METALS	Chromium (VI)	mg/kg	23	16	70	2.5	9.5	5.50	normal	Student's-t	6.13	43	110	WDNR 2003	2.21E-01	No	8.64E-02	No	1.43E-01	No	5.57E-02	No
Chequamegon Bay	METALS	Cobalt	mg/kg	72	72	100	1.1	16	4.51	gamma	Standard Bootstrap	5.17	43.4	NE	Reg V	3.69E-01	No	NC	NA	1.19E-01	No	NC	NA
Chequamegon Bay	METALS	Copper	mg/kg	72	72	100	1.8	700	72.48	gamma	Standard Bootstrap	91.38	32	150	WDNR 2003	2.19E+01	Yes	4.67E+00	Yes	2.86E+00	Yes	6.09E-01	No
Chequamegon Bay	METALS	Iron	mg/kg	72	72	100	2100	93000	11720.83	non-parametric	Standard Bootstrap	13938.74	20000	40000	WDNR 2003	4.65E+00	Yes	2.33E+00	Yes	6.97E+01	No	3.48E+01	No
Chequamegon Bay	METALS	Lead	mg/kg	72	49	68	6.2	200	24.93	gamma	Standard Bootstrap	29.56	36	130	WDNR 2003	5.56E+00	Yes	1.54E+00	Yes	8.21E+01	No	2.27E+01	No
Chequamegon Bay	METALS	Manganese	mg/kg	72	72	100	34	460	148.40	gamma	Standard Bootstrap	167.96	460	1100	WDNR 2003	1.00E+00	Yes	4.18E-01	No	3.65E+01	No	1.53E+01	No
Chequamegon Bay	METALS	Mercury	mg/kg	72	36	50	0.029	1.2	0.10	non-parametric	Standard Bootstrap	0.13	0.18	1.1	WDNR 2003	6.67E+00	Yes	1.09E+00	Yes	7.22E+01	No	1.18E+01	No
Chequamegon Bay	METALS	Nickel	mg/kg	72	63	88	1.4	52	9.21	gamma	Standard Bootstrap	10.74	23	49	WDNR 2003	2.26E+00	Yes	1.06E+00	Yes	4.67E+01	No	2.19E+01	No
Chequamegon Bay	METALS	Selenium	mg/kg	72	21	29	0.83	16	1.63	non-parametric	Standard Bootstrap	1.99	1	NE	SQuiRT	1.60E+01	Yes	NC	NA	1.99E+00	Yes	NC	NA
Chequamegon Bay	METALS	Silver	mg/kg	72	8	11	0.35	2.5	0.55	non-parametric	Standard Bootstrap	0.61	1.6	2.2	WDNR 2003	1.56E+00	Yes	1.14E+00	Yes	1.82E+01	No	2.78E+01	No
Chequamegon Bay	METALS	Thallium	mg/kg	72	14	19	0.7	4.1	1.47	non-parametric	Standard Bootstrap	1.60	0.7	NE	OR	5.86E+00	Yes	NC	NA	2.29E+00	Yes	NC	NA
Chequamegon Bay	METALS	Vanadium	mg/kg	72	71	99	8.3	60	20.15	non-parametric	Standard Bootstrap	22.62	57	NE	SQuiRT	1.05E+00	Yes	NC	NA	3.97E+01	No	NC	NA
Chequamegon Bay	METALS	Zinc	mg/kg	72	72	100	7.3	140	60.95	non-parametric	Standard Bootstrap	67.13	120	460	WDNR 2003	1.17E+00	Yes	3.04E-01	No	5.59E-01	No	1.46E-01	No
Chequamegon Bay	PAH	1-Methylnaphthalene	ug/kg	127	81	64	12	98000	3579.75	non-parametric	Standard Bootstrap	5486.80	NE	NE	T50	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	1-Methylphenanthrene	ug/kg	65	28	43	150	14000	781.89	non-parametric	Standard Bootstrap	1218.71	NE	NE	T50	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	2,3,5-Trimethylnaphthalene	ug/kg OC	65	20	31	190.909	3333333.33	93525.93	non-parametric	Standard Bootstrap	181097.50	988	NE	TLM	3.37E+03	Yes	NC	NA	1.83E+02	Yes	NC	NA
Chequamegon Bay	PAH	2,6-Dimethylnaphthalene	ug/kg	65	26	40	54	56000	2314.12	non-parametric	Standard Bootstrap	4127.43	NE	NE	T50	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	2-Methylnaphthalene	ug/kg	140	99	66	12	2380000	48194.27	non-parametric	Standard Bootstrap	85754.45	NE	240	BC	NC	NA	9.92E+03	Yes	NC	NA	3.57E+02	Yes
Chequamegon Bay	PAH	Acenaphthene	ug/kg dw @ 1%TOC	150	103	69	0.83	1233333.3	30284.81	non-parametric	Standard Bootstrap	50813.16	6.7	89	WDNR 2003	1.84E+05	Yes	1.39E+04	Yes	7.58E+03	Yes	5.71E+02	Yes
Chequamegon Bay	PAH	Acenaphthylene	ug/kg dw @ 1%TOC	147	90	61	0.77	75000	2470.57	non-parametric	Standard Bootstrap	3803.62	5.9	128	WDNR 2003	1.27E+04	Yes	5.86E+02	Yes	6.45E+02	Yes	2.97E+01	Yes
Chequamegon Bay	PAH	Anthracene	ug/kg dw @ 1%TOC	150	98	65	1.39	366666.7	10843.61	non-parametric	Standard Bootstrap	17523.27	57.2	845	WDNR 2003	6.41E+03	Yes	4.34E+02	Yes	3.06E+02	Yes	2.07E+01	Yes
Chequamegon Bay	PAH	Benzo(a)anthracene	ug/kg dw @ 1%TOC	152	129	85	4.77	236666.7	6263.33	non-parametric	Standard Bootstrap	9793.06	108	1050	WDNR 2003	2.19E+03	Yes	2.25E+02	Yes	9.07E+01	Yes	9.33E+00	Yes
Chequamegon Bay	PAH	Benzo(a)pyrene	ug/kg dw @ 1%TOC	155	130	84	3.77	206666.7	5199.29	non-parametric	Standard Bootstrap	7947.04	150	1450	WDNR 2003	1.38E+03	Yes	1.43E+02	Yes	5.30E+01	Yes	5.48E+00	Yes
Chequamegon Bay	PAH	Benzo(b)fluoranthene	ug/kg dw @ 1%TOC	151	125	83	1.98	93333.3	2844.98	non-parametric	Standard Bootstrap	4189.58	240	13400	WDNR 2003	3.89E+02	Yes	6.97E+00	Yes	1.75E+01	Yes	3.13E-01	No
Chequamegon Bay	PAH	Benzo(e)pyrene	ug/kg dw @ 1%TOC	121	100	83	3.62	113333.3	1819.38	non-parametric	Standard Bootstrap	3337.69	150	1450	WDNR 2003	7.56E+02	Yes	7.82E+01	Yes	2.23E+01	Yes	2.30E+00	Yes
Chequamegon Bay	PAH	Benzo(g,h,i)perylene	ug/kg dw @ 1%TOC	150	101	67	0.55	100000	2449.51	lognormal	Standard Bootstrap	3200.98	170	3200	WDNR 2003	5.88E+02	Yes	3.13E+01	Yes	2.18E+01	Yes	1.16E+00	Yes
Chequamegon Bay	PAH	Benzo(k)fluoranthene	ug/kg dw @ 1%TOC	151	102	68	1.98	123333.3	3109.15	lognormal	Standard Bootstrap	4773.51	240	13400	WDNR 2003	5.14E+02	Yes	9.20E+00	Yes	1.99E+01	Yes	3.56E-01	No
Chequamegon Bay	PAH	Biphenyl	ug/kg	65	23	35	49	25000	1058.54	non-parametric	Standard Bootstrap	1846.39	NE	NE	T50	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	Chrysene	ug/kg dw @ 1%TOC	152	131	86	5.08	210000	5686.46	non-parametric	Standard Bootstrap	8746.02	166	1290	WDNR 2003	1.27E+03	Yes	1.63E+02	Yes	5.27E+01	Yes	6.78E+00	Yes
Chequamegon Bay	PAH	Dibenzo(a,h)anthracene	ug/kg dw @ 1%TOC	145	60	41	0.55	19000	1159.98	non-parametric	Standard Bootstrap	1613.56	33	135	WDNR 2003	5.76E+02	Yes	1.41E+02	Yes	4.89E+01	Yes	1.20E+01	Yes
Chequamegon Bay	PAH	Fluoranthene	ug/kg dw @ 1%TOC	152	134	88	7.28	533333.3	13405.71	non-parametric	Standard Bootstrap	20929.75	423	2230	WDNR 2003	1.26E+03	Yes	2.39E+02	Yes	4.95E+01	Yes	9.39E+00	Yes
Chequamegon Bay	PAH	Fluorene	ug/kg dw @ 1%TOC	148	91	61	0.52	500000	12084.04	non-parametric	Standard Bootstrap	20192.02	77.4	536	WDNR 2003	6.46E+03	Yes	9.33E+02	Yes	2.61E+02	Yes	3.77E+01	Yes
Chequamegon Bay	PAH	Indeno(1,2,3-cd)pyrene	ug/kg dw @ 1%TOC	150	96	63	0.55	90666.7	2277.64	non-parametric	Standard Bootstrap	1491.95	200	1200	WDNR 2003	4.83E+02	Yes	3.02E+01	Yes	1.75E+01	Yes	1.09E+00	Yes
Chequamegon Bay	PAH	Naphthalene	ug/kg dw @ 1%TOC	178	126	71	1.67	2710000	77245.64	non-parametric	Standard Bootstrap	119526.42	176	561	WDNR 2003	1.54E+04	Yes	4.83E+03	Yes	6.79E+02	Yes	2.13E+02	Yes
Chequamegon Bay	PAH	Perylene	ug/kg OC	65	19	29	483.636	3033333.33	76168.38	non-parametric	Standard Bootstrap	151070.85	812	NE	TLM	3.74E+03	Yes	NC	NA	1.86E+02	Yes	NC	NA

Table A-5
Sediment Data Summary and Screening (Carbon Adjusted Data)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	TEC	PEC	Source	HQ (Max Hit/TEC)	COC Decision	HQ (Max Hit/PEC)	COC Decision	HQ (95% UCL/TEC)	COC Decision	HQ (95% UCL/PEC)	COC Decision
Chequamegon Bay	PAH	Phenanthrene	ug/kg dw @ 1%TOC	155	122	79	3.03	1833333.3	38877.17	non-parametric	Standard Bootstrap	63952.03	204	1170	WDNR 2003	8.99E+03	Yes	1.57E+03	Yes	3.13E+02	Yes	5.47E+01	Yes
Chequamegon Bay	PAH	Pyrene	ug/kg dw @ 1%TOC	155	135	87	12.02	1000000	20118.60	non-parametric	Standard Bootstrap	32502.93	195	1520	WDNR 2003	5.13E+03	Yes	6.58E+02	Yes	1.67E+02	Yes	2.14E+01	Yes
Chequamegon Bay	SVOC	Dibenzofuran	ug/kg dw @ 1%TOC	106	57	54	0.54	40000	545.59	non-parametric	Standard Bootstrap	1170.73	150	580	WDNR 2003	2.67E+03	Yes	6.90E+01	Yes	7.80E+00	Yes	2.02E+00	Yes
Chequamegon Bay	SVOC	m & p-cresols	ug/kg	65	16	25	8.5	670	268.44	non-parametric	Standard Bootstrap	376.00	52.4	NE	Reg V	1.28E+01	Yes	NC	NA	7.18E+00	Yes	NC	NA
Chequamegon Bay	SVOC	o-Cresol	ug/kg	106	25	24	1.2	64	70.70	non-parametric	Standard Bootstrap	64.00	55.4	NE	Reg V	1.16E+00	Yes	NC	NA	1.16E+00	Yes	NC	NA
Chequamegon Bay	SVOC	p-Cresol	ug/kg	41	25	61	13	1100	78.13	non-parametric	Standard Bootstrap	121.60	52.4	NE	Reg V	2.10E+01	Yes	NC	NA	2.32E+00	Yes	NC	NA
Chequamegon Bay	SVOC	Phenol	ug/kg dw @ 1%TOC	106	26	25	0.53	333.33	76.19	non-parametric	Standard Bootstrap	118.30	4200	12000	WDNR 2003	7.94E-02	No	2.78E-02	No	2.82E-02	No	9.86E-03	No
Chequamegon Bay	TOTAL PAH	Total PAH	ug/kg dw @ 1%TOC	155	148	95	70.45	11646000	293125.63	non-parametric	Standard Bootstrap	477334.36	1610	22800	WDNR 2003	7.23E+03	Yes	5.11E+02	Yes	3.96E+02	Yes	2.09E+01	Yes
Chequamegon Bay	VOC	1,2,4-Trimethylbenzene	ug/kg OC	115	32	28	16.6667	1790000.00	106792.96	non-parametric	Standard Bootstrap	169351.18	1147	NE	TLM	1.56E+03	Yes	NC	NA	1.48E+02	Yes	NC	NA
Chequamegon Bay	VOC	1,3,5-Trimethylbenzene	ug/kg OC	115	21	18	16.6667	88400.00	83489.99	non-parametric	Standard Bootstrap	88400.00	1147	NE	TLM	7.71E+01	Yes	NC	NA	7.71E+01	Yes	NC	NA
Chequamegon Bay	VOC	Benzene	ug/kg dw @ 1%TOC	124	18	15	0.227	317.65	761.16	non-parametric	Standard Bootstrap	317.65	57	110	WDNR 2003	5.57E+00	Yes	2.89E+00	Yes	5.57E+00	Yes	2.89E+00	Yes
Chequamegon Bay	VOC	Ethylbenzene	ug/kg	124	28	23	5	31900	1647.89	non-parametric	Standard Bootstrap	2324.12	175	NE	Reg V	1.82E+02	Yes	NC	NA	1.33E+01	Yes	NC	NA
Chequamegon Bay	VOC	sec-Butyl benzene	ug/kg dw @ 1%TOC	112	10	9	0.167	1.94	841.32	non-parametric	Standard Bootstrap	1.94	25	50	WDNR 2003	7.74E-02	No	3.87E-02	No	7.74E-02	No	3.87E-02	No
Chequamegon Bay	VOC	Styrene	ug/kg	112	9	8	5	10	839.43	non-parametric	Standard Bootstrap	10.00	254	NE	Reg V	3.94E-02	No	NC	NA	3.94E-02	No	NC	NA
Chequamegon Bay	VOC	Toluene	ug/kg dw @ 1%TOC	124	70	56	0.167	14000	905.33	non-parametric	Standard Bootstrap	1472.03	890	1800	WDNR 2003	1.57E-01	Yes	7.78E+00	Yes	1.65E+00	Yes	8.18E-01	No
Chequamegon Bay	VOC	Xylenes (total)	ug/kg dw @ 1%TOC	75	19	25	0.167	35000	2703.19	non-parametric	Standard Bootstrap	4364.84	23	50	WDNR 2003	1.40E+03	Yes	7.00E+02	Yes	1.75E+02	Yes	8.73E+01	Yes

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Only detected constituents were evaluated
10. TEC = Threshold Effect Concentration (
11. PEC = Probable Effect Concentration

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004)
For normally distributed data, the Student-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jackknife UCL was selected

Criteria sources:
CBR for baseline narcotics is 6.94 umol/g lipid
CBR for PAHs is 3.79 umol/g lipid
WDNR 2003 = WDNR 2003 Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application Interim Guidance
ESL=Region V Ecological Screening Levels
Region IV WQS=EPA Region IV Water Management Division Screening List from ACQUIRE
TLM=Target Lipid Model (DiToro and McGrath 2000-See text)
T50 =Logistic model point estimate of T50 concentrations (concentration at which 50% of samples are predicted to be toxic; Field et al. 2002)
SQuiRT=NOAA. Screening Quick Reference Tables
BC= Criria for Managing Contaminated Sediment in British Columbia. MWLAP. 2004
OSWER Tier II=ORNL Tier 2 value
Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D.E. Smorong, and R.A. Lindskoog. 2002
Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environmental Toxicology and Chemistry. 21(9) 1993-2005

Table A-6
Sediment Data Summary
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Chequamegon Bay	CYANIDE	Cyanide	mg/kg	72	1	1	0.61	0.61	1.35	non-parametric	Standard Bootstrap	0.61
Chequamegon Bay	METALS	Aluminum	mg/kg	72	72	100	980	13000	3709.17	non-parametric	Standard Bootstrap	4373.99
Chequamegon Bay	METALS	Antimony	mg/kg	72	22	31	1.45	4.2	1.68	non-parametric	Standard Bootstrap	1.82
Chequamegon Bay	METALS	Arsenic	mg/kg	72	61	85	1.4	30	4.20	non-parametric	Standard Bootstrap	4.91
Chequamegon Bay	METALS	Barium	mg/kg	72	72	100	5.3	180	46.83	normal	Student's-t	52.63
Chequamegon Bay	METALS	Beryllium	mg/kg	72	66	92	0.041	2.6	0.39	gamma	Standard Bootstrap	0.46
Chequamegon Bay	METALS	Cadmium	mg/kg	72	26	36	0.13	1.1	0.38	lognormal	Standard Bootstrap	0.43
Chequamegon Bay	METALS	Chromium	mg/kg	72	68	94	2	31	10.04	non-parametric	Standard Bootstrap	11.65
Chequamegon Bay	METALS	Chromium (III)	mg/kg	23	23	100	3	28	10.22	lognormal	Standard Bootstrap	12.57
Chequamegon Bay	METALS	Chromium (VI)	mg/kg	23	16	70	2.5	9.5	5.50	normal	Student's-t	6.13
Chequamegon Bay	METALS	Cobalt	mg/kg	72	72	100	1.1	16	4.51	gamma	Standard Bootstrap	5.17
Chequamegon Bay	METALS	Copper	mg/kg	72	72	100	1.8	700	72.48	gamma	Standard Bootstrap	91.38
Chequamegon Bay	METALS	Iron	mg/kg	72	72	100	3100	93000	11720.83	non-parametric	Standard Bootstrap	13938.74
Chequamegon Bay	METALS	Lead	mg/kg	72	49	68	6.2	200	24.43	gamma	Standard Bootstrap	29.56
Chequamegon Bay	METALS	Manganese	mg/kg	72	72	100	34	460	148.40	gamma	Standard Bootstrap	167.96
Chequamegon Bay	METALS	Mercury	mg/kg	72	36	50	0.029	1.2	0.10	non-parametric	Standard Bootstrap	0.13
Chequamegon Bay	METALS	Nickel	mg/kg	72	63	88	1.4	52	9.21	gamma	Standard Bootstrap	10.74
Chequamegon Bay	METALS	Selenium	mg/kg	72	21	29	0.83	16	1.63	non-parametric	Standard Bootstrap	1.99
Chequamegon Bay	METALS	Silver	mg/kg	72	8	11	0.35	2.5	0.55	non-parametric	Standard Bootstrap	0.61
Chequamegon Bay	METALS	Thallium	mg/kg	72	14	19	0.7	4.1	1.47	non-parametric	Standard Bootstrap	1.60
Chequamegon Bay	METALS	Vanadium	mg/kg	72	71	99	8.3	60	20.15	non-parametric	Standard Bootstrap	22.62
Chequamegon Bay	METALS	Zinc	mg/kg	72	72	100	7.3	140	60.95	non-parametric	Standard Bootstrap	67.13
Chequamegon Bay	PAH	1-Methylnaphthalene	ug/kg	127	81	64	12	98000	3579.75	non-parametric	Standard Bootstrap	5486.80
Chequamegon Bay	PAH	1-Methylphenanthrene	ug/kg	65	28	43	150	14000	781.89	non-parametric	Standard Bootstrap	1218.71
Chequamegon Bay	PAH	2,3,5-Trimethylnaphthalene	ug/Kg	65	20	31	21	6700	333.65	non-parametric	Standard Bootstrap	559.04
Chequamegon Bay	PAH	2,6-Dimethylnaphthalene	ug/kg	65	26	40	54	56000	2314.12	non-parametric	Standard Bootstrap	4127.43
Chequamegon Bay	PAH	2-Methylnaphthalene	ug/kg	149	99	66	12	2380000	48394.27	non-parametric	Standard Bootstrap	85754.45
Chequamegon Bay	PAH	Acenaphthene	ug/kg	150	103	69	4.9	1020000	22005.86	non-parametric	Standard Bootstrap	37622.62
Chequamegon Bay	PAH	Acenaphthylene	ug/kg	147	90	61	10.0	75000	2304.64	non-parametric	Standard Bootstrap	3558.12
Chequamegon Bay	PAH	Anthracene	ug/kg	150	98	65	6.6	360000	8343.66	non-parametric	Standard Bootstrap	13835.00
Chequamegon Bay	PAH	Benzo(a)anthracene	ug/kg	152	129	85	13.0	150000	5322.40	lognormal	Standard Bootstrap	7735.40
Chequamegon Bay	PAH	Benzo(a)pyrene	ug/kg	155	130	84	14.0	100000	4624.58	lognormal	Standard Bootstrap	6269.37
Chequamegon Bay	PAH	Benzo(b)fluoranthene	ug/kg	151	125	83	12.0	50000	2817.47	lognormal	Standard Bootstrap	3681.96
Chequamegon Bay	PAH	Benzo(e)pyrene	ug/kg	121	100	83	47.0	11000	1323.63	lognormal	Standard Bootstrap	1635.84
Chequamegon Bay	PAH	Benzo(g,h,i)perylene	ug/kg	150	101	67	16.5	37000	2079.95	lognormal	Standard Bootstrap	2700.87
Chequamegon Bay	PAH	Benzo(k)fluoranthene	ug/kg	151	102	68	13.0	71000	2759.87	non-parametric	Standard Bootstrap	3895.77
Chequamegon Bay	PAH	Biphenyl	ug/Kg	65	23	35	49	25000	1058.54	non-parametric	Standard Bootstrap	1846.39
Chequamegon Bay	PAH	Chrysene	ug/kg	152	131	86	16.0	130000	4954.06	lognormal	Standard Bootstrap	7063.66
Chequamegon Bay	PAH	Dibenzo(a,h)anthracene	ug/kg	145	60	41	15	3259	1087.75	non-parametric	Standard Bootstrap	1489.27
Chequamegon Bay	PAH	Fluoranthene	ug/kg	152	134	88	31	330000	10241.12	lognormal	Standard Bootstrap	15426.23
Chequamegon Bay	PAH	Fluorene	ug/kg	148	91	61	5.80	500000	9522.09	non-parametric	Standard Bootstrap	16609.75
Chequamegon Bay	PAH	Indeno(1,2,3-cd)pyrene	ug/kg	150	94	63	6.7	39000.0	1875.43	non-parametric	Standard Bootstrap	2496.77
Chequamegon Bay	PAH	Naphthalene	ug/kg	178	126	71	30	2710000	68265.49	non-parametric	Standard Bootstrap	107468.76
Chequamegon Bay	PAH	Perylene	ug/Kg	65	19	29	43	910.00	310.71	non-parametric	Standard Bootstrap	416.24
Chequamegon Bay	PAH	Phenanthrene	ug/kg	155	122	79	23	1200000	26234.33	non-parametric	Standard Bootstrap	43329.29
Chequamegon Bay	PAH	Pyrene	ug/kg	155	135	87	45	439000	14318.95	lognormal	Standard Bootstrap	21300.94

Table A-6
Sediment Data Summary
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Chequamegon Bay	SVOC	Dibenzofuran	ug/kg	106	57	54	9.20	5100	208.16	non-parametric	Standard Bootstrap	303.32
Chequamegon Bay	SVOC	m & p-cresols	ug/Kg	65	16	25	8.5	670	268.44	non-parametric	Standard Bootstrap	376.00
Chequamegon Bay	SVOC	o-Cresol	ug/kg	106	25	24	1.2	64	70.70	non-parametric	Standard Bootstrap	64.00
Chequamegon Bay	SVOC	p-Cresol	ug/kg	41	25	61	13	1100	78.13	non-parametric	Standard Bootstrap	121.60
Chequamegon Bay	SVOC	Phenol	ug/kg	106	26	25	3	240	86.10	non-parametric	Standard Bootstrap	118.94
Chequamegon Bay	TOTAL PAH	Total PAH	ug/kg	155	148	95	358	9079000	224802.67	non-parametric	Standard Bootstrap	364018.51
Chequamegon Bay	VOC	1,2,4-Trimethylbenzene	ug/kg	115	32	28	5	17900	1144.72	non-parametric	Standard Bootstrap	1798.44
Chequamegon Bay	VOC	1,3,5-Trimethylbenzene	ug/kg	115	21	18	5	1300	856.91	non-parametric	Standard Bootstrap	1300.00
Chequamegon Bay	VOC	Benzene	ug/kg	124	18	15	5	540	775.09	non-parametric	Standard Bootstrap	540.00
Chequamegon Bay	VOC	Ethylbenzene	ug/kg	124	28	23	5	31900	1447.89	non-parametric	Standard Bootstrap	2324.12
Chequamegon Bay	VOC	sec-Butyl benzene	ug/kg	112	10	9	5	10.00	840.26	non-parametric	Standard Bootstrap	10.00
Chequamegon Bay	VOC	Styrene	ug/kg	112	9	8	5	10	839.43	non-parametric	Standard Bootstrap	10.00
Chequamegon Bay	VOC	Toluene	ug/kg	124	70	56	5	14000	999.40	non-parametric	Standard Bootstrap	1569.67
Chequamegon Bay	VOC	Xylenes (total)	ug/kg	75	19	25	5	35000	2712.99	non-parametric	Standard Bootstrap	4365.68

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.

Table A-7
Soil Data Summary and Screening
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	Criteria Source	HQ (Max Hit/Criteria)	COC Decision	HQ (95% UCL/Criteria)	COC Decision
Kreher Park	CYANIDE	Cyanide	mg/kg	25	11	44	0.12	1.4	0.25	Non-parametric	Standard Bootstrap	0.36	5.33	EPA 2003a	1.05E+00	Yes	2.71E-01	No
Kreher Park	METALS	Aluminum	mg/Kg	24	24	100	870	14000	8561.25	Normal	Student's-t	9584.38	NE	NA	NC	NA	NC	NA
Kreher Park	METALS	Antimony	mg/Kg	24	4	17	1.4	2.1	0.95	Non-parametric	Standard Bootstrap	1.10	0.27	EPA 2005	7.78E+00	Yes	4.07E+00	Yes
Kreher Park	METALS	Arsenic	mg/kg	34	31	91	1.3	13.9	4.37	lognormal	Standard Bootstrap	5.38	18	EPA 2005	7.72E-01	No	2.99E-01	No
Kreher Park	METALS	Barium	mg/Kg	24	24	100	10	420	114.58	gamma	Standard Bootstrap	140.60	330	EPA 2005	1.27E+00	Yes	4.26E-01	No
Kreher Park	METALS	Beryllium	mg/Kg	24	23	96	0.1	8.3	1.12	Non-parametric	Standard Bootstrap	1.65	21	EPA 2005	3.95E-01	No	7.86E-02	No
Kreher Park	METALS	Cadmium	mg/kg	34	18	53	0.143	12	0.75	Non-parametric	Standard Bootstrap	1.31	0.36	EPA 2005	3.33E+01	Yes	3.64E+00	Yes
Kreher Park	METALS	Chromium	mg/kg	34	34	100	2.4	29	17.35	Normal	Student's-t	19.18	26	EPA 2005	1.12E+00	Yes	7.38E-01	No
Kreher Park	METALS	Chromium (III)	mg/Kg	24	24	100	2.1	29	19.34	Normal	Student's-t	21.40	26	EPA 2005	1.12E+00	Yes	8.23E-01	No
Kreher Park	METALS	Chromium (VI)	mg/Kg	24	20	83	0.17	0.62	0.27	Normal	Student's-t	0.31	26	EPA 2005	2.38E-02	No	1.19E-02	No
Kreher Park	METALS	Cobalt	mg/Kg	24	24	100	0.91	12	7.03	Non-parametric	Standard Bootstrap	7.65	13	EPA 2005	9.23E-01	No	5.88E-01	No
Kreher Park	METALS	Copper	mg/kg	34	34	100	2.2	120	43.43	gamma	Standard Bootstrap	51.62	54	EPA 2003b	2.22E+00	Yes	9.56E-01	No
Kreher Park	METALS	Iron	mg/kg	34	34	100	4100	94000	20887.65	Non-parametric	Standard Bootstrap	25072.46	NE	NA	NC	NA	NC	NA
Kreher Park	METALS	Lead	mg/kg	34	33	97	5.19	950	104.13	gamma	Standard Bootstrap	153.26	11	EPA 2005	8.64E+01	Yes	1.39E+01	Yes
Kreher Park	METALS	Manganese	mg/Kg	24	24	100	100	670	311.25	Non-parametric	Standard Bootstrap	348.15	152	EPA 2003b	4.41E+00	Yes	2.29E+00	Yes
Kreher Park	METALS	Mercury	mg/kg	34	15	44	0.075	0.8	0.14	Non-parametric	Standard Bootstrap	0.20	0.1	Reg V ESL	8.00E+00	Yes	2.00E+00	Yes
Kreher Park	METALS	Nickel	mg/Kg	24	24	100	2	33	16.41	Non-parametric	Standard Bootstrap	18.10	48	EPA 2003b	6.88E-01	No	3.77E-01	No
Kreher Park	METALS	Selenium	mg/Kg	24	3	13	1.4	2.1	0.83	Non-parametric	Standard Bootstrap	0.95	0.028	EPA 2003b	7.50E+01	Yes	3.39E+01	Yes
Kreher Park	METALS	Silver	mg/Kg	24	6	25	0.72	7.6	0.97	Non-parametric	Standard Bootstrap	1.55	4.04	Reg V ESL	1.88E+00	Yes	3.84E-01	No
Kreher Park	METALS	Thallium	mg/kg	24	1	4	2.4	2.4	0.93	Non-parametric	Standard Bootstrap	1.04	0.057	Reg V ESL	4.21E+01	Yes	1.82E+01	Yes
Kreher Park	METALS	Vanadium	mg/Kg	24	24	100	8.9	63	33.37	Non-parametric	Standard Bootstrap	36.44	78	EPA 2005	8.08E-01	No	4.67E-01	No
Kreher Park	METALS	Zinc	mg/kg	34	34	100	43	4100	253.99	lognormal	Standard Bootstrap	445.94	120	EPA 2003b	3.42E+01	Yes	3.72E+00	Yes
Kreher Park	PAH	Acenaphthene	ug/Kg	24	1	4	490	490	327.83	Non-parametric	Standard Bootstrap	490	682000	EPA 2003a	7.18E-04	No	7.18E-04	No
Kreher Park	PAH	Acenaphthylene	ug/kg	25	6	24	190	27000	1623.86	Non-parametric	Standard Bootstrap	3367.61	682000	EPA 2003a	3.96E-02	No	4.94E-03	No
Kreher Park	PAH	Anthracene	ug/Kg	24	1	4	1600	1600	431.33	Non-parametric	Standard Bootstrap	794.01	1480000	EPA 2003a	1.08E-03	No	4.76E-04	No
Kreher Park	PAH	Benzo(a)anthracene	ug/kg	27	14	52	240	25000	2095.22	lognormal	Standard Bootstrap	3676.16	5210	EPA 2003a	4.80E+00	Yes	7.06E-01	No
Kreher Park	PAH	Benzo(a)pyrene	ug/kg	34	16	47	290	68000	3518.12	Non-parametric	Standard Bootstrap	6823.35	1520	EPA 2003a	4.47E+01	Yes	4.49E+00	Yes
Kreher Park	PAH	Benzo(b)fluoranthene	ug/kg	27	16	59	330	53000	3651.56	lognormal	Standard Bootstrap	6824.57	59000	EPA 2003a	8.86E-01	No	1.14E-01	No
Kreher Park	PAH	Benzo(e)pyrene	ug/Kg	24	10	42	250	49000	2648.00	lognormal	Standard Bootstrap	5976.66	1520	BaP surrogate	3.22E+01	Yes	3.93E+00	Yes
Kreher Park	PAH	Benzo(g,h,i)perylene	ug/kg	27	8	30	210	57000	3724.61	Non-parametric	Standard Bootstrap	7287.91	119000	EPA 2003a	4.79E-01	No	6.12E-02	No
Kreher Park	PAH	Benzo(k)fluoranthene	ug/Kg	24	3	13	460	15000	932.17	Non-parametric	Standard Bootstrap	1937.21	148000	EPA 2003a	1.01E-01	No	1.31E-02	No
Kreher Park	PAH	Chrysene	ug/kg	27	13	48	270	32000	2321.26	lognormal	Standard Bootstrap	4276.34	4730	EPA 2003a	6.77E+00	Yes	9.04E-01	No
Kreher Park	PAH	Fluoranthene	ug/kg	27	15	56	250	25000	2392.61	gamma	Standard Bootstrap	4003.47	122000	EPA 2003a	2.05E-01	No	3.28E-02	No
Kreher Park	PAH	Fluorene	ug/Kg	24	1	4	570	570	331.17	Non-parametric	Standard Bootstrap	547.68	122000	EPA 2003a	4.67E-03	No	4.49E-03	No
Kreher Park	PAH	Indeno(1,2,3-cd)pyrene	ug/kg	27	7	26	190	33000	2543.76	Non-parametric	Standard Bootstrap	4703.07	109000	EPA 2003a	3.03E-01	No	4.31E-02	No
Kreher Park	PAH	Naphthalene	ug/kg	34	7	21	40	2144	333.46	Non-parametric	Standard Bootstrap	512.72	99.4	EPA 2003a	2.16E+01	Yes	5.16E+00	Yes
Kreher Park	PAH	Phenanthrene	ug/kg	34	5	15	410	6800	524.13	Non-parametric	Standard Bootstrap	876.98	65700	EPA 2003a	1.49E-01	No	1.92E-02	No
Kreher Park	PAH	Pyrene	ug/kg	34	17	50	220	52000	3366.59	Non-parametric	Standard Bootstrap	5945.49	78500	EPA 2003a	6.62E-01	No	7.57E-02	No
Kreher Park	PAH	Total PAH	ug/kg	34	21	62	40	462700	26180.01	gamma	Standard Bootstrap	49343.72	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	1,2,4-Trimethylbenzene	ug/kg	24	1	4	19	19	7.98	Non-parametric	Jackknife	8.80	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	1,3,5-Trimethylbenzene	ug/kg	26	2	8	77	114	14.73	Non-parametric	Jackknife	22.89	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	Benzene	ug/kg	34	3	9	23	495	29.69	Non-parametric	Standard Bootstrap	56.05	255	EPA 2003a	1.94E+00	Yes	2.20E-01	No
Kreher Park	VOC	Ethylbenzene	ug/kg	34	4	12	25	301	21.41	Non-parametric	Standard Bootstrap	37.45	5160	EPA 2003a	5.83E-02	No	7.26E-03	No
Kreher Park	VOC	Toluene	ug/kg	34	17	50	12	405	34.04	Non-parametric	Standard Bootstrap	55.40	5450	EPA 2003a	7.43E-02	No	1.02E-02	No
Kreher Park	VOC	Xylenes (total)	ug/kg	10	7	70	29	1104	220.95	gamma	Standard Bootstrap	409.73	10000	EPA 2003a	1.10E-01	No	4.10E-02	No

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Only detected constituents were evaluated

Criteria sources:

EPA 2003a = EPA Region 9 Ecological Screening Levels table (August 22, 2003)
EPA 2005 = Ecological soil screening levels (ECO-SSLs). OSWER, Washington, D.C.
EPA 2003b = Draft Ecological Soil Screening Levels (ECO-SSLs). In: Kapustka, L., W. Clements, L. Ziccardi, P. Paquin, M. Sprenger, and D. Wall. 2004. Issue Paper on Ecological Effects of Metals. Submitted to U.S. EPA Risk Assessment Forum, Washington,
Reg V ESL = EPA Region V Ecological Screening Levels

Data Distribution and 95% UCL:

Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jackknife UCL was selected

Appendix B
Sediment Quality Triad Report

FINAL REPORT

SEDIMENT QUALITY TRIAD INVESTIGATION - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

Northern States Power Company - WI
1414 West Hamilton Avenue
Eau Claire, WI 54701

January, 2007

URS
Milwaukee County Research Park
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25688375

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Table 3.1 Concentration of Total PAHs in Composite Sediment Samples Used for Bioassays

Table 4.1 Effects Endpoints for Bioassays Conducted 2006 - 2006

Table 4.2 Effects Endpoints for Bioassays Conducted 2001

Appendices

Attachment 1 Sediment Investigation

Attachment 2 Overview of Sediment Bioassays

Attachment 3 Benthic Macroinvertebrate Community Investigation

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

µg/g	Micrograms per gram (parts per million)
BSAF	Biota-sediment accumulation factor
BERA	Baseline Ecological Risk Assessment
BSAF	Biota sediment accumulation factors
COPC	Chemical of Potential Concern
USEPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
LOEC	Lowest observed effects concentration
NOC-PAH	Organic carbon normalized PAH.
NOEC	No observed effects concentration
PAH	Polycyclic aromatic hydrocarbon
PEC	Probable effects concentration
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
TEC	Threshold Effects Concentration
UCL	Upper Confidence Limit
WDNR	Wisconsin Department of Natural Resources

In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site) (URS 2005) a Sediment Quality Triad Investigation (Triad) was conducted to evaluate the potential for toxicity of Site sediment to sediment-dwelling invertebrates. The Triad approach evaluates sediment quality by integrating spatially and temporally matched sediment chemistry, biological, and toxicological information (Long and Chapman 1985; Chapman et al. 1987). Benthic invertebrate community analysis and sediment toxicity testing provide site-specific information regarding potential ecological effects of exposure of ecological receptors to COPCs in the Site sediment. These additional lines of evidence supplement traditional bulk sediment chemistry data to provide a more relevant, site-specific assessment of risks.

The Triad approach was originally developed for estuarine systems, namely Puget Sound and San Francisco Bay (Long and Chapman 1985; Chapman et al. 1987). However, numerous freshwater sediment investigations, including those conducted in the Great Lakes region, have utilized the Triad approach. For instance, as part of the Great Lakes National Program of USEPA, Rediske et al. (2001) and Rediske et al. (2002) have used the Triad approach to investigate the extent of sediment contamination in Manistee and Muskegon Lakes, respectively.

The objective of the Triad approach for the Ashland site is to incorporate site-specific ecological effects information to determine whether COPC concentrations in sediment have adverse effects on benthic invertebrate communities or indirectly on fish and wildlife that depend upon these organisms. The conclusions developed from this Triad study will be used to support the baseline ecological risk assessment (BERA) for the Site.

As part of the approved RI/FS Work Plan, a sampling design was developed to optimize the utility of the information being developed from these studies. One of the key objectives of the sampling design was to ensure that the number of and spatial coverage of the Triad samples reflected a gradient of total PAH concentrations in sediment as well as controlled for any potentially confounding variables which may have affected the results of the studies (URS 2005). Potentially confounding variables that were considered in selecting sampling locations in the sediment area included the presence of wood waste in the sediment, substrate grain size, and water depth (using water depth as a variable incorporates other variables including energy regime and light penetration). Information obtained from previous investigations of Chequamegon Bay sediments (SEH 1998a, 2002) was considered in the sampling location selection process.

During the development of the RI/FS Work Plan data from the SEH (1998a) benthic community study was used as the basis for a power analysis to compute the number of benthic samples required to detect differences amongst stations. For this study alpha, the probability of rejecting a null hypothesis when it is actually true, was set at 0.05. Beta, the probability of failing to reject a null hypothesis when it is actually false was set at 0.2; thus the power (1 – beta), the probability of rejecting a false null hypothesis, was set at 0.8.

Attachment 1 (Sediment Investigation) describes how Site Triad stations and Reference stations were selected and sampled for bulk sediment chemistry, sediment toxicity testing and benthic community analysis. Figures showing the locations and tables summarizing the coordinates of the Triad stations are also provided in Attachment 1.

Attachment 2 (Sediment Toxicity Investigation) describes how the sediment toxicity testing was conducted and presents the results.

Attachment 3 (Benthic Macroinvertebrate Community Investigation) presents the results of the benthic community analysis and describes how environmental variables, including differences in sediment chemistry, influenced the structure of the benthic macroinvertebrate community at the Site.

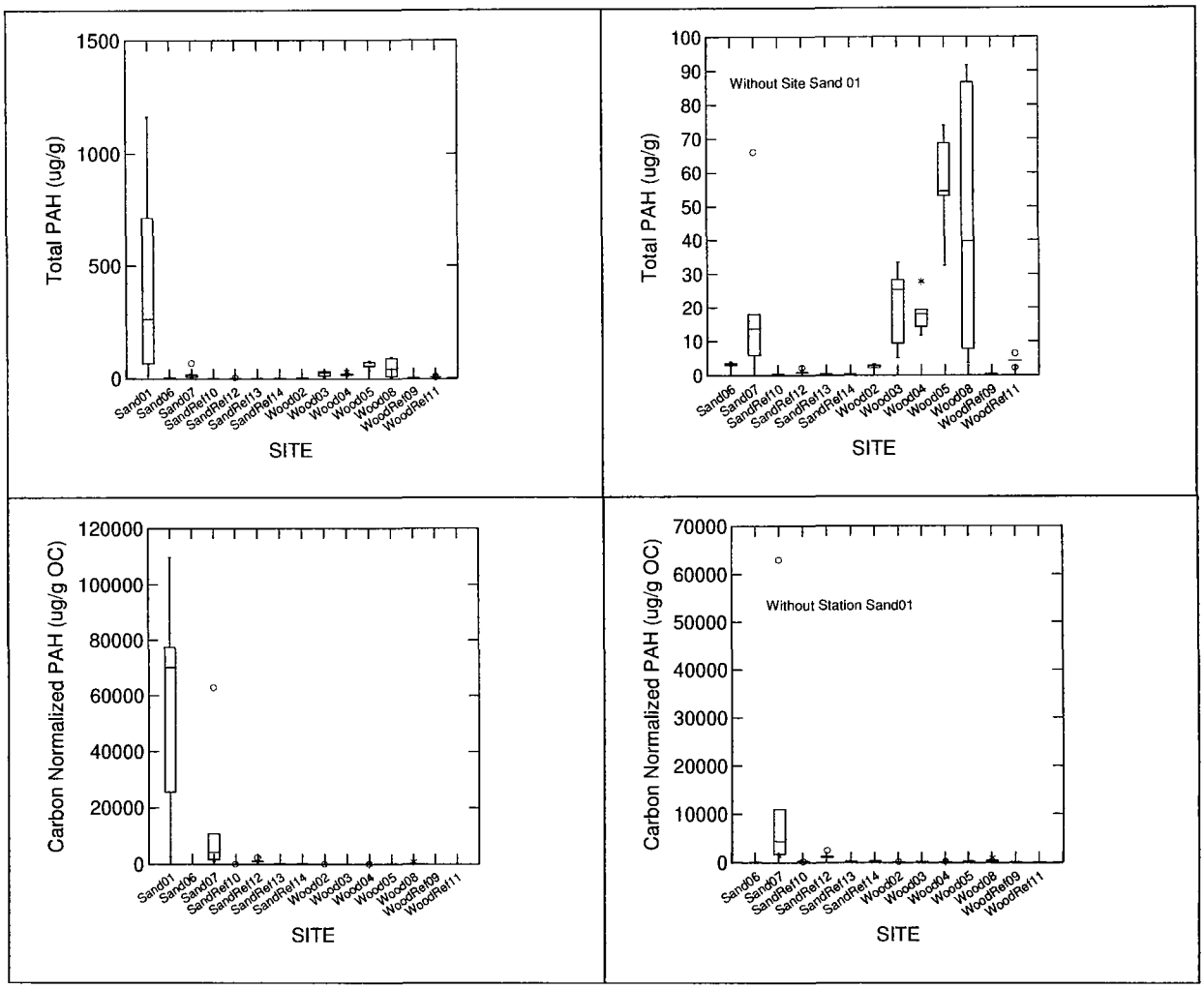
This Triad report integrates these three lines of evidence for use in the BERA.

3.1 SEDIMENT INVESTIGATION

The results of the bulk sediment analysis indicated that several chemicals in Site sediment exceeded WDNR threshold effects concentrations (TEC) and probable effects concentrations (PEC) (WDNR 2003). In particular, a number of polycyclic aromatic hydrocarbon compounds (PAHs) as well as total PAHs (TPAHs) exceeded the PEC at several of the SQT stations. Total PAHs exceeded its TEC at all Triad stations and exceeded its PEC at Stations SQT1, 3, 4, 5, 7 and 8. Copper, lead and mercury exceeded their TEC in several samples. Copper and mercury exceeded their PEC in one sample each, SQT5 and SQT8 respectively. Several VOCs exceeded their TEC in several samples and benzene and total xylenes exceeded their PECs. Figure 3.1 are box and whisker plots[1] of PAH and carbon normalized PAHs (NOC-PAH) at the SQT stations.[2] Considering PAHs on a dry weight basis, Station SQT1 had the highest levels of PAHs followed by Stations SQT 3, 4, 5, 7 and 8. On a NOC-PAH basis, Station SQT1 again had the highest level, followed by Station SQT7.

[1] Box and whisker plots show the maximum, minimum, upper and lower quartile, and median values for all replicates at a station.
[2] Detailed sediment chemistry data is in Attachment 1.

Figure 3.1. Levels of PAHs (in dry weight and organic carbon normalized units) at SQT Stations.



3.2 SEDIMENT BIOASSAYS

Sediment bioassays to evaluate toxicity of Site sediments were conducted using the amphipod, *Hyalella azteca*, the midge, *Chironomus dilutus*, and larvae of the fathead minnow, *Pimephales promelas*. The endpoints measured were survival and growth. *H. azteca* and *P. promelas* bioassays were conducted under both laboratory light and UV light. In addition a bioaccumulation bioassay was conducted with the oligochaete worm, *Lumbriculus variegatus*. The results of the bioassays indicated that sediments at some stations were toxic to these laboratory organisms and that UV light resulted in some incremental effects.[3] High mortality in all Reference Sand stations during several *H. azteca* bioassays indicated that there were effects from other unmeasured environmental stressors.

[3] The relevance of using UV light in laboratory bioassays in discussed in Attachment 2 to this report and the BERA.

Only the results from the sand substrate stations were used to draw conclusions regarding effects thresholds since the carbon normalized values for wood substrate stations are confounded by the form of wood in the sample. Several relatively large pieces of wood in a sample could result in a high organic carbon content and a correspondingly low organic carbon normalized PAH concentrations. As an example Site Wood station SQT8 had a dry weight concentration of 69.9 µg/g but with 28% total organic carbon it resulted in a carbon normalized concentration of only 249.7 µg PAH/gOC. While large pieces of wood debris were removed from the composite sample used for the bioassays, pieces less than ½ inch in size were left in the sample and remained in it for the bioassay. These large pieces of wood would significantly overstate the surface binding capacity of the organic carbon in the sample. This same sample at 1% organic carbon would have had a substantially greater carbon normalized concentration.

The concentrations of total PAHs in the bioassay treatments are summarized in Table 3.1.

Table 3.1. Concentration of Total PAHs in Composite Sediment Samples Used for Bioassays

SQT Station	Substrate Matrix	Total Organic Carbon (%)	Total PAH (µg/g)	Carbon Normalized PAH (µg/g OC)
SQT1	Sand	0.46	166.94	36291.3
SQT1 (50%)	Sand	~0.46	~83.47	~18145.65
SQT1 (25%)	Sand	~0.46	~41.74	~9072.93
SQT1 (12.5%)	Sand	~0.46	~20.87	~4536.41
SQT2	Wood	42	3.20	7.61
SQT3	Sand	40	17.06	42.65
SQT4	Wood	42	14.10	33.57
SQT5	Wood	25	31.25	125.00
SQT6	Sand	9.5	2.30	24.18
SQT7	Sand	0.37	22.51	6083.8
SQT8	Wood	28	69.91	249.69
SQT9	Wood	5.8	.08	1.43#
SQT10	Sand	0.13	.03	20.18#
SQT11	Wood	28	3.80	13.56#
SQT12	Sand	0.03	0.008	25.91#
SQT13*	Sand	0.28	.426	152.14#
SQT14*	Sand	0.39	.426	109.23#

~Estimated based upon dilution, not measured.

*Based upon the average of the five replicate samples collected from these stations for bulk sediment chemistry analysis.

NOC-PAH levels in reference station sediments may be misleading because many PAH compounds were not detected and hence given a value of 1/2DL. For detailed information on PAH composition see the Sediment Investigations report accompanying this report (Attachment 1 to the Sediment Quality Triad Investigation)

3.2.1 *Hyalella azteca* Bioassay

In the first bioassay under laboratory light conditions there was significant mortality at Stations SQT1 and SQT7, compared to the controls, West Bearskin Reference and Wood Reference stations. Results at Station SQT3 were significantly different from the two laboratory controls but not any reference stations. Reference Sand stations SQT10 and SQT12 were also significantly different from the controls, West Bearskin Reference and Wood Reference stations. Only Reference Wood Station SQT11 showed any significant growth effects and that was only compared to the formulated sand control.

A second bioassay with *H. azteca* using two new Reference Sand stations SQT13 and SQT14 was conducted under laboratory light. There was significant mortality in both SQT1 and SQT7 compared to the silica sand control, West Bearskin reference and the Reference Sand stations. However, the results at these two stations were not significantly different from the formulated sand control. SQT6 had significant growth effects but only compared to the silica sand control. The absence of growth effects in the survivors at Station SQT7 where there was significant mortality in both tests and the fact that the West Bearskin Reference had comparable results suggests the significance of the SQT6 growth result is questionable. Unlike the first test there was no significant mortality in SQT3.

A third bioassay was conducted with *H. azteca* in an attempt to identify an effects threshold. It was conducted for 10 days and used a dilution series of 50%, 25% and 12.5% of SQT1 sediment. This sediment was mixed to have the approximate organic carbon content as the original SQT1 as described in Attachment 2. No other Site Sand stations were included in this test. Table 3.1 summarizes the approximate PAH concentration in these treatments. There was significant mortality in SQT1 and the 50% dilution of SQT1 compared to all controls and the Reference Wood stations. Site Wood station SQT8 had significant mortality compared to the silica sand control and the dilution sediment. However, the results for SWT8 were not significantly different from any of the reference stations including West Bearskin. There were significant growth effects in the 25% dilution of SQT1 compared to the Reference Wood station SQT9 however there were no significant growth differences in the 50% dilution compared to any reference stations.

A fourth bioassay was conducted under the same conditions as the third but under UV light. The results of this test indicated significant mortality in Stations SQT1 and all dilutions of SQT1, except the 12.5% dilution, compared to all controls and the Reference Wood stations. In addition Site Wood stations SQT4, SQT5 and SQT8 had significant mortality compared to one or more controls. However, only Site Wood Station SQT5 was different from the Reference Wood stations.

A parallel test to this fourth bioassay provided leaf plugs in the treatment vessels for potential refugia. Survival in the leaf plug treatment was greater than in the no leaf treatment suggesting some moderating effect due to the availability of this refugia. There were growth effects at most stations in the UV bioassay compared to a control but no differences from the Reference Wood results.

3.2.2 *Pimephales promelas* Bioassay

The first bioassay conducted with *Pimephales promelas* was under laboratory light. There was no significant mortality at any stations in this test. There was significantly less growth, however, in SQT1 compared to the silica sand control and to SQT10, a Reference Sand station. There were no significant differences between growth in SQT1 and growth in any other reference stations including West Bearskin.

In the *P. promelas* bioassay conducted under UV light, there was significant mortality in SQT1 and SQT7 compared to all controls and reference stations. There was no significant growth effects at any station compared to the sand control where there were survivors.

3.2.3 *Chironomus dilutus* early life stage Bioassay

There were two attempts at conducting this test, however, in each attempt there was substantial mortality in one or more controls and all of the Reference Wood and Sand stations. While LRSI speculated that the early life stage larvae may have avoided the sediment and remained planktonic and were subsequently flushed from the bioassay vessel, the bottom line is that the results of this test cannot be used as the basis for any conclusions as to the relative toxicity of Site sediments compared to sediments in the region unaffected by Site contaminants.

3.2.4 *Lumbriculus variegatus* Bioaccumulation Bioassay

Bioaccumulation assays were conducted using the worm, *Lumbriculus variegatus*. Prior to conducting the 28-day bioaccumulation test a 4-day screening test was conducted to ensure that the test organisms could survive for the 28 day duration of the test. All worms died at Site Sand stations SQT1 and SQT7 in the screening test so these stations were not used in the 28 day bioaccumulation test.

At the culmination of the 28 day bioaccumulation test levels of PAHs were measured in the worms. These data were used in the BERA.

3.3 BENTHIC MACROINVERTEBRATE COMMUNITY INVESTIGATION

Dominant taxa comprising the benthic macroinvertebrate communities at both Site and Reference stations were chironomids which made up an average 32.6% of the abundance in each sample. Sand Reference Station SQT12 had a range from 84 to 91% chironomids in the five replicate samples. In all, 58 taxa of chironomids were identified. The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa),* oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai),* amphipods (including *Gammarus fasciatus*), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals (See Appendix 1 to Attachment 3). Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

The results of the benthic macroinvertebrate investigation indicated very few patterns in the distribution of these taxa that could be related to levels of PAHs in the sediment. Several

measures of community structure, e.g. percent dominance, percent non-insects and percent gatherers, were positively related to TPAH, while percent chironomids and diversity were negatively related to TPAH. There was also a negative relationship between NOC-PAH and the number of Ephemeroptera/Trichoptera/Odonata (ETO) taxa and with the abundance ratio of ETO/ETO+chironomids. This suggests there may be increasing stress with increased NOC-PAHs. However, there is no consistent pattern that could be related to the Site as Reference Sand stations SQT10 and SQT12 had the lowest abundance ratio of ETO/ETO+chironomids.

Likewise review of the box and whisker plots and cluster diagrams did not identify any consistent trends in station similarity, i.e., there was substantial variability in benthic community structure that couldn't be explained consistently by station category (whether sand or wood substrate), or whether it was a Site or Reference station (Attachment 3).

While levels of PAHs in Site sediments couldn't explain any variation in the benthic community, grain size and substrate type were significant explanatory factors for the variation in the benthic community. For most of the benthic community measures, the finer grain sizes were associated with lower values. Six substrate category effects were significant including:

1) Higher percent non insects, crustacea+mollusca, filter-feeders, and predators at Reference Wood than at Site Wood stations.
2) Lower percent parasites at Reference Wood than at Site Wood stations.
3) Lower percent facultative species at Reference Sand than at Site Sand stations.

However, these six significant results don't support a conclusion that Site stations, whether sand or wood, negatively influence benthic community metrics.

The results of the MANOVA based upon some metrics, e.g., suggested there was some separation of Site Sand from Reference Sand stations and Site Wood from Reference Wood stations (Figure 1.4, 1.5 and 1.6), however these results were not consistent for all metrics and as discussed previously, the ANCOVA provided little evidence that this separation could be explained by the levels of PAH (either as TPAH or NOC-PAH).

The three lines of evidence considered in this Sediment Quality Triad Investigation, i.e. sediment chemistry, sediment bioassays and the benthic macroinvertebrate investigation, did not result in a consistent conclusion. Some bioassay results[4] including the following:

1) Significant mortality at SQT1 and SQT7 in the *H. azteca* in the 28 day test under laboratory light;
2) Significant mortality at SQT1 and the 50% dilution of SQT1 in the 10 day test under laboratory light;
3) Significantly lower growth at SQT1 for *P. promelas* under laboratory light; and
4) Mortality to all *L.variegatus* in SQT1 and SQT7 in the bioaccumulation screening test,

were consistent with what bulk sediment chemistry would predict, i.e., effects were associated with those sediments in which levels of NOC-PAH were highest (See Table 3.1). However, there was considerable variability in benthic community measures that couldn't be related to different levels of PAHs. Rather, differences in the benthic macroinvertebrate structure appeared to be related more to substrate type, either wood or sand and grain size differences.

Based upon the results of the sediment bioassays the no effects concentration (NOEC) for *H. azteca* from both the bioassays conducted by URS during 2005 and 2006 (Table 4.1) and those conducted by SEH in 2001 (Table 4.2) are in the range of 4,500 – 10,000 µg PAH/g organic carbon (OC). For *P. promelas* the NOECs were also fairly similar, 6,084 µg PAH/gOC in 2005-2006 and 3996 µg PAH/gOC in 2001. Because the *C. dilutus* failed in 2005-2006 only the NOEC from 2001 of 735 µg PAH/gOC is available.

Table 4.1. Effects Endpoints for Bioassays Conducted 2005-2006.

Summary of Normal Light Bioassay Results with Three Species for URS 2005-2006				
Organism	**NOEC**		**LOEC**	
	Total PAHs µg/g	**Total PAHs µg/gOC**	**Total PAHs µg/g**	**Total PAHs µg/gOC**
H. azteca	20.9	4,536	22.5	6,084
P. promelas	22.5	6,084	166.9	36,291
C. dilutus	NA	NA	NA	NA

[4] The bioassays under UV light and the *C. dilutus* bioassays are not used in these comparisons for reasons discussed in Attachment 2 and in the BERA.

Table 4.2. Effects Endpoints for Bioassays Conducted in 2001.

Summary of Normal Light Bioassay Results with Three Species Conducted for SEH 2001				
Organism	NOEC[1]		LOEC[1]	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	249.4	9,978	823.1	4842 or 14396[2]
P. promelas	79.9	3,996	249.4	9978
C. tentans	16.2	735	79.9	3996

1) SEH reports that the NOEC and LOEC are for lowest of either mortality or growth endpoints (reduced growth or mortality > 20%

2) The first value is suspect due to apparent problems with TOC analyses. The second value assumes that the true TOC lies between adjacent higher and lower values.

These results must be also considered in light of the significant mortality experienced in the Reference Sand stations during the 2005-2006 bioassays. Considering that *H. azteca* is a relatively sensitive test organism and one that is continually in contact with the sediment, the mortality in the Reference Sand stations suggests the presence of some unmeasured stressor in the sediment in many parts of Chequamegon Bay. If this is so, then the possibility exists that the cause of mortality in SQT1 and SQT7 is not due exclusively to PAH levels in the sediment. Factors responsible for mortality in the Reference Sand stations could have been responsible for the mortality at the Site Sand stations.[5] The other bioassays conducted with *P. promelas* or *C. dilutus* don't help in interpretation of these results. There was no mortality in any stations with *P. promelas* and the bioassays with *C. dilutus* were inconclusive because of significant mortality (or loss) in control as well as reference stations in addition to the site stations.

While levels of PAHs in Site sediments didn't consistently explain any variation in the benthic community, grain size and substrate type were significant explanatory factors. For most of the benthic community measures the finer grain sizes were associated with lower values. The overall results for the benthic community investigation suggest that PAH levels (whether TPAH or NOC-PAH) are playing only a minor role in structuring communities, overshadowed by other substrate effects (e.g., grain size and whether the substrate category was wood or sand). Perhaps this is not surprising as it was expected that a benthic community inhabiting an area with a wood mulch substrate would differ from that inhabiting a sand substrate. It has also been well-established that grain size and substrate type is often a significant explanatory factor of differences in benthic community structure.

In conclusion, bulk sediment chemistry suggests that compared to WDNR sediment quality guideline (WDNR 2003) there should be an no effects threshold between 1.6 and 22.8 µg/g in sediment with 1% organic carbon (@1%OC). These concentrations are the Threshold Effects Concentrations and the Probable Effects Concentrations, respectively. The results of sediment

[5] It should be noted that of the Site Sand stations three of the four Site Sand stations had significant mortality in the first 28-day test and two of the Site Sand stations had significant mortality in the second 28-d test. While two stations in both tests, SQT1 and SQT7 had elevated levels of carbon normalized PAHs, a third Site Sand station, SQT3 also had significant mortality in the first 28-d test. SQT3 had only 42.7 µgPAH/g OC and also had approximately 40% TOC. Total PAH on a non-normalized basis at this station was 17 µg/g. While there was no significant mortality at Sand Station SQT3 in the second 28-d test, there is insufficient consistent information to support a conclusion of whether the same variable that apparently affected the reference stations did or did not affect some or all of the Site Sand stations.

bioassays indicate that there is a no effects threshold for benthic invertebrates such as *H. azteca* in the range of 4,000 to 10,000 µg PAH/gOC. These levels are equivalent to 40 to 100 µg/g @1%OC. For benthic invertebrates like *C. tentans* no effects are predicted at about 735 µg PAH/gOC (or 7.35 @1%OC). The low effects thresholds for these benthic organisms range from about 4,800 to 14,000 µg PAH/gOC (or 48 to 140 @1%OC).

However, no significant effects appear to be manifested at the benthic community level of organization even in areas where PAH levels from benthic samples were greater than in the range of 40,000 to 80,000 µg PAH/gOC (400 to 800 µg/g@1%OC) seen in some of the replicates from Station SQT1 (Figure 3.1). This could be due to a variety of factors such as adaptation of the organisms that actually live in Site sediment or selection of species throughout Chequamegon Bay that are tolerant of a wide range of conditions. It could also be explained by the fact that the levels of PAHs in a six inch (15cm) deep sediment sample are not the exposure medium for the majority of the small benthic epifaunal and infaunal species that constitute the benthic community at the Site and in Chequamegon Bay that may be primarily exposed to the top two to three inches. It is likely that the levels of Site chemicals in the top two to three inches are less than a composite sample of the top six inches.[6] If this is the situation, then comparing the levels of PAHs in the top six inches to the results of grab samples that may have all the benthic organisms in the top two or three inches of the grab effectively separates cause (PAH level) from potential effect (impairment of benthic community).

Lastly, these results could reflect the fact that the species populations that make up benthic communities in Chequamegon Bay are limited by factors other than contaminants in the sediment. Any effects exerted at the individual level, as suggested by the bioassays, are overshadowed by limiting factors such as predation, niche availability (including substrate type and grain size) or food supply. If this is true the reproductive potential of these opportunistic benthic species is sufficient to sustain a benthic community throughout Chequamegon Bay that is fairly similar but has small scale heterogeneity as the result of substrate characteristics. In this scenario, the levels of contaminants in the Site sediment do not have a significant influence on benthic community structure.

[6] Note that the original RI/FS Work Plan recommended sampling only the top four inches (10cm).

Chapman P.M., Dexter, R.N., and E.R. Long. 1987. Synoptic Measures of Sediment Contamination, Toxicity, and Infaunal Community Composition (The Sediment Quality Triad) In San Francisco Bay. Mar. Ecol. Prog. Series 37:75-96

Long, E.R. and P.M. Chapman. 1985. A Sediment Quality Triad: Measures Of Sediment Contamination, Toxicity, And Infaunal Community Composition In Puget Sound. Marine Pollution Bulletin. 16:405-415.

Rediske, R., Gabrosek, J., Thompson, C., Bertin, C., Blunt, J., and P. Meier. 2001. Preliminary Investigation of the Extent of Sediment Contamination in Manistee Lake. Great Lakes national Program Office, U.S. Environmental Protection Agency.

Rediske, R., Thompson, C., Schelske, C., Gabrosek, J., Nalepa, T. and G. Peaslee. 2002. Preliminary investigation of the extent of sediment contamination in Muskegon Lake. Great Lakes national Program Office, U.S. Environmental Protection Agency.

WDNR 2003. Consensus-Based Sediment Quality Guidelines. Recommendations for Use and Application. Interim Guidance. WT-732 2003.

ATTACHMENT 1

SEDIMENT INVESTIGATION - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

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Appendices

Appendix A May 2005 Sediment Chemistry Results

In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site), sediment samples were collected from the Ashland, WI area and analyzed for semi-volatile organic compounds (SVOCs) including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and metals. The results of these analyses were used to support environmental impact studies and ecological and human health risk assessments for the Site.

Three separate field efforts were conducted. A reconnaissance survey to identify reference stations was conducted in May 2005. In June 2005 sediment samples and benthic community samples were collected from both Site and Reference Stations. Two supplemental Reference Stations were sampled in September 2005.

Three types of sediment samples were collected during the June 2005 sampling event to support on-going investigations at the Site:

- Supplemental sediment: Surface sediment samples (0-6 inch depth) were collected for chemical analyses at 14 locations to supplement the existing surface sediment database;
- Sediment Quality Triad (SQT): Temporally and spatially matched surface sediment samples (0-6 inch depth) were collected for benthic invertebrate community analyses, sediment bioassays, and bulk sediment chemical analyses; and
- Sediment cores:
  - Sediment flume (SEDFLUME) cores were collected by the subcontractor Sea Engineering Inc. to support sediment stability studies; and
  - Vertically stratified cores were collected to support age-dating studies.

In addition to collection of the sediment samples, various surveys and other data collection activities were conducted to characterize hydrography and sediment bed morphology in the Site area, including:

- Collection of current, wave and suspended sediment data using in-situ instrumentation;
- Bathymetric survey;
- Side scan sonar survey;
- Subbottom profiling; and
- Underwater videography of bottom morphology.

The results of these investigations are presented in the following reports:

Sampling Program	Data collected	Report
Supplemental Sediment Sampling	Bulk sediment chemistry	This report
Sediment Quality Triad	Bulk sediment chemistry	This report and sediment quality triad report
	Sediment bioassays	Sediment bioassay report and sediment quality triad report
	Benthic community	Sediment quality triad report
Sedflume Cores	Sediment erosion thresholds	"Sedflume Analysis of Ashland, WI Cores" by Sea Engineering Inc. and Sediment Stability Assessment
Vertically stratified cores	Age-dating	Sediment Stability Assessment
In situ monitoring	Wave, current and suspended sediment	Sediment Stability Assessment; and "Instrument Deployment, Sediment Sampling, and Remote Sensing Surveys, Ashland/NSP Lakefront Superfund Site" by OSI
Bathymetric, side scan, subbottom profiling and underwater videography	Sediment morphology	Sediment Stability Assessment; and "Instrument Deployment, Sediment Sampling, and Remote Sensing Surveys, Ashland/NSP Lakefront Superfund Site" by OSI

This field work was conducted during three field efforts between May and September 2005. In May of 2005, URS conducted a reconnaissance survey to locate potential SQT sampling locations at the Site as well as SQT reference sediment stations in other areas of Chequamegon Bay outside of potential Site influence. In situ instrumentation was also deployed in May (See

Appendix A to the Sediment Stability Assessment Report for a full description of the instrumentation deployment and hydrographic surveys).

Data collected during the May reconnaissance effort were used to select sampling locations for the SQT survey conducted in June 2005. During the June field effort an additional 14 surface samples as specified by the RI/FS Work Plan were collected in the Site area. In situ instrumentation that had been deployed in May was retrieved and the various hydrographic surveys were conducted during June. During September of 2005, SQT data were collected from two additional reference stations to supplement reference station data collected in June 2005. Field efforts are described in the following sections.

2.1 MAY FIELD RECONNAISSANCE

During the week of May 9 through 13, 2005, URS conducted a reconnaissance survey of potential SQT sampling locations at the Site as well as various potential reference locations throughout Chequamegon Bay. For the reconnaissance, the subcontractor Ocean Surveys Incorporated (OSI) mobilized the 25-foot *R/V Parker* equipped with a Trimble DGPS Navigational System, OSI Maretrack II trackline control and data logging system, two benthic grab samplers (Van Veen and standard ponar) with wet table and wash pumps, and an underwater television system to support URS in the reconnaissance efforts. OSI mobilized a second vessel, the *R/V Able*, to provide transportation for observers and site logistical support.

Reconnaissance of potential sediment sampling locations included surveillance of the lakebed using underwater videography and the collection of surface sediment samples for bulk sediment chemistry using a Van Veen or standard ponar grab sampler. Summaries of reconnaissance activities are provided in the following sections.

In addition to these activities *in situ* ADCP and AVP current meters were deployed.

2.1.1 Underwater Videography

An underwater TV system was used to record video of the lakebed at the Site and facilitate visual reconnaissance of sediment types at potential reference stations. Underwater videography was collected using a Simrad Model 9030 Underwater Color TV System deployed on a portable tripod mount for downward looking applications and on a sled for forward looking trackline images. Within the Site waters, six video tracklines were recorded to standard DVD media. Results of this survey are presented in Appendix A of the Sediment Stability Assessment report. At potential reference stations, underwater videography was used to visually observe sediment types to determine their compatibility with Site area sediments prior to collecting grab samples. Underwater video from potential reference sampling locations was for reconnaissance purposes only and was not recorded.

2.1.2 Reconnaissance Sediment Sampling

The objectives of the reconnaissance sampling were to:

1. Identify locations within the Site area with total PAH (tPAH) concentrations estimated to be in the range of 2-50, 50-100, 100-150, and 150-300 mg/kg, respectively; and
2. Identify reference stations with similar sediment types as the Site (e.g., hard-packed sand with and without wood waste) that were remote from sources of contamination (PAHs, metals, pesticides, and PCBs).

Sediment sampling at these stations was conducted according to SOP 250 using a Van Veen (24 L) or standard ponar grab sampler (8.2 L). The selection of the grab sampler was dependent on the substrate type. Variable conditions, including hard-packed sediment, and wood debris, prevented the collection of a full grab sample in many of the areas. Modifications to the samplers, including adding additional weight to the Van Veen sampler, did not substantially improve recovery in areas with hard-packed sand or wood debris.

Multiple surficial sediment samples (0-6 inch) were collected from several locations in Site waters and at potential reference areas locations (Figures 2.1 and 2.2). At the prospective locations, the grab sampler was deployed from a davit fixed to the deck of the boat. The sampler was retrieved and inspected to determine whether an acceptable volume of sediment was collected. If the volume of the sample was insufficient, the sampler was emptied, rinsed, and redeployed. Acceptable samples were transferred from the sampler into a clean stainless steel bowl where they were characterized in terms of texture, color, and odor; the presence of wood debris and submerged aquatic vegetation (SAV) were noted in the field log. After each sample was characterized, it was homogenized using a clean stainless steel spatula. The required volume of the homogenized sample was then transferred into glass jars provided by the analytical laboratories. Samples were placed on ice until delivery to the designated analytical laboratory. Unused sediment and wastewater from samples collected within Site waters were transferred to 5-gallon plastic waste buckets on board and later disposed according to proper waste handling procedures for the Site.

Sediment samples were analyzed by both an on-site mobile laboratory (for 12-hour results) and a fixed laboratory (for confirmation). Samples collected within Site waters were analyzed for PAHs by the on-site mobile laboratory (Environmental Chemistry Consulting Services, Inc.). Approximately 10 percent of samples collected within Site waters were split, with one sample analyzed by the mobile laboratory and the other sample analyzed by a fixed laboratory (Northern Lakes Services, Inc.) to verify the results of the mobile laboratory. Samples collected from potential reference locations were analyzed for PAHs, metals, pesticides, and PCBs by the fixed laboratory.

2.2 JUNE SAMPLING EVENT

Tasks completed during the June event included:

1. Further preliminary sampling of Site SQT stations to verify concentrations of tPAHs and finalize station selection;
2. SQT sampling of all Site and reference stations;
3. Collection of an additional 14 supplemental sediment samples in Site waters;
4. Retrieval of *in situ* ADCP and AVP current meters;
5. Conduct of hydrographic, side scan and subbottom profile surveys; and
6. Collection of sediment cores for age-dating and SEDFLUME analysis.

Sediment sampling was conducted at the Site and in Chequamegon Bay from June 13 – June 25, 2005. For the June sampling effort, OSI mobilized *R/V MustDu*, a 28-foot long twin-hulled pontoon vessel equipped with an integrated midship moon-pool and overhead derrick system that enables deployment and recovery of a variety of sediment sampling equipment. An onboard Trimble 4000 Differential GPS system using USCG differential correctors was used to navigate *R/V MustDu* to sampling locations and to record the positions where samples were collected.

Three types of sediment samples were collected during the June sampling event to support on-going investigations at the Site:

- SQT: Temporally and spatially matched surface sediment samples (0-6 inch) were collected for benthic invertebrate community analyses, sediment bioassays, and chemical analyses;
- Supplemental sediment: Surface sediment samples (0-6 inch) were collected for chemical analyses at an additional 14 locations; and
- Sediment cores:
  - SEDFLUME cores were collected by Sea Engineering Inc. (SE) to support sediment stability studies; and
  - Vertically stratified cores were collected to support age-dating studies.

The following sections describe data collection procedures for the June sampling event.

2.2.1 SQT Sampling

Prior to the commencement of sampling the SQT stations, additional reconnaissance samples were collected between June 14 and June 18 to further define areas with target substrates and PAH concentrations. Reconnaissance samples were collected with a petite or standard ponar sampler and were analyzed on-site by a mobile laboratory (Environmental Chemistry Consulting Services, Inc.). Results from the mobile laboratory were available the next sampling day and were utilized to focus the final selection of SQT stations.

SQT sampling consisted of collecting sediment for benthic invertebrate community analyses, sediment bioassays, and chemical analyses at eight Site and four reference SQT stations. SQT sampling commenced on June 18, 2005 and was completed on June 24, 2005. Figure 2.3 depicts the SQT station locations in the Site area; Figure 2.4 depicts the reference SQT stations. Another characteristic considered when identifying these SQT stations was the substrate characteristics: four sand and four wood mulch stations were sampled in the Site area and two sand and two wood mulch stations were sampled in the reference areas. The general locations of SQT stations were selected based on the May and June reconnaissance data; exact locations were selected in the field after confirming the presence of the target substrate type, by preliminary grab sampling, underwater video or diver observation. Additional underwater video tracklines were conducted and recorded to standard DVD media. Results of this survey are presented in Appendix A of the Sediment Stability Analysis report.

Sediment sampling was conducted according to SOP 250 using a petite ponar (36 square inch surface area; 2.4 L volume) or standard ponar grab sampler (8.2 L volume). Petite ponar grab samples were collected for analysis of the benthic invertebrate community. Standard ponar grab samples were collected for chemical analyses and sediment bioassays. At each SQT location, five replicate samples were collected for benthic invertebrate community analysis and five co-located replicates were collected for chemical analyses. Additional grab samples in the station area were collected to obtain a minimum 6 gallons of sediment for sediment bioassays. Bulk sediment for bioassays was stored in a clean plastic container until processing. GPS positions were recorded at each location. Table 2.1 summarizes the SQT stations' coordinates.

At eight of the 12 SQT stations, divers were deployed to operate the ponar samplers due to the heavy wood content of the sediment and the large wood debris present at these stations. Divers also assisted in the reconnaissance of target substrate types within the study area. Divers

equipped in rubber dry suits and positive pressure full-facemask helmets were deployed at SQT stations where adequate samples could not be obtained using the ponar sampler from the surface. Once the diver was deployed at the sampling station, the appropriate grab sampler, as described in the preceding paragraph, was lowered from the deck of the *R/V MustDu*. The diver advanced the sampler into the sediment to obtain a sufficient volume of sample. The sampler was closed by the diver and then retrieved by the crew aboard the *R/V MustDu*. The process was repeated until the required volume of sediment was brought to the surface. Care was taken to maintain consistency in the volume and depth of the diver-assisted samples.

Samples were processed on deck after the required volume of sediment was obtained. Samples for benthic community analyses were passed through a 250-µm bucket sieve. The sample remaining on the sieve was then transferred to 1 L plastic containers and preserved with 70% ethanol. Samples for bulk sediment chemistry analyses were transferred from the sampler into a stainless steel bowl, where the sediment was characterized in terms of texture, color, and odor. The presence of wood debris and SAV also was noted on the field data sheet. After the sample was characterized, samples for VOCs were collected from all replicates and AVS:SEM was collected from one of five replicates. After VOC and AVS:SEM samples were collected, each replicate was homogenized using a stainless steel spatula. The homogenized sample was then transferred into the appropriate laboratory-supplied containers for metals, SVOCs, TOC, and grain size. One composite from all five replicate samples at each station were sampled for PAH forensic analysis. Sediment collected for bioassays was de-watered as much as practicable and transferred to three 2-gallon plastic pails with sealable lids. Large debris including bivalves, plant material, woody material, etc. was removed from the bioassay samples as much as practicable in the field. Unused sediment and wastewater from samples collected within the Site area were transferred to 5-gallon plastic waste buckets on board and later disposed according to proper waste handling procedures for the Site.

Analytical and bioassay samples were placed on ice until delivery to the designated laboratory for analysis; benthic community samples remained preserved in ethanol until delivery to the laboratory. Samples for sediment bioassays were relinquished to a representative of the University of Wisconsin Lake Superior Research Institute (LSRI) Superior, WI at the completion of each sampling day. Analytical samples were shipped from the Site to their respective laboratories within prescribed analytical hold times. Benthic community samples were returned to the URS Milwaukee office, packaged for hazardous material shipment, and shipped to Aquatic Resources Center in Nashville, TN. All samples were received in satisfactory condition by each respective laboratory.

2.2.2 Supplemental Sediment Sampling

As a result of meetings with USEPA and various natural resource trustees on September 8^{h} and 9th, 2005 it was agreed to supplement the sediment quality database with additional sediment samples in the Site area. These sediment samples were collected from 14 additional stations on June 14 and 15, 2005 (Figure 2.5).

Surficial sediment samples were collected using a standard ponar grab sampler at predetermined (by stakeholders) sampling locations according to SOP 250. On deck, samples were transferred from the ponar sampler into a stainless steel bowl, where the sediment was characterized in terms of texture, color, odor, and the presence of wood debris and SAV. After the sediment was characterized, VOC samples were collected. Following collection of VOC samples, the

sediment was homogenized using a stainless steel spatula and transferred into the appropriate laboratory-supplied containers for SVOCs, metals, TOC and grain size.

Analytical samples were placed on ice until delivery to the designated laboratory for analysis. Samples were shipped from the Site to their respective laboratories within prescribed analytical hold times; all samples were received in satisfactory condition by each respective laboratory.

2.2.3 Sediment Coring

Sediment cores were collected from the Site area to support sediment stability studies and age-dating analyses. Three cores were collected on June 16 and 17, 2005 with technical assistance from a representative of SE for use in SEDFLUME erosion testing (Figure 2.6). Cores were collected with a custom-made corer, which consisted of a rectangular plexi-glass core tube. This corer was driven into the sediment with a slide hammer to a specified depth. Recovered core lengths ranged from approximately 1.0 to 1.5 feet. Several attempts were made to collect additional cores from the sampling area; however, sediment conditions precluded recovery at these locations. Successful cores were packaged and returned to SE for SEDFLUME erosion testing (See Appendix B of the Sediment Stability Assessment Report for more details).

Six additional deep cores (up to 1 meter depth) cores were collected from the Site area and vertically subsampled for age-dating analyses (Figure 2.7). All six cores were collected on June 16, 2005; however, an additional core was collected on June 17, 2005 to replace a core that was damaged prior to processing. Cores were collected using an OSI custom-made piston core sampler that consisted of an aluminum cylindrical piston inserted inside a 3-5/8 inch Lexan core tube. Approximately two to three feet of material was recovered with each core. Successful cores were capped and transported to the NSPW building in Ashland, WI for processing by URS personnel.

The top 60 centimeters of each core collected for age-dating were subsampled in approximately two-centimeter intervals and each interval sent for analysis of PAHs, radiometric analyses (Pb-210 and Cs-137), TOC, and grain size. Each Lexan core tube was cut vertically and the core was laid open. Subsamples were collected at two-centimeter intervals, with utensils dedicated for each interval, starting at the top of the core and then transferred directly into the appropriate laboratory-supplied containers. Subsamples for PAHs, TOC, and grain size were placed on ice until delivery to the designated laboratory for analysis. Samples for radiometric analyses were packed without ice and shipped to the designated laboratory after all samples were processed. Analytical samples were shipped from the Site to their respective laboratories within prescribed analytical hold times. A small number of sample containers designated for analytical and radiometric analyses were broken in transit and could not be analyzed. All other samples were received in satisfactory condition by each respective laboratory.

2.3 SEPTEMBER RE-SAMPLING EVENT

Due to excessive mortality in sediment bioassays using sediment from the two sand reference stations, it was decided to collect surface sediment samples from two additional reference stations in Chequamegon Bay. On September 27, 2005, URS collected sediment from these two additional reference stations.

Sampling of the additional two sand reference stations was conducted from aboard *The Swoose*, a 28.5 ft fiberglass-hull fishing boat chartered from Roberta's Charter Service, Bayfield, Wisconsin. Sampling locations targeted were Stations 2-2a and 15-1a that had been identified during the May 2005 reconnaissance (Figure 2.4). The reconnaissance had indicated that the substrate at these stations consists of fine to medium sand with minimal wood material present.

The additional reference stations were located using the vessel's onboard GPS and a hand-held Trimble GeoXT at preselected reference station coordinates obtained during the May 2005 reconnaissance. Once the vessel was positioned at the approximate location of the reconnaissance station, a grab sample was collected to confirm sediment type. If the appropriate sediment was not located, grab samples were collected from adjacent areas until a suitable location was identified. When a suitable location was identified, the boat was anchored and sediment sampling commenced.

Sediment sampling was conducted according to SOP 250 as during the June SQT sampling using a petite ponar (36 square inch surface area; 2.4 L volume) or standard ponar grab sampler (8.2 L volume). Petite ponar grab samples were collected for analysis of the benthic invertebrate community. Standard ponar grab samples were collected for chemical analyses and sediment bioassays. At each location, five replicate samples were collected for benthic invertebrate community analysis and five replicates were collected for bulk sediment chemistry analyses. GPS positions were recorded at the location of each of the five replicates collected at each station (Table 2.1). Additional grab samples were collected to obtain a minimum of 6 gallons of sediment for sediment bioassays. Bulk sediment for bioassays was stored in a clean plastic container until processing. A composite sample was also collected from each station for forensic analysis.

Samples were processed on deck after the required volume of sediment was obtained. Samples for benthic community analyses were passed through a 250-µm bucket sieve; the sample remaining on the sieve was then transferred to 1 L plastic containers and preserved with 70% ethanol. Samples for chemical analyses were transferred from the sampler into a stainless steel bowl, where they were characterized in terms of texture, color, and odor. The presence of wood debris and SAV were noted on the field sheet. After the sample was characterized, samples for VOCs and AVS:SEM were collected. After VOC and AVS:SEM samples were collected, the sample was homogenized using a clean stainless steel spatula. The homogenized sample was then transferred into the appropriate laboratory-supplied containers for metals, SVOCs, TOC, and grain size. Composites of all five replicates were sampled for PAH forensic analysis. Sediment for bioassays was de-watered as much as practicable and transferred to three 2-gallon plastic pails with sealable lids; large debris including bivalves, plant material, woody material, etc. were removed from the bioassay samples to the extent practicable in the field.

Analytical and bioassay samples were placed on ice until delivery to the designated laboratory for analysis; benthic community samples remained preserved in ethanol until delivery to the laboratory. Samples for sediment bioassays were relinquished to a representative of LSRI at the completion of the sampling day. Analytical samples were shipped from the Site to their respective laboratories within prescribed analytical hold times. Benthic community samples were returned to the URS Milwaukee office, packaged for hazardous material shipment, and shipped to Aquatic Resources Center in Franklin, TN. All samples were received in satisfactory condition by each respective laboratory.

3.1 RECONNAISSANCE SAMPLING

Sediment chemistry results from the reconnaissance sampling in the Site area are provided in the Appendix. Concentrations of tPAHs were less than 50 mg/kg at nine of the 15 locations sampled in the Site area. Three bcations had tPAH concentrations between 50 and 100 mg/kg; the tPAH concentration at one location (Station 15) exceeded 100 mg/kg (Appendix A).

Sediment in the Site area was variable, consisting of mostly medium to coarse hard-packed sand in some locations or saw dust and/or wood debris (wood mulch) in other locations. Video transects of the Site area indicated that roughly 95% of the bottom was covered with this wood material. Plank wood and logs were also commonly observed. The variable character of the surface substrate and presence of the wood prevented full recovery of grab samples in most Site areas.

Sediment chemistry results from reconnaissance sampling at preliminary reference areas are presented in Appendix A. Concentrations of PAHs, metals, pesticides, and PCBs in samples from preliminary reference location samples were compared to consensus-based threshold effects concentrations (TEC) and probable effects concentrations (PEC) to evaluate adverse ecological effects (WDNR 2003). Concentrations of tPAHs at preliminary reference locations were generally less than 1 mg/kg[1], with the exception of Stations 21 (1.6 mg/kg), 23 (5.8 mg/kg), and 24 (7.8 mg/kg) (Appendix A). Total PAH concentrations measured at these latter three stations equaled or exceeded the TEC concentration (1.6 mg/kg) for tPAH (assuming 1% sediment organic carbon), but were less than the PEC (22.8 mg/kg).

Metal concentrations in preliminary reference station samples also were compared to TEC and PEC. Antimony was detected at Station 10 at a concentration (2.1 mg/kg) that exceeded its TEC (2.0 mg/kg). Copper concentrations exceeded the TEC (32 mg/kg) at Stations 21, 22, and 23; the copper concentration at Station 22 exceeded the PEC for copper (150 mg/kg).

Pesticide concentrations were generally lower than available effects concentrations, with the exception of alpha-BHC and gamma-BHC (lindane). Concentrations of alpha-BHC exceeded the TEC concentration at Stations 4, 9, and 25 (Appendix A). Concentrations of gamma-BHC exceeded the TEC at Station 2 and the PEC at Stations 9 and 13.

Substrate characteristics at preliminary reference stations are summarized in Table 3.1.

The sediment sampling reconnaissance identified suitable reference locations for the SQT study. Based upon the results of bulk sediment chemistry analysis and observations of the substrate in preliminary reference areas, the priority reference stations for the SQT study included Stations 2, 4, 8, and 10. Substrate at these locations included sand as well as nearby areas containing wood mulch that were considered appropriate for comparisons to Site wood mulch stations. Stations that were not likely suitable reference stations for the SQT study included Stations 22 (SAV present and elevated copper concentrations), 11 (steep slope), 21, (elevated copper concentrations), 23 (elevated copper concentrations), 24 (elevated tPAH concentration), 13 (more distant from Site area), and 26 (more distant from Site area).

[1] An organic carbon concentration of 1% was assumed for purposes of this screening.

3.2 SQT SAMPLING

The results of bulk sediment chemistry analysis from SQT stations are tabulated in Table 3.2. The implications of these results will be discussed in detail in the SQT report and the human health and ecological risk assessment. However, an initial comparison of 95%UCLs for site data to TECs for sediment (WDNR 2003) indicated that few metals exceeded TECs. Total PAHs exceeded its TEC in most samples and frequently exceeded its PEC. Some VOCs exceeded their screening criteria (Table 3.3) in some samples.

3.3 SUPPLEMENTAL SEDIMENT SAMPLING

The results of bulk sediment chemistry analysis from the Supplemental Sediment stations are tabulated in Table 3.4.

The results from these studies will be used in the SQT report (Appendix B to the BERA) and the human health and ecological risk assessment as a line of evidence with which to evaluate the potential effects of sediment contaminants on human and ecological receptors.

WDNR 2003. Consensus-Based Sediment Quality Guidelines. Recommendations for Use and Application. Interim Guidance. WT-732 2003.

Legend

○ Recon SQT stations

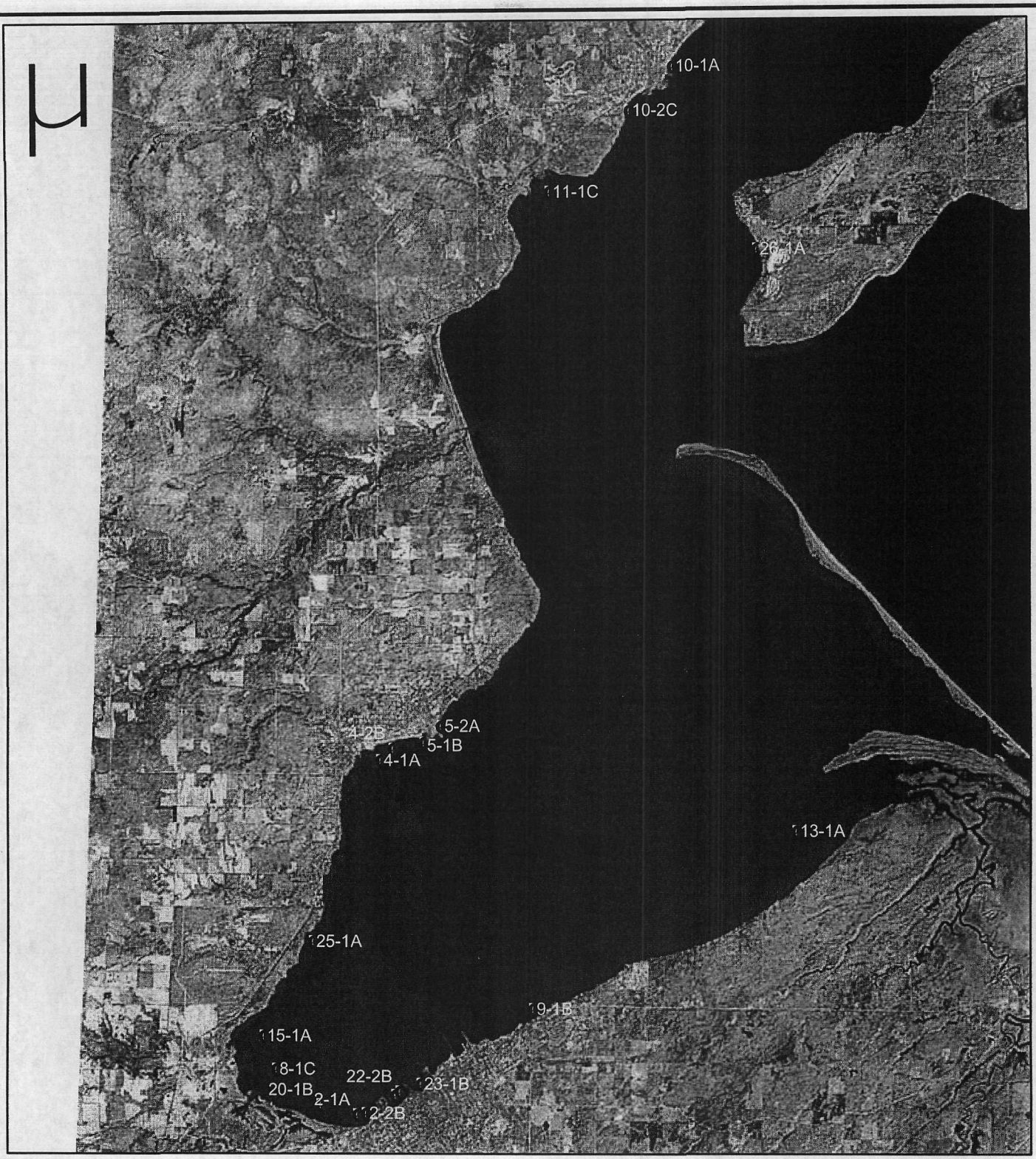
0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE:
FIGURE 2.1
Preliminary Site Sediment Quality Triad Stations Sampled During Reconnaissance Survey, May 9-13, 2005

DRAWN BY:	SCALE:	PROJECT: 25688375
CHECKED BY:	DATE:	SHEET:
APPROVED BY:		

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100



Legend

- Recon reference stations

0 0.5 1 2 3 4 Miles

PROJECT:	ASHLAND/NSP LAKEFRONT SITE ASHLAND, WISCONSIN
TITLE:	**FIGURE 2.2** **Preliminary Reference Stations Sampled During Reconnaissance Survey, May 9-13, 2005**
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CHECKED BY:	DATE:
APPROVED BY:	
PROJECT:	25688375
SHEET:	

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Legend

- SQT Samples

0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: **FIGURE 2.3**
Site Sediment Quality Triad Stations
Collected June 13-25, 2005

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CHECKED BY:	DATE:	SHEET:
APPROVED BY:		

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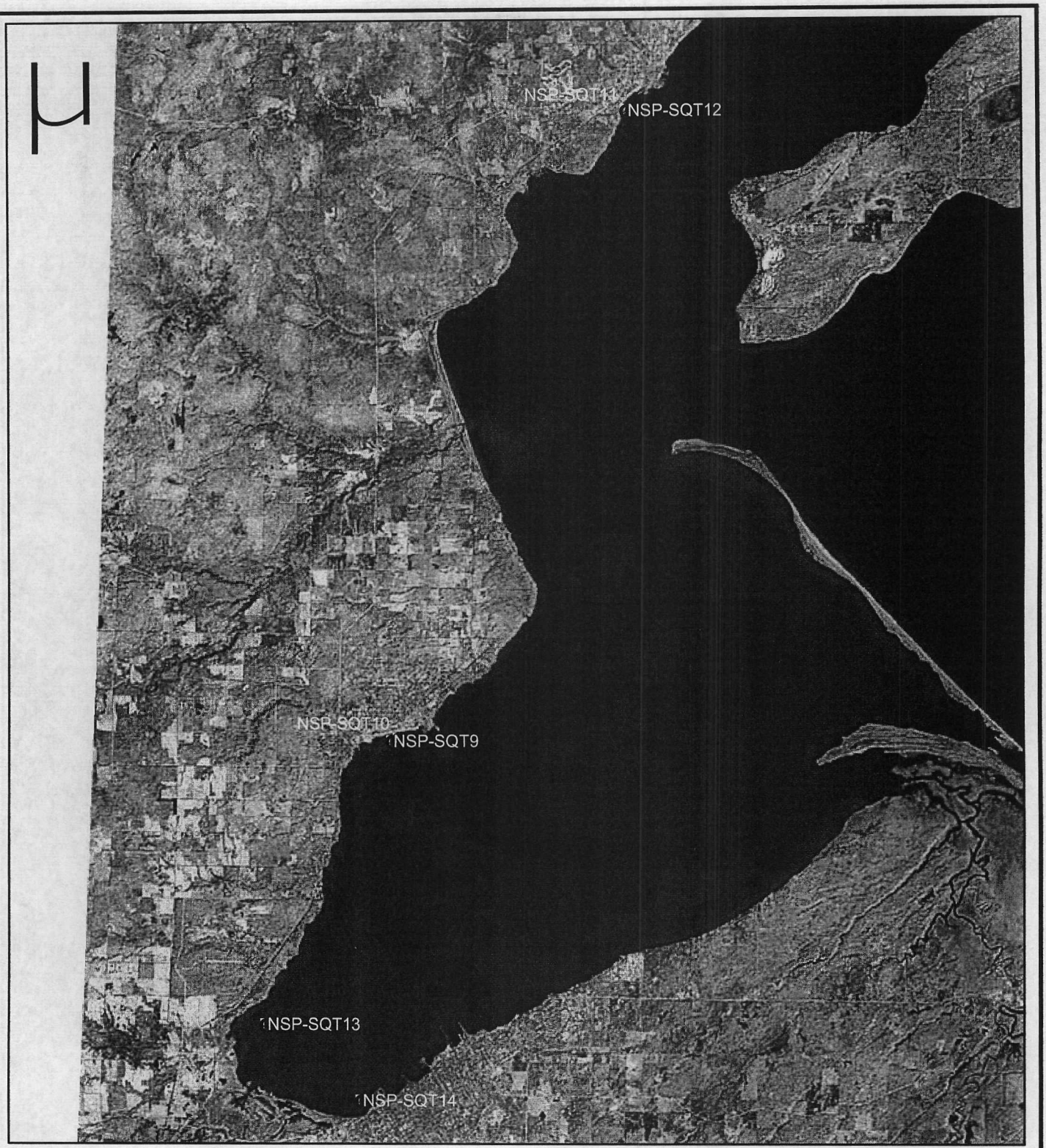
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100



Legend

- SQT reference stations

0 0.5 1 2 3 4 Miles

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE:

FIGURE 2.4
Reference Area Sediment Quality Triad Stations
Collected June 13-25, 2005 and September 27, 2005

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APPROVED BY:		

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10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Legend

- O Supplemental Sediment Samples

0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: **FIGURE 2.5**
Supplemental Sediment Samples
Collected June 13-25, 2005

DRAWN BY:	SCALE:	PROJECT: 25688375
CHECKED BY:	DATE:	SHEET:
APPROVED BY:		

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Legend

- SEDFLUME Cores

0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: **FIGURE 2.6**
Locations of Cores Collected for SEDFLUME Analysis, June 13-25, 2005

DRAWN BY:	SCALE:	PROJECT: 25688375
CHECKED BY:	DATE:	SHEET:
APPROVED BY:		

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10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Legend

- Age Dating Sediment Cores

0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: **FIGURE 2.7**
Location of Cores Collected for Age-Dating Analysis, June 13-25, 2005

DRAWN BY:	SCALE:	PROJECT: 25688375
CHECKED BY:	DATE:	SHEET:
APPROVED BY:		

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414-831-4100

Table 2.1. Sediment Quality Triad Stations Coordinates Ashland/Northern States Power Lakefront Superfund Site, Ashland, WI

Date	Time_UTC	Station	Easting	Northing	Depth
06/19/05	17:29	SQT1	1745879.4	522294.4	7.6
06/19/05	18:43	SQT2	1745937.1	522840.1	10.1
06/21/05	19:36	SQT3	1745514.5	522489.4	10.6
06/22/05	13:44	SQT4	1745584.1	522486.2	10.3
06/22/05	17:12	SQT5	1745578.1	522333.1	9.8
06/22/05	20:27	SQT6	1745267.2	523072.1	15.2
06/23/05	14:38	SQT7	1745872.2	522312.9	8.1
06/24/05	12:22	SQT8	1746041.6	522673.6	9.0
06/18/05	19:30	SQT9	1742592.2	547728.7	6.8
06/24/05	16:46	SQT10	1743125.5	547946.8	7.7
06/21/05	14:21	SQT11	1761807.2	597767.7	13.9
06/20/05	18:20	SQT12	1761705.9	597698.6	8.8
09/27/06	10:40	SQT13	1732328.0	525049.0	8.2
09/27/06	15:30	SQT14	1740097.0	518956.0	7.9-8.3

Table 3.1. Characteristics of Potential Reference Stations, Reconnaissance Sampling May 9-13, 2005. Ashland/Northern States Power Lakefront Superfund Site, Ashland, WI

SAMPLE ID	Sample Collected	LOCATION [WISP FT NAD83-north] EASTING	NORTHING	MEASURED WATER DEPTH (ft)	NOTES
2-2b	YES	1740491.0	518691.6	7.5	some wood chips with good sample
4-1a	YES	1741619.9	546787.0	9.2	sand ripples 1-2"/ sand w wood chips -possible wood chip site
4-2b	YES	1742594.4	547730.6	6.8	med. sand w wood chips and little SAV
5-1b	YES	1745031.3	548206.1	9.7	good sample
5-2a	YES	1746402.1	549488.4	8.4	small ripples, fine to med sand no wood
8-1c	YES	1733252.8	522238.0	9.2	silty sand/some wood chips
9-1b	YES	1753857.4	527034.8	7.9	good sample, silty sand ('mud')
10-1a	YES	1765266.9	601284.4	6.4	sand ripples 1-2", well-sorted sand, some "sawdust", near drain culvert some smell
10-2c	YES	1761736.0	597763.6	12.4	silty sand with some wood chips - kept -possible wood chip site
11-1c	YES	1755294.9	591409.4	7.8	sand ripples med. sand - steep slope
13-1a	YES	1775002.4	541153.6	7.9	full bucket - fine sand, no wood
15-1a	YES	1732217.8	524889.5	8.4	ponar - sand
20-1b	YES	1736849.1	519412.5	7.5	fine to medium sand
21-1c	YES	1742815.8	520166.0	8.2	sandy silt - trace wood chips
22-2b	YES	1743149.1	520455.3	8.5	SAV - fine sand with trace wood chips
23-1b	YES	1744801.0	521063.0	8.4	good sample/mostly silty sand, some wood chips
24-1a	YES	1746517.1	523272.0	8.2	full bucket - silt (cohesive 'mud')
25-1a	YES	1736240.2	532429.7	9.7	sand ripples (1-2"), cohesive silty sand ('mud")
26-1a	YES	1771962.3	586878.3	7.5	Magdeline Is - small ripples, med sand

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 NSP-SE-SQDUP09-0605-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-A-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-B-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-C-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-D-061905 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	0.67 U	0.335	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	0.0012 U	0.0006	NA	NA	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	4.7	4.7	NA	NA	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	0.023	0.023	NA	NA	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	0.0009 U	0.00045	NA	NA	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	1.8	1.8	NA	NA	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	0.093 B	0.093	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	0 U	0	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	1.8 U	0.9	NA	NA	1.7 U	0.85	1.9 U	0.95	1.8 U	0.9	1.8 U	0.9
METALS													
Aluminum	mg/Kg	1200	1200	NA	NA	1000	1000	1100	1100	1200	1200	1200	1200
Antimony	mg/Kg	1.3 UJ	0.65	NA	NA	1.4 UJ	0.7	1.4 UJ	0.7	1.6 UJ	0.8	1.6 UJ	0.8
Arsenic	mg/Kg	1.1 U	0.55	NA	NA	1.1 U	0.55	1.6 J	1.6	1.3 U	0.65	1.2 U	0.6
Barium	mg/Kg	8.4	8.4	NA	NA	5.7	5.7	6.2	6.2	7.1	7.1	7.1	7.1
Beryllium	mg/Kg	0.08 U	0.04	NA	NA	0.041 J	0.041	0.048 J	0.048	0.068 U	0.034	0.19	0.19
Cadmium	mg/Kg	0.29 U	0.145	NA	NA	0.28 U	0.14	0.29 U	0.145	0.25 U	0.125	0.32 U	0.16
Chromium	mg/Kg	5.7 J	5.7	NA	NA	4.6	4.6	4.4	4.4	2 J	2	5.2	5.2
Cobalt	mg/Kg	2.2	2.2	NA	NA	1.8 J	1.8	1.9 J	1.9	1.5 J	1.5	1.4 J	1.4
Copper	mg/Kg	7.3	7.3	NA	NA	4.4	4.4	6.1	6.1	7.2	7.2	4.7	4.7
Iron	mg/Kg	5600	5600	NA	NA	4800	4800	4700	4700	4800	4800	4500	4500
Lead	mg/Kg	6.4 U	3.2	NA	NA	6.1 U	3.05	6.4 U	3.2	5.5 U	2.75	6.9 U	3.45
Magnesium	mg/Kg	560	560	NA	NA	440	440	530	530	580	580	540	540
Manganese	mg/Kg	45	45	NA	NA	38	38	40	40	41	41	40	40
Mercury	mg/Kg	0.072 U	0.036	NA	NA	0.069 U	0.0345	0.074 U	0.037	0.073 U	0.0365	0.071 U	0.0355
Nickel	mg/Kg	2.9 J	2.9	NA	NA	2 J	2	2.7 J	2.7	1.4 J	1.4	2 J	2
Selenium	mg/Kg	1.2 U	0.6	NA	NA	1.3 U	0.65	1.3 U	0.65	1.5 U	0.75	1.4 U	0.7
Silver	mg/Kg	0.58 U	0.29	NA	NA	0.54 U	0.27	0.58 U	0.29	0.5 U	0.25	0.62 U	0.31
Thallium	mg/Kg	1.6 U	0.8	NA	NA	1.6 U	0.8	1.6 U	0.8	1.9 U	0.95	1.8 U	0.9
Vanadium	mg/Kg	16	16	NA	NA	14	14	12	12	14	14	13	13
Zinc	mg/Kg	13	13	NA	NA	9.5	9.5	10	10	11	11	11	11
OTHER													
Calcium	mg/Kg	740	740	NA	NA	600	600	1000	1000	680 J	680	690	690
Potassium	mg/Kg	140	140	NA	NA	97	97	110	110	120	120	120	120
Sodium	mg/Kg	27 U	13.5	NA	NA	30	30	30	30	27	27	24 U	12
Solids, percent	%	72.8	72.8	NA	NA	76.6	76.6	70.8	70.8	72.1	72.1	73.9	73.9

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 NSP-SE-SQDUP09-0605-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-A-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-B-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-C-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-D-061905 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	33000	33000	29000 D	29000	5200	5200	850	850	21000	21000	60000 J	60000
1-Methylphenanthrene	ug/Kg	5400 J	5400	3900	3900	790 J	790	150 J	150	3200 J	3200	8300 J	8300
2,3,5-Trimethylnaphthalene	ug/Kg	3000 J	3000	1000	1000	350 U	175	71 U	35.5	1900 J	1900	4900 J	4900
2,6-Dimethylnaphthalene	ug/Kg	20000	20000	8500	8500	2900	2900	340	340	13000	13000	33000 J	33000
2-Methylnaphthalene	ug/Kg	56000	56000	49000 D	49000	8600	8600	1300	1300	35000	35000	100000 J	100000
Acenaphthene	ug/Kg	44000	44000	37000 D	37000	6700	6700	930	930	28000	28000	74000 J	74000
Acenaphthylene	ug/Kg	2100 J	2100	1400	1400	310 U	155	140 J	140	1300 J	1300	3500 J	3500
Anthracene	ug/Kg	13000	13000	11000	11000	1900	1900	270	270	8500	8500	21000 J	21000
Benzo(a)anthracene	ug/Kg	7800	7800	7100	7100	1300	1300	480	480	5200	5200	12000 J	12000
Benzo(a)pyrene	ug/Kg	7500	7500	6200	6200	1200	1200	540	540	4800	4800	11000 J	11000
Benzo(b)fluoranthene	ug/Kg	5400 J	5400	2800	2800	940 J	940	450	450	3500	3500	8000 J	8000
Benzo(e)pyrene	ug/Kg	4100 J	4100	3400	3400	690 J	690	310	310	2700 J	2700	6200 J	6200
Benzo(g,h,i)perylene	ug/Kg	3000 J	3000	3000	3000	520 J	520	240	240	2000 J	2000	4900 J	4900
Benzo(k)fluoranthene	ug/Kg	1900 UJ	950	3700	3700	380 U	190	130 J	130	1400 J	1400	3800 U	1900
Biphenyl	ug/Kg	8600	8600	5700	5700	1300	1300	170 J	170	5500	5500	15000 J	15000
Chrysene	ug/Kg	7400	7400	6300	6300	1200	1200	460	460	4800	4800	11000 J	11000
Dibenzo(a,h)anthracene	ug/Kg	1700 U	850	570	570	340 U	170	68 U	34	850 U	425	3400 U	1700
Fluoranthene	ug/Kg	20000	20000	16000	16000	3200	3200	740	740	13000	13000	32000 J	32000
Fluorene	ug/Kg	16000	16000	11000	11000	2300	2300	300	300	10000	10000	26000 J	26000
Indeno(1,2,3-cd)pyrene	ug/Kg	1600 UJ	800	2900	2900	310 U	155	170 J	170	1400 J	1400	3100 U	1550
Naphthalene	ug/Kg	55000	55000	54000 D	54000	11000	11000	2600	2600	36000	36000	130000 J	130000
Perylene	ug/Kg	2700 U	1350	910	910	540 U	270	110 U	55	1300 U	650	5400 U	2700
Phenanthrene	ug/Kg	58000	58000	55000 D	55000	8900	8900	1100	1100	37000	37000	95000 J	95000
Pyrene	ug/Kg	31000	31000	30000 D	30000	5000	5000	1200	1200	20000	20000	49000 J	49000
TOTAL PAH													
Total PAH	ug/kg	404250	404250	349380	349380	64755	64755	12994.5	12994.5	260275	260275	712650	712650
Total PAH_0	ug/kg	400300	400300	349380	349380	63640	63640	12870	12870	259200	259200	704800	704800
Total PAH Carbon Normalized	ug PAH/kg OC	NC	66818182	NC	1164600000	NC	25696429	NC	2625152	NC	70154987	NC	77461957
% CARBON													
Soot	%	NA	NA	0.08	0.08	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	6050	6050	300	300	2520	2520	4950	4950	3710	3710	9200	9200
Total Organic Carbon (TOC)	%	NC	0.605	NC	0.03	NC	0.252	NC	0.495	NC	0.371	NC	0.92

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 NSP-SE-SQDUP09-0605-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-A-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-B-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-C-061905 6/19/2005 (0-0.5)		NSP-SQT1 NSP-SE-SQT1-0605-D-061905 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	1400	1400	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	1100	1100	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	1600 UJ	800	1200	1200	320 U	160	63 U	31.5	1300 J	1300	3200 U	1600
Dibenzothiophene	ug/kg	NA	NA	2800	2800	NA	NA	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	2700 U	1350	12	12	550 U	275	110 U	55	1400 U	700	5500 U	2750
o-Cresol	ug/Kg	1300 U	650	5.6 J	5.6	260 U	130	52 U	26	650 U	325	2600 U	1300
Pentachlorophenol	ug/kg	NA	NA	7.5 J	7.5	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	1400 U	700	10	10	280 U	140	56 U	28	700 U	350	2800 U	1400
VOCs													
1,2,3-Trimethylbenzene	ug/kg	470 U	235	NA	NA	38 U	19	38 U	19	470 U	235	240 U	120
1,2,4-Trimethylbenzene	ug/kg	1000 J	1000	NA	NA	96 J	96	63 J	63	1200	1200	180 U	90
1,3,5-Trimethylbenzene	ug/kg	410 U	205	NA	NA	33 U	16.5	33 U	16.5	410 U	205	210 U	105
Benzene	ug/kg	380 U	190	NA	NA	30 U	15	30 U	15	380 U	190	190 U	95
Ethylbenzene	ug/kg	640 J	640	NA	NA	71 J	71	82 J	82	760 J	760	330 J	330
m & p-Xylenes	ug/kg	630 U	315	NA	NA	50 U	25	50 U	25	630 U	315	310 U	155
o-Xylene	ug/kg	320 U	160	NA	NA	25 U	12.5	25 U	12.5	320 U	160	160 U	80
sec-Butyl benzene	ug/kg	480 U	240	NA	NA	39 U	19.5	39 U	19.5	480 U	240	240 U	120
Styrene	ug/kg	430 U	215	NA	NA	35 U	17.5	35 U	17.5	430 U	215	220 U	110
Toluene	ug/kg	260 U	130	NA	NA	21 U	10.5	35 J	35	260 U	130	130 U	65

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting limit
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 NSP-SE-SQT1-0605-E-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-A-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-AD 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-B-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-C-061905 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	1.2 U	0.6	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0032 B	0.0032	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.29	0.29	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.046	0.046	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0015 U	0.00075	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.022 U	0.011	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.36	0.36	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	0 U	0	NA	NA
CYANIDE													
Cyanide	mg/Kg	1.8 U	0.9	NA	NA	4.5 U	2.25	NA	NA	3.2 U	1.6	3.5 U	1.75
METALS													
Aluminum	mg/Kg	1200	1200	NA	NA	1300	1300	NA	NA	1400	1400	1600	1600
Antimony	mg/Kg	1.6 UJ	0.8	NA	NA	3.4 UJ	1.7	NA	NA	2.7 UJ	1.35	3.6 U	1.8
Arsenic	mg/Kg	1.9 J	1.9	NA	NA	3 J	3	NA	NA	2.9 J	2.9	2.8 U	1.4
Barium	mg/Kg	6.2	6.2	NA	NA	46	46	NA	NA	35	35	29	29
Beryllium	mg/Kg	0.04 U	0.02	NA	NA	0.1 U	0.05	NA	NA	0.074 U	0.037	0.32	0.32
Cadmium	mg/Kg	0.3 U	0.15	NA	NA	0.75 U	0.375	NA	NA	0.55 U	0.275	0.56 U	0.28
Chromium	mg/Kg	5.3	5.3	NA	NA	2.5 J	2.5	NA	NA	4.4	4.4	2.8 J	2.8
Cobalt	mg/Kg	1.6 J	1.6	NA	NA	4.1 J	4.1	NA	NA	2.6 J	2.6	3.2 J	3.2
Copper	mg/Kg	2.5	2.5	NA	NA	72	72	NA	NA	65	65	41	41
Iron	mg/Kg	5100	5100	NA	NA	6600	6600	NA	NA	5100	5100	4700	4700
Lead	mg/Kg	6.5 U	3.25	NA	NA	16 U	8	NA	NA	12 U	6	13 J	13
Magnesium	mg/Kg	530	530	NA	NA	690	690	NA	NA	790	790	740	740
Manganese	mg/Kg	42	42	NA	NA	97	97	NA	NA	84	84	78	78
Mercury	mg/Kg	0.095 J	0.095	NA	NA	0.075 U	0.0375	NA	NA	0.12 J	0.12	0.13 J	0.13
Nickel	mg/Kg	1.7 J	1.7	NA	NA	6 J	6	NA	NA	5.9 J	5.9	3.7 J	3.7
Selenium	mg/Kg	1.5 U	0.75	NA	NA	3.1 U	1.55	NA	NA	2.5 U	1.25	3.3 U	1.65
Silver	mg/Kg	0.58 U	0.29	NA	NA	1.5 U	0.75	NA	NA	1.1 U	0.55	1.1 U	0.55
Thallium	mg/Kg	1.9 U	0.95	NA	NA	4.1 J	4.1	NA	NA	3.2 U	1.6	4.2 U	2.1
Vanadium	mg/Kg	15	15	NA	NA	11	11	NA	NA	11	11	12	12
Zinc	mg/Kg	8	8	NA	NA	50	50	NA	NA	43	43	39	39
OTHER													
Calcium	mg/Kg	640	640	NA	NA	8400	8400	NA	NA	6300	6300	5000	5000
Potassium	mg/Kg	130	130	NA	NA	120 J	120	NA	NA	170	170	180	180
Sodium	mg/Kg	22 U	11	NA	NA	38 U	19	NA	NA	34 U	17	38 U	19
Solids, percent	%	73.5	73.5	NA	NA	29.9	29.9	NA	NA	42.2	42.2	37.6	37.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 *NSP-SE-SQT1-0605-E-061905* 6/19/2005 (0-0.5)		NSP-SQT2 *NSP-SE-SQT2-0605* 6/19/2005 (0-0.5)		NSP-SQT2 *NSP-SE-SQT2-0605-A-061905* 6/19/2005 (0-0.5)		NSP-SQT2 *NSP-SE-SQT2-0605-AD* 6/19/2005 (0-0.5)		NSP-SQT2 *NSP-SE-SQT2-0605-B-061905* 6/19/2005 (0-0.5)		NSP-SQT2 *NSP-SE-SQT2-0605-C-061905* 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	98000	98000	140	140	160 U	80	150	150	160 U	80	63 U	31.5
1-Methylphenanthrene	ug/Kg	14000	14000	260	260	190 U	95	300	300	190 U	95	78 U	39
2,3,5-Trimethylnaphthalene	ug/Kg	6700 J	6700	21	21	180 U	90	29	29	180 U	90	71 U	35.5
2,6-Dimethylnaphthalene	ug/Kg	56000	56000	54	54	200 U	100	57	57	200 U	100	82 U	41
2-Methylnaphthalene	ug/Kg	160000	160000	240	240	160 U	80	260	260	160 U	80	62 U	31
Acenaphthene	ug/Kg	120000	120000	89	89	160 U	80	89	89	160 U	80	65 U	32.5
Acenaphthylene	ug/Kg	5800 J	5800	120	120	150 U	75	130	130	150 U	75	61 U	30.5
Anthracene	ug/Kg	36000	36000	120	120	190 U	95	130	130	190 U	95	77 U	38.5
Benzo(a)anthracene	ug/Kg	21000	21000	230	230	170 U	85	290	290	170 U	85	270	270
Benzo(a)pyrene	ug/Kg	20000	20000	240	240	170 U	85	290	290	440 J	440	340	340
Benzo(b)fluoranthene	ug/Kg	14000	14000	170	170	190 U	95	220	220	190 U	95	350	350
Benzo(e)pyrene	ug/Kg	11000 J	11000	180	180	190 U	95	230	230	190 U	95	240 J	240
Benzo(g,h,i)perylene	ug/Kg	8400 J	8400	140	140	160 U	80	180	180	160 U	80	65 U	32.5
Benzo(k)fluoranthene	ug/Kg	3800 U	1900	170	170	190 U	95	210	210	190 U	95	76 U	38
Biphenyl	ug/Kg	25000	25000	49	49	150 U	75	55	55	150 U	75	60 U	30
Chrysene	ug/Kg	20000	20000	260	260	180 U	90	320	320	180 U	90	300	300
Dibenzo(a,h)anthracene	ug/Kg	3400 U	1700	33	33	170 U	85	39	39	170 U	85	68 U	34
Fluoranthene	ug/Kg	55000	55000	460	460	190 U	95	540	540	190 U	95	370	370
Fluorene	ug/Kg	44000	44000	68	68	160 U	80	72	72	160 U	80	65 U	32.5
Indeno(1,2,3-cd)pyrene	ug/Kg	6100 J	6100	130	130	160 U	80	160	160	160 U	80	62 U	31
Naphthalene	ug/Kg	190000	190000	440	440	150 U	75	500	500	150 U	75	61 U	30.5
Perylene	ug/Kg	5400 U	2700	51	51	270 U	135	62	62	270 U	135	110 U	55
Phenanthrene	ug/Kg	160000	160000	440	440	180 U	90	480	480	180 U	90	290	290
Pyrene	ug/Kg	85000	85000	710	710	180 U	90	810	810	570 J	570	560	560
TOTAL PAH													
Total PAH	ug/kg	1162300	1162300	4815	4815	4250 U	2125	5603	5603	2960	2960	3283	3283
Total PAH_0	ug/kg	1156000	1156000	4815	4815	150 U	75	5603	5603	1010	1010	2720	2720
Total PAH Carbon Normalized	ug PAH/kg OC	NC	109650943	NC	48150	NC	3284	NC	NC	NC	7688	NC	7045
CARBON													
Soot	%	NA	NA	2.2	2.2	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	10600	10600	100000	100000	647000	647000	NA	NA	385000	385000	466000	466000
Total Organic Carbon (TOC)	%	NC	1.06	NC	10	NC	64.7	NC	NC	NC	38.5	NC	46.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT1 NSP-SE-SQT1-0605-E-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-A-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-AD 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-B-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-C-061905 6/19/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	60	60	NA	NA	72	72	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	42	42	NA	NA	49	49	NA	NA	NA	NA
Dibenzofuran	ug/Kg	5100 J	5100	59	59	160 U	80	68	68	160 U	80	63 U	31.5
Dibenzothiophene	ug/kg	NA	NA	36	36	NA	NA	38	38	NA	NA	NA	NA
m & p-cresols	ug/Kg	5500 U	2750	670	670	270 U	135	560	560	270 U	135	110 U	55
o-Cresol	ug/Kg	2600 U	1300	36 J	36	130 U	65	49 J	49	130 U	65	52 U	26
Pentachlorophenol	ug/kg	NA	NA	51 J	51	NA	NA	66	66	NA	NA	NA	NA
Phenol	ug/Kg	2800 U	1400	160	160	140 U	70	140	140	140 U	70	56 U	28
VOCs													
1,2,3-Trimethylbenzene	ug/kg	240 U	120	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	180 U	90	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	210 U	105	NA	NA	16 U	8	NA	NA	16 U	8	16 U	8
Benzene	ug/kg	190 U	95	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	190 U	95	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	310 U	155	NA	NA	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	160 U	80	NA	NA	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	240 U	120	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
Styrene	ug/kg	220 U	110	NA	NA	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5
Toluene	ug/kg	130 U	65	NA	NA	390	390	NA	NA	1200	1200	640	640

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT2 NSP-SE-SQT2-0605-D-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-E-061905 6/19/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQDUP12-0605-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-AD 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	2.2	2.2	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	0.0018 U	0.0009	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	NA	NA	0.29	0.29	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	NA	NA	0.067	0.067	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	NA	NA	0.0012 U	0.0006	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	NA	NA	0.42	0.42	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	NA	NA	0.3	0.3	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	0.5	0.5	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	3.6 U	1.8	3.1 U	1.55	3 U	1.5	NA	NA	5 U	2.5	NA	NA
METALS													
Aluminum	mg/Kg	1300	1300	1500	1500	2000	2000	NA	NA	980	980	NA	NA
Antimony	mg/Kg	3.4 U	1.7	3.2 U	1.6	2 U	1	NA	NA	2.7 U	1.35	NA	NA
Arsenic	mg/Kg	3.6 J	3.6	2.6 U	1.3	3.5 J	3.5	NA	NA	6.5 J	6.5	NA	NA
Barium	mg/Kg	36	36	23	23	25	25	NA	NA	44	44	NA	NA
Beryllium	mg/Kg	0.1 J	0.1	0.24 J	0.24	0.23	0.23	NA	NA	0.26 J	0.26	NA	NA
Cadmium	mg/Kg	0.61 J	0.61	0.55 U	0.275	0.46 U	0.23	NA	NA	0.7 U	0.35	NA	NA
Chromium	mg/Kg	2.9 J	2.9	3.7 J	3.7	5.8	5.8	NA	NA	2.7 J	2.7	NA	NA
Cobalt	mg/Kg	1.9 J	1.9	2.1 J	2.1	3.1	3.1	NA	NA	3.2 J	3.2	NA	NA
Copper	mg/Kg	48	48	16	16	13	13	NA	NA	40	40	NA	NA
Iron	mg/Kg	5100	5100	3600	3600	6100	6100	NA	NA	6300	6300	NA	NA
Lead	mg/Kg	13 U	6.5	12 U	6	18 J	18	NA	NA	15 U	7.5	NA	NA
Magnesium	mg/Kg	650	650	710	710	440 J	440	NA	NA	560 J	560	NA	NA
Manganese	mg/Kg	81	81	68	68	73	73	NA	NA	86	86	NA	NA
Mercury	mg/Kg	0.077 U	0.0385	0.11 J	0.11	0.071 U	0.0355	NA	NA	0.084 U	0.042	NA	NA
Nickel	mg/Kg	4.7 J	4.7	4.4 J	4.4	5.2 J	5.2	NA	NA	6.6 J	6.6	NA	NA
Selenium	mg/Kg	3.1 U	1.55	3 U	1.5	1.9 U	0.95	NA	NA	2.6 U	1.3	NA	NA
Silver	mg/Kg	1.1 U	0.55	1.1 U	0.55	0.9 U	0.45	NA	NA	1.4 U	0.7	NA	NA
Thallium	mg/Kg	4 U	2	3.8 U	1.9	2.4 U	1.2	NA	NA	3.3 U	1.65	NA	NA
Vanadium	mg/Kg	9.6	9.6	11	11	15	15	NA	NA	8.3	8.3	NA	NA
Zinc	mg/Kg	42	42	28	28	35	35	NA	NA	67	67	NA	NA
OTHER													
Calcium	mg/Kg	7100	7100	4900	4900	3800	3800	NA	NA	7800	7800	NA	NA
Potassium	mg/Kg	110	110	170	170	230	230	NA	NA	78 J	78	NA	NA
Sodium	mg/Kg	32 U	16	40 U	20	42	42	NA	NA	32 U	16	NA	NA
Solids, percent	%	37.2	37.2	42.9	42.9	44.7	44.7	NA	NA	27	27	NA	NA

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT2 NSP-SE-SQT2-0605-D-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-E-061905 6/19/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQDUP12-0605-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-AD 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	63 U	31.5	160 U	80	160 U	80	790	790	160 U	80	980	980
1-Methylphenanthrene	ug/Kg	78 U	39	190 U	95	190 U	95	640	640	190 U	95	770	770
2,3,5-Trimethylnaphthalene	ug/Kg	71 U	35.5	180 U	90	180 U	90	140	140	180 U	90	160	160
2,6-Dimethylnaphthalene	ug/Kg	82 U	41	200 U	100	200 U	100	640	640	200 U	100	520	520
2-Methylnaphthalene	ug/Kg	62 U	31	160 U	80	160 U	80	1800	1800	160 U	80	2200	2200
Acenaphthene	ug/Kg	65 U	32.5	160 U	80	160 U	80	760	760	660	660	870	870
Acenaphthylene	ug/Kg	61 U	30.5	150 U	75	150 U	75	780	780	920	920	990	990
Anthracene	ug/Kg	77 U	38.5	190 U	95	190 U	95	1200	1200	720	720	1500	1500
Benzo(a)anthracene	ug/Kg	260	260	170 U	85	700	700	2100	2100	2500	2500	3000	3000
Benzo(a)pyrene	ug/Kg	340 J	340	170 U	85	890 J	890	2400	2400	3200	3200	3500	3500
Benzo(b)fluoranthene	ug/Kg	360 J	360	190 U	95	800 J	800	1300	1300	2500	2500	1900	1900
Benzo(e)pyrene	ug/Kg	230 J	230	190 U	95	550 J	550	1500	1500	1900	1900	2200	2200
Benzo(g,h,i)perylene	ug/Kg	65 UJ	32.5	160 U	80	160 UJ	80	1200	1200	1200	1200	1800	1800
Benzo(k)fluoranthene	ug/Kg	76 UJ	38	190 U	95	190 UJ	95	1500	1500	1100	1100	2300	2300
Biphenyl	ug/Kg	60 U	30	150 U	75	150 U	75	280	280	150 U	75	340	340
Chrysene	ug/Kg	290	290	180 U	90	730	730	2000	2000	2500	2500	3000	3000
Dibenzo(a,h)anthracene	ug/Kg	68 UJ	34	170 U	85	170 UJ	85	280	280	170 U	85	410	410
Fluoranthene	ug/Kg	260	260	190 U	95	940	940	2900	2900	2500	2500	3800	3800
Fluorene	ug/Kg	65 U	32.5	160 U	80	160 U	80	510	510	160 U	80	610	610
Indeno(1,2,3-cd)pyrene	ug/Kg	62 U	31	160 U	80	160 U	80	1200	1200	840	840	1800	1800
Naphthalene	ug/Kg	61 U	30.5	150 U	75	150 U	75	2700	2700	570	570	3000	3000
Perylene	ug/Kg	110 UJ	55	270 U	135	270 UJ	135	390	390	270 U	135	590	590
Phenanthrene	ug/Kg	73 U	36.5	180 U	90	420 J	420	2300	2300	1700	1700	3000	3000
Pyrene	ug/Kg	510	510	180 U	90	1800 J	1800	5000	5000	4700	4700	6400	6400
TOTAL PAH													
Total PAH	ug/kg	2849.5	2849.5	4250 U	2125	8230	8230	34310	34310	28330	28330	45640	45640
Total PAH_0	ug/kg	2250	2250	150 U	75	6830	6830	34310	34310	27510	27510	45640	45640
Total PAH Carbon Normalized	ug PAH/kg OC	NC	7982	NC	7535	NC	43089	NC	418415	NC	65126	NC	NC
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	5.2	5.2	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	357000	357000	282000	282000	191000	191000	82000	82000	435000	435000	NA	NA
Total Organic Carbon (TOC)	%	NC	35.7	NC	28.2	NC	19.1	NC	8.2	NC	43.5	NC	NC

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT2 NSP-SE-SQT2-0605-D-061905 6/19/2005 (0-0.5)		NSP-SQT2 NSP-SE-SQT2-0605-E-061905 6/19/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQDUP12-0605-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-AD 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	600	600	NA	NA	860	860
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	350	350	NA	NA	480	480
Dibenzofuran	ug/Kg	63 U	31.5	160 U	80	160 U	80	180	180	160 U	80	220	220
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	280	280	NA	NA	320	320
m & p-cresols	ug/Kg	110 U	55	270 U	135	270 U	135	290	290	270 U	135	280	280
o-Cresol	ug/Kg	52 U	26	130 U	65	130 U	65	28 J	28	130 U	65	26 J	26
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	28 J	28	NA	NA	40 U	20
Phenol	ug/Kg	56 U	28	140 U	70	140 U	70	200	200	140 U	70	95	95
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	NA	NA
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	NA	NA
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	NA	NA	16 U	8	NA	NA
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	NA	NA
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	NA	NA
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA	25 U	12.5	NA	NA
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA	13 U	6.5	NA	NA
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	NA	NA
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5	NA	NA
Toluene	ug/kg	790	790	1200	1200	250 J	250	NA	NA	300	300	NA	NA

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT3 NSP-SE-SQT3-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-E-062105 6/21/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-A-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	2.8	2.8	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	0.002 U	0.001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	0.069 B	0.069	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	0.074	0.074	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	0.0014 U	0.0007	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	0.022 B	0.022	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	0.36	0.36	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		0.19	0.19	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	3.8 U	1.9	3.7 U	1.85	3.7 U	1.85	2.6 U	1.3	NA	NA	4.5 U	2.25
METALS													
Aluminum	mg/Kg	1600	1600	2900	2900	2700	2700	4400	4400	NA	NA	1500	1500
Antimony	mg/Kg	2.6 U	1.3	2.6 U	1.3	2.7 U	1.35	1.8 U	0.9	NA	NA	3 U	1.5
Arsenic	mg/Kg	4.1 J	4.1	4.4 J	4.4	4 J	4	2.9 J	2.9	NA	NA	4.7 J	4.7
Barium	mg/Kg	35	35	51	51	45	45	33	33	NA	NA	65	65
Beryllium	mg/Kg	0.21 J	0.21	0.32	0.32	0.32	0.32	0.43	0.43	NA	NA	0.8	0.8
Cadmium	mg/Kg	0.66 U	0.33	0.57 J	0.57	0.48 U	0.24	0.36 U	0.18	NA	NA	0.9 J	0.9
Chromium	mg/Kg	3.7 J	3.7	10	10	8.6	8.6	13	13	NA	NA	3.9 J	3.9
Cobalt	mg/Kg	2.3 J	2.3	3.7	3.7	4.4	4.4	4.4	4.4	NA	NA	2.7 J	2.7
Copper	mg/Kg	18	18	71	71	59	59	36	36	NA	NA	58	58
Iron	mg/Kg	6700	6700	9700	9700	9000	9000	11000	11000	NA	NA	11000	11000
Lead	mg/Kg	16 J	16	36 J	36	19 J	19	25 J	25	NA	NA	16 U	8
Magnesium	mg/Kg	790 J	790	1100 J	1100	1300 J	1300	1900 J	1900	NA	NA	970	970
Manganese	mg/Kg	84	84	130	130	130	130	120	120	NA	NA	250	250
Mercury	mg/Kg	0.065 U	0.0325	0.073 U	0.0365	0.073 U	0.0365	0.077 U	0.0385	NA	NA	0.076 UJ	0.038
Nickel	mg/Kg	5.7 J	5.7	10	10	7.6 J	7.6	9.1	9.1	NA	NA	8 J	8
Selenium	mg/Kg	2.4 U	1.2	2.4 U	1.2	2.5 U	1.25	1.7 U	0.85	NA	NA	2.8 U	1.4
Silver	mg/Kg	1.3 U	0.65	0.93 U	0.465	0.94 U	0.47	0.7 U	0.35	NA	NA	1.4 U	0.7
Thallium	mg/Kg	3 U	1.5	3.1 U	1.55	3.2 U	1.6	2.1 U	1.05	NA	NA	3.6 U	1.8
Vanadium	mg/Kg	11	11	17	17	16	16	27	27	NA	NA	12	12
Zinc	mg/Kg	58	58	77	77	79	79	45	45	NA	NA	80	80
OTHER													
Calcium	mg/Kg	5900	5900	6700	6700	6400	6400	3600	3600	NA	NA	13000	13000
Potassium	mg/Kg	150	150	370	370	340	340	500	500	NA	NA	180	180
Sodium	mg/Kg	38 U	19	53 U	26.5	52	52	63	63	NA	NA	41 U	20.5
Solids, percent	%	34.9	34.9	36	36	36.2	36.2	51.2	51.2	NA	NA	29.6	29.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT3 NSP-SE-SQT3-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-E-062105 6/21/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-A-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	650	650	160 U	80
1-Methylphenanthrene	ug/Kg	190 U	95	190 U	95	190 U	95	190 U	95	510	510	190 U	95
2,3,5-Trimethylnaphthalene	ug/Kg	180 U	90	180 U	90	180 U	90	180 U	90	92	92	180 U	90
2,6-Dimethylnaphthalene	ug/Kg	200 U	100	200 U	100	200 U	100	200 U	100	360	360	200 U	100
2-Methylnaphthalene	ug/Kg	160 U	80	570	570	470 J	470	160 U	80	1400	1400	160 U	80
Acenaphthene	ug/Kg	160 U	80	490 J	490	160 U	80	160 U	80	540	540	160 U	80
Acenaphthylene	ug/Kg	150 U	75	1200	1200	980	980	150 U	75	520	520	540	540
Anthracene	ug/Kg	190 U	95	720	720	190 U	95	190 U	95	870	870	190 U	95
Benzo(a)anthracene	ug/Kg	900	900	2800	2800	2300	2300	430 J	430	1700	1700	1400	1400
Benzo(a)pyrene	ug/Kg	1100	1100	3800	3800	3300 J	3300	600	600	1800	1800	1900	1900
Benzo(b)fluoranthene	ug/Kg	940	940	3200	3200	2900 J	2900	480 J	480	1100	1100	1600	1600
Benzo(e)pyrene	ug/Kg	700	700	2200	2200	2000 J	2000	390 J	390	1200	1200	1200	1200
Benzo(g,h,i)perylene	ug/Kg	160 U	80	1300	1300	1000 J	1000	160 U	80	820	820	720	720
Benzo(k)fluoranthene	ug/Kg	190 U	95	1300	1300	1100 J	1100	190 U	95	1100	1100	190 U	95
Biphenyl	ug/Kg	150 U	75	150 U	75	150 U	75	150 U	75	210	210	150 U	75
Chrysene	ug/Kg	950	950	2900	2900	2300	2300	450 J	450	1700	1700	1500	1500
Dibenzo(a,h)anthracene	ug/Kg	170 U	85	170 U	85	170 UJ	85	170 U	85	190	190	170 U	85
Fluoranthene	ug/Kg	1200	1200	2800	2800	2000	2000	410 J	410	2400	2400	1200	1200
Fluorene	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	370	370	160 U	80
Indeno(1,2,3-cd)pyrene	ug/Kg	160 U	80	880	880	670	670	160 U	80	810	810	160 U	80
Naphthalene	ug/Kg	150 U	75	820	820	680	680	150 U	75	2100	2100	150 U	75
Perylene	ug/Kg	270 U	135	820 J	820	270 UJ	135	270 U	135	300	300	270 U	135
Phenanthrene	ug/Kg	180 U	90	1900	1900	920	920	180 U	90	1900	1900	640	640
Pyrene	ug/Kg	2100	2100	5000	5000	3700	3700	790	790	4300	4300	2300	2300
TOTAL PAH													
Total PAH	ug/kg	9380	9380	33305	33305	25235	25235	5040	5040	26942	26942	14245	14245
Total PAH_0	ug/kg	7890	7890	32700	32700	24320	24320	3550	3550	26942	26942	13000	13000
Total PAH Carbon Normalized	ug PAH/kg OC	NC	52994	NC	87186	NC	69327	NC	44211	NC	168388	NC	36432
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	9.1	9.1	NA	NA
Total Organic Carbon (TOC)	mg/Kg	177000	177000	382000	382000	364000	364000	114000	114000	160000	160000	391000	391000
Total Organic Carbon (TOC)	%	NC	17.7	NC	38.2	NC	36.4	NC	11.4	NC	16	NC	39.1

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT3 NSP-SE-SQT3-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT3 NSP-SE-SQT3-0605-E-062105 6/21/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-A-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	420	420	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	260	260	NA	NA
Dibenzofuran	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	130	130	160 U	80
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	200	200	NA	NA
m & p-cresols	ug/Kg	270 U	135	270 U	135	270 U	135	270 U	135	240	240	270 U	135
o-Cresol	ug/Kg	130 U	65	130 U	65	130 U	65	130 U	65	30 J	30	130 U	65
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	12 J	12	NA	NA
Phenol	ug/Kg	140 U	70	140 U	70	140 U	70	140 U	70	140	140	140 U	70
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8	NA	NA	16 U	8
Benzene	ug/kg	15 U	7.5	54	54	45 J	45	15 U	7.5	NA	NA	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5
Toluene	ug/kg	630 J	630	340	340	400	400	350	350	NA	NA	260	260

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT4 NSP-SE-SQT4-0605-AD 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-D-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQDUP13-0605-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	1.3 U	0.65	1.7 U	0.85
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0061 B	0.0061	0.0081 B	0.0081
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.71	0.71	0.66	0.66
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.065	0.065	0.11	0.11
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0016 U	0.0008	0.0021 U	0.00105
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.039 B	0.039	0.043 B	0.043
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.74	0.74	1	1
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	0 U	0	0 U	0
CYANIDE													
Cyanide	mg/Kg	NA	NA	4.3 U	2.15	4.4 U	2.2	4.3 U	2.15	3.9 U	1.95	4.7 U	2.35
METALS													
Aluminum	mg/Kg	NA	NA	1600	1600	1600	1600	1600	1600	1900	1900	1800	1800
Antimony	mg/Kg	NA	NA	3.8 J	3.8	3 U	1.5	3.9 U	1.95	3.1 U	1.55	3.5 U	1.75
Arsenic	mg/Kg	NA	NA	4.1 J	4.1	4 J	4	3.4 J	3.4	3.8 J	3.8	5 J	5
Barium	mg/Kg	NA	NA	60	60	61	61	57	57	61	61	51	51
Beryllium	mg/Kg	NA	NA	0.93	0.93	0.26 J	0.26	0.14 J	0.14	0.31 J	0.31	0.32 J	0.32
Cadmium	mg/Kg	NA	NA	0.73 U	0.365	0.77 J	0.77	0.7 U	0.35	1 J	1	0.66 U	0.33
Chromium	mg/Kg	NA	NA	5.2 J	5.2	5.5	5.5	5.6	5.6	4.3 J	4.3	5	5
Cobalt	mg/Kg	NA	NA	3.4 J	3.4	3.3 J	3.3	3.6 J	3.6	3.9 J	3.9	2.9 J	2.9
Copper	mg/Kg	NA	NA	74	74	74	74	72	72	77	77	64	64
Iron	mg/Kg	NA	NA	9000	9000	9300	9300	8800	8800	9600	9600	9600	9600
Lead	mg/Kg	NA	NA	19 J	19	21 J	21	15 U	7.5	15 J	15	31 J	31
Magnesium	mg/Kg	NA	NA	910	910	1000	1000	970	970	1200	1200	1200	1200
Manganese	mg/Kg	NA	NA	140	140	170	170	150	150	100	100	89	89
Mercury	mg/Kg	NA	NA	0.073 UJ	0.0365	0.073 UJ	0.0365	0.44 J	0.44	0.066 UJ	0.033	0.079 UJ	0.0395
Nickel	mg/Kg	NA	NA	10 J	10	10 J	10	7.7 J	7.7	8.7 J	8.7	9.3 J	9.3
Selenium	mg/Kg	NA	NA	2.8 U	1.4	2.8 U	1.4	3.6 U	1.8	2.9 U	1.45	3.2 U	1.6
Silver	mg/Kg	NA	NA	1.4 U	0.7	1.5 U	0.75	1.4 U	0.7	1.3 U	0.65	1.3 U	0.65
Thallium	mg/Kg	NA	NA	3.6 U	1.8	3.6 U	1.8	4.6 U	2.3	3.7 U	1.85	6 J	6
Vanadium	mg/Kg	NA	NA	13	13	13	13	12	12	14	14	12	12
Zinc	mg/Kg	NA	NA	100	100	89	89	80	80	98	98	100	100
OTHER													
Calcium	mg/Kg	NA	NA	10000	10000	11000	11000	10000	10000	10000	10000	7600	7600
Potassium	mg/Kg	NA	NA	130	130	160	160	190	190	190	190	200	200
Sodium	mg/Kg	NA	NA	38 U	19	36 U	18	37 U	18.5	38 U	19	43 U	21.5
Solids, percent	%	NA	NA	31	31	30.8	30.8	31.2	31.2	34	34	28.5	28.5

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT4 NSP-SE-SQT4-0605-AD 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-D-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQDUP13-0605-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	810	810	160 U	80	160 U	80	160 U	80	160 U	80	320 U	160
1-Methylphenanthrene	ug/Kg	650	650	190 U	95	190 U	95	190 U	95	190 U	95	1700	1700
2,3,5-Trimethylnaphthalene	ug/Kg	100	100	180 U	90	180 U	90	180 U	90	180 U	90	350 U	175
2,6-Dimethylnaphthalene	ug/Kg	410	410	200 U	100	200 U	100	200 U	100	200 U	100	1600	1600
2-Methylnaphthalene	ug/Kg	1800	1800	160 U	80	160 U	80	160 U	80	160 U	80	1500	1500
Acenaphthene	ug/Kg	590	590	540	540	160 U	80	160 U	80	160 U	80	2000	2000
Acenaphthylene	ug/Kg	740	740	950	950	150 U	75	730	730	620	620	2500	2500
Anthracene	ug/Kg	1000	1000	640	640	190 U	95	190 U	95	190 U	95	2200	2200
Benzo(a)anthracene	ug/Kg	2400	2400	2400	2400	1200	1200	1900	1900	1700	1700	6300	6300
Benzo(a)pyrene	ug/Kg	2600	2600	3400	3400	1700	1700	2700	2700	2300 J	2300	8700	8700
Benzo(b)fluoranthene	ug/Kg	1500	1500	2800	2800	1400	1400	2300	2300	2200 J	2200	7100	7100
Benzo(e)pyrene	ug/Kg	1600	1600	2000	2000	1000	1000	1600	1600	1500 J	1500	5100	5100
Benzo(g,h,i)perylene	ug/Kg	1300	1300	1000	1000	160 U	80	790	790	600 J	600	3100	3100
Benzo(k)fluoranthene	ug/Kg	1600	1600	1200	1200	190 U	95	910	910	650 J	650	2400	2400
Biphenyl	ug/Kg	260	260	150 U	75	150 U	75	150 U	75	150 U	75	300 U	150
Chrysene	ug/Kg	2400	2400	2400	2400	1400	1400	1900	1900	1700	1700	6300	6300
Dibenzo(a,h)anthracene	ug/Kg	300	300	170 U	85	170 U	85	170 U	85	170 UJ	85	340 U	170
Fluoranthene	ug/Kg	2900	2900	2400	2400	1200	1200	1600	1600	1700	1700	7200	7200
Fluorene	ug/Kg	420	420	160 U	80	160 U	80	160 U	80	160 U	80	1300	1300
Indeno(1,2,3-cd)pyrene	ug/Kg	1300	1300	650	650	160 U	80	160 U	80	160 U	80	2200	2200
Naphthalene	ug/Kg	2500	2500	150 U	75	150 U	75	150 U	75	150 U	75	1900	1900
Perylene	ug/Kg	430	430	720 J	720	270 U	135	270 U	135	270 UJ	135	540 U	270
Phenanthrene	ug/Kg	2200	2200	1600	1600	180 U	90	710	710	820	820	6800	6800
Pyrene	ug/Kg	5200	5200	4300	4300	2300	2300	3100	3100	3100	3100	12000	12000
TOTAL PAH													
Total PAH	ug/kg	35010	35010	27760	27760	11690	11690	19390	19390	18040	18040	82825	82825
Total PAH_0	ug/kg	35010	35010	27000	27000	10200	10200	18240	18240	16890	16890	81900	81900
Total PAH Carbon Normalized	ug PAH/kg OC	NC	NC	NC	60217	NC	22481	NC	40907	NC	41663	NC	188667
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	NA	NA	461000	461000	520000	520000	474000	474000	433000	433000	439000	439000
Total Organic Carbon (TOC)	%	NC	NC	NC	46.1	NC	52	NC	47.4	NC	43.3	NC	43.9

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT4 NSP-SE-SQT4-0605-AD 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-D-062205 6/22/2005 (0-0.5)		NSP-SQT4 NSP-SE-SQT4-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQDUP13-0605-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	630	630	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	370	370	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	160	160	160 U	80	160 U	80	160 U	80	160 U	80	320 U	160
Dibenzothiophene	ug/kg	220	220	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	340	340	270 U	135	270 U	135	270 U	135	270 U	135	550 U	275
o-Cresol	ug/Kg	40 J	40	130 U	65	130 U	65	130 U	65	130 U	65	260 U	130
Pentachlorophenol	ug/kg	95 U	47.5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	240	240	140 U	70	140 U	70	140 U	70	140 U	70	280 U	140
VOCs													
1,2,3-Trimethylbenzene	ug/kg	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	NA	NA	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 UJ	7.5
Ethylbenzene	ug/kg	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 UJ	7.5
m & p-Xylenes	ug/kg	NA	NA	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	NA	NA	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	NA	NA	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	NA	NA	410	410	210	210	210	210	280	280	280	280

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-AD 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-D-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	1.5 U	0.75	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	0.0068 B	0.0068	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	0.6	0.6	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	0.1	0.1	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	0.0019 U	0.00095	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	0.036 B	0.036	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	0.98	0.98	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	0 U	0	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	NA	NA	4.5 U	2.25	NA	NA	3.7 U	1.85	3.6 U	1.8	4.5 U	2.25
METALS													
Aluminum	mg/Kg	NA	NA	1300	1300	NA	NA	2300	2300	1500	1500	1400	1400
Antimony	mg/Kg	NA	NA	2.6 U	1.3	NA	NA	4.2 J	4.2	2.8 J	2.8	3.2 U	1.6
Arsenic	mg/Kg	NA	NA	6.3 J	6.3	NA	NA	3.2 J	3.2	4 J	4	5.4 J	5.4
Barium	mg/Kg	NA	NA	42	42	NA	NA	34	34	36	36	45	45
Beryllium	mg/Kg	NA	NA	0.6 J	0.6	NA	NA	0.88	0.88	0.26	0.26	0.26 J	0.26
Cadmium	mg/Kg	NA	NA	0.52 U	0.26	NA	NA	0.65 U	0.325	0.51 U	0.255	0.57 U	0.285
Chromium	mg/Kg	NA	NA	5.4	5.4	NA	NA	5.9	5.9	4.2	4.2	5	5
Cobalt	mg/Kg	NA	NA	3.3 J	3.3	NA	NA	2.8 J	2.8	3 J	3	3.4 J	3.4
Copper	mg/Kg	NA	NA	47	47	NA	NA	19	19	24	24	52	52
Iron	mg/Kg	NA	NA	7100	7100	NA	NA	7700	7700	7300	7300	7600	7600
Lead	mg/Kg	NA	NA	20 J	20	NA	NA	28 J	28	24 J	24	25 J	25
Magnesium	mg/Kg	NA	NA	870	870	NA	NA	980	980	890	890	870	870
Manganese	mg/Kg	NA	NA	88	88	NA	NA	99	99	82	82	80	80
Mercury	mg/Kg	NA	NA	0.075 UJ	0.0375	NA	NA	1.2 J	1.2	0.07 UJ	0.035	0.076 UJ	0.038
Nickel	mg/Kg	NA	NA	7.9 J	7.9	NA	NA	7.2 J	7.2	6.7 J	6.7	8.4 J	8.4
Selenium	mg/Kg	NA	NA	2.5 U	1.25	NA	NA	1.8 U	0.9	2.2 U	1.1	2.9 U	1.45
Silver	mg/Kg	NA	NA	1 U	0.5	NA	NA	1.3 U	0.65	1 U	0.5	1.1 U	0.55
Thallium	mg/Kg	NA	NA	3.4 J	3.4	NA	NA	2.9 J	2.9	3.5 J	3.5	3.7 U	1.85
Vanadium	mg/Kg	NA	NA	9.7	9.7	NA	NA	19	19	12	12	11	11
Zinc	mg/Kg	NA	NA	78	78	NA	NA	68	68	54	54	97	97
OTHER													
Calcium	mg/Kg	NA	NA	8100	8100	NA	NA	5300	5300	5800	5800	6900	6900
Potassium	mg/Kg	NA	NA	140	140	NA	NA	220	220	150	150	130	130
Sodium	mg/Kg	NA	NA	36 U	18	NA	NA	44	44	37	37	33 U	16.5
Solids, percent	%	NA	NA	29.9	29.9	NA	NA	36.7	36.7	37.4	37.4	29.6	29.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-AD 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-D-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	1800	1800	320 U	160	1800	1800	320 U	160	320 U	160	320 U	160
1-Methylphenanthrene	ug/Kg	2100	2100	1400	1400	1900	1900	1800	1800	390 U	195	1300	1300
2,3,5-Trimethylnaphthalene	ug/Kg	390	390	350 U	175	390	390	350 U	175	350 U	175	350 U	175
2,6-Dimethylnaphthalene	ug/Kg	1200	1200	410 U	205	1100	1100	410 U	205	410 U	205	410 U	205
2-Methylnaphthalene	ug/Kg	4000	4000	1200	1200	3600	3600	310 U	155	310 U	155	1300	1300
Acenaphthene	ug/Kg	2300	2300	1800	1800	1900	1900	1100	1100	880 J	880	1700	1700
Acenaphthylene	ug/Kg	1400	1400	2100	2100	1300	1300	1500	1500	1000 J	1000	2600	2600
Anthracene	ug/Kg	3600	3600	1900	1900	3100	3100	1900	1900	380 U	190	1700	1700
Benzo(a)anthracene	ug/Kg	5100	5100	5400	5400	5100	5100	4300	4300	2700	2700	5900	5900
Benzo(a)pyrene	ug/Kg	4800	4800	7100	7100	4800	4800	4900	4900	3400	3400	8600	8600
Benzo(b)fluoranthene	ug/Kg	2600	2600	5800	5800	2500	2500	3900	3900	2800	2800	7100	7100
Benzo(e)pyrene	ug/Kg	2800	2800	4000	4000	2800	2800	2700	2700	2000	2000	4700	4700
Benzo(g,h,i)perylene	ug/Kg	2200	2200	3500	3500	2200	2200	2000	2000	1500	1500	3400	3400
Benzo(k)fluoranthene	ug/Kg	3000	3000	1900	1900	3100	3100	1200 J	1200	380 U	190	2300	2300
Biphenyl	ug/Kg	650	650	300 U	150	560	560	300 U	150	300 U	150	300 U	150
Chrysene	ug/Kg	4800	4800	5100	5100	4700	4700	4200	4200	2800	2800	6000	6000
Dibenzo(a,h)anthracene	ug/Kg	480	480	340 U	170	520	520	340 U	170	340 U	170	340 U	170
Fluoranthene	ug/Kg	8600	8600	6000	6000	8100	8100	6900	6900	3600	3600	6400	6400
Fluorene	ug/Kg	1600	1600	1100	1100	1400	1400	320 U	160	320 U	160	1200	1200
Indeno(1,2,3-cd)pyrene	ug/Kg	2200	2200	2600	2600	2200	2200	1400	1400	1100	1100	2400	2400
Naphthalene	ug/Kg	4300	4300	1500	1500	3500	3500	310 U	155	310 U	155	1800	1800
Perylene	ug/Kg	760	760	540 U	270	750	750	540 U	270	540 U	270	540 U	270
Phenanthrene	ug/Kg	8500	8500	5400	5400	7500	7500	4100	4100	2700	2700	4400	4400
Pyrene	ug/Kg	16000 D	16000	9800	9800	13000 D	13000	11000	11000	5900	5900	10000	10000
TOTAL PAH													
Total PAH	ug/kg	85180	85180	68730	68730	77820	77820	54500	54500	32555	32555	73930	73930
Total PAH_0	ug/kg	85180	85180	67600	67600	77820	77820	52900	52900	30380	30380	72800	72800
Total PAH Carbon Normalized	ug PAH/kg OC	NC	925870	NC	146859	NC	NC	NC	228992	NC	175973	NC	151186
CARBON													
Soot	%	13	13	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	92000	92000	468000	468000	NA	NA	238000	238000	185000	185000	489000	489000
Total Organic Carbon (TOC)	%	NC	9.2	NC	46.8	NC	NC	NC	23.8	NC	18.5	NC	48.9

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-AD 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-C-062205 6/22/2005 (0-0.5)		NSP-SQT5 NSP-SE-SQT5-0605-D-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	1200	1200	NA	NA	1200	1200	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	970	970	NA	NA	910	910	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	450	450	320 U	160	440	440	320 U	160	320 U	160	320 U	160
Dibenzothiophene	ug/kg	890	890	NA	NA	730	730	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	590	590	550 U	275	370	370	550 U	275	550 U	275	550 U	275
o-Cresol	ug/Kg	48 J	48	260 U	130	64	64	260 U	130	260 U	130	260 U	130
Pentachlorophenol	ug/kg	58 U	29	NA	NA	50 U	25	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	220	220	280 U	140	110	110	280 U	140	280 U	140	280 U	140
VOCs													
1,2,3-Trimethylbenzene	ug/kg	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	NA	NA	16 U	8	NA	NA	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	NA	NA	62 J	62	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	NA	NA	77 J	77	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	NA	NA	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	NA	NA	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	NA	NA	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	NA	NA	370	370	NA	NA	180	180	520	520	280	280

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-AD 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-C-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	4 U	2	NA	NA	3.8 U	1.9	NA	NA	3.4 U	1.7	3.4 U	1.7
METALS													
Aluminum	mg/Kg	1400	1400	NA	NA	11000	11000	NA	NA	10000	10000	10000	10000
Antimony	mg/Kg	3.5 J	3.5	NA	NA	2.4 U	1.2	NA	NA	2.7 U	1.35	2.6 U	1.3
Arsenic	mg/Kg	4.9 J	4.9	NA	NA	4.7 J	4.7	NA	NA	5.3 J	5.3	5.3 J	5.3
Barium	mg/Kg	38	38	NA	NA	77	77	NA	NA	71	71	69	69
Beryllium	mg/Kg	0.26 J	0.26	NA	NA	0.85	0.85	NA	NA	0.78	0.78	0.66	0.66
Cadmium	mg/Kg	0.59 U	0.295	NA	NA	0.57 U	0.285	NA	NA	0.57 U	0.285	0.57 U	0.285
Chromium	mg/Kg	6.1	6.1	NA	NA	28	28	NA	NA	25	25	27	27
Cobalt	mg/Kg	3.4 J	3.4	NA	NA	10	10	NA	NA	8.2	8.2	8.5	8.5
Copper	mg/Kg	43	43	NA	NA	110	110	NA	NA	75	75	110	110
Iron	mg/Kg	7100	7100	NA	NA	21000	21000	NA	NA	19000	19000	19000	19000
Lead	mg/Kg	17 J	17	NA	NA	39 J	39	NA	NA	39 J	39	21 J	21
Magnesium	mg/Kg	840	840	NA	NA	4800	4800	NA	NA	4500	4500	4400	4400
Manganese	mg/Kg	79	79	NA	NA	270	270	NA	NA	240	240	270	270
Mercury	mg/Kg	0.068 UJ	0.034	NA	NA	0.066 J	0.066	NA	NA	0.082 J	0.082	0.068 UJ	0.034
Nickel	mg/Kg	8.3 J	8.3	NA	NA	21	21	NA	NA	23	23	21	21
Selenium	mg/Kg	2.2 U	1.1	NA	NA	2.3 U	1.15	NA	NA	2.5 U	1.25	2.4 U	1.2
Silver	mg/Kg	1.2 U	0.6	NA	NA	1.1 U	0.55	NA	NA	1.1 U	0.55	1.1 U	0.55
Thallium	mg/Kg	2.8 U	1.4	NA	NA	2.9 U	1.45	NA	NA	3.1 U	1.55	3.1 U	1.55
Vanadium	mg/Kg	11	11	NA	NA	46	46	NA	NA	41	41	43	43
Zinc	mg/Kg	69	69	NA	NA	82	82	NA	NA	87	87	77	77
OTHER													
Calcium	mg/Kg	6000	6000	NA	NA	4500	4500	NA	NA	4100	4100	3900	3900
Potassium	mg/Kg	160	160	NA	NA	1400	1400	NA	NA	1300	1300	1400	1400
Sodium	mg/Kg	37 U	18.5	NA	NA	130	130	NA	NA	120	120	130	130
Solids, percent	%	33.3	33.3	NA	NA	35.7	35.7	NA	NA	38.8	38.8	39	39

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-AD 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-C-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	320 U	160	300	300	63 U	31.5	360	360	63 U	31.5	63 U	31.5
1-Methylphenanthrene	ug/Kg	1200 J	1200	210	210	78 U	39	200	200	78 U	39	78 U	39
2,3,5-Trimethylnaphthalene	ug/Kg	350 U	175	63	63	71 U	35.5	74	74	71 U	35.5	71 U	35.5
2,6-Dimethylnaphthalene	ug/Kg	410 U	205	110	110	82 U	41	130	130	82 U	41	82 U	41
2-Methylnaphthalene	ug/Kg	960 J	960	520	520	62 U	31	640	640	62 U	31	62 U	31
Acenaphthene	ug/Kg	1400	1400	71	71	65 U	32.5	87	87	65 U	32.5	65 U	32.5
Acenaphthylene	ug/Kg	1600	1600	200	200	61 U	30.5	220	220	61 U	30.5	61 U	30.5
Anthracene	ug/Kg	1500	1500	210	210	77 U	38.5	250	250	77 U	38.5	77 U	38.5
Benzo(a)anthracene	ug/Kg	4000	4000	560	560	320	320	730	730	260	260	290	290
Benzo(a)pyrene	ug/Kg	5400	5400	660	660	510	510	870	870	380 J	380	430 J	430
Benzo(b)fluoranthene	ug/Kg	4400	4400	430	430	520	520	610	610	360 J	360	410 J	410
Benzo(e)pyrene	ug/Kg	3200	3200	530	530	350	350	680	680	270 J	270	320 J	320
Benzo(g,h,i)perylene	ug/Kg	2000	2000	440	440	65 U	32.5	560	560	65 UJ	32.5	65 UJ	32.5
Benzo(k)fluoranthene	ug/Kg	1600	1600	410	410	76 U	38	560	560	76 UJ	38	210 J	210
Biphenyl	ug/Kg	300 U	150	65	65	60 U	30	80	80	60 U	30	60 U	30
Chrysene	ug/Kg	4000	4000	670	670	340	340	870	870	290	290	320	320
Dibenzo(a,h)anthracene	ug/Kg	340 U	170	120	120	68 U	34	150	150	68 UJ	34	68 UJ	34
Fluoranthene	ug/Kg	5100	5100	670	670	280	280	800	800	260	260	300	300
Fluorene	ug/Kg	320 U	160	79	79	65 U	32.5	93	93	65 U	32.5	65 U	32.5
Indeno(1,2,3-cd)pyrene	ug/Kg	1400	1400	380	380	62 U	31	460	460	62 U	31	62 U	31
Naphthalene	ug/Kg	1200	1200	540	540	61 U	30.5	610	610	61 U	30.5	61 U	30.5
Perylene	ug/Kg	540 U	270	200	200	110 U	55	270	270	110 UJ	55	110 UJ	55
Phenanthrene	ug/Kg	4200	4200	600	600	73 U	36.5	720	720	73 U	36.5	230 J	230
Pyrene	ug/Kg	8600	8600	1000	1000	460	460	1300	1300	400	400	470	470
TOTAL PAH													
Total PAH	ug/kg	53050	53050	9038	9038	3379.5	3379.5	11465	11465	2819.5	2819.5	3505	3505
Total PAH_0	ug/kg	51760	51760	9038	9038	2780	2780	10700	10700	2220	2220	2980	2980
Total PAH Carbon Normalized	ug PAH/kg OC	NC	146143	NC	645571	NC	34450	NC	NC	NC	34011	NC	47687
CARBON													
Soot	%	NA	NA	2.5	2.5	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	363000	363000	14000	14000	98100	98100	NA	NA	82900	82900	73500	73500
Total Organic Carbon (TOC)	%	NC	36.3	NC	1.4	NC	9.81	NC	NC	NC	8.29	NC	7.35

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT5 NSP-SE-SQT5-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-A-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-AD 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-B-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-C-062205 6/22/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	150	150	NA	NA	200	200	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	100	100	NA	NA	100	100	NA	NA	NA	NA
Dibenzofuran	ug/Kg	320 U	160	100	100	63 U	31.5	110	110	63 U	31.5	63 U	31.5
Dibenzothiophene	ug/kg	NA	NA	84	84	NA	NA	98	98	NA	NA	NA	NA
m & p-cresols	ug/Kg	550 U	275	81	81	110 U	55	73	73	110 U	55	110 U	55
o-Cresol	ug/Kg	260 U	130	30	30	52 U	26	25	25	52 U	26	52 U	26
Pentachlorophenol	ug/kg	NA	NA	17 U	8.5	NA	NA	12 U	6	NA	NA	NA	NA
Phenol	ug/Kg	280 U	140	38	38	56 U	28	44	44	56 U	28	56 U	28
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	NA	NA	16 U	8	NA	NA	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	NA	NA	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	NA	NA	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	NA	NA	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5
Toluene	ug/kg	330	330	NA	NA	39	39	NA	NA	43	43	58	58

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT6 NSP-SE-SQT6-0605-D-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQDUP14-0605-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-A-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-B-062305 6/23/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	1.2 U	0.6	NA	NA	0.69 U	0.345	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	0.0043 B	0.0043	NA	NA	0.0012 U	0.0006	NA	NA	NA	NA	NA	NA
Copper	umole/g	0.76	0.76	NA	NA	0.055 B	0.055	NA	NA	NA	NA	NA	NA
Lead	umole/g	0.095	0.095	NA	NA	0.014	0.014	NA	NA	NA	NA	NA	NA
Mercury	umole/g	0.0015 U	0.00075	NA	NA	0.0009 U	0.00045	NA	NA	NA	NA	NA	NA
Nickel	umole/g	0.092 B	0.092	NA	NA	0.013 U	0.0065	NA	NA	NA	NA	NA	NA
Zinc	umole/g	0.57	0.57	NA	NA	0.12	0.12	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		0 U	0	NA	NA	0 U	0	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	2.9 U	1.45	3.6 U	1.8	55 U	27.5	NA	NA	1.7 U	0.85	1.8 U	0.9
METALS													
Aluminum	mg/Kg	6400	6400	10000	10000	1100	1100	NA	NA	1200	1200	1300	1300
Antimony	mg/Kg	2 U	1	2.5 U	1.25	1.6 UJ	0.8	NA	NA	1.3 UJ	0.65	1.4 UJ	0.7
Arsenic	mg/Kg	5.3 J	5.3	4.6 J	4.6	2.4 J	2.4	NA	NA	1.7 J	1.7	1.4 J	1.4
Barium	mg/Kg	46	46	72	72	5.7	5.7	NA	NA	5.3	5.3	6.2	6.2
Beryllium	mg/Kg	0.66	0.66	0.63	0.63	0.11 J	0.11	NA	NA	0.29	0.29	0.16	0.16
Cadmium	mg/Kg	0.48 U	0.24	0.63 U	0.315	0.26 U	0.13	NA	NA	0.22 U	0.11	0.25 U	0.125
Chromium	mg/Kg	18	18	26	26	2.8 J	2.8	NA	NA	5.4 J	5.4	5.4 J	5.4
Cobalt	mg/Kg	7.8	7.8	8.1	8.1	1.6 J	1.6	NA	NA	1.9	1.9	1.1 J	1.1
Copper	mg/Kg	40	40	100	100	4.3	4.3	NA	NA	1.8	1.8	3.5	3.5
Iron	mg/Kg	14000	14000	20000	20000	3800	3800	NA	NA	4900	4900	4700	4700
Lead	mg/Kg	29 J	29	38 J	38	5.7 U	2.85	NA	NA	4.9 U	2.45	5.4 U	2.7
Magnesium	mg/Kg	2900	2900	4700	4700	590	590	NA	NA	680	680	700	700
Manganese	mg/Kg	180	180	270	270	31	31	NA	NA	39	39	40	40
Mercury	mg/Kg	0.07 UJ	0.035	0.07 UJ	0.035	0.072 U	0.036	NA	NA	0.067 U	0.0335	0.07 U	0.035
Nickel	mg/Kg	16	16	21	21	1.9 U	0.95	NA	NA	1.8 UJ	0.9	3 UJ	1.5
Selenium	mg/Kg	1.8 U	0.9	2.3 U	1.15	1.5 U	0.75	NA	NA	1.2 U	0.6	1.3 U	0.65
Silver	mg/Kg	0.93 U	0.465	1.2 U	0.6	0.51 U	0.255	NA	NA	0.44 U	0.22	0.48 U	0.24
Thallium	mg/Kg	2.4 U	1.2	3 U	1.5	1.9 U	0.95	NA	NA	1.5 U	0.75	1.7 U	0.85
Vanadium	mg/Kg	33	33	44	44	8.6	8.6	NA	NA	14	14	15	15
Zinc	mg/Kg	61	61	81	81	10	10	NA	NA	7.3	7.3	9.6	9.6
OTHER													
Calcium	mg/Kg	3600	3600	4500	4500	610	610	NA	NA	560	560	690	690
Potassium	mg/Kg	810	810	1400	1400	110	110	NA	NA	120	120	120	120
Sodium	mg/Kg	94	94	130	130	20	20	NA	NA	23	23	23	23
Solids, percent	%	45.1	45.1	37.7	37.7	73.4	73.4	NA	NA	78.8	78.8	75.4	75.4

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT6 NSP-SE-SQT6-0605-D-062205 6/22/2005 *(0-0.5)*		NSP-SQT6 NSP-SE-SQT6-0605-E-062205 6/22/2005 *(0-0.5)*		NSP-SQT7 NSP-SE-SQDUP14-0605-062305 6/23/2005 *(0-0.5)*		NSP-SQT7 NSP-SE-SQT7-0605 6/23/2005 *(0-0.5)*		NSP-SQT7 NSP-SE-SQT7-0605-A-062305 6/23/2005 *(0-0.5)*		NSP-SQT7 NSP-SE-SQT7-0605-B-062305 6/23/2005 *(0-0.5)*	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	63 U	31.5	63 U	31.5	63 U	31.5	470	470	2500	2500	160 U	80
1-Methylphenanthrene	ug/Kg	78 U	39	78 U	39	78 U	39	440	440	1100 J	1100	260 J	260
2,3,5-Trimethylnaphthalene	ug/Kg	71 U	35.5	71 U	35.5	71 U	35.5	78	78	570 J	570	180 U	90
2,6-Dimethylnaphthalene	ug/Kg	82 U	41	82 U	41	82 U	41	360	360	3400	3400	370 J	370
2-Methylnaphthalene	ug/Kg	62 U	31	62 U	31	62 U	31	570	570	2300	2300	160 U	80
Acenaphthene	ug/Kg	65 U	32.5	65 U	32.5	65 U	32.5	1800 D	1800	7600	7600	690	690
Acenaphthylene	ug/Kg	61 U	30.5	61 U	30.5	95 J	95	150	150	540 J	540	150 U	75
Anthracene	ug/Kg	77 U	38.5	77 U	38.5	77 U	38.5	1300 D	1300	3000	3000	640 J	640
Benzo(a)anthracene	ug/Kg	260	260	310	310	300 J	300	1000 D	1000	2200	2200	800	800
Benzo(a)pyrene	ug/Kg	350 J	350	470 J	470	380 J	380	850 D	850	2200	2200	810	810
Benzo(b)fluoranthene	ug/Kg	360 J	360	460 J	460	290	290	390	390	1500	1500	590 J	590
Benzo(e)pyrene	ug/Kg	260 J	260	340 J	340	220 J	220	450	450	1200 J	1200	440 J	440
Benzo(g,h,i)perylene	ug/Kg	65 UJ	32.5	65 UJ	32.5	170 J	170	400 G	400	1000 J	1000	380 J	380
Benzo(k)fluoranthene	ug/Kg	76 UJ	38	220 J	220	110 J	110	500	500	620 J	620	190 U	95
Biphenyl	ug/Kg	60 U	30	60 U	30	60 U	30	160	160	1100 J	1100	150 U	75
Chrysene	ug/Kg	310	310	390	390	290 J	290	940 D	940	2100	2100	680	680
Dibenzo(a,h)anthracene	ug/Kg	68 UJ	34	68 UJ	34	68 U	34	81	81	340 U	170	170 U	85
Fluoranthene	ug/Kg	280	280	390	390	370 J	370	2800 D	2800	5400	5400	1600	1600
Fluorene	ug/Kg	65 U	32.5	65 U	32.5	65 U	32.5	680	680	2900	2900	320 J	320
Indeno(1,2,3-cd)pyrene	ug/Kg	62 U	31	62 U	31	110 J	110	380	380	720 J	720	250 J	250
Naphthalene	ug/Kg	61 U	30.5	61 U	30.5	61 U	30.5	520	520	310 U	155	150 U	75
Perylene	ug/Kg	110 UJ	55	110 UJ	55	110 U	55	130	130	540 U	270	270 U	135
Phenanthrene	ug/Kg	210 J	210	310	310	250	250	5400 D	5400	15000	15000	2400	2400
Pyrene	ug/Kg	460	460	560	560	640 J	640	4600 D	4600	8500	8500	2700	2700
TOTAL PAH													
Total PAH	ug/kg	3053	3053	3975	3975	3656	3656	24459	24459	66045	66045	13720	13720
Total PAH_0	ug/kg	2490	2490	3450	3450	3225	3225	20948	20948	65450	65450	12930	12930
Total PAH Carbon Normalized	ug PAH/kg OC	NC	54421	NC	46930	NC	594472	NC	489180000	NC	62900000	NC	4314465
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	0.01 U	0.005	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	56100	56100	84700	84700	6150	6150	100 U	50	1050	1050	3180	3180
Total Organic Carbon (TOC)	%	NC	5.61	NC	8.47	NC	0.615	NC	0.005	NC	0.105	NC	0.318

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT6 NSP-SE-SQT6-0605-D-062205 6/22/2005 (0-0.5)		NSP-SQT6 NSP-SE-SQT6-0605-E-062205 6/22/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQDUP14-0605-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-A-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-B-062305 6/23/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	190	190	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	150	150	NA	NA	NA	NA
Dibenzofuran	ug/Kg	63 U	31.5	63 U	31.5	63 U	31.5	73	73	320 U	160	160 U	80
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	270	270	NA	NA	NA	NA
m & p-cresols	ug/Kg	110 U	55	110 U	55	110 U	55	8.5	8.5	550 U	275	270 U	135
o-Cresol	ug/Kg	52 U	26	52 U	26	52 U	26	1.2 J	1.2	260 U	130	130 U	65
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	4 U	2	NA	NA	NA	NA
Phenol	ug/Kg	56 U	28	56 U	28	56 U	28	3 J	3	280 U	140	140 U	70
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	47 J	47	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	22 J	22	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	NA	NA	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5
Toluene	ug/kg	39	39	47	47	33 J	33	NA	NA	11 U	5.5	32 J	32

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT7 NSP-SE-SQT7-0605-C-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-D MS/MSD-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-E-062305 6/23/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-AD 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	0.67 U	0.335	NA	NA	NA	NA	NA	NA	1.5 U	0.75	NA	NA
Cadmium	umole/g	0.0012 U	0.0006	NA	NA	NA	NA	NA	NA	0.0026 U	0.0013	NA	NA
Copper	umole/g	0.054 B	0.054	NA	NA	NA	NA	NA	NA	0.17 B	0.17	NA	NA
Lead	umole/g	0.016	0.016	NA	NA	NA	NA	NA	NA	0.039	0.039	NA	NA
Mercury	umole/g	0.0009 U	0.00045	NA	NA	NA	NA	NA	NA	0.0018 U	0.0009	NA	NA
Nickel	umole/g	0.013 U	0.0065	NA	NA	NA	NA	NA	NA	0.092 B	0.092	NA	NA
Zinc	umole/g	0.11	0.11	NA	NA	NA	NA	NA	NA	0.33	0.33	NA	NA
SEM/AVS Ratio		0 U	0	NA	NA	NA	NA	NA	NA	0 U	0	NA	NA
CYANIDE													
Cyanide	mg/Kg	2 U	1	1.8 U	0.9	1.7 U	0.85	NA	NA	4.7 UJ	2.35	NA	NA
METALS													
Aluminum	mg/Kg	1200	1200	1200	1200	1200	1200	NA	NA	1900	1900	NA	NA
Antimony	mg/Kg	1.8 UJ	0.9	1.6 UJ	0.8	1.3 UJ	0.65	NA	NA	3.3 U	1.65	NA	NA
Arsenic	mg/Kg	1.4 U	0.7	1.6 J	1.6	1.6 J	1.6	NA	NA	4.9 J	4.9	NA	NA
Barium	mg/Kg	7.4	7.4	6.1	6.1	5.6	5.6	NA	NA	29	29	NA	NA
Beryllium	mg/Kg	0.13	0.13	0.13	0.13	0.33	0.33	NA	NA	0.46	0.46	NA	NA
Cadmium	mg/Kg	0.26 U	0.13	0.25 U	0.125	0.22 U	0.11	NA	NA	0.62 U	0.31	NA	NA
Chromium	mg/Kg	5 J	5	4.2 J	4.2	5.3 J	5.3	NA	NA	3.5 UJ	1.75	NA	NA
Cobalt	mg/Kg	2	2	1.7	1.7	1.7	1.7	NA	NA	1.5 J	1.5	NA	NA
Copper	mg/Kg	6.8	6.8	4.3	4.3	2.5	2.5	NA	NA	9.7	9.7	NA	NA
Iron	mg/Kg	4700	4700	4200	4200	4300	4300	NA	NA	3900	3900	NA	NA
Lead	mg/Kg	7.6 UJ	3.8	5.4 U	2.7	4.9 U	2.45	NA	NA	14 UJ	7	NA	NA
Magnesium	mg/Kg	640	640	590	590	590	590	NA	NA	570	570	NA	NA
Manganese	mg/Kg	40	40	38	38	38	38	NA	NA	63	63	NA	NA
Mercury	mg/Kg	0.078 U	0.039	0.071 U	0.0355	0.068 U	0.034	NA	NA	0.08 U	0.04	NA	NA
Nickel	mg/Kg	3.9 UJ	1.95	2.9 U	1.45	2.4 UJ	1.2	NA	NA	4.9 UJ	2.45	NA	NA
Selenium	mg/Kg	1.7 U	0.85	1.5 U	0.75	1.3 U	0.65	NA	NA	3.1 U	1.55	NA	NA
Silver	mg/Kg	0.5 U	0.25	0.49 U	0.245	0.43 U	0.215	NA	NA	1.2 U	0.6	NA	NA
Thallium	mg/Kg	2.1 U	1.05	1.9 U	0.95	1.6 U	0.8	NA	NA	4 U	2	NA	NA
Vanadium	mg/Kg	14	14	12	12	13	13	NA	NA	10	10	NA	NA
Zinc	mg/Kg	14	14	9.7	9.7	8	8	NA	NA	28	28	NA	NA
OTHER													
Calcium	mg/Kg	640	640	690	690	600	600	NA	NA	3300	3300	NA	NA
Potassium	mg/Kg	120	120	130	130	120	120	NA	NA	170	170	NA	NA
Sodium	mg/Kg	28	28	23	23	22	22	NA	NA	83	83	NA	NA
Solids, percent	%	67.6	67.6	74.5	74.5	77	77	NA	NA	28.2	28.2	NA	NA

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT7 NSP-SE-SQT7-0605-C-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-D MS/MSD 062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-E-062305 6/23/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-AD 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	63 U	31.5	63 U	31.5	300 J	300	23000 D	23000	22000	22000	12000 D	12000
1-Methylphenanthrene	ug/Kg	78 U	39	78 U	39	400 J	400	350	350	390 U	195	480	480
2,3,5-Trimethylnaphthalene	ug/Kg	71 U	35.5	71 U	35.5	180 U	90	210	210	350 U	175	270	270
2,6-Dimethylnaphthalene	ug/Kg	82 U	41	82 U	41	610 J	610	2000	2000	4200	4200	1800	1800
2-Methylnaphthalene	ug/Kg	62 U	31	62 U	31	330 J	330	32000 D	32000	23000	23000	18000 D	18000
Acenaphthene	ug/Kg	65 U	32.5	65 U	32.5	1100	1100	11000	11000	14000	14000	8000 D	8000
Acenaphthylene	ug/Kg	150 J	150	61 U	30.5	150 U	75	120	120	310 U	155	180	180
Anthracene	ug/Kg	130 J	130	77 U	38.5	960	960	770	770	380 U	190	930	930
Benzo(a)anthracene	ug/Kg	520 J	520	140 J	140	830	830	260	260	340 U	170	610	610
Benzo(a)pyrene	ug/Kg	670 J	670	150 J	150	830	830	190	190	340 U	170	500	500
Benzo(b)fluoranthene	ug/Kg	470	470	110 J	110	610 J	610	140	140	380 U	190	410	410
Benzo(e)pyrene	ug/Kg	370 J	370	76 U	38	460 J	460	150	150	380 U	190	370	370
Benzo(g,h,i)perylene	ug/Kg	300 J	300	65 U	32.5	340 J	340	110	110	330 U	165	280	280
Benzo(k)fluoranthene	ug/Kg	180 J	180	76 U	38	190 U	95	150	150	380 U	190	420	420
Biphenyl	ug/Kg	60 U	30	60 U	30	150 U	75	1600	1600	300 U	150	1400	1400
Chrysene	ug/Kg	510 J	510	120 J	120	760	760	280	280	360 U	180	640	640
Dibenzo(a,h)anthracene	ug/Kg	68 U	34	68 U	34	170 U	85	25	25	340 U	170	81	81
Fluoranthene	ug/Kg	620 J	620	270	270	1900	1900	740	740	370 U	185	1300	1300
Fluorene	ug/Kg	65 U	32.5	65 U	32.5	560	560	2600	2600	2900	2900	2600	2600
Indeno(1,2,3-cd)pyrene	ug/Kg	210 J	210	62 U	31	270 J	270	100	100	310 U	155	300	300
Naphthalene	ug/Kg	61 U	30.5	61 U	30.5	250 J	250	44000 D	44000	20000	20000	25000 D	25000
Perylene	ug/Kg	110 U	55	110 U	55	270 U	135	43	43	540 U	270	110	110
Phenanthrene	ug/Kg	370	370	370	370	3700	3700	3300	3300	2500	2500	4100	4100
Pyrene	ug/Kg	1100 J	1100	460	460	3300	3300	1100	1100	360 U	180	2000	2000
TOTAL PAH													
Total PAH	ug/kg	5992.5	5992.5	2221	2221	18065	18065	124238	124238	91680	91680	81781	81781
Total PAH_0	ug/kg	5600	5600	1620	1620	17510	17510	124238	124238	88600	88600	81781	81781
Total PAH Carbon Normalized	ug PAH/kg OC	NC	1628397	NC	1014155	NC	10882530	NC	2958048	NC	296699	NC	NC
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	1.4	1.4	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	3680	3680	2190	2190	1660	1660	42000	42000	309000	309000	NA	NA
Total Organic Carbon (TOC)	%	NC	0.368	NC	0.219	NC	0.166	NC	4.2	NC	30.9	NC	NC

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT7 NSP-SE-SQT7-0605-C-062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-D MS/MSD 062305 6/23/2005 (0-0.5)		NSP-SQT7 NSP-SE-SQT7-0605-E-062305 6/23/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-AD 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	48	48	NA	NA	120	120
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	63	63	NA	NA	97	97
Dibenzofuran	ug/Kg	63 U	31.5	63 U	31.5	160 U	80	880	880	320 U	160	840	840
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	480	480	NA	NA	550	550
m & p-cresols	ug/Kg	110 U	55	110 U	55	270 U	135	270	270	550 U	275	200	200
o-Cresol	ug/Kg	52 U	26	52 U	26	130 U	65	36 J	36	260 U	130	35 J	35
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	50 U	25	NA	NA	43 U	21.5
Phenol	ug/Kg	56 U	28	56 U	28	140 U	70	95	95	280 U	140	66	66
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	270	270	NA	NA
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	1000	1000	NA	NA
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	NA	NA	140	140	NA	NA
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	120	120	NA	NA
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA	250	250	NA	NA
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA	270	270	NA	NA
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA	290	290	NA	NA
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	NA	NA
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5	NA	NA
Toluene	ug/kg	29 J	29	17 J	17	29 J	29	NA	NA	230	230	NA	NA

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT8 NSP-SE-SQT8-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-E-062405 6/24/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-A-061805 6/18/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	3.1 UJ	1.55	8.9 UJ	4.45	2.9 UJ	1.45	7 UJ	3.5	NA	NA	3.3 U	1.65
METALS													
Aluminum	mg/Kg	2000	2000	3400	3400	1200	1200	1500	1500	NA	NA	750	750
Antimony	mg/Kg	2.3 U	1.15	5.5 U	2.75	2.2 U	1.1	3.7 U	1.85	NA	NA	1.8 UJ	0.9
Arsenic	mg/Kg	2.8 J	2.8	5.9 J	5.9	2.6 J	2.6	4.8 J	4.8	NA	NA	1.8 J	1.8
Barium	mg/Kg	20	20	72	72	19	19	33	33	NA	NA	12	12
Beryllium	mg/Kg	0.2	0.2	0.49 J	0.49	2.6	2.6	0.17 J	0.17	NA	NA	0.057 U	0.0285
Cadmium	mg/Kg	0.41 U	0.205	1.3 U	0.65	0.46 U	0.23	0.71 U	0.355	NA	NA	0.42 U	0.21
Chromium	mg/Kg	3.9 U	1.95	5.8 UJ	2.9	25	25	3.1 UJ	1.55	NA	NA	1 J	1
Cobalt	mg/Kg	2.3 J	2.3	4.6 J	4.6	16	16	1.4 J	1.4	NA	NA	0.8 U	0.4
Copper	mg/Kg	11	11	52	52	240	240	10	10	NA	NA	3.2	3.2
Iron	mg/Kg	5600	5600	13000	13000	93000	93000	4900	4900	NA	NA	2100	2100
Lead	mg/Kg	9 U	4.5	43 UJ	21.5	25 J	25	16 U	8	NA	NA	9.3 U	4.65
Magnesium	mg/Kg	930	930	1800	1800	620	620	770	770	NA	NA	210	210
Manganese	mg/Kg	69	69	210	210	460	460	90	90	NA	NA	35	35
Mercury	mg/Kg	0.074 U	0.037	0.081 U	0.0405	0.087 J	0.087	0.064 U	0.032	NA	NA	0.078 U	0.039
Nickel	mg/Kg	4.6 UJ	2.3	8 UJ	4	52	52	4.2 UJ	2.1	NA	NA	2 U	1
Selenium	mg/Kg	2.2 U	1.1	5.1 U	2.55	2 U	1	3.5 U	1.75	NA	NA	1.7 U	0.85
Silver	mg/Kg	0.81 U	0.405	2.5 U	1.25	0.91 U	0.455	1.4 U	0.7	NA	NA	0.83 U	0.415
Thallium	mg/Kg	2.7 U	1.35	6.5 U	3.25	2.6 U	1.3	4.4 U	2.2	NA	NA	2.2 U	1.1
Vanadium	mg/Kg	14	14	22	22	0.55 U	0.275	11	11	NA	NA	5.9	5.9
Zinc	mg/Kg	30	30	86	86	59	59	29	29	NA	NA	7.9	7.9
OTHER													
Calcium	mg/Kg	2400	2400	8000	8000	2100	2100	5700	5700	NA	NA	2600	2600
Potassium	mg/Kg	210	210	440	440	110	110	140	140	NA	NA	160	160
Sodium	mg/Kg	36	36	130	130	19 U	9.5	30 U	15	NA	NA	29 U	14.5
Solids, percent	%	42.7	42.7	15	15	46.5	46.5	19	19	NA	NA	40.1	40.1

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT8 NSP-SE-SQT8-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-E-062405 6/24/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-A-061805 6/18/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	1800	1800	24000	24000	750	750	70000	70000	7.2	7.2	32 U	16
1-Methylphenanthrene	ug/Kg	390 U	195	390 U	195	190 U	95	970 U	485	130	130	39 U	19.5
2,3,5-Trimethylnaphthalene	ug/Kg	350 U	175	350 U	175	180 U	90	880 U	440	1.3 J	1.3	35 U	17.5
2,6-Dimethylnaphthalene	ug/Kg	410 U	205	410 U	205	200 U	100	15000	15000	1.7 J	1.7	41 U	20.5
2-Methylnaphthalene	ug/Kg	1300	1300	25000	25000	160 U	80	96000	96000	11	11	31 U	15.5
Acenaphthene	ug/Kg	320 U	160	11000	11000	160 U	80	41000	41000	2.9	2.9	32 U	16
Acenaphthylene	ug/Kg	310 U	155	310 U	155	150 U	75	770 U	385	7.9	7.9	31 U	15.5
Anthracene	ug/Kg	380 U	190	380 U	190	190 U	95	960 U	480	4	4	38 U	19
Benzo(a)anthracene	ug/Kg	340 U	170	340 U	170	170 U	85	860 U	430	3	3	34 U	17
Benzo(a)pyrene	ug/Kg	340 U	170	340 U	170	170 U	85	850 U	425	2.5 J	2.5	34 U	17
Benzo(b)fluoranthene	ug/Kg	380 U	190	380 U	190	190 U	95	940 U	470	3.4	3.4	38 U	19
Benzo(e)pyrene	ug/Kg	380 U	190	380 U	190	190 U	95	950 U	475	3.5	3.5	38 U	19
Benzo(g,h,i)perylene	ug/Kg	330 U	165	330 U	165	160 U	80	810 U	405	3.3 G	3.3	33 U	16.5
Benzo(k)fluoranthene	ug/Kg	380 U	190	380 U	190	190 U	95	950 U	475	3	3	38 U	19
Biphenyl	ug/Kg	300 U	150	300 U	150	150 U	75	5900	5900	8.2	8.2	30 U	15
Chrysene	ug/Kg	360 U	180	360 U	180	180 U	90	890 U	445	5.5	5.5	36 U	18
Dibenzo(a,h)anthracene	ug/Kg	340 U	170	340 U	170	170 U	85	850 U	425	0.56 J	0.56	34 U	17
Fluoranthene	ug/Kg	370 U	185	370 U	185	190 U	95	940 U	470	27	27	37 U	18.5
Fluorene	ug/Kg	320 U	160	320 U	160	160 U	80	9700	9700	5.3	5.3	32 U	16
Indeno(1,2,3-cd)pyrene	ug/Kg	310 U	155	310 U	155	160 U	80	780 U	390	2.5 J	2.5	31 U	15.5
Naphthalene	ug/Kg	860 J	860	23000	23000	930	930	140000	140000	38	38	31 U	15.5
Perylene	ug/Kg	540 U	270	540 U	270	270 U	135	1300 U	650	2.4 J	2.4	54 U	27
Phenanthrene	ug/Kg	370 U	185	370 U	185	180 U	90	12000	12000	40	40	37 U	18.5
Pyrene	ug/Kg	360 U	180	360 U	180	180 U	90	890 U	445	20	20	36 U	18
TOTAL PAH													
Total PAH	ug/kg	7750	7750	86630	86630	3650	3650	396895	396895	334.16	334.16	852 U	426
Total PAH_0	ug/kg	3960	3960	83000	83000	1680	1680	389600	389600	334.16	334.16	30 U	15
Total PAH Carbon Normalized	ug PAH/kg OC	NC	57836	NC	181996	NC	43870	NC	878086	NC	10443	NC	32030
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	0.9	0.9	NA	NA
Total Organic Carbon (TOC)	mg/Kg	134000	134000	476000	476000	83200	83200	452000	452000	32000	32000	13300	13300
Total Organic Carbon (TOC)	%	NC	13.4	NC	47.6	NC	8.32	NC	45.2	NC	3.2	NC	1.33

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT8 NSP-SE-SQT8-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT8 NSP-SE-SQT8-0605-E-062405 6/24/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-A-061805 6/18/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	0.88 J	0.88	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	1.1 J	1.1	NA	NA
Dibenzofuran	ug/Kg	320 U	160	320 U	160	160 U	80	790 U	395	9.8	9.8	32 U	16
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	0.87 J	0.87	NA	NA
m & p-cresols	ug/Kg	550 U	275	550 U	275	270 U	135	1400 U	700	730	730	270	270
o-Cresol	ug/Kg	260 U	130	260 U	130	130 U	65	650 U	325	14 J	14	26 U	13
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	16 U	8	NA	NA
Phenol	ug/Kg	280 U	140	280 U	140	140 U	70	700 U	350	42	42	28 U	14
VOCs													
1,2,3-Trimethylbenzene	ug/kg	120	120	620	620	80	80	1600	1600	NA	NA	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	700	700	3300	3300	600	600	5000	5000	NA	NA	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	150	150	760	760	120	120	1300	1300	NA	NA	16 U	8
Benzene	ug/kg	60	60	360	360	49 J	49	160	160	NA	NA	15 U	7.5
Ethylbenzene	ug/kg	80	80	770	770	120	120	3200	3200	NA	NA	15 U	7.5
m & p-Xylenes	ug/kg	130	130	610	610	150	150	1000	1000	NA	NA	25 U	12.5
o-Xylene	ug/kg	290	290	1300	1300	69	69	2400	2400	NA	NA	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5
Toluene	ug/kg	280	280	320	320	240	240	100	100	NA	NA	210	210

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT9 *NSP-SE-SQT9-0605-B-061805* 6/18/2005 (0-0.5)		NSP-SQT9 *NSP-SE-SQT9-0605-C-061805* 6/18/2005 (0-0.5)		NSP-SQT9 *NSP-SE-SQT9-0605-D-061805* 6/18/2005 (0-0.5)		NSP-SQT9 *NSP-SE-SQT9-0605-E-061805* 6/18/2005 (0-0.5)		NSP-SQT10 *NSP-SE-SQDUP15-0605-062405* 6/24/2005 (0-0.5)		NSP-SQT10 *NSP-SE-SQT10-0605* 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	1.1 U	0.55	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	0.002 U	0.001	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	0.049 B	0.049	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	0.015	0.015	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	0.0014 U	0.0007	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	0.065 B	0.065	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	0.073 B	0.073	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	0 U	0	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	2.4 U	1.2	3.4 U	1.7	3.5 U	1.75	2.1 U	1.05	2 U	1	NA	NA
METALS													
Aluminum	mg/Kg	630	630	900	900	920	920	640	640	420	420	NA	NA
Antimony	mg/Kg	1.7 U	0.85	2.3 U	1.15	2.7 UJ	1.35	1.6 U	0.8	1.5 UJ	0.75	NA	NA
Arsenic	mg/Kg	1.4 J	1.4	2.1 J	2.1	3.2 J	3.2	1.3 U	0.65	1.2 U	0.6	NA	NA
Barium	mg/Kg	7.9	7.9	13	13	12	12	6.9	6.9	3.6	3.6	NA	NA
Beryllium	mg/Kg	0.68	0.68	0.054 U	0.027	0.074 U	0.037	0.042 U	0.021	0.061 J	0.061	NA	NA
Cadmium	mg/Kg	0.3 U	0.15	0.4 U	0.2	0.55 U	0.275	0.31 U	0.155	0.25 U	0.125	NA	NA
Chromium	mg/Kg	1.1 J	1.1	1.8 J	1.8	1.8 J	1.8	1.1 J	1.1	0.9 UJ	0.45	NA	NA
Cobalt	mg/Kg	0.79 J	0.79	0.76 U	0.38	1 U	0.5	0.58 U	0.29	0.47 U	0.235	NA	NA
Copper	mg/Kg	2.2	2.2	3.1	3.1	2.7	2.7	1.8	1.8	1.4	1.4	NA	NA
Iron	mg/Kg	2000	2000	1700	1700	2300	2300	1700	1700	1200	1200	NA	NA
Lead	mg/Kg	6.5 U	3.25	8.8 U	4.4	12 U	6	6.7 U	3.35	5.5 U	2.75	NA	NA
Magnesium	mg/Kg	280	280	260	260	290	290	180	180	200	200	NA	NA
Manganese	mg/Kg	34	34	29	29	34	34	25	25	18	18	NA	NA
Mercury	mg/Kg	0.072 U	0.036	0.073 U	0.0365	0.083 U	0.0415	0.083 U	0.0415	0.077 U	0.0385	NA	NA
Nickel	mg/Kg	1.4 U	0.7	1.9 U	0.95	5.4 J	5.4	1.5 J	1.5	1.2 U	0.6	NA	NA
Selenium	mg/Kg	1.6 U	0.8	2.1 U	1.05	2.5 U	1.25	1.5 U	0.75	1.4 U	0.7	NA	NA
Silver	mg/Kg	0.59 U	0.295	0.79 U	0.395	1.1 U	0.55	0.6 U	0.3	0.49 U	0.245	NA	NA
Thallium	mg/Kg	2 U	1	2.7 U	1.35	3.1 U	1.55	1.9 U	0.95	1.8 U	0.9	NA	NA
Vanadium	mg/Kg	5.6	5.6	6.9	6.9	6.8	6.8	4.3	4.3	2.7	2.7	NA	NA
Zinc	mg/Kg	6	6	8.4	8.4	8.5	8.5	5.2	5.2	4.7	4.7	NA	NA
OTHER													
Calcium	mg/Kg	1400	1400	2900	2900	2300 J	2300	1000	1000	350	350	NA	NA
Potassium	mg/Kg	110	110	150	150	120	120	82	82	73	73	NA	NA
Sodium	mg/Kg	18 U	9	21 U	10.5	22 U	11	20 U	10	8.5 U	4.25	NA	NA
Solids, percent	%	55.9	55.9	45.1	45.1	66.8	66.8	61.7	61.7	68.2	68.2	NA	NA

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT9 NSP-SE-SQT9-0605-B-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-C-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-D-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-E-061805 6/18/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQDUP15-0605-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	2.6	2.6
1-Methylphenanthrene	ug/Kg	39 U	19.5	39 U	19.5	39 U	19.5	39 U	19.5	39 U	19.5	1.6	1.6
2,3,5-Trimethylnaphthalene	ug/Kg	35 U	17.5	35 U	17.5	35 U	17.5	35 U	17.5	35 U	17.5	0.63 J	0.63
2,6-Dimethylnaphthalene	ug/Kg	41 U	20.5	41 U	20.5	41 U	20.5	41 U	20.5	41 U	20.5	1.2	1.2
2-Methylnaphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	3.2	3.2
Acenaphthene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	0.22 J	0.22
Acenaphthylene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	0.49 J	0.49
Anthracene	ug/Kg	38 U	19	38 U	19	38 U	19	38 U	19	38 U	19	0.49 J	0.49
Benzo(a)anthracene	ug/Kg	34 U	17	34 U	17	34 U	17	34 U	17	34 U	17	0.96	0.96
Benzo(a)pyrene	ug/Kg	34 UJ	17	34 UJ	17	34 U	17	34 UJ	17	34 U	17	1	1
Benzo(b)fluoranthene	ug/Kg	38 UJ	19	38 UJ	19	38 U	19	38 UJ	19	38 U	19	1.2	1.2
Benzo(e)pyrene	ug/Kg	38 UJ	19	38 UJ	19	38 U	19	38 UJ	19	38 U	19	1.1	1.1
Benzo(g,h,i)perylene	ug/Kg	33 UJ	16.5	33 UJ	16.5	33 U	16.5	33 UJ	16.5	33 U	16.5	1	1
Benzo(k)fluoranthene	ug/Kg	38 UJ	19	38 UJ	19	38 U	19	38 UJ	19	38 U	19	0.88	0.88
Biphenyl	ug/Kg	30 U	15	30 U	15	30 U	15	30 U	15	30 U	15	1.4	1.4
Chrysene	ug/Kg	36 U	18	36 U	18	36 U	18	36 U	18	36 U	18	1.4	1.4
Dibenzo(a,h)anthracene	ug/Kg	34 UJ	17	34 UJ	17	34 U	17	34 UJ	17	34 U	17	0.19 J	0.19
Fluoranthene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	3.2	3.2
Fluorene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	0.32 J	0.32
Indeno(1,2,3-cd)pyrene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	0.94	0.94
Naphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	3.3	3.3
Perylene	ug/Kg	54 UJ	27	54 UJ	27	54 U	27	54 UJ	27	54 U	27	1	1
Phenanthrene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	3.5	3.5
Pyrene	ug/Kg	36 U	18	36 U	18	36 U	18	36 U	18	36 U	18	2.7	2.7
TOTAL PAH													
Total PAH	ug/kg	852 U	426	852 U	426	852 U	426	852 U	426	852 U	426	34.52	34.52
Total PAH_0	ug/kg	30 U	15	30 U	15	30 U	15	30 U	15	30 U	15	34.52	34.52
Total PAH Carbon Normalized	ug PAH/kg OC	NC	52985	NC	6871	NC	41765	NC	40571	NC	255090	NC	690400
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.01 U	0.005
Total Organic Carbon (TOC)	mg/Kg	8040	8040	62000	62000	10200	10200	10500	10500	1670	1670	100 U	50
Total Organic Carbon (TOC)	%	NC	0.804	NC	6.2	NC	1.02	NC	1.05	NC	0.167	NC	0.005

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT9 NSP-SE-SQT9-0605-B-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-C-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-D-061805 6/18/2005 (0-0.5)		NSP-SQT9 NSP-SE-SQT9-0605-E-061805 6/18/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQDUP15-0605-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605 6/24/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.24 J	0.24
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.17 J	0.17
Dibenzofuran	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	0.92	0.92
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.23 J	0.23
m & p-cresols	ug/Kg	55 U	27.5	390	390	430	430	170 J	170	110 J	110	61	61
o-Cresol	ug/Kg	26 U	13	26 U	13	26 U	13	26 U	13	26 U	13	0.46 J	0.46
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.3 U	1.15
Phenol	ug/Kg	28 U	14	28 U	14	28 U	14	28 U	14	28 U	14	7.2	7.2
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8	NA	NA
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA
Toluene	ug/kg	47	47	510	510	240	240	87	87	27 J	27	NA	NA

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT10 NSP-SE-SQT10-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-E MS/MSD-062405 6/24/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	0.69 U	0.345	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	0.0012 U	0.0006	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	0.016 B	0.016	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	0.0068	0.0068	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	0.0009 U	0.00045	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	0.013 U	0.0065	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	0.028 B	0.028	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	0 U	0	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	1.9 UJ	0.95	1.9 UJ	0.95	1.9 UJ	0.95	2.1 UJ	1.05	1.8 UJ	0.9	NA	NA
METALS													
Aluminum	mg/Kg	440	440	370	370	420	420	490	490	400	400	NA	NA
Antimony	mg/Kg	1.7 U	0.85	1.2 U	0.6	1.3 U	0.65	1.4 U	0.7	1.5 U	0.75	NA	NA
Arsenic	mg/Kg	1.4 U	0.7	1.2 J	1.2	1.4 J	1.4	1.1 U	0.55	1.2 U	0.6	NA	NA
Barium	mg/Kg	3.9	3.9	3.3	3.3	3.6	3.6	4.3	4.3	3.1	3.1	NA	NA
Beryllium	mg/Kg	0.57 J	0.57	0.041 J	0.041	0.042 J	0.042	0.046 U	0.023	0.048 J	0.048	NA	NA
Cadmium	mg/Kg	0.29 U	0.145	0.26 U	0.13	0.31 U	0.155	0.34 U	0.17	0.3 U	0.15	NA	NA
Chromium	mg/Kg	1.3 UJ	0.65	0.87 UJ	0.435	0.99 UJ	0.495	1.2 UJ	0.6	1.1 UJ	0.55	NA	NA
Cobalt	mg/Kg	0.55 U	0.275	0.48 U	0.24	0.59 U	0.295	0.64 U	0.32	0.56 U	0.28	NA	NA
Copper	mg/Kg	1.6	1.6	1.3	1.3	1.4	1.4	1.5	1.5	1.2	1.2	NA	NA
Iron	mg/Kg	1200	1200	1100	1100	1100	1100	1200	1200	1100	1100	NA	NA
Lead	mg/Kg	6.4 U	3.2	5.6 U	2.8	6.8 U	3.4	7.5 U	3.75	6.5 U	3.25	NA	NA
Magnesium	mg/Kg	190	190	140	140	140	140	150	150	160	160	NA	NA
Manganese	mg/Kg	14	14	18	18	13	13	14	14	16	16	NA	NA
Mercury	mg/Kg	0.076 U	0.038	0.074 U	0.037	0.074 U	0.037	0.081 U	0.0405	0.073 U	0.0365	NA	NA
Nickel	mg/Kg	1.4 U	0.7	1.2 U	0.6	1.5 U	0.75	1.6 U	0.8	1.4 U	0.7	NA	NA
Selenium	mg/Kg	1.6 U	0.8	1.2 U	0.6	1.2 U	0.6	1.3 U	0.65	1.4 U	0.7	NA	NA
Silver	mg/Kg	0.57 U	0.285	0.5 U	0.25	0.61 U	0.305	0.67 U	0.335	0.58 U	0.29	NA	NA
Thallium	mg/Kg	2 U	1	1.5 U	0.75	1.5 U	0.75	1.6 U	0.8	1.8 U	0.9	NA	NA
Vanadium	mg/Kg	2.9	2.9	2.9	2.9	2.8	2.8	3.3	3.3	2.8	2.8	NA	NA
Zinc	mg/Kg	4.8	4.8	5.7	5.7	4.8	4.8	5.4	5.4	4.6	4.6	NA	NA
OTHER													
Calcium	mg/Kg	240	240	210	210	250	250	270	270	200	200	NA	NA
Potassium	mg/Kg	77	77	71	71	69	69	93	93	53	53	NA	NA
Sodium	mg/Kg	9.6 U	4.8	13 U	6.5	10 U	5	12 U	6	9.8 U	4.9	NA	NA
Solids, percent	%	68.9	68.9	70.7	70.7	71.4	71.4	64.9	64.9	72.2	72.2	NA	NA

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT10 NSP-SE-SQT10-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-E MS/MSD-062405 6/24/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	39	39
1-Methylphenanthrene	ug/Kg	39 U	19.5	39 U	19.5	39 U	19.5	39 U	19.5	39 U	19.5	120	120
2,3,5-Trimethylnaphthalene	ug/Kg	35 U	17.5	35 U	17.5	35 U	17.5	35 U	17.5	35 U	17.5	8.1 J	8.1
2,6-Dimethylnaphthalene	ug/Kg	41 U	20.5	41 U	20.5	41 U	20.5	41 U	20.5	41 U	20.5	10 J	10
2-Methylnaphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	47	47
Acenaphthene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	7.5 J	7.5
Acenaphthylene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	8.5 J	8.5
Anthracene	ug/Kg	38 U	19	38 U	19	38 U	19	38 U	19	38 U	19	12 J	12
Benzo(a)anthracene	ug/Kg	34 U	17	34 U	17	34 U	17	34 U	17	34 U	17	18 J	18
Benzo(a)pyrene	ug/Kg	34 U	17	34 U	17	34 U	17	34 U	17	34 U	17	15 J	15
Benzo(b)fluoranthene	ug/Kg	38 U	19	38 U	19	38 U	19	38 U	19	38 U	19	14 J	14
Benzo(e)pyrene	ug/Kg	38 U	19	38 U	19	38 U	19	38 U	19	38 U	19	14 J	14
Benzo(g,h,i)perylene	ug/Kg	33 U	16.5	33 U	16.5	33 U	16.5	33 U	16.5	33 U	16.5	10 J	10
Benzo(k)fluoranthene	ug/Kg	38 U	19	38 U	19	38 U	19	38 U	19	38 U	19	12 J	12
Biphenyl	ug/Kg	30 U	15	30 U	15	30 U	15	30 U	15	30 U	15	8.1 J	8.1
Chrysene	ug/Kg	36 U	18	36 U	18	36 U	18	36 U	18	36 U	18	27	27
Dibenzo(a,h)anthracene	ug/Kg	34 U	17	34 U	17	34 U	17	34 U	17	34 U	17	1.7 J	1.7
Fluoranthene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	96	96
Fluorene	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	9.7 J	9.7
Indeno(1,2,3-cd)pyrene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	9 J	9
Naphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	31 U	15.5	66	66
Perylene	ug/Kg	54 U	27	54 U	27	54 U	27	54 U	27	54 U	27	9.9 J	9.9
Phenanthrene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	37 U	18.5	93	93
Pyrene	ug/Kg	36 U	18	36 U	18	36 U	18	36 U	18	36 U	18	84	84
TOTAL PAH													
Total PAH	ug/kg	852 U	426	852 U	426	852 U	426	852 U	426	852 U	426	739.5	739.5
Total PAH_0	ug/kg	30 U	15	30 U	15	30 U	15	30 U	15	30 U	15	739.5	739.5
Total PAH Carbon Normalized	ug PAH/kg OC	NC	37699	NC	150530	NC	163846	NC	176763	NC	173171	NC	9481
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4	4
Total Organic Carbon (TOC)	mg/Kg	11300	11300	2830	2830	2600	2600	2410	2410	2460	2460	78000	78000
Total Organic Carbon (TOC)	%	NC	1.13	NC	0.283	NC	0.26	NC	0.241	NC	0.246	NC	7.8

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT10 NSP-SE-SQT10-0605-A-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-B-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-C-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-D-062405 6/24/2005 (0-0.5)		NSP-SQT10 NSP-SE-SQT10-0605-E MS/MSD-062405 6/24/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	3 J	3
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.2 J	4.2
Dibenzofuran	ug/Kg	32 U	16	32 U	16	32 U	16	32 U	16	32 U	16	15 J	15
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5.8 J	5.8
m & p-cresols	ug/Kg	120 J	120	150 J	150	55 U	27.5	160 J	160	55 U	27.5	440	440
o-Cresol	ug/Kg	26 U	13	26 U	13	26 U	13	26 U	13	26 U	13	40 J	40
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	89 U	44.5
Phenol	ug/Kg	28 U	14	28 U	14	28 U	14	28 U	14	28 U	14	180	180
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8	NA	NA
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	NA	NA
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	NA	NA
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	NA	NA
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	NA	NA
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	NA	NA
Toluene	ug/kg	21 J	21	11 U	5.5	15 J	15	11 U	5.5	20 J	20	NA	NA

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT11 NSP-SE-SQT11-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-AD 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-E-062105 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	1.8 U	0.9	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0057 B	0.0057	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.12 B	0.12	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.038	0.038	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0022 U	0.0011	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.034 U	0.017	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.33	0.33	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	0 U	0	NA	NA
CYANIDE													
Cyanide	mg/Kg	4.2 U	2.1	NA	NA	4.4 U	2.2	7.2 U	3.6	4.6 U	2.3	4.8 U	2.4
METALS													
Aluminum	mg/Kg	1000	1000	NA	NA	760	760	650	650	550	550	660	660
Antimony	mg/Kg	3.2 U	1.6	NA	NA	2.9 U	1.45	4.2 U	2.1	3 U	1.5	3.5 U	1.75
Arsenic	mg/Kg	3.4 J	3.4	NA	NA	2.9 J	2.9	3.7 J	3.7	4.9 J	4.9	2.8 U	1.4
Barium	mg/Kg	33	33	NA	NA	24	24	28	28	25	25	24	24
Beryllium	mg/Kg	1	1	NA	NA	0.48	0.48	0.11 U	0.055	0.12 J	0.12	3	3
Cadmium	mg/Kg	0.75 U	0.375	NA	NA	0.63 U	0.315	0.79 U	0.395	0.63 J	0.63	0.73 U	0.365
Chromium	mg/Kg	3.6 J	3.6	NA	NA	2.2 J	2.2	2 J	2	13	13	2.7 J	2.7
Cobalt	mg/Kg	1.6 J	1.6	NA	NA	1.2 U	0.6	1.5 U	0.75	1.1 U	0.55	1.4 U	0.7
Copper	mg/Kg	10	10	NA	NA	10	10	9.7	9.7	8.8	8.8	7	7
Iron	mg/Kg	3600	3600	NA	NA	2900	2900	2200	2200	2500	2500	2200	2200
Lead	mg/Kg	16 U	8	NA	NA	17 J	17	17 U	8.5	13 U	6.5	16 U	8
Magnesium	mg/Kg	310 J	310	NA	NA	300 J	300	340 J	340	460 J	460	460 J	460
Manganese	mg/Kg	73	73	NA	NA	67	67	45	45	66	66	42	42
Mercury	mg/Kg	0.083 U	0.0415	NA	NA	0.086 U	0.043	0.077 U	0.0385	0.076 U	0.038	0.082 U	0.041
Nickel	mg/Kg	3.9 J	3.9	NA	NA	4.3 J	4.3	3.7 U	1.85	3.7 J	3.7	3.5 U	1.75
Selenium	mg/Kg	2.9 U	1.45	NA	NA	2.7 U	1.35	3.9 U	1.95	2.8 U	1.4	3.3 U	1.65
Silver	mg/Kg	1.5 U	0.75	NA	NA	1.2 U	0.6	1.5 U	0.75	1.1 U	0.55	1.4 U	0.7
Thallium	mg/Kg	3.8 U	1.9	NA	NA	3.5 U	1.75	5 U	2.5	3.5 U	1.75	4.2 U	2.1
Vanadium	mg/Kg	8.8	8.8	NA	NA	6.7	6.7	6.7	6.7	6	6	5.2	5.2
Zinc	mg/Kg	27	27	NA	NA	24	24	25	25	21	21	21	21
OTHER													
Calcium	mg/Kg	6600	6600	NA	NA	5200	5200	6200	6200	5800	5800	5500	5500
Potassium	mg/Kg	110 J	110	NA	NA	99 J	99	45 J	45	43 J	43	86 J	86
Sodium	mg/Kg	30 U	15	NA	NA	26 U	13	24 U	12	18 U	9	23 U	11.5
Solids, percent	%	31.9	31.9	NA	NA	30.6	30.6	18.7	18.7	29.6	29.6	27.6	27.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT11 NSP-SE-SQT11-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-AD 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-E-062105 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	320 U	160	1100	1100	160 U	80	320 U	160	320 U	160	320 U	160
1-Methylphenanthrene	ug/Kg	390 U	195	810	810	190 U	95	390 U	195	390 U	195	390 U	195
2,3,5-Trimethylnaphthalene	ug/Kg	350 U	175	79	79	180 U	90	350 U	175	350 U	175	350 U	175
2,6-Dimethylnaphthalene	ug/Kg	410 U	205	190	190	200 U	100	410 U	205	410 U	205	410 U	205
2-Methylnaphthalene	ug/Kg	310 U	155	1300	1300	160 U	80	310 U	155	310 U	155	310 U	155
Acenaphthene	ug/Kg	320 U	160	500	500	160 U	80	320 U	160	320 U	160	320 U	160
Acenaphthylene	ug/Kg	310 U	155	620	620	150 U	75	310 U	155	310 U	155	310 U	155
Anthracene	ug/Kg	380 U	190	580	580	190 U	95	380 U	190	380 U	190	380 U	190
Benzo(a)anthracene	ug/Kg	340 UJ	170	1600	1600	170 U	85	340 U	170	340 U	170	340 U	170
Benzo(a)pyrene	ug/Kg	340 UJ	170	2700	2700	170 UJ	85	340 UJ	170	340 UJ	170	340 UJ	170
Benzo(b)fluoranthene	ug/Kg	380 UJ	190	2200	2200	190 UJ	95	380 UJ	190	380 UJ	190	380 UJ	190
Benzo(e)pyrene	ug/Kg	380 UJ	190	2000	2000	190 UJ	95	380 U	190	380 UJ	190	380 UJ	190
Benzo(g,h,i)perylene	ug/Kg	330 UJ	165	2000	2000	160 UJ	80	330 UJ	165	330 UJ	165	330 UJ	165
Benzo(k)fluoranthene	ug/Kg	380 U	190	2200	2200	190 UJ	95	380 UJ	190	380 UJ	190	380 UJ	190
Biphenyl	ug/Kg	300 U	150	430	430	150 U	75	300 U	150	300 U	150	300 U	150
Chrysene	ug/Kg	360 UJ	180	3200	3200	180 U	90	360 U	180	360 U	180	360 U	180
Dibenzo(a,h)anthracene	ug/Kg	340 U	170	330	330	170 UJ	85	340 UJ	170	340 UJ	170	340 UJ	170
Fluoranthene	ug/Kg	370 U	185	8900	8900	190 U	95	370 U	185	370 U	185	370 U	185
Fluorene	ug/Kg	320 U	160	1200	1200	160 U	80	320 U	160	320 U	160	320 U	160
Indeno(1,2,3-cd)pyrene	ug/Kg	310 U	155	2100	2100	160 U	80	310 U	155	310 U	155	310 U	155
Naphthalene	ug/Kg	310 U	155	3300	3300	150 U	75	310 U	155	310 U	155	310 U	155
Perylene	ug/Kg	540 UJ	270	410	410	270 UJ	135	540 UJ	270	540 UJ	270	540 UJ	270
Phenanthrene	ug/Kg	370 U	185	13000	13000	180 U	90	370 U	185	370 U	185	370 U	185
Pyrene	ug/Kg	360 U	180	9500	9500	180 U	90	2300 J	2300	360 U	180	360 U	180
TOTAL PAH													
Total PAH	ug/kg	8520 U	4260	60249	60249	4250 U	2125	6380	6380	8520 U	4260	8520 U	4260
Total PAH_0	ug/kg	300 U	150	60249	60249	150 U	75	2300	2300	300 U	150	300 U	150
Total PAH Carbon Normalized	ug PAH/kg OC	NC	8537	NC	NC	NC	4159	NC	13991	NC	6751	NC	10240
CARBON													
Soot	%	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	499000	499000	NA	NA	511000	511000	456000	456000	631000	631000	416000	416000
Total Organic Carbon (TOC)	%	NC	49.9	NC	NC	NC	51.1	NC	45.6	NC	63.1	NC	41.6

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT11 NSP-SE-SQT11-0605-A-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-AD 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-B-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-C-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-D-062105 6/21/2005 (0-0.5)		NSP-SQT11 NSP-SE-SQT11-0605-E-062105 6/21/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	280	280	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	210	210	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	320 U	160	840	840	160 U	80	320 U	160	320 U	160	320 U	160
Dibenzothiophene	ug/kg	NA	NA	680	680	NA	NA	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	550 U	275	330	330	270 U	135	550 U	275	550 U	275	550 U	275
o-Cresol	ug/Kg	260 U	130	46 J	46	130 U	65	260 U	130	260 U	130	260 U	130
Pentachlorophenol	ug/kg	NA	NA	97 U	48.5	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	280 U	140	210	210	140 U	70	280 U	140	280 U	140	280 U	140
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	NA	NA	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	370	370	NA	NA	110	110	410	410	120	120	380	380

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQDUP11-0605-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-A-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-B-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-C-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-D-062005 6/20/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.62 U	0.31	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0012 U	0.0006	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.016 B	0.016	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0072	0.0072	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.0008 U	0.0004	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.012 U	0.006	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	0.037 B	0.037	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	0 U	0	NA	NA
CYANIDE													
Cyanide	mg/Kg	1.8 U	0.9	NA	NA	1.8 U	0.9	1.8 U	0.9	1.8 U	0.9	1.7 U	0.85
METALS													
Aluminum	mg/Kg	890	890	NA	NA	910	910	930	930	960	960	890	890
Antimony	mg/Kg	1.6 U	0.8	NA	NA	1.7 U	0.85	1.4 U	0.7	1.6 U	0.8	1.4 U	0.7
Arsenic	mg/Kg	1.3 U	0.65	NA	NA	1.4 U	0.7	1.1 U	0.55	1.2 U	0.6	1.1 U	0.55
Barium	mg/Kg	7.2	7.2	NA	NA	7.2	7.2	7.6	7.6	7.5	7.5	7	7
Beryllium	mg/Kg	1	1	NA	NA	0.18	0.18	1.6	1.6	0.051 J	0.051	0.035 U	0.0175
Cadmium	mg/Kg	0.29 U	0.145	NA	NA	0.28 U	0.14	0.27 U	0.135	0.29 U	0.145	0.26 U	0.13
Chromium	mg/Kg	1.5 J	1.5	NA	NA	1.6 J	1.6	2.3	2.3	2.7	2.7	2.5	2.5
Cobalt	mg/Kg	0.84 J	0.84	NA	NA	1.2 J	1.2	1.7 J	1.7	1.2 J	1.2	1.2 J	1.2
Copper	mg/Kg	2.2	2.2	NA	NA	2.1	2.1	2.3	2.3	2.1	2.1	2.6	2.6
Iron	mg/Kg	3400	3400	NA	NA	3500	3500	3800	3800	3600	3600	3300	3300
Lead	mg/Kg	6.3 U	3.15	NA	NA	6.1 U	3.05	5.9 U	2.95	6.4 U	3.2	5.6 U	2.8
Magnesium	mg/Kg	350	350	NA	NA	370	370	360	360	260	260	370	370
Manganese	mg/Kg	31	31	NA	NA	33	33	38	38	32	32	28	28
Mercury	mg/Kg	0.072 U	0.036	NA	NA	0.071 U	0.0355	0.07 U	0.035	0.07 U	0.035	0.068 U	0.034
Nickel	mg/Kg	4.9 U	2.45	NA	NA	1.3 U	0.65	4.6 U	2.3	5 U	2.5	4.4 U	2.2
Selenium	mg/Kg	1.5 U	0.75	NA	NA	1.6 U	0.8	1.3 U	0.65	1.4 U	0.7	1.3 U	0.65
Silver	mg/Kg	0.56 U	0.28	NA	NA	0.55 U	0.275	0.53 U	0.265	0.57 U	0.285	0.5 U	0.25
Thallium	mg/Kg	1.9 U	0.95	NA	NA	2.1 U	1.05	1.7 U	0.85	1.8 U	0.9	1.7 U	0.85
Vanadium	mg/Kg	8.2	8.2	NA	NA	9.2	9.2	8.3	8.3	8.5	8.5	8.7	8.7
Zinc	mg/Kg	6.6	6.6	NA	NA	7	7	7.2	7.2	6.7	6.7	6.4	6.4
OTHER													
Calcium	mg/Kg	420	420	NA	NA	430	430	440	440	420	420	480	480
Potassium	mg/Kg	98	98	NA	NA	110	110	110	110	120	120	110	110
Sodium	mg/Kg	24 U	12	NA	NA	23 U	11.5	24 U	12	25 U	12.5	22 U	11
Solids, percent	%	73.4	73.4	NA	NA	74.4	74.4	75.6	75.6	74.8	74.8	78	78

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQDUP11-0605-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-A-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-B-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-C-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-D-062005 6/20/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	63 U	31.5	0.32 J	0.32	160 U	80	63 U	31.5	63 U	31.5	63 U	31.5
1-Methylphenanthrene	ug/Kg	78 U	39	0.27 J	0.27	190 U	95	78 U	39	78 U	39	78 U	39
2,3,5-Trimethylnaphthalene	ug/Kg	71 U	35.5	0.071 J	0.071	180 U	90	71 U	35.5	71 U	35.5	71 U	35.5
2,6-Dimethylnaphthalene	ug/Kg	82 U	41	0.22 J	0.22	200 U	100	82 U	41	82 U	41	82 U	41
2-Methylnaphthalene	ug/Kg	62 U	31	0.54 J	0.54	160 U	80	62 U	31	62 U	31	62 U	31
Acenaphthene	ug/Kg	65 U	32.5	0.094 J	0.094	160 U	80	65 U	32.5	65 U	32.5	65 U	32.5
Acenaphthylene	ug/Kg	61 U	30.5	0.38 J	0.38	150 U	75	61 U	30.5	61 U	30.5	61 U	30.5
Anthracene	ug/Kg	77 U	38.5	0.38 J	0.38	190 U	95	77 U	38.5	77 U	38.5	77 U	38.5
Benzo(a)anthracene	ug/Kg	68 U	34	0.66 J	0.66	170 U	85	68 U	34	68 U	34	68 U	34
Benzo(a)pyrene	ug/Kg	68 U	34	0.95	0.95	170 U	85	68 U	34	68 U	34	68 U	34
Benzo(b)fluoranthene	ug/Kg	75 U	37.5	0.88	0.88	190 U	95	75 U	37.5	75 U	37.5	75 U	37.5
Benzo(e)pyrene	ug/Kg	76 U	38	0.96	0.96	190 U	95	76 U	38	76 U	38	76 U	38
Benzo(g,h,i)perylene	ug/Kg	65 U	32.5	1.2	1.2	160 U	80	65 U	32.5	65 U	32.5	65 U	32.5
Benzo(k)fluoranthene	ug/Kg	76 U	38	0.78 J	0.78	190 U	95	76 U	38	76 U	38	76 U	38
Biphenyl	ug/Kg	60 U	30	0.53 J	0.53	150 U	75	60 U	30	60 U	30	60 U	30
Chrysene	ug/Kg	71 U	35.5	0.95	0.95	180 U	90	71 U	35.5	71 U	35.5	71 U	35.5
Dibenzo(a,h)anthracene	ug/Kg	68 U	34	0.22 J	0.22	170 U	85	68 U	34	68 U	34	68 U	34
Fluoranthene	ug/Kg	75 U	37.5	2	2	190 U	95	75 U	37.5	75 U	37.5	75 U	37.5
Fluorene	ug/Kg	65 U	32.5	0.14 JB	0.14	160 U	80	65 U	32.5	65 U	32.5	65 U	32.5
Indeno(1,2,3-cd)pyrene	ug/Kg	62 U	31	1	1	160 U	80	62 U	31	62 U	31	62 U	31
Naphthalene	ug/Kg	61 U	30.5	0.75 JB	0.75	150 U	75	61 U	30.5	61 U	30.5	61 U	30.5
Perylene	ug/Kg	110 U	55	0.68 J	0.68	270 U	135	110 U	55	110 U	55	110 U	55
Phenanthrene	ug/Kg	73 U	36.5	2	2	180 U	90	73 U	36.5	73 U	36.5	73 U	36.5
Pyrene	ug/Kg	71 U	35.5	2	2	180 U	90	71 U	35.5	71 U	35.5	71 U	35.5
TOTAL PAH													
Total PAH	ug/kg	1703 U	851.5	17.975	17.975	4250 U	2125	1703 U	851.5	1703 U	851.5	1703 U	851.5
Total PAH_0	ug/kg	60 U	30	17.975	17.975	150 U	75	60 U	30	60 U	30	60 U	30
Total PAH Carbon Normalized	ug PAH/kg OC	NC	1115990	NC	359500	NC	2340308	NC	990116	NC	976491	NC	1088875
CARBON													
Soot	%	NA	NA	0.01 U	0.005	NA	NA	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	763	763	100 U	50	908	908	860	860	872	872	782	782
Total Organic Carbon (TOC)	%	NC	0.0763	NC	0.005	NC	0.0908	NC	0.086	NC	0.0872	NC	0.0782

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQDUP11-0605-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-A-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-B-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-C-062005 6/20/2005 (0-0.5)		NSP-SQT12 NSP-SE-SQT12-0605-D-062005 6/20/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	0.2 J	0.2	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	0.082 J	0.082	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	63 U	31.5	0.15 J	0.15	160 U	80	63 U	31.5	63 U	31.5	63 U	31.5
Dibenzothiophene	ug/kg	NA	NA	0.14 J	0.14	NA	NA	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	110 U	55	13	13	270 U	135	110 U	55	110 U	55	110 U	55
o-Cresol	ug/Kg	52 U	26	2.2 U	1.1	130 U	65	52 U	26	52 U	26	52 U	26
Pentachlorophenol	ug/kg	NA	NA	2.2 U	1.1	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	56 U	28	12	12	140 U	70	56 U	28	56 U	28	56 U	28
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	NA	NA	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	NA	NA	11 U	5.5	11 U	5.5	11 U	5.5	11 U	5.5

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQT12-0605-E-062005 6/20/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQDUP01-0905-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-A-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-B-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-C-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	2	2	NA	NA	1.2	1.2	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	0.0049 B	0.0049	NA	NA	0.014 B	0.014	NA	NA	NA	NA
Copper	umole/g	NA	NA	0.047 B	0.047	NA	NA	0.052 B	0.052	NA	NA	NA	NA
Lead	umole/g	NA	NA	0.0072 B	0.0072	NA	NA	0.016 B	0.016	NA	NA	NA	NA
Mercury	umole/g	NA	NA	0.001 U	0.0005	NA	NA	0.0009 U	0.00045	NA	NA	NA	NA
Nickel	umole/g	NA	NA	0.072 B	0.072	NA	NA	0.044 B	0.044	NA	NA	NA	NA
Zinc	umole/g	NA	NA	0.48	0.48	NA	NA	0.14	0.14	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	0.3	0.3	NA	NA	0.22	0.22	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	1.8 U	0.9	1.9 U	0.95	NA	NA	1.8 U	0.9	2 U	1	1.9 U	0.95
METALS													
Aluminum	mg/Kg	850	850	1400	1400	NA	NA	1200	1200	1200	1200	1200	1200
Antimony	mg/Kg	1.5 U	0.75	1.2 UJ	0.6	NA	NA	1.3 UJ	0.65	1.8 UJ	0.9	1.7 UJ	0.85
Arsenic	mg/Kg	1.2 U	0.6	0.97 U	0.485	NA	NA	1 U	0.5	1.4 U	0.7	1.4 U	0.7
Barium	mg/Kg	7	7	9	9	NA	NA	7.5	7.5	7.7	7.7	8.3	8.3
Beryllium	mg/Kg	0.042 U	0.021	0.096 J	0.096	NA	NA	0.11	0.11	0.061 J	0.061	0.087 J	0.087
Cadmium	mg/Kg	0.31 U	0.155	0.33 J	0.33	NA	NA	0.22 U	0.11	0.3 U	0.15	0.34 U	0.17
Chromium	mg/Kg	1.9 J	1.9	3.6	3.6	NA	NA	3.2	3.2	3.2	3.2	3.2	3.2
Cobalt	mg/Kg	0.84 J	0.84	1.2 J	1.2	NA	NA	1.1 J	1.1	0.86 J	0.86	1.2 J	1.2
Copper	mg/Kg	2	2	2.9	2.9	NA	NA	2.3	2.3	2.2	2.2	2.4	2.4
Iron	mg/Kg	3700	3700	3700	3700	NA	NA	3500	3500	3400	3400	3400	3400
Lead	mg/Kg	6.8 U	3.4	7.4 J	7.4	NA	NA	4.9 U	2.45	7.4 J	7.4	7.4 U	3.7
Magnesium	mg/Kg	330	330	510	510	NA	NA	470	470	450	450	490	490
Manganese	mg/Kg	32	32	39	39	NA	NA	34	34	35	35	36	36
Mercury	mg/Kg	0.072 U	0.036	0.079 U	0.0395	NA	NA	0.079 U	0.0395	0.079 U	0.0395	0.079 U	0.0395
Nickel	mg/Kg	5.3 U	2.65	2.7 J	2.7	NA	NA	1.9 J	1.9	2.2 J	2.2	3 J	3
Selenium	mg/Kg	1.4 U	0.7	1.1 U	0.55	NA	NA	1.2 U	0.6	1.7 U	0.85	1.6 U	0.8
Silver	mg/Kg	0.61 U	0.305	0.58 U	0.29	NA	NA	0.43 U	0.215	0.59 U	0.295	0.67 U	0.335
Thallium	mg/Kg	1.7 U	0.85	1.4 U	0.7	NA	NA	1.5 U	0.75	2.2 U	1.1	2.1 U	1.05
Vanadium	mg/Kg	9.2	9.2	9.2	9.2	NA	NA	8	8	7.2	7.2	8	8
Zinc	mg/Kg	6.6	6.6	10	10	NA	NA	8.6	8.6	8.6	8.6	9	9
OTHER													
Calcium	mg/Kg	450	450	1700 J	1700	NA	NA	460 J	460	440	440	470	470
Potassium	mg/Kg	97	97	190	190	NA	NA	170	170	190	190	210	210
Sodium	mg/Kg	23 U	11.5	34	34	NA	NA	28	28	30	30	33	33
Solids, percent	%	73.3	73.3	66	66	NA	NA	70	70	68.6	68.6	64.4	64.4

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQT12-0605-E-062005 6/20/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQDUP01-0905-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-A-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-B-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-C-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	63 U	31.5	32 U	16	0.59 J	0.59	32 U	16	32 U	16	32 U	16
1-Methylphenanthrene	ug/Kg	78 U	39	39 U	19.5	0.53 J	0.53	39 U	19.5	39 U	19.5	39 U	19.5
2,3,5-Trimethylnaphthalene	ug/Kg	71 U	35.5	35 U	17.5	0.14 J	0.14	35 U	17.5	35 U	17.5	35 U	17.5
2,6-Dimethylnaphthalene	ug/Kg	82 U	41	41 U	20.5	0.22 J	0.22	41 U	20.5	41 U	20.5	41 U	20.5
2-Methylnaphthalene	ug/Kg	62 U	31	31 U	15.5	0.81 J	0.81	31 U	15.5	31 U	15.5	31 U	15.5
Acenaphthene	ug/Kg	65 U	32.5	32 U	16	0.073 J	0.073	32 U	16	32 U	16	32 U	16
Acenaphthylene	ug/Kg	61 U	30.5	31 U	15.5	0.19 J	0.19	31 U	15.5	31 U	15.5	31 U	15.5
Anthracene	ug/Kg	77 U	38.5	38 U	19	0.21 J	0.21	38 U	19	38 U	19	38 U	19
Benzo(a)anthracene	ug/Kg	68 U	34	34 U	17	0.71 J	0.71	34 U	17	34 U	17	34 U	17
Benzo(a)pyrene	ug/Kg	68 U	34	34 U	17	0.51 J	0.51	34 U	17	34 U	17	34 U	17
Benzo(b)fluoranthene	ug/Kg	75 U	37.5	38 U	19	1.2	1.2	38 U	19	38 U	19	38 U	19
Benzo(e)pyrene	ug/Kg	76 U	38	38 U	19	0.95	0.95	38 U	19	38 U	19	38 U	19
Benzo(g,h,i)peryfene	ug/Kg	65 U	32.5	33 U	16.5	0.92 J	0.92	33 U	16.5	33 U	16.5	33 U	16.5
Benzo(k)fluoranthene	ug/Kg	76 U	38	38 U	19	0.99	0.99	38 U	19	38 U	19	38 U	19
Biphenyl	ug/Kg	60 U	30	30 U	15	0.85 J	0.85	30 U	15	30 U	15	30 U	15
Chrysene	ug/Kg	71 U	35.5	36 U	18	1.9	1.9	36 U	18	36 U	18	36 U	18
Dibenzo(a,h)anthracene	ug/Kg	68 U	34	34 U	17	0.19 J	0.19	34 U	17	34 U	17	34 U	17
Fluoranthene	ug/Kg	75 U	37.5	37 U	18.5	3.6	3.6	37 U	18.5	37 U	18.5	37 U	18.5
Fluorene	ug/Kg	65 U	32.5	32 U	16	0.18 J	0.18	32 U	16	32 U	16	32 U	16
Indeno(1,2,3-cd)pyrene	ug/Kg	62 U	31	31 U	15.5	0.76 J	0.76	31 U	15.5	31 U	15.5	31 U	15.5
Naphthalene	ug/Kg	61 U	30.5	31 U	15.5	1.1	1.1	31 U	15.5	31 U	15.5	31 U	15.5
Perylene	ug/Kg	110 U	55	54 U	27	2.3	2.3	54 U	27	54 U	27	54 U	27
Phenanthrene	ug/Kg	73 U	36.5	37 U	18.5	1.2	1.2	37 U	18.5	37 U	18.5	37 U	18.5
Pyrene	ug/Kg	71 U	35.5	36 U	18	2.7	2.7	36 U	18	36 U	18	36 U	18
TOTAL PAH													
Total PAH	ug/kg	1703 U	851.5	852 U	426	22.823	22.823	852 U	426	852 U	426	852 U	426
Total PAH_0	ug/kg	60 U	30	30 U	15	22.823	22.823	30 U	15	30 U	15	30 U	15
Total PAH Carbon Normalized	ug PAH/kg OC	NC	924539	NC	117680	NC	17556	NC	154909	NC	176033	NC	167717
CARBON													
Soot	%	NA	NA	NA	NA	0.01 U	0.005	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	921	921	3620	3620	1300	1300	2750	2750	2420	2420	2540	2540
Total Organic Carbon (TOC)	%	NC	0.0921	NC	0.362	NC	0.13	NC	0.275	NC	0.242	NC	0.254

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT12 NSP-SE-SQT12-0605-E-062005 6/20/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQDUP01-0905-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-A-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-B-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-C-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	0.18 J	0.18	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	0.17 J	0.17	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	63 U	31.5	32 U	16	0.28 J	0.28	32 U	16	32 U	16	32 U	16
Dibenzothiophene	ug/kg	NA	NA	NA	NA	0.13 J	0.13	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	110 U	55	160 J	160	130	130	55 U	27.5	110 J	110	55 U	27.5
o-Cresol	ug/Kg	52 U	26	26 U	13	1.2 J	1.2	26 U	13	26 U	13	26 U	13
Pentachlorophenol	ug/kg	NA	NA	NA	NA	6.3	6.3	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	56 U	28	28 U	14	1.4 JB	1.4	28 U	14	28 U	14	28 U	14
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	NA	NA	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	NA	NA	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	NA	NA	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	NA	NA	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	11 U	5.5	NA	NA	11 U	5.5	11 U	5.5	11 U	5.5

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT13 NSP-SE-SQT13-0905-D-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-E-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQDUP02-0905 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-A-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-B-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM													
Acid Volatile Sulfide	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lead	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	umole/g	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SEM/AVS Ratio		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CYANIDE													
Cyanide	mg/Kg	2 U	1	1.9 U	0.95	NA	NA	NA	NA	1.8 U	0.9	1.8 U	0.9
METALS													
Aluminum	mg/Kg	1600	1600	1300	1300	NA	NA	NA	NA	1500	1500	1500	1500
Antimony	mg/Kg	1.6 UJ	0.8	1.7 UJ	0.85	NA	NA	NA	NA	1.4 UJ	0.7	1.7 UJ	0.85
Arsenic	mg/Kg	1.2 U	0.6	1.4 U	0.7	NA	NA	NA	NA	2.4 J	2.4	1.3 U	0.65
Barium	mg/Kg	10	10	8.4	8.4	NA	NA	NA	NA	9.3	9.3	9.8	9.8
Beryllium	mg/Kg	1.5	1.5	0.11 J	0.11	NA	NA	NA	NA	0.11 J	0.11	0.17	0.17
Cadmium	mg/Kg	0.25 U	0.125	0.27 U	0.135	NA	NA	NA	NA	0.3 U	0.15	0.28 U	0.14
Chromium	mg/Kg	3.7	3.7	3.7	3.7	NA	NA	NA	NA	5.4	5.4	4.9	4.9
Cobalt	mg/Kg	1.4 J	1.4	1.2 J	1.2	NA	NA	NA	NA	1.7 J	1.7	2.1	2.1
Copper	mg/Kg	2.8	2.8	2.4	2.4	NA	NA	NA	NA	3.6	3.6	3.5	3.5
Iron	mg/Kg	4200	4200	3600	3600	NA	NA	NA	NA	5100	5100	5500	5500
Lead	mg/Kg	5.5 U	2.75	5.9 U	2.95	NA	NA	NA	NA	6.6 U	3.3	6.1 U	3.05
Magnesium	mg/Kg	620	620	520	520	NA	NA	NA	NA	620	620	610	610
Manganese	mg/Kg	44	44	35	35	NA	NA	NA	NA	56	56	55	55
Mercury	mg/Kg	0.079 U	0.0395	0.079 U	0.0395	NA	NA	NA	NA	0.079 U	0.0395	0.079 U	0.0395
Nickel	mg/Kg	2.8 J	2.8	3 J	3	NA	NA	NA	NA	5.2	5.2	3.6 J	3.6
Selenium	mg/Kg	1.5 U	0.75	1.6 U	0.8	NA	NA	NA	NA	1.3 U	0.65	1.6 U	0.8
Silver	mg/Kg	0.5 U	0.25	0.53 U	0.265	NA	NA	NA	NA	0.59 U	0.295	0.55 U	0.275
Thallium	mg/Kg	1.9 U	0.95	2 U	1	NA	NA	NA	NA	1.7 U	0.85	2 U	1
Vanadium	mg/Kg	9.1	9.1	7.8	7.8	NA	NA	NA	NA	13	13	14	14
Zinc	mg/Kg	11	11	9.5	9.5	NA	NA	NA	NA	10	10	11	11
OTHER													
Calcium	mg/Kg	540	540	490	490	NA	NA	NA	NA	3400	3400	680	680
Potassium	mg/Kg	240	240	190	190	NA	NA	NA	NA	200	200	190	190
Sodium	mg/Kg	36	36	29	29	NA	NA	NA	NA	43	43	25	25
Solids, percent	%	68.2	68.2	70.6	70.6	NA	NA	NA	NA	63.1	63.1	60.1	60.1

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	*Units*	NSP-SQT13 NSP-SE-SQT13-0905-D-092705 9/27/2005 *(0-0.5)*		NSP-SQT13 NSP-SE-SQT13-0905-E-092705 9/27/2005 *(0-0.5)*		NSP-SQT14 NSP-SE-SQDUP02-0905 9/27/2005 *(0-0.5)*		NSP-SQT14 NSP-SE-SQT14-0905 9/27/2005 *(0-0.5)*		NSP-SQT14 NSP-SE-SQT14-0905-A-092705 9/27/2005 *(0-0.5)*		NSP-SQT14 NSP-SE-SQT14-0905-B-092705 9/27/2005 *(0-0.5)*	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs													
1-Methylnaphthalene	ug/Kg	32 U	16	32 U	16	1.8	1.8	2.2	2.2	32 U	16	32 U	16
1-Methylphenanthrene	ug/Kg	39 U	19.5	39 U	19.5	1.4	1.4	2.9	2.9	39 U	19.5	39 U	19.5
2,3,5-Trimethylnaphthalene	ug/Kg	35 U	17.5	35 U	17.5	0.45 J	0.45	0.63 J	0.63	35 U	17.5	35 U	17.5
2,6-Dimethylnaphthalene	ug/Kg	41 U	20.5	41 U	20.5	0.77 J	0.77	0.98	0.98	41 U	20.5	41 U	20.5
2-Methylnaphthalene	ug/Kg	31 U	15.5	31 U	15.5	2.8	2.8	3.8	3.8	31 U	15.5	31 U	15.5
Acenaphthene	ug/Kg	32 U	16	32 U	16	0.36 J	0.36	0.41 J	0.41	32 U	16	32 U	16
Acenaphthylene	ug/Kg	31 U	15.5	31 U	15.5	0.99	0.99	1.2	1.2	31 U	15.5	31 U	15.5
Anthracene	ug/Kg	38 U	19	38 U	19	0.99	0.99	1.2	1.2	38 U	19	38 U	19
Benzo(a)anthracene	ug/Kg	34 U	17	34 U	17	2.8	2.8	3.3	3.3	34 U	17	34 U	17
Benzo(a)pyrene	ug/Kg	34 U	17	34 U	17	1.6	1.6	2.2	2.2	34 U	17	34 U	17
Benzo(b)fluoranthene	ug/Kg	38 U	19	38 U	19	3.3	3.3	3.6	3.6	38 U	19	38 U	19
Benzo(e)pyrene	ug/Kg	38 U	19	38 U	19	3.2	3.2	3.5	3.5	38 U	19	38 U	19
Benzo(g,h,i)perylene	ug/Kg	33 U	16.5	33 U	16.5	2.7	2.7	3.3	3.3	33 U	16.5	33 U	16.5
Benzo(k)fluoranthene	ug/Kg	38 U	19	38 U	19	2.6	2.6	3	3	38 U	19	38 U	19
Biphenyl	ug/Kg	30 U	15	30 U	15	0.89	0.89	1.4	1.4	30 U	15	30 U	15
Chrysene	ug/Kg	36 U	18	36 U	18	4.7	4.7	5.5	5.5	36 U	18	36 U	18
Dibenzo(a,h)anthracene	ug/Kg	34 U	17	34 U	17	0.61 J	0.61	0.72 J	0.72	34 U	17	34 U	17
Fluoranthene	ug/Kg	37 U	18.5	37 U	18.5	6	6	7	7	37 U	18.5	37 U	18.5
Fluorene	ug/Kg	32 U	16	32 U	16	0.9	0.9	1	1	32 U	16	32 U	16
Indeno(1,2,3-cd)pyrene	ug/Kg	31 U	15.5	31 U	15.5	2.4	2.4	2.6	2.6	31 U	15.5	31 U	15.5
Naphthalene	ug/Kg	31 U	15.5	31 U	15.5	3.2	3.2	4.9	4.9	31 U	15.5	31 U	15.5
Perylene	ug/Kg	54 U	27	54 U	27	4.2	4.2	6	6	54 U	27	54 U	27
Phenanthrene	ug/Kg	37 U	18.5	37 U	18.5	5.4	5.4	5.5	5.5	37 U	18.5	37 U	18.5
Pyrene	ug/Kg	36 U	18	36 U	18	5.9	5.9	7.3	7.3	36 U	18	36 U	18
TOTALPAHS													
Total PAH	ug/kg	852 U	426	852 U	426	59.96	59.96	74.14	74.14	852 U	426	852 U	426
Total PAH_0	ug/kg	30 U	15	30 U	15	59.96	59.96	74.14	74.14	30 U	15	30 U	15
Total PAH Carbon Normalized	ug PAH/kg OC	NC	138762	NC	145392	NC	37475	NC	18535	NC	129091	NC	100235
CARBON													
Soot	%	NA	NA	NA	NA	0.01 U	0.005	0.05	0.05	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	3070	3070	2930	2930	1600	1600	4000	4000	3300	3300	4250	4250
Total Organic Carbon (TOC)	%	NC	0.307	NC	0.293	NC	0.16	NC	0.4	NC	0.33	NC	0.425

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT13 NSP-SE-SQT13-0905-D-092705 9/27/2005 (0-0.5)		NSP-SQT13 NSP-SE-SQT13-0905-E-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQDUP02-0905 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-A-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-B-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs													
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	0.46 J	0.46	0.77 J	0.77	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	0.59 J	0.59	0.82 J	0.82	NA	NA	NA	NA
Dibenzofuran	ug/Kg	32 U	16	32 U	16	1.5	1.5	1.9	1.9	32 U	16	32 U	16
Dibenzothiophene	ug/kg	NA	NA	NA	NA	0.5 J	0.5	0.49 J	0.49	NA	NA	NA	NA
m & p-cresols	ug/Kg	190 J	190	290	290	3.4	3.4	55	55	55 U	27.5	160 J	160
o-Cresol	ug/Kg	26 U	13	26 U	13	0.65 J	0.65	0.71 J	0.71	26 U	13	26 U	13
Pentachlorophenol	ug/kg	NA	NA	NA	NA	0.78 JB	0.78	1.6 JB	1.6	NA	NA	NA	NA
Phenol	ug/Kg	28 U	14	28 U	14	0.83 JB	0.83	0.94 JB	0.94	28 U	14	28 U	14
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	NA	NA	NA	NA	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	NA	NA	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	NA	NA	NA	NA	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	NA	NA	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	NA	NA	NA	NA	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	NA	NA	NA	NA	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	NA	NA	NA	NA	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	NA	NA	NA	NA	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	NA	NA	NA	NA	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	11 U	5.5	NA	NA	NA	NA	11 U	5.5	11 U	5.5

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT14 NSP-SE-SQT14-0905-C MS/MSD-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-D-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-E-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
AVS/SEM							
Acid Volatile Sulfide	umole/g	1.1	1.1	NA	NA	NA	NA
Cadmium	umole/g	0.0022 B	0.0022	NA	NA	NA	NA
Copper	umole/g	0.044 B	0.044	NA	NA	NA	NA
Lead	umole/g	0.0082 B	0.0082	NA	NA	NA	NA
Mercury	umole/g	0.0009 U	0.00045	NA	NA	NA	NA
Nickel	umole/g	0.027 U	0.0135	NA	NA	NA	NA
Zinc	umole/g	0.14	0.14	NA	NA	NA	NA
SEM/AVS Ratio		1.3	1.3	NA	NA	NA	NA
CYANIDE							
Cyanide	mg/Kg	1.9 U	0.95	1.7 U	0.85	1.8 U	0.9
METALS							
Aluminum	mg/Kg	1900	1900	1500	1500	1800	1800
Antimony	mg/Kg	1.9 UJ	0.95	1.5 UJ	0.75	1.4 UJ	0.7
Arsenic	mg/Kg	1.7 J	1.7	1.2 J	1.2	1.1 U	0.55
Barium	mg/Kg	12	12	9.9	9.9	12	12
Beryllium	mg/Kg	0.17	0.17	0.14	0.14	0.19	0.19
Cadmium	mg/Kg	0.3 U	0.15	0.24 U	0.12	0.23 U	0.115
Chromium	mg/Kg	5.5	5.5	5	5	5.9	5.9
Cobalt	mg/Kg	2	2	1.5 J	1.5	1.8	1.8
Copper	mg/Kg	4	4	3.7	3.7	4.3	4.3
Iron	mg/Kg	5700	5700	5200	5200	5700	5700
Lead	mg/Kg	6.5 U	3.25	5.3 U	2.65	5.6 J	5.6
Magnesium	mg/Kg	770	770	640	640	770	770
Manganese	mg/Kg	69	69	56	56	73	73
Mercury	mg/Kg	0.079 U	0.0395	0.079 U	0.0395	0.079 U	0.0395
Nickel	mg/Kg	3.4 J	3.4	3.3 J	3.3	3.5 J	3.5
Selenium	mg/Kg	1.8 U	0.9	1.4 U	0.7	1.3 U	0.65
Silver	mg/Kg	0.58 U	0.29	0.48 U	0.24	0.45 U	0.225
Thallium	mg/Kg	2.3 U	1.15	1.7 U	0.85	1.7 U	0.85
Vanadium	mg/Kg	13	13	12	12	14	14
Zinc	mg/Kg	11	11	10	10	12	12
OTHER							
Calcium	mg/Kg	780	780	1200	1200	800	800
Potassium	mg/Kg	240	240	200	200	230	230
Sodium	mg/Kg	29	29	26	26	29	29
Solids, percent	%	71.7	71.7	73.7	73.7	74.1	74.1

Table 3.2. Sediment Analytical Results - SQT Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT14 NSP-SE-SQT14-0905-C MS/MSD-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-D-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-E-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
PAHs							
1-Methylnaphthalene	ug/Kg	32 U	16	32 U	16	32 U	16
1-Methylphenanthrene	ug/Kg	39 U	19.5	39 U	19.5	39 U	19.5
2,3,5-Trimethylnaphthalene	ug/Kg	35 U	17.5	35 U	17.5	35 U	17.5
2,6-Dimethylnaphthalene	ug/Kg	41 U	20.5	41 U	20.5	41 U	20.5
2-Methylnaphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5
Acenaphthene	ug/Kg	32 U	16	32 U	16	32 U	16
Acenaphthylene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5
Anthracene	ug/Kg	38 U	19	38 U	19	38 U	19
Benzo(a)anthracene	ug/Kg	34 U	17	34 U	17	34 U	17
Benzo(a)pyrene	ug/Kg	34 U	17	34 U	17	34 U	17
Benzo(b)fluoranthene	ug/Kg	38 U	19	38 U	19	38 U	19
Benzo(e)pyrene	ug/Kg	38 U	19	38 U	19	38 U	19
Benzo(g,h,i)perylene	ug/Kg	33 U	16.5	33 U	16.5	33 U	16.5
Benzo(k)fluoranthene	ug/Kg	38 U	19	38 U	19	38 U	19
Biphenyl	ug/Kg	30 U	15	30 U	15	30 U	15
Chrysene	ug/Kg	36 U	18	36 U	18	36 U	18
Dibenzo(a,h)anthracene	ug/Kg	34 U	17	34 U	17	34 U	17
Fluoranthene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5
Fluorene	ug/Kg	32 U	16	32 U	16	32 U	16
Indeno(1,2,3-cd)pyrene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5
Naphthalene	ug/Kg	31 U	15.5	31 U	15.5	31 U	15.5
Perylene	ug/Kg	54 U	27	54 U	27	54 U	27
Phenanthrene	ug/Kg	37 U	18.5	37 U	18.5	37 U	18.5
Pyrene	ug/Kg	36 U	18	36 U	18	36 U	18
TOTAL PAH							
Total PAH	ug/kg	852 U	426	852 U	426	852 U	426
Total PAH_0	ug/kg	30 U	15	30 U	15	30 U	15
Total PAH Carbon Normalized	ug PAH/kg OC	NC	125664	NC	87835	NC	120339
CARBON							
Soot	%	NA	NA	NA	NA	NA	NA
Total Organic Carbon (TOC)	mg/Kg	3390	3390	4850	4850	3540	3540
Total Organic Carbon (TOC)	%	NC	0.339	NC	0.485	NC	0.354

Table 3.2. Sediment Analytical Results - SQT Stations
Bascline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SQT14 NSP-SE-SQT14-0905-C MS/MSD-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-D-092705 9/27/2005 (0-0.5)		NSP-SQT14 NSP-SE-SQT14-0905-E-092705 9/27/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
SVOCs							
Benzo(a)fluoranthene	ug/kg	NA	NA	NA	NA	NA	NA
Benzo(b)fluorene	ug/kg	NA	NA	NA	NA	NA	NA
Dibenzofuran	ug/Kg	32 U	16	32 U	16	32 U	16
Dibenzothiophene	ug/kg	NA	NA	NA	NA	NA	NA
m & p-cresols	ug/Kg	55 U	27.5	110 J	110	55 U	27.5
o-Cresol	ug/Kg	26 U	13	26 U	13	26 U	13
Pentachlorophenol	ug/kg	NA	NA	NA	NA	NA	NA
Phenol	ug/Kg	28 U	14	28 U	14	28 U	14
VOCs							
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	11 U	5.5	11 U	5.5

Notes:
umole/g = Micromole per gram
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting li
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.3. Sediment Screening Criteria
Ashland/Northern States Power Lakefront Superfund Site
Ashland, WI

VOCs	Criteria	TEC	MEC	PEC	Source
1,2,3-TRIMETHYLBENZENE	µg/kg OC	1147			TLM
1,2,4-TRIMETHYLBENZENE	µg/kg OC	1147			TLM
1,3,5-TRIMETHYLBENZENE	µg/kg OC	1147			TLM
BENZENE	µg/kg dw @ 1%OC	57	83.5	110	WDNR 2003
ETHYLBENZENE	µg/kg	175			Reg V
M,P-XYLENE (SUM OF ISOMERS)	µg/kg dw @ 1%OC	25	37.5	50	WDNR 2003
O-XYLENE	µg/kg dw @ 1%OC	25	37.5	50	WDNR 2003
SEC-BUTYLBENZENE	µg/kg dw @ 1%OC	25	37.5	50	WDNR 2003
STYRENE	µg/kg OC	254			Reg V
TOLUENE	µg/kg dw @ 1%OC	890	1345	1800	WDNR 2003
PAHs					
1-METHYLNAPHTHALENE	µg/kg		94.00		T50
1-METHYLPHENANTHRENE	µg/kg		112		T50
2,3,5-TRIMETHYLNAPHTHALENE	µg/kg OC	988.0			TLM
2,6-DIMETHYLNAPHTHALENE	µg/kg		133.0		T50
2-METHYLNAPHTHALENE	µg/kg		120.0	240.0	BC
ACENAPHTHENE	µg/kg dw @ 1%OC	6.7	48.0	89.0	WDNR 2003
ACENAPHTHYLENE	µg/kg dw @ 1%OC	5.9	67.0	128.0	WDNR 2003
ANTHRACENE	µg/kg dw @ 1%OC	57.2	451.0	845.0	WDNR 2003
BENZO(A)ANTHRACENE	µg/kg dw @ 1%OC	108.0	579.0	1050.0	WDNR 2003
BENZO(A)PYRENE	µg/kg dw @ 1%OC	150.0	800.0	1450.0	WDNR 2003
BENZO(B)FLUORANTHENE	µg/kg dw @ 1%OC	240.0	6820.0	13400.0	WDNR 2003
BENZO(E)PYRENE	µg/kg dw @ 1%OC	150.0	800.0	1450.0	WDNR 2003
BENZO(G,H,I)PERYLENE	µg/kg dw @ 1%OC	170.0	1685.0	3200.0	WDNR 2003
BENZO(K)FLUORANTHENE	µg/kg dw @ 1%OC	240.0	6820.0	13400.0	WDNR 2003
BIPHENYL (DIPHENYL)	µg/kg		73.0		T50
CHRYSENE	µg/kg dw @ 1%OC	166.0	728.0	1290.0	WDNR 2003
DIBENZ(A,H)ANTHRACENE	µg/kg dw @ 1%OC	33.0	84.0	135.0	WDNR 2003
FLUORANTHENE	µg/kg dw @ 1%OC	423.0	1327.0	2230.0	WDNR 2003
FLUORENE	µg/kg dw @ 1%OC	77.4	307.0	536.0	WDNR 2003
INDENO(1,2,3-C,D)PYRENE	µg/kg dw @ 1%OC	200.0	1700.0	3200.0	WDNR 2003
NAPHTHALENE	µg/kg dw @ 1%OC	176.0	369.0	561.0	WDNR 2003
PERYLENE	µg/kg OC	812.0			TLM
PHENANTHRENE	µg/kg dw @ 1%OC	204.0	687.0	1170.0	WDNR 2003
PYRENE	µg/kg dw @ 1%OC	195.0	858.0	1520.0	WDNR 2003
TOTAL PAHs	µg/kg dw @ 1%OC	1610.0	12205.0	22800.0	WDNR 2003
Other SVOCs					
CRESOLS, M & P	µg/kg	52.4			Reg V
2-METHYLPHENOL (O-CRESOL)	µg/kg	55.4			Reg V
DIBENZOFURAN	µg/kg dw @ 1%OC	150.0	365.0	580.0	WDNR 2003
PHENOL	µg/kg dw @ 1%OC	4200.0	8100.0	12000.0	WDNR 2003
Metals					
Aluminum	µg/g	25500.0			SQuiRT
Antimony	µg/g	2.0	13.5	25.0	WDNR 2003
Arsenic	µg/g	9.8	21.4	33.0	WDNR 2003
Barium	µg/g	48.0			OR
Beryllium	µg/g	122.0			OR
Cadmium	µg/g	1.0	3.0	5.0	WDNR 2003
Chromium	µg/g	43.0	76.5	110.0	WDNR 2003
Cobalt	µg/g	43.4			Reg V
Copper	µg/g	32.0	91.0	150.0	WDNR 2003
Iron	µg/g	20000.0	30000.0	40000.0	WDNR 2003
Lead	µg/g	36.0	83.0	130.0	WDNR 2003
Manganese	µg/g	460.0	780.0	1100.0	WDNR 2003
Mercury	µg/g	0.2	0.6	1.1	WDNR 2003
Nickel	µg/g	23.0	36.0	49.0	WDNR 2003
Selenium	µg/g	1.0			SQuiRT
Silver	µg/g	1.6		2.2	WDNR 2003
Thallium	µg/g	0.7			OR
Vanadium	µg/g	57.0			SQuiRT
Zinc	µg/g	120.0	290.0	460.0	WDNR 2003
Cyanides	µg/g	0.1			Reg V
SEM:AVS	µg/g	1.0			

µg/g micrograms per gram; equvalent to milligrams per kilogram
CBR for baseline narcotics is 6.94 umol/g lipid
CBR for PAHs is 3.79 umol/g lipid

WDNR 2003 = WDNR 2003. Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application Interim Guidance □
ESL=Region V Ecological Screening Levels
Region IV WQS=EPA Region IV Water Management Division Screening List from ACQUIRE
TLM=Target Lipid Model (DiToro and McGrath 2000-See text)
T50 =Logistic model point estimate of T50 concentrations (concentration at which 50% of samples are predicted to be toxic; Field et al . 2002).
SQuiRT=NOAA. Screening Quick Reference Tables
BC= Critria for Managing Contaminated Sediment in British Columbia. MWLAP. 2004.
OR=Oregon DEQ Level 2 Screening Level Values
Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D.E. Smorong, and R.A. Lindskoog. 2002.
Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environmental Toxicology and Chemistry 21(9):1993-20

Table 3.4. Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-1 NSP-SE-SS-1-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-2 NSP-SE-SS-2-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-3 NSP-SE-SS-3-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-4 NSP-SE-SS-4-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-5 NSP-SE-SQDUP01-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-5 NSP-SE-SS-5-0605-061405 6/14/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
CYANIDE													
Cyanide	mg/Kg	3.7 U	1.85	3.9 U	1.95	2.6 U	1.3	2.6 U	1.3	3.9 U	1.95	3.9 U	1.95
METALS													
Aluminum	mg/Kg	11000	11000	11000	11000	6300	6300	5400	5400	9900	9900	11000	11000
Antimony	mg/Kg	3 UJ	1.5	3 UJ	1.5	1.9 UJ	0.95	2.1 UJ	1.05	2.2 UJ	1.1	2.9 UJ	1.45
Arsenic	mg/Kg	5.1 J	5.1	5 J	5	3.7 J	3.7	3.2 J	3.2	1.9 J	1.9	4.1 J	4.1
Barium	mg/Kg	74	74	76	76	38	38	40	40	68	68	75	75
Beryllium	mg/Kg	0.68	0.68	0.71	0.71	0.46	0.46	0.38 J	0.38	0.53 J	0.53	0.54 J	0.54
Cadmium	mg/Kg	0.76 J	0.76	0.6 U	0.3	0.41 U	0.205	0.41 U	0.205	0.6 U	0.3	0.62 U	0.31
Chromium	mg/Kg	27	27	28	28	15	15	14	14	24	24	27	27
Cobalt	mg/Kg	9.5	9.5	10	10	6.9	6.9	6.3	6.3	9.7	9.7	11	11
Copper	mg/Kg	330	330	700	700	33	33	29	29	80	80	89	89
Iron	mg/Kg	20000	20000	21000	21000	14000	14000	15000	15000	18000	18000	20000	20000
Lead	mg/Kg	35 J	35	46 J	46	51	51	49	49	38 J	38	38 J	38
Magnesium	mg/Kg	4600	4600	4600	4600	2900	2900	2300	2300	4000	4000	4700 J	4700
Manganese	mg/Kg	280	280	270	270	170	170	160	160	290	290	290 J	290
Mercury	mg/Kg	0.075 U	0.0375	0.098 J	0.098	0.077 U	0.0385	0.077 U	0.0385	0.077 U	0.0385	0.081 J	0.081
Nickel	mg/Kg	21	21	22	22	10	10	11	11	17	17	22 J	22
Selenium	mg/Kg	2.8 J	2.8	4 J	4	2.9 J	2.9	1.9 U	0.95	2 U	1	3.4 J	3.4
Silver	mg/Kg	1.2 U	0.6	1.2 U	0.6	0.79 U	0.395	0.81 U	0.405	1.2 U	0.6	1.2 U	0.6
Thallium	mg/Kg	3.6 U	1.8	3.5 U	1.75	2.3 U	1.15	2.4 U	1.2	2.6 UJ	1.3	3.4 U	1.7
Vanadium	mg/Kg	47	47	48	48	31	31	26	26	46 U	23	50 J	50
Zinc	mg/Kg	82	82	110	110	56	56	59	59	84	84	89 J	89
OTHER													
Calcium	mg/Kg	4600	4600	4600	4600	2600	2600	2400	2400	4700	4700	4700 J	4700
Potassium	mg/Kg	1400	1400	1500	1500	810	810	680	680	1300	1300	1500 J	1500
Sodium	mg/Kg	150	150	140	140	84	84	73	73	130	130	130 J	130
Solids, percent	%	34.9	34.9	30.8	30.8	53.2	53.2	51	51	34.1	34.1	34.4	34.4
PAHs													
1-Methylnaphthalene	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80
4-Methylphenanthrene	ug/Kg	190 U	95	190 U	95	190 U	95	190 U	95	190 U	95	190 U	95
2,3,5-Trimethylnaphthalene	ug/Kg	180 U	90	180 U	90	180 U	90	180 U	90	180 U	90	180 U	90
2,6-Dimethylnaphthalene	ug/Kg	200 U	100	200 U	100	200 U	100	200 U	100	200 U	100	200 U	100
2-Methylnaphthalene	ug/Kg	160 U	80	620	620	160 U	80	360 J	360	160 U	80	160 U	80
Acenaphthene	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80
Acenaphthylene	ug/Kg	150 U	75	810	810	150 U	75	150 U	75	150 U	75	150 U	75
Anthracene	ug/Kg	190 U	95	190 U	95	190 U	95	190 U	95	190 U	95	190 U	95
Benzo(a)anthracene	ug/Kg	710	710	1900	1900	400 J	400	880	880	170 U	85	570 J	570
Benzo(a)pyrene	ug/Kg	920	920	2800	2800	510 J	510	1300	1300	170 U	85	750 J	750
Benzo(b)fluoranthene	ug/Kg	890	890	2400	2400	590 J	590	1400	1400	190 U	95	750 J	750
Benzo(e)pyrene	ug/Kg	640	640	1700	1700	420 J	420	890	890	190 U	95	550 J	550
Benzo(g,h,i)perylene	ug/Kg	160 U	80	1100	1100	160 U	80	480 J	480	160 U	80	160 UJ	80
Benzo(k)fluoranthene	ug/Kg	190 U	95	1000	1000	190 U	95	450 J	450	190 U	95	190 UJ	95
Biphenyl	ug/Kg	150 U	75	150 U	75	150 U	75	150 U	75	150 U	75	150 U	75
Chrysene	ug/Kg	810	810	2000	2000	490 J	490	1100	1100	180 U	90	650 J	650
Dibenzo(a,h)anthracene	ug/Kg	170 U	85	170 U	85	170 U	85	170 U	85	170 U	85	170 U	85
Fluoranthene	ug/Kg	890	890	2000	2000	780	780	1500	1500	190 U	95	620 J	620
Fluorene	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80
Indeno(1,2,3-cd)pyrene	ug/Kg	160 U	80	660	660	160 U	80	160 U	80	160 U	80	160 UJ	80
Naphthalene	ug/Kg	150 U	75	680	680	150 U	75	330 J	330	150 U	75	150 U	75
Perylene	ug/Kg	270 U	135	600 J	600	270 U	135	270 U	135	270 U	135	270 U	135
Phenanthrene	ug/Kg	690	690	1300	1300	610	610	1500	1500	180 U	90	180 UJ	90
Pyrene	ug/Kg	1100	1100	2900	2900	800	800	1700	1700	600	600	890 J	890

Table 3.4. Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-1 NSP-SE-SS-1-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-2 NSP-SE-SS-2-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-3 NSP-SE-SS-3-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-4 NSP-SE-SS-4-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-5 NSP-SE-SQDUP01-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-5 NSP-SE-SS-5-0605-061405 6/14/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
TOTAL PAH													
Total PAH	ug/kg	8050	8050	23250	23250	6000	6000	12960	12960	2635	2635	6270	6270
Total PAH_0	ug/kg	6650	6650	22470	22470	4600	4600	11890	11890	600	600	4780	4780
Total PAH Carbon Normalized	ug PAH/kg OC	NC	71875	NC	219340	NC	172414	NC	254617	NC	19812	NC	47143
CARBON													
Total Organic Carbon (TOC)	mg/Kg	112000	112000	106000	106000	34800	34800	50900	50900	133000	133000	133000	133000
Total Organic Carbon (TOC)	%	NC	11.2	NC	10.6	NC	3.48	NC	5.09	NC	13.3	NC	13.3
SVOCs													
Dibenzofuran	ug/Kg	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80	160 U	80
m & p-cresols	ug/Kg	270 U	135	270 U	135	270 U	135	270 U	135	270 U	135	270 U	135
o-Cresol	ug/Kg	130 U	65	130 U	65	130 U	65	130 U	65	130 U	65	130 U	65
Phenol	ug/Kg	140 U	70	140 U	70	140 U	70	140 U	70	140 U	70	140 U	70
VOCs													
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	52	52	11 U	5.5	58	58	62	62	38	38

Notes:
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting limit
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.4. Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-6 NSP-SE-SS-6-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-7 NSP-SE-SS-7-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-8 NSP-SE-SS-8-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-9 NSP-SE-SS-9-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-10 NSP-SE-SS-10-0605 MS/MSD-061505 6/15/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
CYANIDE											
Cyanide	mg/Kg	6.4 U	3.2	4.5 U	2.25	3.5 U	1.75	4.8 U	2.4	2.8 U	1.4
METALS											
Aluminum	mg/Kg	13000	13000	2400	2400	6100	6100	5700	5700	7300	7300
Antimony	mg/Kg	4.8 UJ	2.4	2.9 UJ	1.45	1.9 UJ	0.95	3.4 UJ	1.7	1.7 UJ	0.85
Arsenic	mg/Kg	11 J	11	3.8 J	3.8	5.1 J	5.1	4.2 J	4.2	2.9 J	2.9
Barium	mg/Kg	110	110	42	42	56	56	71	71	39	39
Beryllium	mg/Kg	0.68 J	0.68	0.15 J	0.15	0.21 J	0.21	0.34 J	0.34	0.27 J	0.27
Cadmium	mg/Kg	1.1 U	0.55	0.67 U	0.335	0.56 U	0.28	0.78 U	0.39	0.43 U	0.215
Chromium	mg/Kg	31	31	5.2	5.2	15	15	16	16	18	18
Cobalt	mg/Kg	16	16	3.7 J	3.7	8.8	8.8	10	10	8	8
Copper	mg/Kg	170	170	52	52	65	65	110	110	29	29
Iron	mg/Kg	27000	27000	8000	8000	14000	14000	15000	15000	15000	15000
Lead	mg/Kg	50 J	50	15 U	7.5	14 J	14	17 U	8.5	46	46
Magnesium	mg/Kg	5600	5600	1200	1200	2700	2700	2600	2600	3600	3600
Manganese	mg/Kg	450	450	150	150	220	220	240	240	210	210
Mercury	mg/Kg	0.077 U	0.0385	0.075 U	0.0375	0.1 J	0.1	0.11 J	0.11	0.036 J	0.036
Nickel	mg/Kg	22	22	5.9 J	5.9	8.6 J	8.6	9.7 J	9.7	14	14
Selenium	mg/Kg	5.7 J	5.7	2.8 J	2.8	2.6 J	2.6	4.1 J	4.1	1.6 U	0.8
Silver	mg/Kg	2.1 U	1.05	1.3 U	0.65	1.1 U	0.55	1.5 U	0.75	0.84 U	0.42
Thallium	mg/Kg	5.7 U	2.85	3.4 U	1.7	2.3 U	1.15	4.1 U	2.05	2 U	1
Vanadium	mg/Kg	60	60	16	16	31	31	37	37	47	47
Zinc	mg/Kg	130	130	47	47	59	59	100	100	43	43
OTHER											
Calcium	mg/Kg	10000	10000	7400	7400	6800	6800	9600	9600	4400	4400
Potassium	mg/Kg	1700	1700	320	320	760	760	740	740	980	980
Sodium	mg/Kg	160	160	48 U	24	82	82	83	83	100	100
Solids, percent	%	20.5	20.5	30.9	30.9	38.2	38.2	27.7	27.7	59	59
PAHs											
1-Methylnaphthalene	ug/Kg	160 U	80	63 U	31.5	63 U	31.5	63 U	31.5	160 U	80
1-Methylphenanthrene	ug/Kg	190 U	95	78 U	39	78 U	39	78 U	39	190 U	95
2,3,5-Trimethylnaphthalene	ug/Kg	180 U	90	71 U	35.5	71 U	35.5	71 U	35.5	180 U	90
2,6-Dimethylnaphthalene	ug/Kg	200 U	100	82 U	41	82 U	41	82 U	41	200 U	100
2-Methylnaphthalene	ug/Kg	160 U	80	62 U	31	62 U	31	62 U	31	160 U	80
Acenaphthene	ug/Kg	160 U	80	65 U	32.5	65 U	32.5	65 U	32.5	160 U	80
Acenaphthylene	ug/Kg	150 U	75	61 U	30.5	61 U	30.5	61 U	30.5	150 U	75
Anthracene	ug/Kg	190 U	95	77 U	38.5	77 U	38.5	77 U	38.5	190 U	95
Benzo(a)anthracene	ug/Kg	170 U	85	250	250	68 U	34	270	270	680	680
Benzo(a)pyrene	ug/Kg	1000	1000	310 J	310	210 J	210	320 J	320	920	920
Benzo(b)fluoranthene	ug/Kg	1100	1100	340 J	340	240 J	240	330 J	330	910	910
Benzo(e)pyrene	ug/Kg	190 U	95	76 UJ	38	76 UJ	38	76 UJ	38	560 J	560
Benzo(g,h,i)perylene	ug/Kg	160 U	80	65 UJ	32.5	65 UJ	32.5	65 UJ	32.5	160 U	80
Benzo(k)fluoranthene	ug/Kg	190 U	95	76 UJ	38	76 UJ	38	76 UJ	38	190 U	95
Biphenyl	ug/Kg	150 U	75	60 U	30	60 U	30	60 U	30	150 U	75
Chrysene	ug/Kg	180 U	90	300	300	200 J	200	310	310	710	710
Dibenzo(a,h)anthracene	ug/Kg	170 U	85	68 UJ	34	68 UJ	34	68 UJ	34	170 U	85
Fluoranthene	ug/Kg	1100	1100	450	450	230 J	230	340	340	670	670
Fluorene	ug/Kg	160 U	80	65 U	32.5	65 U	32.5	65 U	32.5	160 U	80
Indeno(1,2,3-cd)pyrene	ug/Kg	160 U	80	62 U	31	62 U	31	62 U	31	160 U	80
Naphthalene	ug/Kg	150 U	75	61 U	30.5	61 U	30.5	61 U	30.5	150 U	75
Perylene	ug/Kg	270 U	135	110 UJ	55	110 UJ	55	110 UJ	55	270 U	135
Phenanthrene	ug/Kg	180 U	90	370	370	73 U	36.5	73 U	36.5	180 U	90
Pyrene	ug/Kg	1400	1400	570	570	310	310	470	470	1100	1100

Table 3.4. Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-6 NSP-SE-SS-6-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-7 NSP-SE-SS-7-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-8 NSP-SE-SS-8-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-9 NSP-SE-SS-9-0605-061405 6/14/2005 (0-0.5)		NSP-SE-SS-10 NSP-SE-SS-10-0605 MS/MSD-061505 6/15/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
TOTAL PAH											
Total PAH	ug/kg	6360	6360	3191	3191	1861.5	1861.5	2677.5	2677.5	7040	7040
Total PAH_0	ug/kg	4600	4600	2590	2590	1190	1190	2040	2040	5550	5550
Total PAH Carbon Normalized	ug PAH/kg OC	NC	37193	NC	9729	NC	13489	NC	11692	NC	434568
CARBON											
Total Organic Carbon (TOC)	mg/Kg	171000	171000	328000	328000	138000	138000	229000	229000	16200	16200
Total Organic Carbon (TOC)	%	NC	17.1	NC	32.8	NC	13.8	NC	22.9	NC	1.62
SVOCs											
Dibenzofuran	ug/Kg	160 U	80	63 U	31.5	63 U	31.5	63 U	31.5	160 U	80
m & p-cresols	ug/Kg	270 U	135	110 U	55	110 U	55	110 U	55	270 U	135
o-Cresol	ug/Kg	130 U	65	52 U	26	52 U	26	52 U	26	130 U	65
Phenol	ug/Kg	140 U	70	56 U	28	56 U	28	56 U	28	140 U	70
VOCs											
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	85	85	130	130	91	91	220	220	29 J	29

Notes:
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Table 3.4, Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-11 NSP-SE-SS-11-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-12 NSP-SE-SS-12-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-13 NSP-SE-SS-13-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-14 NSP-SE-SS-14-0605-061505 6/15/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
CYANIDE									
Cyanide	mg/Kg	2.5 U	1.25	2.7 U	1.35	2.7 U	1.35	1.7 U	0.85
METALS									
Aluminum	mg/Kg	8500	8500	1700	1700	2000	2000	1300	1300
Antimony	mg/Kg	2.1 UJ	1.05	5.1 J	5.1	1.7 UJ	0.85	1.2 UJ	0.6
Arsenic	mg/Kg	2.1 J	2.1	1.8 U	0.9	1.8 J	1.8	0.97 U	0.485
Barium	mg/Kg	49	49	11	11	10	10	6.9	6.9
Beryllium	mg/Kg	0.77 J	0.77	0.12 U	0.06	0.12 U	0.06	0.069 U	0.0345
Cadmium	mg/Kg	0.44 U	0.22	0.45 U	0.225	0.44 U	0.22	0.26 U	0.13
Chromium	mg/Kg	20	20	8.2	8.2	11	11	4.8	4.8
Cobalt	mg/Kg	8.3	8.3	2.4 J	2.4	3.3	3.3	2.2	2.2
Copper	mg/Kg	24	24	2.8	2.8	3.7	3.7	2.5	2.5
Iron	mg/Kg	18000	18000	9200	9200	11000	11000	5000	5000
Lead	mg/Kg	39	39	9.8 U	4.9	9.6 U	4.8	5.6 U	2.8
Magnesium	mg/Kg	4200	4200	870	870	1200	1200	620	620
Manganese	mg/Kg	190	190	94	94	98	98	74	74
Mercury	mg/Kg	0.13 J	0.13	0.08 U	0.04	0.08 U	0.04	1.3	1.3
Nickel	mg/Kg	17	17	3.8 J	3.8	5.2 J	5.2	2.8 J	2.8
Selenium	mg/Kg	2 U	1	2.1 U	1.05	1.5 U	0.75	1.1 U	0.55
Silver	mg/Kg	0.86 U	0.43	0.88 U	0.44	0.86 U	0.43	0.5 U	0.25
Thallium	mg/Kg	2.5 UJ	1.25	2.7 UJ	1.35	2 UJ	1	1.4 UJ	0.7
Vanadium	mg/Kg	42	42	25	25	30	30	13	13
Zinc	mg/Kg	76	76	16	16	16	16	8.9	8.9
OTHER									
Calcium	mg/Kg	4700	4700	1200	1200	1300	1300	830	830
Potassium	mg/Kg	1100	1100	210	210	200	200	150	150
Sodium	mg/Kg	110	110	34 U	17	40 U	20	24 U	12
Solids, percent	%	52.7	52.7	49.2	49.2	49.1	49.1	76.4	76.4
PAHs									
1-Methylnaphthalene	ug/Kg	160 U	80	32 U	16	32 U	16	32 U	16
1-Methylphenanthrene	ug/Kg	190 U	95	39 U	19.5	39 U	19.5	39 U	19.5
2,3,5-Trimethylnaphthalene	ug/Kg	180 U	90	35 U	17.5	35 U	17.5	35 U	17.5
2,6-Dimethylnaphthalene	ug/Kg	200 U	100	41 U	20.5	41 U	20.5	41 U	20.5
2-Methylnaphthalene	ug/Kg	160 U	80	31 U	15.5	31 U	15.5	31 U	15.5
Acenaphthene	ug/Kg	160 U	80	32 U	16	32 U	16	32 U	16
Acenaphthylene	ug/Kg	300 J	300	31 U	15.5	31 U	15.5	31 U	15.5
Anthracene	ug/Kg	190 U	95	38 U	19	38 U	19	38 U	19
Benzo(a)anthracene	ug/Kg	530 J	530	34 U	17	34 U	17	34 U	17
Benzo(a)pyrene	ug/Kg	790	790	34 U	17	34 U	17	34 U	17
Benzo(b)fluoranthene	ug/Kg	740	740	38 U	19	38 U	19	38 U	19
Benzo(e)pyrene	ug/Kg	500 J	500	38 U	19	38 U	19	38 U	19
Benzo(g,h,i)perylene	ug/Kg	400 J	400	33 U	16.5	33 U	16.5	33 U	16.5
Benzo(k)fluoranthene	ug/Kg	190 U	95	38 U	19	38 U	19	38 U	19
Biphenyl	ug/Kg	150 U	75	30 U	15	30 U	15	30 U	15
Chrysene	ug/Kg	590 J	590	36 U	18	36 U	18	36 U	18
Dibenzo(a,h)anthracene	ug/Kg	170 U	85	34 U	17	34 U	17	34 U	17
Fluoranthene	ug/Kg	680	680	37 U	18.5	37 U	18.5	37 U	18.5
Fluorene	ug/Kg	160 U	80	32 U	16	32 U	16	32 U	16
Indeno(1,2,3-cd)pyrene	ug/Kg	160 U	80	31 U	15.5	31 U	15.5	31 U	15.5
Naphthalene	ug/Kg	150 U	75	31 U	15.5	31 U	15.5	31 U	15.5
Perylene	ug/Kg	270 U	135	54 U	27	54 U	27	54 U	27
Phenanthrene	ug/Kg	460 J	460	37 U	18.5	37 U	18.5	37 U	18.5
Pyrene	ug/Kg	930	930	36 U	18	36 U	18	36 U	18

Table 3.4. Sediment Analytical Results - Supplemental Sediment Stations
Baseline Ecological Risk Assessment
Ashland /Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	NSP-SE-SS-11 NSP-SE-SS-11-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-12 NSP-SE-SS-12-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-13 NSP-SE-SS-13-0605-061505 6/15/2005 (0-0.5)		NSP-SE-SS-14 NSP-SE-SS-14-0605-061505 6/15/2005 (0-0.5)	
		Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result	Analytical Result	Risk Result
TOTAL PAH									
Total PAH	ug/kg	7165	7165	852 U	426	852 U	426	852 U	426
Total PAH_0	ug/kg	5920	5920	30 U	15	30 U	15	30 U	15
Total PAH Carbon Normalized	ug PAH/kg OC	NC	221142	NC	204808	NC	235359	NC	300000
CARBON									
Total Organic Carbon (TOC)	mg/Kg	32400	32400	2080	2080	1810	1810	1420	1420
Total Organic Carbon (TOC)	%	NC	3.24	NC	0.208	NC	0.181	NC	0.142
SVOCs									
Dibenzofuran	ug/Kg	160 U	80	32 U	16	32 U	16	32 U	16
m & p-cresols	ug/Kg	270 U	135	55 U	27.5	55 U	27.5	55 U	27.5
o-Cresol	ug/Kg	130 U	65	26 U	13	26 U	13	26 U	13
Phenol	ug/Kg	140 U	70	28 U	14	28 U	14	28 U	14
VOCs									
1,2,3-Trimethylbenzene	ug/kg	19 U	9.5	NA	NA	19 U	9.5	19 U	9.5
1,2,4-Trimethylbenzene	ug/kg	15 U	7.5	NA	NA	15 U	7.5	15 U	7.5
1,3,5-Trimethylbenzene	ug/kg	16 U	8	16 U	8	16 U	8	16 U	8
Benzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
Ethylbenzene	ug/kg	15 U	7.5	15 U	7.5	15 U	7.5	15 U	7.5
m & p-Xylenes	ug/kg	25 U	12.5	25 U	12.5	25 U	12.5	25 U	12.5
o-Xylene	ug/kg	13 U	6.5	13 U	6.5	13 U	6.5	13 U	6.5
sec-Butyl benzene	ug/kg	19 U	9.5	19 U	9.5	19 U	9.5	19 U	9.5
Styrene	ug/kg	17 U	8.5	17 U	8.5	17 U	8.5	17 U	8.5
Toluene	ug/kg	11 U	5.5	NA	NA	11 U	5.5	11 U	5.5

Notes:
mg/kg = Miligram/kilogram
ug/kg = Micrograms per kilogram
ug PAH/kg OC = Micrograms PAH per kilogram Organic Carbon
PAHs = Polycyclic Aromatic Hydrocarbons
Total PAH = The sum of PAHs with NDs equivalent to 1/2 the reporting
Total PAH_0 = The sum of PAHs with NDs equivalent to zero
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NC = Not Calculated
NA = Not analyzed for this constituent

Appendix A Table A.1
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Site Samples Analyzed On Site by ECCS

Analyte	Lab	units	Reporting Limit ug/kg	SED-SE-1-2A-0505	Flag	SED-SE-1-4A-0505	Flag	SED-SE-1-5A-0505	Flag	SED-SE-1-5C-0505	Flag	SED-SE-1-6A-0505	Flag	SED-SE-1-7B-0505	Flag	SED-SE-1-8B-0505	Flag	SED-SE-1-9A-0505	Flag	SED-SE-1-10C-0505	Flag
Dilution Factor	ECCS			1		1		1		1		1		1		1		1		1	
Solids, Total	ECCS	%		80.86		80.08		38.14		38.10		29.09		31.90		30.78		31.53		35.63	
Naphthalene	ECCS	ug/kg	200	247.35	U	249.75	U	996.42		1260.00		687.62	U	627.03	U	649.73	U	634.30	U	1515.59	
1-MethylNaphthalene	ECCS	ug/kg	200	247.35	U	249.75	U	1022.64		1076.25		687.62	U	627.03	U	649.73	U	634.30	U	1178.80	
2-MethylNaphthalene	ECCS	ug/kg	200	247.35	U	249.75	U	524.43	U	525.00		687.62	U	627.03	U	649.73	U	634.30	U	617.46	
Acenaphthylene	ECCS	ug/kg	200	247.35	U	249.75	U	1914.18		2310.00		687.62	U	627.03	U	649.73	U	634.30	U	2975.06	
Acenaphthene	ECCS	ug/kg	200	247.35	U	249.75	U	810.00		656.25		687.62	U	627.03	U	649.73	U	634.30	U	926.20	
Fluorene	ECCS	*ug/kg*	*200*	247.35	U	249.75	U	681.76		603.75		687.62	U	627.03	U	649.73	U	634.30	U	785.86	
Phenanthrene	ECCS	ug/kg	200	247.35	U	249.75	U	2123.95		2415.00		687.62	U	627.03	U	649.73	U	951.44		2554.06	
Anthracene	ECCS	ug/kg	200	247.35	U	249.75	U	1415.97		1312.50		687.62	U	627.03	U	649.73	U	634.30	U	1712.06	
Fluoranthene	ECCS	ug/kg	200	247.35	U	249.75	U	3592.36		3465.00		687.62	U	627.03	U	877.13		1078.30		3732.85	
Pyrene	ECCS	ug/kg	200	247.35	U	249.75	U	6109.63		5486.25		1134.57		627.03		1364.42		1205.16		6230.78	
Benzo(a)anthracene	ECCS	ug/kg	200	247.35	U	249.75	U	4483.89		4462.50		790.76		627.03	U	779.67		697.73		4743.25	
Chrysene	ECCS	ug/kg	200	247.35	U	274.73		4195.45		4541.25		1306.48		1003.24		649.73	U	792.87		5108.11	
Benzo(b)fluoranthene	ECCS	ug/kg	200	247.35	U	249.75	U	3277.70		3806.25		687.62	U	627.03	U	649.73		729.44		4294.18	
Benzo(k)fluoranthene	ECCS	ug/kg	200	247.35	U	249.75	U	3959.46		4095.00		687.62	U	627.03	U	649.73	U	697.73		3929.32	
Benzo(e)pyrene	ECCS	ug/kg	200	247.35	U	249.75	U	3671.02		4016.25		687.62	U	627.03	U	649.73	U	634.30	U	4378.38	
Benzo(a)pyrene	ECCS	ug/kg	200	247.35	U	249.75	U	6581.62		6720.00		1100.19		627.03	U	1104.53		1141.73		7577.97	
Indeno(123cd)pyrene	ECCS	ug/kg	200	247.35	U	249.75	U	2700.82		2966.25		687.62	U	627.03	U	714.70		634.30	U	3367.99	
Dibenz(ah)anthracene	ECCS	ug/kg	200	247.35	U	249.75	U	1494.63		1627.50		687.62	U	627.03	U	649.73	U	634.30	U	1627.86	
Benzo(ghi)perylene	ECCS	ug/kg	200	247.35	U	249.75	U	3300.00		3517.50		756.38		627.03	U	747.18		634.30		4378.38	
Total	ECCS	ug/kg		0		274.73		52360.00		54862.50		5088.38		1630.27		6237.37		7928.70		61634.17	

Siite Samples Analyzed by NLS

Reference Area Samples Analyzed by NLS - Reference Area Samples Analyzed by NLS - Reference Area Samples Analyzed

Analyte	Lab	units	Reporting Limit ug/kg	NSP-SE-1-9A-0505	Flag	NSP-SE-1-13A-0505	Flag	NSP-SE-1-15C-0505	Flag	NSP-SE-21-1C-0505	Flag	NSP-SE-24-1A-0505	Flag	NSP-SE-8-1C-0505	Flag	NSP-SE-22-2B-0505	Flag	NSP-SE-20-1B-0505	Flag	NSP-SE-23-1B-0505	Flag
Acenaphthene	NLS	ug/kg	32	0	U	0	U	710		0	U	0	U	0	U	0	U	0	U	0	U
Acenaphthylene	NLS	ug/kg	31	0	U	0	U	2400		0	U	430		0	U	0	U	0	U	0	U
Anthracene	NLS	ug/kg	38	0	U	0	U	950		0	U	170	J	0	U	0	U	0	U	0	U
Benzo(a)anthracene	NLS	ug/kg	34	340		83	J	4500		160	J	700		0	U	0	U	0	U	430	
Benzo(a)pyrene	NLS	ug/kg	34	440		120		7300		170	J	1100		0	U	0	U	0	U	490	
Benzo(b)fluoranthene	NLS	ug/kg	38	500		110	J	6400		200	J	1000		0	U	0	U	0	U	600	
Benzo(g,h,i)perylene	NLS	ug/kg	33	200		0	U	2300		0	U	360		0	U	0	U	0	U	200	J
Benzo(k)fluoranthene	NLS	ug/kg	38	160		0	U	2400		0	U	390		0	U	0	U	0	U	200	J
Chrysene	NLS	ug/kg	36	390		87	J	4700		200	J	760		0	U	0	U	0	U	560	
Dibenzo(a,h,)anthracene	NLS	*ug/kg*	34	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Dibenzofuran	NLS	ug/kg	32	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Fluoranthene	NLS	ug/kg	37	570		100	J	3600		250		660		0	U	0	U	0	U	730	
Fluorene	NLS	ug/kg	32	0	U	0	U	570		0	U	0		0	U	0	U	0	U	0	U
Indeno(1,2,3-cd) Pyrene	NLS	ug/kg	31	140		0	U	1400		0	U	210		0	U	0	U	0	U	0	U
1-Methylnaphthalene	NLS	ug/kg	32	0	U	0	U	450		0	U	0	U	0	U	0	U	0	U	170	J
2-Methylnaphthalene	NLS	ug/kg	31	0	U	0	U	740		0	U	0	U	0	U	0	U	0	U	270	
2-Methylphenol	NLS	ug/kg	26	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
3 & 4-Methylphenol	NLS	ug/kg	55	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Naphthalene	NLS	ug/kg	31	0	U	0	U	880		0	U	0	U	0	U	0	U	0	U	210	
Phenanthrene	NLS	ug/kg	37	470		63	J	1800		220	J	290		0	U	0	U	0	U	710	
Phenol	NLS	ug/kg	28	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Pyrene	NLS	ug/kg	36	620		140		6400		290		1100		0	U	0	U	0	U	820	
Benzo (e) pyrene	NLS	ug/kg	38	310		73	J	4400		150	J	660		0	U	0	U	0	U	440	
Total PAH	NLS	ug/kg		4140		776		51900		1640		7830		0	U	0	U	0	U	5830	

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estimated value)

Appendix A Table A.1
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Site Samples Analyzed On Site by ECCS

Analyte	Lab	units	Reporting Limit ug/kg	SED-SE-2-2A-0505	Flag	SED-SE-2-1A-0505	Flag	SED-SE-9-1A-0505	Flag	SED-SE-1-13A-0505	Flag	SED-SE-1-11C-0505	Flag	SED-SE-1-12A-0505	Flag	SED-SE-1-15C-0505	Flag	SED-SE-1-15A-0505	Flag	SED-SE-1-12G-0505	Flag
Dilution Factor	ECCS			1		1		1		1		1		1		1		1		1	
Solids, Total	ECCS	%		72.57		78.31		67.82		82.92		36.97		84.26		41.12		35.60		32.75	
Naphthalene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	622.09		2124.33		1434.97		1910.28		824.50	
1-MethylNaphthalene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	1495.34		1337.69		1629.35		610.74	
2-MethylNaphthalene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	1151.18		753.97		870.86		610.74	U
Acenaphthylene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	237.36	U	3672.56		4129.57		3084.25	
Acenaphthene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	1625.89		1143.12		1516.98		1007.72	
Fluorene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	688.33		559.40		1601.26		824.50	
Phenanthrene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	2741.46		2553.77		3342.98		2137.60	
Anthracene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	540.94	U	901.95		2334.87		2500.22		1832.23	
Fluoranthene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	757.32		1068.10		4961.61		6798.34		5099.69	
Pyrene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	1325.31		1685.23		8220.70		10871.72		9252.74	
Benzo(a)anthracene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	973.70		466.58		7466.73		8652.43		7084.60	
Chrysene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	595.04		474.71		7004.62		8849.08		6840.31	
Benzo(b)fluoranthene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	676.18		249.22		5569.65		6910.71		5252.38	
Benzo(k)fluoranthene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	595.04		249.22		6469.55		7528.74		5985.27	
Benzo(e)pyrene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	811.42		296.69		6372.26		7444.46		6626.55	
Benzo(a)pyrene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	1352.36		534.05		10823.12		13400.03		10413.15	
Indeno(123cd)pyrene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	676.18		237.36	U	4840.00		5927.48		4702.71	
Dibenz(ah)anthracene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	595.04		237.36	U	2553.77		3258.71		2442.97	
Benzo(ghl)perylene	ECCS	ug/kg	200	275.60	U	255.38	U	294.88	U	241.20	U	784.37		250.00		6299.30		7584.92		6321.18	
Total	ECCS	ug/kg		0.00		0.00		0.00		0.00		9764.06		16021.51		84371.66		100000.00		80343.07	

by NLS - Reference Area Samples Analyzed by NLS - Reference Area Samples Analyzed by NLS - Reference Area Samples Analyzed by NLS - Reference Area Samples Analyzed by NLS - Refer

Analyte	Lab	units	Reporting Limit ug/kg	NSP-SE-11-1C-0505	Flag	NSP-SE-2-2B-0505	Flag	NSP-SE-9-1B-0505	Flag	NSP-SE-26-1A-0505	Flag	NSP-SE-10-2C-0505	Flag	NSP-SE-10-1A-0505	Flag	NSP-SE-5-2A-0505	Flag	NSP-SE-13-1A-0505	Flag	NSP-SE-15-1A-0505	Flag
Acenaphthene	NLS	ug/kg	32	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Acenaphthylene	NLS	ug/kg	31	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Anthracene	NLS	ug/kg	38	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Benzo(a)anthracene	NLS	ug/kg	34	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Benzo(a)pyrene	NLS	ug/kg	34	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Benzo(b)fluoranthene	NLS	ug/kg	38	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Benzo(g,h,i)perylene	NLS	ug/kg	33	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Benzo(k)fluoranthene	NLS	ug/kg	38	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Chrysene	NLS	ug/kg	36	0	U	57	J	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Dibenzo(a,h,)anthracene	NLS	ug/kg	34	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Dibenzofuran	NLS	ug/kg	32	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Fluoranthene	NLS	ug/kg	37	0	U	65	J	85	J	0	U	0	U	0	U	0	U	0	U	0	U
Fluorene	NLS	ug/kg	32	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Indeno(1,2,3-cd) Pyrene	NLS	ug/kg	31	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
1-Methylnaphthalene	NLS	ug/kg	32	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
2-Methylnaphthalene	NLS	ug/kg	31	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
2-Methylphenol	NLS	ug/kg	26	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
3 & 4-Methylphenol	NLS	ug/kg	55	0	U	0	U	0	U	0	U	0	U	680		0	U	0	U	0	U
Naphthalene	NLS	ug/kg	31	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Phenanthrene	NLS	ug/kg	37	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Phenol	NLS	ug/kg	28	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Pyrene	NLS	ug/kg	36	0	U	66	J	78	J	0	U	0	U	0	U	0	U	0	U	0	U
Benzo (e) pyrene	NLS	ug/kg	38	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U	0	U
Total PAH	NLS	ug/kg		0	U	188		163		0	U	0	U	0	U	0	U	0	U	0	U

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estir

Appendix A Table A.1
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Site Samples Analyzed On Site by ECCS

Analyte	Lab	units	Reporting Limit ug/kg
Dilution Factor	ECCS		
Solids, Total	ECCS	%	
Naphthalene	ECCS	ug/kg	200
1-MethylNaphthalene	ECCS	ug/kg	200
2-MethylNaphthalene	ECCS	ug/kg	200
Acenaphthylene	ECCS	ug/kg	200
Acenaphthene	ECCS	ug/kg	200
Fluorene	ECCS	ug/kg	200
Phenanthrene	ECCS	ug/kg	200
Anthracene	ECCS	ug/kg	200
Fluoranthene	ECCS	ug/kg	200
Pyrene	ECCS	ug/kg	200
Benzo(a)anthracene	ECCS	ug/kg	200
Chrysene	ECCS	ug/kg	200
Benzo(b)fluoranthene	ECCS	ug/kg	200
Benzo(k)fluoranthene	ECCS	ug/kg	200
Benzo(e)pyrene	ECCS	ug/kg	200
Benzo(a)pyrene	ECCS	ug/kg	200
Indeno(123cd)pyrene	ECCS	ug/kg	200
Dibenz(ah)anthracene	ECCS	ug/kg	200
Benzo(ghi)perylene	ECCS	ug/kg	200
Total	ECCS	ug/kg	

ence Area Samples Analyzed by NLS- - Reference Area Samples Analyzed by NLS

Analyte	Lab	units	Reporting Limit ug/kg	NSP-SE-4-1A-0505	Flag	NSP-SE-25-1A-0505	Flag	NSP-SE-5-1B-0505	Flag	NSP-SE-4-2B-0505	Flag
Acenaphthene	NLS	ug/kg	32	0	U	0	U	0	U	0	U
Acenaphthylene	NLS	ug/kg	31	0	U	0	U	0	U	0	U
Anthracene	NLS	ug/kg	38	0	U	0	U	0	U	0	U
Benzo(a)anthracene	NLS	ug/kg	34	0	U	0	U	0	U	0	U
Benzo(a)pyrene	NLS	ug/kg	34	0	U	0	U	0	U	0	U
Benzo(b)fluoranthene	NLS	ug/kg	38	0	U	0	U	0	U	0	U
Benzo(g,h,i)perylene	NLS	ug/kg	33	0	U	0	U	0	U	0	U
Benzo(k)fluoranthene	NLS	ug/kg	38	0	U	0	U	0	U	0	U
Chrysene	NLS	ug/kg	36	0	U	0	U	0	U	0	U
Dibenzo(a,h,)anthracene	NLS	ug/kg	34	0	U	0	U	0	U	0	U
Dibenzofuran	NLS	ug/kg	32	0	U	0	U	0	U	0	U
Fluoranthene	NLS	ug/kg	37	0	U	0	U	0	U	0	U
Fluorene	NLS	ug/kg	32	0	U	0	U	0	U	0	U
Indeno(1,2,3-cd) Pyrene	NLS	ug/kg	31	0	U	0	U	0	U	0	U
1-Methylnaphthalene	NLS	ug/kg	32	0	U	0	U	0	U	0	U
2-Methylnaphthalene	NLS	ug/kg	31	0	U	0	U	0	U	0	U
2-Methylphenol	NLS	ug/kg	26	0	U	0	U	0	U	0	U
3 & 4-Methylphenol	NLS	ug/kg	55	480		190		0	U	0	U
Naphthalene	NLS	ug/kg	31	0	U	0	U	0	U	0	U
Phenanthrene	NLS	ug/kg	37	0	U	0	U	0	U	0	U
Phenol	NLS	ug/kg	28	0	U	0	U	0	U	0	U
Pyrene	NLS	ug/kg	36	0	U	0	U	0	U	0	U
Benzo (e) pyrene	NLS	ug/kg	38	0	U	0	U	0	U	0	U
Total PAH	NLS	ug/kg		0	U	0	U	0	U	0	U

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estir

Appendix A Table A.2.
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	LOD (detection limit)	LOQ (quant. Limit)	NSP-SE-21-1C-0505 FLAG	NSP-SE-24-1A-0505 FLAG	NSP-SE-8-1C-0505 FLAG	NSP-SE-22-2B-0505 FLAG	NSP-SE-20-1B-0505 FLAG	NSP-SE-23-1B-0505 FLAG	NSP-SE-11-1C-0505 FLAG	NSP-SE-2-2B 0505 FLAG
Solids, percent	%	0.1		54.1	53.4	62.3	45.9	76.6	50.5	73.2	63.2
ALUMINUM	mg/kg	11	40	5500	8100	4200	6500	1100	4700	540	2300
ANTIMONY	mg/kg	1.5	5.2	0	1.5 J	0	0	1.6 J	1.8 J	0	1.6 J
ARSENIC	mg/kg	1.2	4.1	3.9 J	2.2 J	1.8 J	5.1 J	1.0 J	3.3 J	0	1.8 J
BARIUM	mg/kg	0.25	0.51	45	44	26	47	7.4	36	5.2	18
BERYLLIUM	mg/kg	0.25	0.89	0.22	0.084 J	0	0.13 J	0.099 J	0.25	0.045 J	0.044 J
CADMIUM	mg/kg	0.38	1.4	0	0	0	0	0	0	0	0
CALCIUM	mg/kg	76	150	2500	4900	2100	3300	570	3100	270	2200
Chromium (III)	mg/kg	0.76	1.5	14	18	12	16	3.6	13	1.2 J	8.6
Chromium (VI)	mg/kg	0.27		0	0.32	0	0	0	0	0	0
CHROMIUM	mg/kg	0.76	2.7	14	18	12	16	3.6	13	1.2 J	8.6
COBALT	mg/kg	0.71	2.5	7	7.9	4.4	7.2	1.7 J	5.7	0.96 J	3.2
COPPER	mg/kg	0.3	1.1	84	23	7.1	270	1.7	120	1.1	7.9
IRON	mg/kg	14	53	14000	15000	11000	13000	4400	10000	2200	8700
LEAD	mg/kg	8.2	30	25 J	31 J	7.8 J	32 J	0	21 J	0	0 U
MAGNESIUM	mg/kg	76	150	2000	4300	1800	2800.0	440	2100	230	990
MANGANESE	mg/kg	0.17	0.51	120	180	130	120	40	120	20	110
MERCURY	mg/kg	0.073	0.26	0	0	0	0	0	0.15 J	0	0
NICKEL	mg/kg	1.8	6.4	16	17	7.6	15	1.3 J	11	0	4.4 J
POTASSIUM	mg/kg	18	67	590	1100.0	500	820	120	610	60.0	300
SELENIUM	mg/kg	1.4	4.7	0	0	0	0	0	0	0	0
SILVER	mg/kg	0.74	2.6	0	0	0	0	0	0	0	0
SODIUM	mg/kg	1.7	6.1	98	100	110	100	31	120	22	53
THALLIUM	mg/kg	1.7	6.2	0	0	0	0	0	0	0	0
VANADIUM	mg/kg	0.44	1.6	37	43	30	37	12	28	5.2	23
ZINC	mg/kg	0.34	1	48	57	24	60	6.6	54	3.6	17
Aldrin	ug/kg	0.48	1.5	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
alpha-BHC	ug/kg	0.28	0.89	0 U	0 U	1.8	0 U	2	0 U	4.1	1.9
beta-BHC	ug/kg	0.53	1.7	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
delta-BHC	ug/kg	0.25	0.81	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Lindane	ug/kg	0.37	1.2	0 U	0 U	0 U	0 U	1.2	0 U	1.6	3.9
Chlordane	ug/kg	0.64	2.1	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDD	ug/kg	0.41	1.3	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDE	ug/kg	0.45	1.4	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDT	ug/kg	0.64	2	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Dieldrin	ug/kg	0.38	1.2	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan I	ug/kg	0.51	1.6	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan II	ug/kg	0.4	1.2	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan Sulfate	ug/kg	0.33	1	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Endrin	ug/kg	0.33	1.1	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Endrin Aldehyde	ug/kg	0.48	1.5	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Heptachlor	ug/kg	0.43	1.4	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0.95 J
Heptachlor Epoxide	ug/kg	0.42	1.3	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Methoxychlor	ug/kg	0.77	2.5	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Toxaphene	ug/kg	18.9	63	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1016	ug/kg	4.3	14.4	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1221	ug/kg	12.6	40.2	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1232	ug/kg	3.1	10.5	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1242	ug/kg	5.5	18.2	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1248	ug/kg	3.3	11	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1254	ug/kg	2.1	6.6	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1260	ug/kg	4.1	13.7	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U
Total PCBs	ug/kg	4.3	14.4	0 U	0 U	0 U	0 U	0 U	0 U	0 U	0 U

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estimated value)

Appendix A Table A.2.
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	LOD (detection limit)	LOQ (quant. Limit)	NSP-SE-9-1B 0505	FLAG	NSP-SE-26-1A-0505	FLAG	NSP-SE-10-2C-0505	FLAG	NSP-SE-10-1A-0505	FLAG	NSP-SE-5-2A 0505	FLAG
Solids, percent	%	0.1		65.9		72.6		69.8		68.5		69.5	
ALUMINUM	mg/kg	11	40	3500		720		1400		1300		380	
ANTIMONY	mg/kg	1.5	5.2	0		0	J	2.1	J	1.6	J	0	
ARSENIC	mg/kg	1.2	4.1	1.9	J	1.9	J	0		0		0	
BARIUM	mg/kg	0.25	0.51	18		4.2		11		11		2.6	
BERYLLIUM	mg/kg	0.25	0.89	0		0.097	J	0.19		0.051	J	0.47	
CADMIUM	mg/kg	0.38	1.4	0		0		0		0		0	
CALCIUM	mg/kg	76	150	1900		390		690		940		140	
Chromium (III)	mg/kg	0.76	1.5	10		2.2		52		3.6		0.66	J
Chromium (VI)	mg/kg	0.27		0		0		0		0		0	
CHROMIUM	mg/kg	0.76	2.7	10		2.2		5.2		3.6		0.66	J
COBALT	mg/kg	0.71	2.5	3.5		1.1	J	1.3	J	1.9		0.55	J
COPPER	mg/kg	0.3	1.1	6		1.2		3.7		4.7		0.85	
IRON	mg/kg	14	53	10000		4000		4100		5800		1000	
LEAD	mg/kg	8.2	30	5.8	J	0		0		21	J	0	J
MAGNESIUM	mg/kg	76	150	1600.0		360		540		620		160	
MANGANESE	mg/kg	0.17	0.51	100		33		37		70		15	
MERCURY	mg/kg	0.073	0.26	0		0		0		0		0	
NICKEL	mg/kg	1.8	6.4	6.9		1.5	J	2	J	2.5	J	0	
POTASSIUM	mg/kg	18	67	430		69		190		160.0		80	
SELENIUM	mg/kg	1.4	4.7	0		0		0		0		0	
SILVER	mg/kg	0.74	2.6	0		0		0		0		0	
SODIUM	mg/kg	1.7	6.1	53		28		38		49		9.9	
THALLIUM	mg/kg	1.7	6.2	0		0		0		0		0	
VANADIUM	mg/kg	0.44	1.6	26		11		12		13		2.2	
ZINC	mg/kg	0.34	1	19		7.3		13		21		2.6	
Aldrin	ug/kg	0.48	1.5	0	U	0	U	0	U	0	U	0	U
alpha-BHC	ug/kg	0.28	0.89	35		0	U	4.6		0	U	4.5	
beta-BHC	ug/kg	0.53	1.7	0	U	0	U	0	U	0	U	2.2	J
delta-BHC	ug/kg	0.25	0.81	0	U	0	U	0	U	0	U	0	U
Lindane	ug/kg	0.37	1.2	11		0	U	0	U	0	U	2.6	
Chlordane	ug/kg	0.64	2.1	0	U	0	U	0	U	0	U	0	U
4,4`-DDD	ug/kg	0.41	1.3	0	U	0	U	0	U	0	U	0	U
4,4`-DDE	ug/kg	0.45	1.4	0	U	0	U	0	U	0	U	0	U
4,4`-DDT	ug/kg	0.64	2	0	U	0	U	0	U	0	U	0	U
Dieldrin	ug/kg	0.38	1.2	0	U	0	U	0	U	0	U	0	U
Endosulfan I	ug/kg	0.51	1.6	0	U	0	U	0	U	0	U	0	U
Endosulfan II	ug/kg	0.4	1.2	0	U	0	U	0	U	0	U	0	U
Endosulfan Sulfate	ug/kg	0.33	1	0	U	0	U	0	U	0	U	0	U
Endrin	ug/kg	0.33	1.1	0	U	0	U	0	U	0	U	0	U
Endrin Aldehyde	ug/kg	0.48	1.5	0	U	0	U	0	U	0	U	0	U
Heptachlor	ug/kg	0.43	1.4	1	J	0	U	0	U	0	U	0	U
Heptachlor Epoxide	ug/kg	0.42	1.3	0	U	0	U	0	U	0	U	0	U
Methoxychlor	ug/kg	0.77	2.5	0	U	0	U	0	U	0	U	0	U
Toxaphene	ug/kg	18.9	63	0	U	0	U	0	U	0	U	0	U
Aroclor-1016	ug/kg	4.3	14.4	0	U	0	U	0	U	0	U	0	U
Aroclor-1221	ug/kg	12.6	40.2	0	U	0	U	0	U	0	U	0	U
Aroclor-1232	ug/kg	3.1	10.5	0	U	0	U	0	U	0	U	0	U
Aroclor-1242	ug/kg	5.5	18.2	0	U	0	U	0	U	0	U	0	U
Aroclor-1248	ug/kg	3.3	11	0	U	0	U	0	U	0	U	0	U
Aroclor-1254	ug/kg	2.1	6.6	0	U	0	U	0	U	0	U	0	U
Aroclor-1260	ug/kg	4.1	13.7	0	U	0	U	0	U	0	U	0	U
Total PCBs	ug/kg	4.3	14.4	0	U	0	U	0	U	0	U	0	U

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estimated

Appendix A Table A.2.
May 2005 Sediment Chemistry Results Reconnaissance
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	LOD (detection limit)	LOQ (quant. Limit)	NSP-SE-13-1A-0505 FLAG	NSP-SE-15-1A-0505 FLAG	NSP-SE-4-1A 0505 FLAG	NSP-SE-25-1A-0505 FLAG	NSP-SE-5-1B 0505 FLAG	NSP-SE-4-2B 0505 FLAG
Solids, percent	%	0.1		70.9	66.8	31.4	62.8	64.4	67
ALUMINUM	mg/kg	11	40	900	1100	2400	2600	660	570
ANTIMONY	mg/kg	1.5	5.2	1.3 J	1.6 J	0	0	2.0 J	1.2 J
ARSENIC	mg/kg	1.2	4.1	2.1 J	1.7 J	2.2 J	0	1.2 J	0
BARIUM	mg/kg	0.25	0.51	5.3	7.8	18	16	4.4	6.3
BERYLLIUM	mg/kg	0.25	0.89	1.2	0.096 J	0.13 J	0.078 J	0	0
CADMIUM	mg/kg	0.38	1.4	0	0	0	0	0	0
CALCIUM	mg/kg	76	150	390	510	2000	1700	320	710
Chromium (III)	mg/kg	0.76	1.5	2.3	2.3	4.4	5.8	1.4 J	1.3 J
Chromium (VI)	mg/kg	0.27		0	0	0	0.36	0	0
CHROMIUM	mg/kg	0.76	2.7	2.3	2.3	4.4	6.2	1.4 J	1.3 J
COBALT	mg/kg	0.71	2.5	1.2 J	1.3 J	2.3 J	2.6	0.88 J	0.97 J
COPPER	mg/kg	0.3	1.1	1.6	1.9	4.9	4.9	1.7	1.5
IRON	mg/kg	14	53	3000	3500	3000	6500	1800	2000
LEAD	mg/kg	8.2	30	0	0	0	0	0 J	0
MAGNESIUM	mg/kg	76	150	360.0	460	890	1000	230	260.0
MANGANESE	mg/kg	0.17	0.51	33	37	53	75	25	34
MERCURY	mg/kg	0.073	0.26	0	0	0	0	0	0
NICKEL	mg/kg	1.8	6.4	1.6 J	2.1 J	3.6 J	3.8 J	0	0
POTASSIUM	mg/kg	18	67	110	180	370	360	95	110
SELENIUM	mg/kg	1.4	4.7	0	0	0	0	0	0
SILVER	mg/kg	0.74	2.6	0	0	0	0	0	0
SODIUM	mg/kg	1.7	6.1	12	28	40	57	21	15
THALLIUM	mg/kg	1.7	6.2	0	0	0	0	0	0
VANADIUM	mg/kg	0.44	1.6	8.6	8.2	9.1	15	7.0	5.5
ZINC	mg/kg	0.34	1	5.9	8.3	22	16	7.4	5.7
Aldrin	ug/kg	0.48	1.5	0 U	0 U	0 U	0 U	0 U	0 U
alpha-BHC	ug/kg	0.28	0.89	7.1	1.7	7.9	24	4.3	3.5
beta-BHC	ug/kg	0.53	1.7	0 U	0 U	0 U	3.2 J	0 U	0 U
delta-BHC	ug/kg	0.25	0.81	0 U	0 U	0 U	0 U	0 U	0 U
Lindane	ug/kg	0.37	1.2	0 U	1.4	0 U	2.8	2.9	2.8
Chlordane	ug/kg	0.64	2.1	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDD	ug/kg	0.41	1.3	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDE	ug/kg	0.45	1.4	0 U	0 U	0 U	0 U	0 U	0 U
4,4`-DDT	ug/kg	0.64	2	0 U	0 U	0 U	0 U	0 U	0 U
Dieldrin	ug/kg	0.38	1.2	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan I	ug/kg	0.51	1.6	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan II	ug/kg	0.4	1.2	0 U	0 U	0 U	0 U	0 U	0 U
Endosulfan Sulfate	ug/kg	0.33	1	0 U	0 U	0 U	0 U	0 U	0 U
Endrin	ug/kg	0.33	1.1	0 U	0 U	0 U	0 U	0 U	0 U
Endrin Aldehyde	ug/kg	0.48	1.5	0 U	0 U	0 U	0 U	0 U	0 U
Heptachlor	ug/kg	0.43	1.4	0 U	0.59 J	0 U	0 U	0 U	0 U
Heptachlor Epoxide	ug/kg	0.42	1.3	0 U	0 U	0 U	0 U	0 U	0 U
Methoxychlor	ug/kg	0.77	2.5	0 U	0 U	0 U	0 U	0 U	0 U
Toxaphene	ug/kg	18.9	63	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1016	ug/kg	4.3	14.4	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1221	ug/kg	12.6	40.2	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1232	ug/kg	3.1	10.5	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1242	ug/kg	5.5	18.2	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1248	ug/kg	3.3	11	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1254	ug/kg	2.1	6.6	0 U	0 U	0 U	0 U	0 U	0 U
Aroclor-1260	ug/kg	4.1	13.7	0 U	0 U	0 U	0 U	0 U	0 U
Total PCBs	ug/kg	4.3	14.4	0 U	0 U	0 U	0 U	0 U	0 U

U = Not detected
J = Between Limit of Detection and Limit of Quantification (estimated

ATTACHMENT 2

OVERVIEW OF SEDIMENT BIOASSAYS - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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The primary objective of the sediment bioassays was to determine the levels of sediment contaminants that were associated with adverse effects on laboratory animals. A secondary objective was to determine whether UV light modulated this toxicity. As part of the second objective UV bioassays were modified by including refugia in the test beakers to evaluate whether behavioral adaptations, i.e taking shelter, would decrease exposure and therefore effects from UV light. The sediment bioassays were conducted by Lake Superior Research Institute (LSRI), the same facility that had conducted sediment bioassays for the Site on two previous occasions under contract to WDNR.

A series of bioassays was carried out using bulk sediments collected from Site stations and a number of different reference stations. Both Site and reference stations included those with sandy substrate and those with a wood mulch substrate, a dominant characteristic of Site substrate. Laboratory control sediments included pure silica sand and an artificial formulated sediment. In addition, a certified non-toxic sediment from West Bearskin Lake served as an external reference sediment. Regional reference sediments were collected from stations within Chequamegon Bay, but remote (the closest was over a mile away) from the Site. The stations tested and their TPAH concentrations are summarized in Table 1.1 and the locations of the Site and Reference stations are shown in Figures 2.1 and 2.2 in the Sediment Investigations report accompanying this report (Attachment 1 to the Sediment Quality Triad Investigation).

Bioassays were conducted using the amphipod, *Hyalella azteca*, the midge, *Chironomus dilutus* (formerly *C. tentans*), and larvae of the fathead minnow, *Pimephales promelas*. The endpoints measured were survival and growth. As part of the UV bioassays, field measurements of UV light were made at different depths, and under different incident light conditions, at the Site. Based upon these field measurements of UV light, the specific UV light exposures to be used in the UV bioassays were determined in consultation with Dr. David Mount of USEPA ERL-Duluth.[1] In addition a bioaccumulation bioassay was conducted with the oligochaete worm, *Lumbriculus variegatus*. The bulk sediment chemistry for the individual PAHs measured at Stations SQT1 through SQT12 composite sediment samples used in these bioassays is summarized in Appendix 1 to this report. Bulk sediment chemistry data for the sediment from reference Stations SQT13 and SQT14 used in the bioassays was not measured but was estimated for PAHs by taking an average of all five bulk sediment replicates (Table 1.1) collected at that station. The bulk sediment chemistry for all of the replicate Triad sediment samples is found in Table 3.2 in Attachment 1 of this Triad report. The LSRI report which provides the details and results of these bioassays as well as the UV data is found in Appendix 2. Test methodologies followed USEPA protocol (See Appendix 2 and RI/FS Work Plan SOPs 330 and 335).

[1]Note that USEPA commented on the original of this report, "While it ends up having little impact on the final UV levels used in the UV studies, the analysis used to derive the UV exposures contains errors. Most significantly, the authors used an average of readings taken at 1000 and 1400 hours to create an estimate for 1200 hours. Because solar noon is at approximately 1300 hours at Ashland under Daylight Savings Time, and because solar irradiance is for all practical purposes symmetrical around solar noon, the 1400 hour readings would have been the appropriate estimate of the 1200 hour readings rather than the mean of 1000 and 1400. The estimated clear sky irradiance curve was re-modeled after correcting this error, and obtained Figure 2. While this curve lies above the curve used by the authors, a more detailed algorithm was used to estimate total daily UV dose, by using the same basic approach as the authors, but using 0.1 hour time steps. This more detailed averaging altered the total UV exposure estimate by the nearly exact opposite amount as recalculating the daily irradiance curve. The net effect is that recalculated values were very close to the target values used originally derived. It is brought up here only for the record in case similar calculations are used later in the RI/FS process."

In general, for the bioassays conducted in 2005 and 2006, survival and growth were uniformly high and within acceptance criteria (80%) in the silica sand control and West Bearskin Lake reference sediments, but the formulated sediment control was variable amongst bioassays with survival in some tests below acceptance criteria. Survival in reference sediments collected at six different locations within Chequamegon Bay was also highly variable.

The focus of this summary of sediment bioassay conducted at the Site is largely confined to sand rather than wood stations. This is because there is a great heterogeneity of sediments defined as wood. Large pieces of wood debris and wood "mulch" were found in the wood sediments, and bioassay sediments were sieved to remove those greater than approximately 0.5 inches in size. However, even the inclusion of even smaller pieces can significantly influence TOC measurements and as a result also carbon normalized PAH concentrations. As an example Site Wood station SQT8 had a dry weight concentration of 69.9 µg/g but with 28% total organic carbon it resulted in a carbon normalized concentration of only 249.7 µg PAH/gOC. While large pieces of wood debris were removed from the composite sample used for the bioassays, pieces in the range of ½ inch or less in size were left in the sample and remained in it for the bioassay. These large pieces of wood would significantly overstate the surface binding capacity of the organic carbon in the sample. This same sample at 1% organic carbon would have had a substantially greater carbon normalized concentration.

Because of these factors, the no observed effects concentrations (NOECs) and lowest observed effects concentrations (LOECs) reported below are based on sand stations only.

The survival and growth data for each bioassay conducted during 2005 and 2006 are discussed in detail below.

1.1 *HYALELLA AZTECA*

Three 28-day bioassays were conducted with *H. azteca* because of high mortality rates in reference station sediments. One 10-day bioassay was also conducted.

1.1.1 Bioassays Conducted between 29 June and 4 November 2005 –Laboratory Light

Chronic 28-day bioassays were conducted with *H. azteca* exposed to bulk sediment collected from 8 Site stations, 5 reference stations (West Bearskin Lake and 4 Chequamegon Bay locations), and 2 control sediments (silica sand and formulated sediment). Survival was reduced[2] below silica sand and formulated sediment controls at 2 Site Sand stations (SQT1 and SQT7) and 2 Reference Sand stations (SQT10 and SQT12) and a reference station often used by USEPA, West Bearskin Lake (Table 1.2). In the first 28-day test survival was reduced below the silica sand control and the West Bearskin reference at SQT3. However, in the repeat of this 28 day bioassay, survival at SQT3 was no different than in the silica sand control. The body weights of the surviving organisms from Site stations were not significantly lower than the silica sand control (Table 1.2) other than for SQT6 in the second test.

The apparent effects at SQT3 in the first 28-day test are not considered to be reliable because survival in reference stations was even lower, despite very low TPAH concentrations, and because this result was not repeated in the second test. The growth effect at SQT6 in the second

[2] Only differences amongst treatments that are significant will be discussed as being different.

test is not considered reliable because there were no growth effects in treatments with two orders of magnitude higher carbon normalized PAHs nor was there a growth effect in the first 28-day *H. azteca* test.

If the results at SQT3 in the first 28 day bioassay are considered an artifact, the lowest PAH concentration associated with significant toxicity at a Site Sand station was 6083.8 µg PAH/g organic carbon (OC) (22.51 µg/g and 0.4%TOC) and the highest Site Sand showing no significant toxicity had a concentration of 42.7 µg PAH/g OC (17.1 µg/g and 40%TOC).

An additional consideration in evaluating these results is that survival was lower at Reference Sand stations SQT10 and SQT12 than at several Site stations (both Sand and Wood) containing higher levels of PAHs. Thus, it was not clear from these results that the toxicity at Site stations was entirely due to PAHs.

Because of the high mortality in the Sand Reference stations in the first test, a second test was conducted using these 2 Reference Sand sediments, silica sand control, and 1 Site Wood sediment (SQT5). Again survival in these reference stations was low. Survival in one of the reference sediments (SQT10) was significantly below the silica sand control survival (Table 1.2). Survival in SQT 12 was only 76.3%.

As a result of the apparent toxicity of these two Reference Sand sediments, two different Reference Sand locations (SQT13 and SQT14) were sampled and tested along with the original Site sediments and controls. Survival in these two new Reference Sand sediments was again low, 37.5 and 52.5%, respectively but not significantly lower than the silica sand control. However, examination of Table 1.2 shows that this is due to the relatively large variance (standard deviation >20%) in the survival data for these two Sand Reference stations. Site Sand stations SQT1 and SQT7 again had significantly reduced survival compared to the silica sand control, West Bearskin reference as well as the two Reference Sand stations. However, the results at these two stations were not significantly different from the formulated sand control. Survival in Site Sand sediment SQT3 that was significantly different in June-July, was not significantly different in these tests. There was significantly lower growth in Site Sand station SQT6 compared to the silica sand control but not the formulated sand or West Bearskin reference sediment. However, as previously discussed, because neither survival nor growth effects were found at SQT6 in previous tests, this sublethal effect was not considered as a LOEC. Furthermore, survival was 90% in SQT6 and there were no growth effects at substantially higher TPAH concentrations, even in SQT7 which had significant mortality.

In summary, under normal laboratory light, the lowest concentration consistently causing toxicity to *H. azteca* in Site sediment was 6083.8 µg PAH/g OC (22.5 µg/g) at SQT7. The NOEC would then be from the only other sand station tested, SQT6. This NOEC would be 24 µg PAH/g OC (2.3 µg/g and 9.5% TOC). This is a substantial data gap and it is likely that the NOEC for Sand stations would be higher.

Because of the large data gap between no-effect and effects stations, this NOEC is considered unreliable. In addition, there is evidence that factors other than Site-related PAHs may have contributed to this toxicity. The high mortality at all Reference Sand Stations (SQT10, SQT12, SQT13 and SQT14) during the two tests suggest that there were other stressors at sandy substrate locations in Chequamegon Bay.

1.1.2 Bioassays Conducted between 3 and 13 January 2006 - Laboratory Light

Because of the substantial gap between the LOEC and the only other concentrations tested, it was decided to identify an effects threshold by conducting a dilution series at carbon-normalized PAH concentrations intermediate between SQT1 and approximately ½ the concentration of SQT7, on a carbon normalized basis, to identify an effects threshold. Since it was determined in previous tests that survival was consistently lowest at Site Sand Station SQT1, this sediment was retested at 100% of SQT1 and dilutions of 50, 25, and 12.5% dilutions in 10-day tests. Dilutions were made using West Bearskin reference sediment and silica sand as a diluent. These diluents were mixed to produce approximately the same organic carbon concentration as the original SQT1 sediment (See Appendix 2). No tests were conducted with Reference Sand stations SQT11, SQT12, SQT13, or SQT14 because of excessive mortality in previous bioassays.

Survival in the dilution sediment control, West Bearskin Neck and the 2 Wood Reference stations was high (Table 1.3). However, survival at SQT1 and 50% SQT1, and well as the formerly non-toxic SQT8 was significantly lower than the silica sand control and Reference Wood stations survival. However, since SQT8 was non-toxic in previous 28-day tests, and because of the issues associated with identifying effects levels in Wood stations this result was not considered as the LOEC. In addition, the SQT8 result is questionable because of the extremely high standard deviation. SQT1 at 25 and 12.5 % dilutions were non-toxic and had no effects on growth compared to the silica sand control. The highest no effect concentration was approximately 9072.9 µg PAH/gOC (41.7 µg/g and 0.46 TOC) at 25% SQT1 and the lowest effect concentrations was 18,145.7 µg PAH/g OC (83.47 µg/g and 0.46 TOC) (Table 1.3).

1.1.3 Bioassays Conducted between 3 and 13 January 2006 - UV light

Measurements of UVA and UVB light made at the Site during June and September were used as the basis for the UV light exposures (Appendix 2). These values were then adjusted for solar noon at the summer solstice, the period when UV light is most intense for the longest duration (See footnote 1). This was the hypothetical worst case UV exposure regime. Assuming that clear sky conditions would be present for 75% of the time over the duration of the bioassay, exposure intensity was calculated for the water depth at Station SQT1, the deepest of the Site stations where UV light was measured. .

Due to the spectral characteristics of the artificial UV light source (Q-Panel Co.), it was not possible to reproduce exactly the UV exposure regime of 45 µW UVA/cm^2 and 0.4 µW UVB/cm^2 that were established as the test regime in discussions between URS and USEPA. *H. azteca* were exposed to sediments in the presence of mean intensities of 42.4 µW UVA/cm^2 and 3.03 µW UVB/cm^2 for 16-hrs per day. While the UVA values are very similar, the UVB exposures were approximately 8-fold higher than desired.

The 10-day study design for the UV test was the same as that established for the 10-day dilution series test with *H. azteca* under laboratory light, i.e., a dilution series of SQT1 and 50, 25, and 12.5% dilutions of SQT1 using West Bearskin reference sediment and silica sand as a diluent to SQT1.

The addition of UV light increased the toxicity of the sediment at Site stations, but not the reference stations (Table 1.3). Survival was significantly lower than the silica sand control in SQT1 and the 50 and 25% dilutions of SQT1, and in SQT4, SQT5 and SQT8 sediments.

However, the significant effects at SQT4 and SQT5 occurred at lower concentrations i.e., 33.6 µg PAH/gOC (14.1 µg/g and 42% TOC) and 125.0 µg PAH/gOC (31.25 µg/g and 25% TOC) than caused no effects at the 12.5% dilution of SQT1 4536.4 µg PAH/gOC (20.9 µg/g and 0.46% TOC), suggesting that the UV light, itself, may contribute to toxicity in some other manner than just photoactivation of PAHs Survival was slightly, but not significantly, higher than in normal light at location SQT8 and was essentially unchanged from the normal lab light bioassay at SQT 2.

The addition of leaf plugs to provide a potential refugia for *H. azteca* to avoid UV light substantially reduced toxicity in the 25 and 12.5% dilutions compared to the treatments with no leaf plugs, suggesting that under normal field conditions, these organisms would have avoided the UV light (Table 1.3). These results were similar to those of Hatch and Burton (1999) who also reported that, in the laboratory, *H. azteca* avoided UV light by hiding under leaf litter when available.

The body weights of the surviving organisms in all treatments were not significantly lower than the silica sand control organisms (Table 1.3).

In conclusion, UV light increased the toxicity of PAHs, but UV light in and of itself may have been an additional stressor, and, except at concentrations that caused significant toxicity without UV light, this was largely ameliorated when the organisms were provided with refugia. Because UVB light levels were approximately 8-fold higher than the estimated level found at the bottom depth, it is not certain that these effects were due to UVA light alone or would be found at the Site at depths of interest, i.e. at the depths associated with likely cleanup levels. This is important because UVB was not detectable at bottom depths in several of the readings made at the Site during June and September, and may not be measurable at the exact sediment water interface, i.e in the nepheloid layer, even during the summer solstice.[3]

1.2 *PIMEPHALES PROMELAS*

1.2.1 Bioassays Conducted between 8 and 15 July 2005 - Laboratory Light

Seven-day bioassays were conducted with *P. promelas* exposed to laboratory water overlying bulk sediments collected from 8 Site locations, 5 reference locations (including West Bearskin), and 2 control sediments (silica sand and formulated sediment). Survival was significantly lower than the silica sand control only at Reference Wood station SQT9, and the body weight of the surviving organisms was significantly lower than the silica sand control only at SQT1 (Table 1.4). Since the PAH concentration at reference station SQT9 was only an estimated 1.4 µg PAH/gOC (0.08 µg/g and 5.8% TOC), this suggests that other sources of toxicity are present in these sediments.

The no effect concentration was 6,083.8 µg PAH/gOC (22.5 µg/g and 0.37 TOC) and the lowest effect level was 36,291 µg PAH/gOC (166.9 µg/g and 0.46 TOC).

[3] The photometer used in these measurements actually rests on the bottom while organisms, even epifauna, would likely be shaded by the a near-interface layer of suspended fine sediment and organic material.

1.2.2 Bioassays conducted between 8 and 15 July 2005 - UV light

The same treatments as for laboratory light were repeated in the presence of UV light. The same UV light measurements used to estimate the UV light regime for bottom-dwelling organisms used for *H. azteca* were used to estimate UV light levels for fish larvae that might exist at mid-water depths. However, due to the spectral characteristics of the artificial UV light source (Q-Panel Co.), it was not possible to reproduce exactly the UV exposure regime of 229 µW UVA/cm^2 and 5.4 µW UVB/cm^2 that were established as the test regime in discussions between URS and USEPA. *P. promelas* were exposed to sediments at mean intensities of 238 µW UVA/cm^2 and 18.2 µW UVB/cm^2 for 16-hrs per day. While the UVA values are very similar, the UVB exposures were approximately 3.4-fold higher than desired.

Only sediments SQT1 and SQT7 had significantly lower survival than the silica sand control (Table 1.4). However, while not tested for statistical significance, there was lower survival in both controls and most of the reference stations in the UV bioassay than in the bioassay under laboratory light tests suggesting that factors other than just photoactivation of PAHs may be a contributing factor to increased effects (See Section 5.1 in the BERA).

Body weight in the surviving organisms was not significantly different from the silica sand control (Table 1.4). Observations made during these tests showed 100% mortality at SQT1 within 6-hours of the onset of the UV light, but mortality was not monitored in SQT7 so that it is not clear if the mortality occurred during a period of time that larval fish might spend at mid-water depths.

1.3 *CHIRONOMUS DILUTUS*

Early life stage bioassays with *C. dilutus* were attempted on two occasions, both with unsatisfactory results. The first bioassays were terminated before the required test duration because of excessive losses of larvae from the bioassay beakers. Only data from the second attempt are presented here because the tests were allowed to go to completion (Table 1.5). Survival was significantly lower than the silica sand control in the formulated sediment control, the 4 reference sediments, and all Site sediments except SQT6. Observations of this test showed that many larval organisms did not settle into the sediments and were washed out of the bioassay beakers. These organisms were counted as mortalities. Body weight was higher in the surviving (or remaining) organisms from the Site sediments than in the silica sand control. This suggests that reduced competition for food may have contributed to these greater body weights in both Site and reference sediments. The other factor that may be significant is the early life stage. These organisms are placed into the bioassays within 4-hrs of hatch and may be prone to drift as they would in the natural environment. Observations in the laboratory showed that many midge larvae settled in the water bath that surrounds the bioassay beakers.

1.4 SUMMARY OF 2005 AND 2006 BIOASSAY RESULTS

The results of the 2005 and 2006 bulk sediment bioassays are shown in Table 1.6. For *H. azteca* a LOEC of 6084 µg PAH/gOC (22.5 µg/g and 0.37 TOC) observed at Station SQT7 is proposed. This was the lowest concentration consistently causing toxicity to *H. azteca* in Site sediment during the first two 28 day tests. In selecting this as the *H. azteca* LOEC the following results were considered:

1) There was significant mortality in SQT3 42.7 µg PAH/gOC (17.1 µg/g and 40% TOC) in the first 28 day test. However, this was not repeated in the second test. In addition there were significant effects in Reference Sand stations which had approximately the same carbon normalized concentrations;
2) There were significant growth effects in the second *H. azteca* test in SQT6. However, there were no significant growth effects at this station in the first test and there were also no growth effects at SQT7 in either of the 28 day tests despite significant mortality. It was concluded that the result at SQT6 was likely due to chance.
3) Although the LOEC in the dilution series was 50% SQT1 which was 18,146 µg PAH/gOC (93.47 µg/g), this test was a 10 day test.
4) There was significant mortality at Reference Sand stations during these 28-day tests. This suggests that there were other factors in the sediment that contributed to the observed effects. Based upon this, the LOEC is probably conservative.

The NOEC selected for *H. azteca* was 4536 µg PAH/gOC (20.9 µg/g and 0.46% TOC). This is the 12.5% dilution of SQT1. Although there were no effects in the 25% dilution of SQT1, this would have led to a NOEC of 9978 µg PAH/gOC (41.7 µg/g and 0.46% TOC). Because this is higher than the LOEC, this was considered illogical so the next lowest no effects concentration (12.5% SQT1) was selected. This also compensates for the dilution test being only a 10 day test.

In the tests conducted with *H. azteca* under UV light, the LOEC was 4536 µg PAH/gOC (20.9 µg/g and 0.46% TOC) at which concentrations there were growth effects. This effect was not observed when leaf plugs were provided.

In the *P. promelas* test the NOEC was 6084 µg PAH/gOC(22.5 µg/g and 0.37 TOC) and the LOEC 36291 µg PAH/g OC (166.94 µg/g and 0.46% TOC) (Table 1.6). Under UV light the NOEC for *P. promelas* was 24.2 µg PAH/g OC (2.3 µg/g and 9.5% TOC) and the LOEC was 6084 µg PAH/gOC(22.5 µg/g and 0.37 TOC).

Due to the high reference site mortalities for the midge, no NOEC or LOEC values are proposed for this species.

As part of the Ecological Risk Assessment Supplement, WDNR (SEH 2002) conducted a series of sediment bioassays at Site and reference stations with *H. azteca, P. promelas,* and *C. dilutus.* In addition, they evaluated the incremental effects of UV light on sediment toxicity to *H. azteca.* Their data are of use in the present BERA because they did not have the same problems with reference station toxicity or midge bioassays and because their significantly higher no effect concentrations suggest that, as discussed above, the unexplained and unmeasured stressors at Reference Sand stations in 2005-2006 may have affected the results of the 28-day tests.

The data below summarize the SEH results and the NOEC and LOEC endpoints as reported in

Table 21 in the SEH supplemental Risk Assessment (SEH 2002).

2.1 *HYALELLA AZTECA*

2.1.1 Bioassays conducted between 27 May and 10 July 2001 - Laboratory Light

H. azteca were exposed for 28-days to sediments collected from 2 stations designated Contaminated Sand (CS) and Contaminated Wood (CW) at different dilutions. These contaminated sediments were diluted with sediments collected from stations designated Reference Sand and Reference Wood, respectively. Exposures were conducted at 100%, 50%, 25%, 10%, and 1% of the both the CS and CW stations. The 100% CS contained 23,231 µg PAH/gOC (836.3 µg/g and 4% TOC) (Table 2.1).[4]

Survival in the silica sand control did not meet USEPA test acceptance criteria (77.5 vs. 80%), but survival in reference sediments was high (Table 2.2). There was no effect on survival at the 25% dilution of CS (9,978 µg PAH /gOC: 249.4 µg/g and 2.5% TOC). There was significant mortality in the 50% dilution of CS (4842 µg PAH /gOC: 823.1 µg/g and 17% TOC).[5] There were no reported growth differences compared to the silica sand control. Table 2.3 summarizes NOEC and LOEC for *H.azteca.* The fact that the 25% dilution had a higher organic carbon normalized concentration of PAHs than the 50% dilution[6] leads to the illogical result of the LOEC being a lower concentrations than the NOEC on an organic carbon normalized basis.

2.1.2 Bioassays conducted between 12 June and 10 July 2001 - UV light

H. azteca were exposed in the presence of UV light for 28-days to sediments collected from CS and CW at the same dilutions as for the test above under laboratory light The UV light intensity was increased for 4-hrs/day to simulate the increase in UV light present at midday. For 12 of the 16-hr light exposure, the mean UVA and UVB were 45.9 µW/cm^2 and 2.52 µW/cm^2, respectively. For the remaining 4-hr midday period, UVA and UVB were 69.5 µW/cm^2 UVA and 3.99 µW/cm^2, respectively. It should be noted that these UVB levels during 12 of the 16 hours of exposure are very close to those used by URS, but that the levels used during the 4-hour mid-day period are far greater than were measured at the Site in 2005.

[4] Note that there may be some potential problems with the reported concentrations (Table 2.1).

[5] If the concentration of this treatment is corrected by linearly interpolating between the 25% and 100% dilution the corrected concentration is 14,396 µg PAH/g OC.

[6] Note that on a dry weight basis the 25% dilution was less than the 50% dilution, however the TOC was reported as 17%, which is inconsistent with the TOC in the remaining dilution series and may have been incorrectly reported.

The silica sand control and the reference station tests met performance criteria, but the formulated control sediment failed (Table 2.2). The toxicity of the diluted sediments was increased approximately four-fold by the addition of UV light so that the no effect dilutions were 1% in CS (735 µg PAH/g OC: 16.2 µg/g and 2.2% TOC) and 10% in CW (1963 µg PAH/g OC: 104.1 µg/g and 5% TOC). LOECs were 3996 µg PAH/g OC (79.9 µg/g and 2% TOC) for CS and 1310 µg PAH/g OC (301.4 µg/g and 5% TOC)[7] for CW. However, the mortality found in the formulated sediment shows that factors other than PAHs in these sediments may have contributed to the observed effects

2.2 *PIMEPHALES PROMELAS* – LABORATORY LIGHT

The NOECs and LOECs reported by SEH (2002) were 3,996 µg PAH/gOC (79.9 µg/g and 2% TOC) and 9,978 µg PAH/gOC (249.4 µg/g and 2.5% TOC) respectively, for Contaminated Sand (Table 2.3).

2.3 *CHIRONOMUS DILUTUS* – LABORATORY LIGHT

The NOECs and LOECs reported by SEH (2002) were 735 µg PAH/gOC (16.2 µg/g and 2.2% TOC) and 3,996 µg PAH/gOC (79.9 µg/g and 2% TOC) respectively, for Contaminated Sand (Table 2.3).

2.4 BIOASSAYS CONDUCTED IN 1998 BY SEH

Several bioassays were conducted in 1998 by SEH (1998). These included the following:

- 10-day tests for *C. dilutus, H.azteca, Lumbriculus variegatus* (both under laboratory light and UV light);
- 48-hour tests using *Daphnia* under both normal and UV light; and,
- 7-day elutriate tests using *P. promelas*.

These tests only used sediment from one Contaminated Site Sand (583.6 µg PAH/g OC) and one Reference Sand station (92.2 µg PAH/g OC) and one Contaminated Site Wood (21776.5 µg PAH/g OC) and one Reference Wood Station (114.8 µg PAH/g OC). Because there was only one Site station for each substrate type no endpoint thresholds could be established with any confidence. Results of these tests are provided in Table 2.4 but are not used in the synthesis of bioassay results (Section 4).

[7] This concentration is questionable since it is less than the 10% dilution.

A bioaccumulation bioassay was conducted using the worm *Lumbriculus variegatus* to evaluate accumulation of PAHs from Site sediment by a benthic invertebrate. These data were also used in the wildlife food chain modeling to estimate dose to invertivorous wildlife. Preliminary 4-day bioaccumulation screening tests were first conducted with sediment from all of the Site stations. Complete toxicity was found at stations SQT1 and SQT7. As a result, the full 28-day bioaccumulation tests were conducted with the formulated control, and at 5 Site Wood[8], 1 Site Sand, 2 Reference Sand and 2 Reference Wood stations. Four replicates were tested with each treatment, but in some cases, replicates within a treatment had to be combined in order to provide sufficient tissue (2g) for the chemical analyses of the tissues.

At the end of the tests, levels of PAHs were measured in the worms (Table 3.1). There was insufficient tissue at the West Bearskin reference station, Site Sand Station SQT6 and Site Wood stations SQT 3 and SQT4 so only 3 replicates could be analyzed from those stations. There was insufficient tissue at Site Wood station SQT5 and Reference Wood station SQT11 so that only 2 replicates could be analyzed from those stations. Because of the inadequate growth in the formulated sediment and at the woody reference station, it is not clear if these insufficient tissue data were due to the Site contaminants or other, unknown, causes.

Tissue levels in worms tested with Site sediment ranged from 0.448 µg PAH/g wet weight at station SQT2 to 13.1 µg PAH/g at station SQT5 (Table 3.1). Analysis of worms exposed to the formulated control and West Bearskin reference sediments also revealed the presence of relatively low levels of the LMW PAHs naphthalene, 1- and 2-methylnaphthelene, acenaphthene, acenaphthylene, and anthracene, and relatively high levels of phenanthrene, in these organisms (Table 3.1).

[8] This assumes that station SQT3 is classified as a Wood station.

4.1 EFFECTS OF COPCS ON BENTHIC INVERTEBRATES

Exposure of four species of aquatic organisms to Site sediments in the laboratory was used to determine the levels of sediment contaminants that were associated with adverse effects to laboratory animals. Because these sediments contain all of the Site COPCs, the results of these tests represent the cumulative toxicity of all of the COPCs, not just the PAHs. However, of the COPCs measured in sediments PAHs were, by far, the most widespread and highest level of any COPC. Therefore the focus of this discussion will be on the potential effects of PAHs.

As previously discussed, because of the heterogeneity of the wood mulch substrate which includes wood debris made up of sawdust size particles to branches and logs with corresponding differences in total organic carbon content as well adsorptive capacity, the focus of this discussion will be on what is nominally sand substrate. While the sand substrate may include lesser amounts of decomposing wood material it is primarily considered sand for purposes of this discussion.

The following summarizes the results of toxicity tests using Site sediment that were conducted from 2001 to 2006.

4.1.1 *H. azteca*

There was significant mortality to *H. azteca*, generally the most sensitive organism used in sediment bioassays, in all of the Reference Sand sediments collected in 2005-2006 (Ingersoll et al. 1996). Furthermore the mortality was consistent in four different Reference Sand stations collected from four different locations in Chequamegon Bay and on two different occasions four months apart. In addition, this mortality was observed during three different bioassays with *H. azteca* during three different bioassays conducted months apart. This strongly suggests that there were unmeasured variables that affected the outcome of the bioassays and that not all of these adverse effects were attributable to Site-related contaminants.[9]

Observations by the bioassay laboratory personnel of a strong organic odor in the reference sediments suggests that additional organic chemicals may be widely dispersed within Chequamegon Bay. Although both ammonia and sulfides were measured in these tests neither appeared to be related to the elevated mortality.

When compared against the Reference Wood sediments and silica sand control treatments in 2005-2006, only Site sediment SQT1 and SQT7 showed significant and consistent mortality under normal laboratory light conditions. Based upon results of all the *H. azteca* bioassays, the NOEC and LOEC selected for the bioassays conducted in 2006 with *H.azteca* were 4536 µg PAH/g OC (20.87 µg/g and 0.46% TOC) and 6084 µg PAH/g OC (22.51 µg/g and 0.37% TOC) respectively (Table 4.1). These endpoint concentrations are lower than those found in the SEH (2002) bioassays which were a NOEC of 9,978 µg PAH/gOC (249.4 µg/g and 2.5% TOC) and a LOEC of about 14,396 µg PAH/g OC (823.1 µg/g and 17% TOC)[10], but will be used as the

[9] Although the *C. dilutus* test conducted in 2006 was not successful, it should also be noted that there was significant mortality (or loss to the system) to *C. dilutus* at both Reference Sand and Reference Wood stations.

[10] This assumes a corrected normalized PAH concentration.

recommended NOEC and LOEC for *H. azteca* (Table 2.3). The fact that the recommended NOEC is from a 10-day test is balanced by the higher NOEC from the SEH (2002) bioassay.

4.1.2 *P. promelas*

As expected for a receptor that does not normally contact the sediment, fathead minnow larvae were relatively insensitive to PAHs in bulk sediments, with no mortality reported at 36,291 µg PAH/gOC (166.9 µg/g and 0.46% TOC) in 2005-2006. However there was a growth effect at this station and a NOEC of 6,084 µg PAH/gOC (22.5 µg/g and 0.37% TOC) was selected (Table 1.6). The NOEC in 2001 was 3,996 µg PAH/gOC (79.9 µg/g and 2% TOC) (Table 2-3). The average of these two NOECs (5040 µg PAH/gOC: 51.2 µg/g) is proposed as the NOEC (Table 4.1).

An average of the 2001 LOEC (9,978 µg PAH/gOC (249.4 µg/g and 2.5% TOC) and the 2005-2006 LOEC (36,291 µg PAH/gOC: 166.9 µg/g and 0.46% TOC) or 23,135 µg PAH/gOC (208.3 µg/g) is proposed as the LOEC.

4.1.3 *C. dilutus*

Ingersoll et al. (1996) reported that, in general, in bioassays conducted in the Great Lakes, *H. azteca* is more sensitive than *C. dilutus*. However, in the 2005-2006 test series, low survival with *C. dilutus* at all 6 reference stations made evaluation of Site sediment inconclusive due to additional unknown factors. This test was attempted twice and failed both times. The relatively low test acceptance criteria of 70% in controls (vs. 80% for *H. azteca*) also suggests that culture and bioassay procedures are not as well understood for this species as for *H. azteca*.

SEH (2001) reported a NOEC of 735 µg PAH/gOC (16.2 µg/g and 2.2% TOC) and a LOEC of 3996 µg PAH/gOC (79.9 µg/g and 2% TOC) in Contaminated Sand sediments (Table 4.1) These are the only values for these endpoints and will be used as the proposed NOEC and LOEC. It should be noted however, that the LOEC concentration of 3,996 µg PAH/gOC resulted in only 10% survival difference from the control (71.5 vs. 82.5%), or approximately 90% of the control value and had sufficient survival to exceed the performance criteria for this test.

4.2 SUMMARY OF PROPOSED MULTISPECIES SEDIMENT THRESHOLD AND MEDIAN EFFECTS BENCHMARKS

The average of three species NOECs was 3437 µg PAH/gOC; the average LOEC was 11,072 µg PAH/gOC (Table 4.1).

The average of these values, 7254 µg TPAH/gOC could be considered a representative multi-species median effects sediment benchmark.

4.3 EFFECTS OF UV LIGHT

Until relatively recently, only normal laboratory light was used in sediment bioassays, and all sediment quality criteria are based on tests that used normal laboratory light. However, several laboratory and at least one field study have shown that UV light increases the toxicity of accumulated PAHs under certain conditions. In the studies reported here, UV light substantially increased the toxicity in the laboratory to *H. azteca* at concentrations of 9073 µg PAH/gOC (25%

dilution), and increased the toxicity to a lesser extent at 4536 µg PAH/gOC (12.5% dilution) (Table 1.3). In addition UV light caused decreased survival at Site Wood stations SQT 4 and SQT5.

In 2001, toxicity to *H. azteca* exposed to UV light was increased significantly at 3,996 µg PAH/gOC (10% CS) approximately half the concentration required in 2005-2006 in the dilution series. In the 2005-2006 bioassays the availability of refugia, under which *H. azteca* could avoid UV exposure, led to substantial decreases in toxicity at the 12.5% and 25% dilution.

The toxicity to fathead minnow larvae was significantly increased by UV light in 2005-2006 at 6308.8 µg TPAH/gOC (22.5 µg/g and 0.37% TOC). They were not tested under UV light in the 2001 bioassays.

No effects endpoints are proposed for UV light as there is uncertainty as to how well laboratory results predict what happens in the field, particularly for UVB.

4.4 UNCERTAINTIES ASSOCIATED WITH BULK SEDIMENT TOXICITY AND BIOACCUMULATION TESTS

There are a number of uncertainties associated with extrapolating the observations made in laboratory studies to the field. In laboratory studies there are several factors which are different from what would be experienced by an ecological receptor in the field. Although standard methodologies have been developed to minimize these differences, they still exist and result in uncertainties. These uncertainties are related to the disruption of sediments during sampling, the distribution of these sediments to the bioassay beakers, the use of laboratory-reared organisms, the confinement of these organisms to the designated exposure regime, and the exposure of these organisms to UV light. It is more likely than not that these uncertainties are all biased in a conservative direction. That is, laboratory bioassays over predict the potential for adverse effects.

General Uncertainty Associated with Bioassays

During sediment sampling it was occasionally noted that removal of the sampling device with the sample led to the appearance of sheen on the water surface. This indicates that hydrocarbons were released by the action of disrupting the sediment surface. This also suggests that organisms placed into bioassays with the homogenized sediments were exposed to much higher concentrations of hydrocarbons than they would experience in undisturbed surface sediments at the Site. This would be particularly true for instance if the sheen came from a deeper horizon, say 4-6 inches depth, than where benthic organisms actually live, say 2-3 inches. In addition in the bioassay beakers there is little opportunity for these hydrocarbons to disperse and perhaps eventually degrade as they night in the field.

In most of the bioassays conducted, the body weight of the surviving organisms was as great or greater than that of the controls. This suggests that either, once some of the organisms had died, the survivors had additional nutritional resources that allowed them to resist toxicity in some unknown manner, or that the survivors were genetically pre-disposed to resist toxicity and thrive. In either case, these conditions replicate what would occur in the field where nutritional resources are not limited as they are in the laboratory where nutritional resources are limited so as to reduce fouling within the bioassay beakers.

In nature, organisms are selected for physiological robustness, but laboratory-reared organisms are selected to survive under specific laboratory conditions. Survival of populations in the field is dependent upon the ability for populations to compensate for variable conditions which include stressors, both chemical and physical, such as UV light. Laboratory populations, on the other hand have relatively "narrow" selective pressures and they are therefore less able to adapt to changing conditions or different stressors.

Uncertainty Associated with Bioassay Duration

In compiling and synthesizing the results of the series of bioassays conducted in 2001 and 2005-2006 there is uncertainty associated with the interpretation of the bioassays with *H. azteca* because bioassays were conducted for two different time periods, 10- and 28-days. In common practice, 10-d tests are considered to be acute bioassays while 28-d tests are considered to be chronic bioassays. However, the difference in the response of the organisms may not be significantly different between these two durations because, according to the target-lipid model (DiToro et al. 2000), toxicity is dependent upon the concentration of PAH within the organism. The concentration within the organism is, in turn, dependent upon the bioavailability of PAHs from the sediment and their ability to partition into the animal. Therefore, if the critical body residue (McCarty et al. 1992; Mackay et al. 1992) for a specific endpoint is reached in the organism in a short period of time, no greater toxicity will be exhibited even if exposure is continued. This was also observed in studies by Hickie et al. (1995) who found that even in repeated periods of exposure followed by periods in clean water, a specific endpoint was reached when the critical body residue was achieved regardless of the duration or discontinuous nature of the exposure. Conversely, while sublethal endpoints may be reached after a certain duration, more severe sublethal endpoints or death may be reached with a longer exposure. However, since the comparison between the 10-day and 28-day bioassays in this discussion relies primarily on mortality, we conclude that duration was not an important source of uncertainty in the *H. azteca* bioassays. When the 10-day data were analysed by USEPA using probit analysis (See USEPA Comments to the BERA), the EC20 was calculated to be 9,593 µg PAH/gOC. In light of the close correspondence of 10- and 28-day tests results in which both reference and control survival was high, the proposed NOEC and LOEC for *H. azteca*, of 4536 and 6084 µg PAH/gOC are conservative.

Uncertainties Associated with UV Light Exposures

The addition of UV light led to increased toxicity in the bioassays. However there are three major sources of uncertainty in applying the results of these tests directly to Site conditions: 1) the dosage of UVB light was greater than measured at near-bottom depths at Stations SQT1 and SQT2, 2) there was no accounting for further UV light absorption by the near-bottom nepheloid layer, and 3) most animals, including benthic invertebrates such as *H. azteca*, and *L. variegatus* and larvae of fish such as *P. promelas*, avoid UV light when given the opportunity.

SEH (2001) selected UVA and UVB exposure levels based on levels measured from 0.5 to 1.6 m (1.6 to 5.0 feet) deep at the Site in June 2001. The UVA and UVB levels used in the bioassay for 12 of the 16 hours per day were reported as 45.9 $\pm$ 10.1 uW UVA/cm^2, and 2.52 $\pm$ 0.5 uW UVB/cm^2. These were increased to 69.5 $\pm$ 16.9 µW/cm2 UVA and 3.99 $\pm$ 0.9 µW/cm2 for 4 of the 16 hours. URS (2005) measured UV light at near bottom depths at Station SQT 1 and SQT 2 in June and September 2005 (7.6 and 10.1 feet deep respectively) and adjusted these values to

reflect possible summer solstice conditions (June 21). The UVA and UVB levels measured were 45 uW UVA/cm^2 and 0.4 uW UVB/cm^2. Although LSRI attempted to achieve these same UV conditions, even through the use of only the UVA bulbs, ultimately the levels measured in the bioassays were 42.4 uW UVA/cm^2, and 3.03 uW UVB/cm^2 (the UVA bulbs "leaked" sufficient UVB to reach this level). Therefore, both UVA and UVB levels in the SEH tests were exceptionally high for at least 4-hours per day, and in the URS tests UVB was 8-fold higher than measured in the field.

In an additional *H. azteca* bioassay conducted with UV light, 1 cm plugs of aged leaf plugs were added to a second set of exposure vessels to provide potential refugia for test organisms while being exposed to UV light. This resulted in a substantial decrease in the level of toxicity found with UV light alone. However, although these bioassays were partially successful in providing refugia the particulate matter that was resuspended during water changes also covered the leaf plugs and reduced the available refugia as the bioassays continued. In the field, it would be expected that new refugia would be exposed when old refugia were buried such that the availability of refugia would not change. In summary, despite attempts to exactly replicate conditions in the field by taking UV measurements, and providing refugia, because of the factors described above the results of these UV bioassays still are likely to overestimate exposures under field conditions.

In the field there also are additional factors, besides refugia, that decrease exposure of organisms to UV light. Specifically, dissolved organic matter (DOM) and particulate organic matter (POM, such as phytoplankton) also decrease UV penetration, but neither is a component of the water that was used in the UV bioassays. Although UV intensity was adjusted to account for these factors, in the field they are temporally variable and may not have been well-represented.

In addition the bottom nepheloid layer[11] was not entirely accounted for in the measurements of UV. The bottom nepheloid layer that normally overlies sediments is composed of suspended sediments and organic detritus and ahs the potential to effectively limit the amount of UV that reaches the actual sediment surface. Harrsch and Rea (1982) reported that in summer, diatoms comprised nearly all of the organic fraction and 60% of the total (1.05 to 2.4 mg/L) at six locations in Lake Michigan. Observations made during the bioassays also showed that fine particulate matter remained suspended for long periods of time after the distribution of sediments into the beakers (Appendix 2). However, it is likely that the suspended particulates observed during the bioassay would only represent a small portion of the total suspended particulate portion of the nepheloid layer in the field because diatom populations would be severely limited in the laboratory by the twice daily changes of laboratory water. Furthermore, observations indicated that this suspended particulate component decreased over the 10-days of the bioassay, something that does not occur in nature.

Field measurements of UVB light made at the Site also suggested that light penetration to bottom depths was lower than predicted by the absorbance of water alone, suggesting that the nepheloid layer may have been thicker than the photodetector is deep. However, because the geometry of the photodetector prevented measurements precisely at the sediment-water interface (i.e., the

[11] The term "nepheloid layer" is used here to describe the relatively mobile layer of suspended fine sediments and organic matter that is found overlying the sediment bed. Depending upon conditions this layer may be centimeters to inches in depth.

sensory part of the photodector is about 1 3/8 to 2 3/8 inches above the surface), the additional ameliorative effect of the remaining 5 inches of the nepheloid layer is not known.

Under laboratory conditions, *H. azteca* must compete for both food and refuge from UV light. However, in the field, benthic organisms are able to move greater distances and inhabit a variety of detritus-rich (food) habitats where they are protected from UV light. It is also unlikely that *H azteca* would forage for food in bright sunlight, since organisms that are adapted to UV light exposure are normally pigmented and *H. azteca* is white. Foraging in bright sunlight has the additional risk of increased predation by foraging demersal fish.

URS also exposed *P. promelas* to UV light calculated to be representative of levels of exposure at mid-water depths. *P. promelas* was exposed to 229 uW UVA/cm^2 and 5.4 uW UVB/cm^2 for 7-days.[12] Fish larvae typically feed on the bottom, and are negatively phototactic. It is also unlikely that larval fish would be exposed to mid-water depth UV light for 16-hours per day. Larval fish that spend 16-hrs at mid-water depths or less are at greatly increased risk of predation and possibly starvation. As fish age they acquire the pigmentation necessary to reduce predation from above and withstand UV light exposure, but larvae are unpigmented and ill-adapted to the UV bioassay conditions. Because a fish in the field would vary its vertical position and because UVB light levels in the bioassay were approximately 3.4-fold higher than the estimated level found at the mid-depth, it is very likely that this bioassay overpredicts UV effects to the fish. In these tests, there was also a difference in survival amongst controls and reference stations in bioassays conducted under normal laboratory light compared to those conducted under UV light. This suggests that UV light may have contributed to the increased toxicity in a manner unrelated to photoactivation of PAHs.

Uncertainties Associated with *C. dilutus* Bioassays

C. dilutus, unlike *H. azteca* and *P. promelas* is an infaunal species that may receive a major portion of the it's exposure through direct contact with sediment pore water. Therefore, even in the field, *C. dilutus* is probably exposed to greater concentrations of PAHs than either *H. azteca* or *P. promelas*. However, as discussed in the benthic community investigation report (Attachment 3 in Appendix B to the BERA), chironomid populations were not significantly different at Site stations than at reference stations. The apparent discrepancy between the bioassay results and the field results is likely an artifact of the bioassay conditions. As discussed above for *H. azteca*, when sediments are collected from six inches beneath the sediment surface, unweathered PAHs also may be collected and result in an exposure that may not be representative of the composition in the upper few centimeters that the majority of chironomids inhabit. Therefore, when *C. dilutus* was exposed to these mixed composited sediments during the bioassays, they likely were exposed to conditions that they do not encounter in the field.

In the early life stage tests conducted by URS, the presence of unweathered sediments may also have contributed to the failure of these larvae to settle, although it is apparent that they do settle in the field. Based upon these factors, the proposed NOEC and LOEC for *C. dilutus* is biased conservative.

[12] The resultant UVB dose was 3.4-fold greater than the calculated mid-water exposure dose.

Uncertainty Associated with *Lumbriculu* s Bioassays

Analysis of the body residues from the *L. variegatus* tests showed an unexpectedly high percentage of high molecular weight PAHs. High molecular weight (HMW) PAHs are not expected to be taken up from the water column and must have been the result of sediment ingestion (Leppanen and Kukkonen 1998). The normal procedure in this test is to remove the worms from the contaminated sediment for 24-hours to allow clearance of the ingested sediment. The presence of the HWM PAHs in the worms suggests that this may not have been entirely successful. The resulting body residues for *L. variegatus* were used to represent all benthic invertebrates that might be ingested by wildlife. However, most benthic invertebrates do not ingest sediment and would not accumulate PAHs to the same degree as *L. variegatus*. Therefore, the doses to wildlife are biased conservatively.

DiToro, D., J. McGrath, and D. Hansen. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. I. Water and tissue. Env. Toxicol. Chem. 19: 1951-1970.

Harrsch, E. and D. Rea. 1982. Composition and distribution of suspended sediments in Lake Michigan during summer stratification. Env. Geol. 2: 87-98.

Hickie, B., L. McCarty, and D. Dixon. 1995. A residue-based toxicokinetic model for pulse-exposure toxicity in aquatic systems. Env. Toxicol. Chem. 14: 2187-2197.

Leppanen, M. and J. Kukkonen. 1998. relative importance of ingested sediment and pore water as bioaccumulation routes for pyrene to oligochaete (*Lumbriculus variegatus*, Muller). Env. Sci. Technol. 32: 1503-1508.

Mackay, D., H. Puig, and L. McCarty. 1992. An equation describing the time corse and variability in uptake and toxicity of narcotic chemicals in fish. Env. Toxicol. Chem. 11: 941-951.

McCarty, L. D. Mackay, A. Smith, G. Ozburn, and D. Dixon. 1992. Residue-based interpretation of toxicity and bioconcentration QSARs from aquatic bioassays: Neutral narcotic organics. Env. Toxicol. Chem. 1: 917-930.

SEH 1998. Ecological Risk Assessment. Ashland Lakefront Property.

SEH 2002. Ecological Risk Assessment Supplement. Ashland/NSP Site.

URS 2006. Sediment Quality Triad Investigation. Ashland/Northern States Power Lakefront Superfund Site. (This is Appendix B to the BERA)

TABLES

Table 1.1
Normalized Total PAH in URS Bioassay Samples (2005-2006)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

SQT Station	Substrate Matrix	Total PAHs (µg/g)	Total Organic Carbon (%)	Carbon Normalized PAH (µg/g OC)
SQT1	Sand	166.94	0.46	36291.3
SQT1 (50%)	Sand	~83.47	~0.46	~18145.65
SQT1 (25%)	Sand	~41.74	~0.46	~9072.93
SQT1 (12.5%)	Sand	~20.87	~0.46	~4536.41
SQT2	Wood	3.20	42	7.61
SQT3	Wood[1]	17.06	40	42.65
SQT4	Wood	14.10	42	33.57
SQT5	Wood	31.25	25	125.00
SQT6	Sand	2.30	9.5	24.18
SQT7	Sand	22.51	0.37	6083.8
SQT8	Wood	69.91	28	249.69
SQT9	Reference Wood	.08	5.8	1.43#
SQT10	Reference Sand	.03	0.13	20.18#
SQT11	Reference Wood	3.80	28	13.56#
SQT12	Reference Sand	.01	0.03	25.91#
SQT13*	Reference Sand		0.28	152.14#
SQT14*	Reference Sand		0.39	109.23#

1. Although this station was originally designated a Sand station, after analysis was conducted, the level of organic carbon at this station would classify it as a wood station.

~ Estimated based upon dilution. See LSRI report (Appendix 2) for explanation.

* Based upon the average of the five replicate samples collected from these stations for bulk sediment chemistry analysis.

NOC-PAH levels in reference station sediments may be misleading because many PAH compounds were not detected and hence given a value of 1/2DL. For detailed information on PAH composition see the Sediment Investigations report accompanying this report (Attachment 1 to the Sediment Quality Triad Investigation)

Table 1.2
Chronic Bioassays Results with *H. azteca* and Normal Laboratory Light
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Chronic Bioassays Results with *Hyalella azteca* and Normal Laboratory Light						
	29 June to 27 July 2005			12 August to 2 September 2005	7 October to 4 November 2005	
	Treatment	Mean % survival	Mean dry weight (mg)	Mean % survival	Mean % survival	Mean dry weight (mg)
Control	Silica Sand	95.0 (7.6)	0.49 (0.25)	97.5 (4.6)	87.5 (8.9)	0.48 (0.09)
	Formulated Sediment	80.0 (10.7)	0.46 (0.07)		20.0 (12.0)	0.85 (0.14)
Reference	West Bearskin	95.0 (10.7)	0.24 (0.05)		88.8 (15.5)	0.24 (0.04)
	SQT9	80.0 (16.9)	0.38 (0.08)		65.0 (16.9)	0.37 (0.10)
	SQT10	40.0 (12.0) [abcde]	0.49 (0.07)	50.0 (18.5) [acd]		
	SQT11	90.0 (10.7)	0.23 (0.06) [b]		85.0 (7.6)	0.26 (0.05)
	SQT12	48.8 (29.5) [abcde]	0.45 (0.23)	76.3 (18.5)		
	SQT13				37.5 (21.9)	0.43 (0.09)
	SQT14				52.5 (26.6)	0.34 (0.12)
Site	SQT6	91.3 (6.4)	0.28 (0.05)		90.0 (10.7)	0.24 (0.05) [a]
	SQT2	91.3 (15.5)	0.31 (0.06)		83.8 (13.0)	0.31 (0.09)
	SQT7	6.3 (5.2) [abcdefg]	0.40 (0.34)		17.5 (16.7) [achi]	0.41 (0.18)
	SQT4	95.0 (5.3)	0.26 (0.04)		90.0 (14.1)	0.26 (0.04)
	SQT3	72.5 (8.9) [ac]	0.42 (0.08)		87.5 (10.4)	0.27 (0.02)
	SQT5	91.3 (8.3)	0.33 (0.04)	81.3 (18.1)	81.3 (12.5)	0.26 (0.05)
	SQT1	0.0 (0.0) [abcdefg]	0.00 (0.00)		0.0 (0.0) [achi]	
	SQT8	77.5 (17.5)	0.33 (0.06)		85.0 (9.3)	0.26 (0.04)

Standard Deviation from the mean ().

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[e] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

f Survival significantly reduced relative to the SQT10 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

g Survival significantly reduced relative to the SQT12 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

Table 1.3
Acute Bioassays Results with *H. azteca* with Normal Laboratory and UV Light
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Acute Bioassays Results with *Hyalella azteca* with Normal Laboratory and UV Light					
		Laboratory Light		UV Light	
	Treatment	Mean % survival	Mean dry weight (mg)	Mean % survival	Mean dry weight (mg)
Control	Silica Sand	100 (0.0)	0.15 (0.02)	98.8 (9.9)	0.12 (0.02)
	Leaf Plugs			98.8 (9.9)	0.17 (0.03)
Reference	West Bearskin	97.5 (7.1)	0.11 (0.01)	91.3 (6.4)	0.11 (0.01)
	Dilution Sediment	101.3 (8.3)	0.11 (0.02)	97.5 (4.6)	0.11 (0.01)
	SQT9	97.5 (4.6)	0.18 (0.02)	91.3 (11.3)	0.16 (0.03)
	SQT11	93.8 (7.4)	0.13 (0.01)	78.8 (12.5)	0.12 (0.02)
Site	12.5% SQT1	97.5 (4.6)	0.12 (0.02)	78.8 (21.0)	0.12 (0.04)[b]
	12.5% SQT1and Leaf Plugs			95.0 (7.6)	0.16 (0.02)
	25 % SQT1	82.5 (34.5)	0.10 (0.01)e	11.3 (14.6)[abcdef]	0.11 (0.03)[b]
	25% SQT1 and Leaf Plugs			55.0 (17.7)[abcdef]	0.12 (0.03)[b]
	50% SQT1	15.0 (10.7)[acdef]	0.12 (0.07)	0.0 (0.0)[abcdef]	
	50% SQT1 and Leaf Plugs			0.0 (0.0)[abcdef]	
	SQT1	0.0 (0.0)[acdef]		0.0 (0.0)[abcdef]	
	SQT1 and Leaf Plugs			0.0 (0.0)[abcdef]	
	SQT2	92.5 (7.1)	0.13 (0.02)	91.3 (8.3)	0.12 (0.02)[b]
	SQT4	93.8 (5.2)	0.18 (0.02)	71.3 (12.5)[abd]	0.11 (0.02)[be]
	SQT5	92.5 (10.4)	0.18 (0.03)	40.0 (20.0)[abcdef]	0.12 (0.03)[b]
	SQT8	73.8 (32.0)[ad]	0.19 (0.04)	86.3 (16.0)[a]	0.16 (0.03)

Standard Deviation from the mean ().

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the silica sand and leaf plug control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d] Survival significantly reduced relative to the dilution sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[e] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[f] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 1.4
Acute Bioassays Results with *P. promelas* with Normal Lab and UV Light
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Acute Bioassays Results with *Pimephales promelas* with Normal Laboratory and UV Light					
		Laboratory Light		UV Light	
	Treatment	Mean % survival	Mean dry weight (mg)	Mean % survival	Mean dry weight (mg)
Control	Silica Sand	95.0 (7.6)	0.71 (0.13)	81.3 (1.2)	0.54 (0.09)
	Formulated Sediment	91.3 (6.4)	0.58 (0.07)	73.8 (1.9)	0.57 (0.07)
Reference	West Bearskin	82.5 (16.7)	0.67 (0.31)	87.5 (0.9)	0.59 (0.16)
	SQT9	70.0 (27.3)[abg]	0.67 (0.19)	82.5 (1.7)	0.68 (0.10)
	SQT10	96.3 (5.2)	0.75 (0.16)	78.8 (1.2)	0.54 (0.15)
	SQT11	90.0 (7.6)	0.61 (0.06)	73.8 (1.2)	0.64 (0.13)
	SQT12	93.8 (5.2)	0.63 (0.06)	81.3 (2.0)	0.67 (0.04)
Site	SQT6	93.8 (7.4)	0.57 (0.13)	77.5 (1.8)	0.62 (0.09)
	SQT2	90.0 (10.7)	0.67 (0.10)	75.0 (1.9)	0.56 (0.07)
	SQT7	90.0 (7.6)	0.54 (0.10)	38.8 (2.2)[abcdefg]	0.63 (0.18
	SQT4	91.3 (8.3)	0.54 (0.06)	61.3 (1.5)	0.50 (0.11)
	SQT3	82.5 (14.9)	0.63 (0.16)	68.8 (2.9)	0.45 (0.11)
	SQT5	93.8 (9.2)	0.71 (0.09)	60.0 (1.5)	0.58 (0.09)
	SQT1	76.3 (13.0)	0.47 (0.06)[ae]	0.0 (0.0)[abcdefg]	
	SQT8	93.8 (7.4)	0.68 (0.07)	71.3 (1.4)	0.61 (0.08)

Standard Deviation from the mean ().

[a] Survival or growth significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[e] Survival or growth significantly reduced relative to the SQT10 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[f] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[g] Survival significantly reduced relative to the SQT12 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

Table 1.5
Chronic Bioassays Results with *C. dilutus* and Normal Laboratory Light
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Chronic Bioassays Results with *Chironomus dilutus* and Normal Laboratory Light			
	Treatment	**Mean % survival**	**Mean dry weight (mg)**
Control	Silica Sand	100 (17.7)	0.86 (0.14)
	Formulated Sediment	30 (20.0)	1.50 (0.81)
Reference	West Bearskin	97 (9.2)	1.23 (0.07)
	SQT9	17 (27.8)	2.50 (1.56)
	SQT13	23 (28)	2.44 (0.54)
	SQT11	3 (7.4)	1.5
	SQT14	30 (28.2)	2.58 (0.80)
Site	SQT6	96 (16.0)	1.23 (0.12)
	SQT2	0 (0)abc	
	SQT7	4 (10.7)abc	2.9
	SQT4	7 (9.9)ab	2.50 (0.26)
	SQT3	13 (12.0)ab	3.37 (0.73)
	SQT5	6 (11.7)abc	
	SQT1	1 (3.5)abc	
	SQT8	1 (3.5)abc	

Standard Deviation from the mean ().

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

c Survival significantly reduced relative to the SQT14 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 1.6
Summary of Normal Light Bioassay Results with Three Species for URS 2005-2006
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Summary of Normal Light Bioassay Results with Three Species for URS 2005-2006				
Organism	NOEC		LOEC	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	20.9	4,536	22.5	6,084
P. promelas	22.5	6,084	166.9	36,291
C. dilutus	NA	NA	NA	NA

Table 2.1
Bulk Sediment Chemistry from 2001 Bioassay Samples (SEH 2002)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Station	Total PAH (µg/g)	Total Organic Carbon (%)	Carbon Normalized PAH (µg/g OC)
100% Contaminated Sand	836.3	4	23,231
50% Contaminated Sand	823.1	17	4,842[1]
25% Contaminated Sand	249.4	2.5	9,978
10% Contaminated Sand	79.91	2	3,996
1% Contaminated Sand	16.17	2.2	735
100% Contaminated Wood	759.3	48	1,582[2]
50% Contaminated Wood	660.9	23	2,873
25% Contaminated Wood	301.4	23	1,310[3]
10% Contaminated Wood	104.1	5	1,963
1% Contaminated Wood	20.08	14	143

1. This is less than the concentration at the 25% dilution.
2. This is less than the concentration at the 50% dilution.
3. This is less than the concentration at the 10% dilution.

Table 2.2
Chronic Bioassays Results with *H. azteca* with Normal Lab and UV Light
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Chronic Bioassays Results with Hyalella azteca with Normal Laboratory and UV Light					
	Laboratory Light			UV Light	
	Treatment	Mean % survival	Mean dry weight (mg)	Mean % survival	Mean dry weight (mg)
Control	Silica Sand	77.5 (15.8)[ce]	0.189 (0.03)[b]	95 (5.3)	0.171 (0.01)[b]
	Formulated Sediment	92.5 (10.4)	0.558 (0.082)	70 (15.1)[acde]	0.494 (0.77)
Reference	West Bearskin	97.5 (4.6)	0.183 (0.027)[b]	97.5 (4.6)	0.178 (0.014)[b]
	Reference Sand	86.2 (20)	0.27 (0.092)[b]	92.5 (7.1)	0.211 (0.04)[b]
	Reference Wood	97.5 (7.1)	0.236 (0.025)[b]	98.7 (3.5)	0.242 (0.023)[b]
Site	1% Sand 1	97.5 (4.6)	0.22 (0.03)[b]	98.7 (3.5)	0.19 (0.041)[b]
	10% Sand 1	95 (7.6)	0.209 (0.054)[b]	68.7 (9.9)[acd]	0.289 (0.043)[b]
	25% Sand 1	83.7 (16.9)	0.259 (0.055)[b]	13.8 (9.2)[abcd]	0.497 (0.08)
	50% Sand 1	46.2 (11.9)[abcd]	0.43 (0.066)[b]	0[abcd]	
	100% Sand 1	0[abcd]		0[abcd]	
	100% Sand 2	5 (5.3)[abcd]	0.573 (0.066)[b]	0[abcd]	
	1% Wood 1	95 (5.3)	0.218 (0.025)[b]	95 (5.3)	0.226 (0.032)[b]
	10% Wood 1	90 (17.7)	0.245 (0.071)[b]	82.5 (20.5)[ce]	0.292 (0.1)[b]
	25% Wood 1	87.5 (10.4)	0.214 (0.053)[b]	32.5 (12.8)[abce]	0.495 (0.127)
	50% Wood 1	86.2 (10.6)	0.256 (0.029)[b]	0[abce]	
	100% Wood 1	2.5 (4.6)[abce]	0.415 (0.276)	0[abce]	
	100% Wood 2				
	Repeat 10% Sand 1	92.5 (8.9)	0.205 (0.029)		
	Repeat 10% Wood 1	92.5 (8.9)	0.232 (0.021)		
	Repeat 100% Wood 2	91.3 (8.3)	0.227 (0.028)	36.2 (20.7)[abce]	0.485 (0.141)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Bonferroni T-test.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Bonferroni T-test.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Bonferroni T-test.

[d] Survival significantly reduced relative to the sand reference sediment control by one-way ANOVA and Bonferroni T-test.

[e] Survival significantly reduced relative to the wood reference sediment by one-way ANOVA and Bonferroni T-test.

Table 2.3
Summary of Normal Light Bioassay Results with Three Species Conducted for SEH 2001
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Summary of Normal Light Bioassay Results with Three Species Conducted for SEH 2001				
Organism	NOEC[1]		LOEC[1]	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	249.4	9,978	823.1	4842
P. promelas	79.9	3,996	249.4	9978
C. tentans	16.2	735	79.9	3996

1) SEH reports that the NOEC and LOEC are for lowest of either mortality or growth endpoints (reduced growth or mortality > 20%

Table 2.4
Compilation of Bioassays Conducted in 1998 by SEH.
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Study	Substrate	Duration (days)	Endpoint	Concentration µg/g OC	Comments
H. azteca	Sand	10	NOEC	584	This was the highest concentration tested. Mortality and growth endpoints for 584 µg PAH /g OC were compared to reference station but not performance control. There was no significant mortality compared to reference, however there were significant growth effects compared to reference. Although not tested, based upon SD, there was no significant mortality in contaminated sand compared to performance control, however there were significant growth effects (based upon mean wt per individual) compared to performance control.
			LOEC	> maximum	
	Wood		NOEC	115	This was the Reference Wood station
			LOEC	21,777	This was the only Site Wood concentration tested. LOEC may be lower.
L. variegatus	Sand	10	NOEC	> maximum	We were advised that survival percent in the SEH Table 5 should be multiplied by 10. On this basis, survival was not significantly different from the reference. This was the highest concentration tested. Too big a data gap to be useful
			LOEC	> maximum	
	Wood		NOEC	115	The NOEC is the reference wood concentration. We were advised that survival percent in the SEH Table 5 should be multiplied by 10. Too big a data gap to be useful
			LOEC	21,777	
	Sand/UV		NOEC	< 92	Aqueous exposures after exposure to sediment. Effects at all concentrations including both reference stations.
			LOEC		
	Wood/UV		NOEC		
			LOEC		
D. magna	Sand	48-h	NOEC	Aqueous concentration not measured	These are aqueous exposures. No significant effects in any treatment except in one replicate out of a total of ten replicates in two tests. The one replicate was from the contaminated wood station (21776 µgPAH/gOC).
			LOEC		
	Wood		NOEC		
			LOEC		

Table 2.4
Compilation of Bioassays Conducted in 1998 by SEH.
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site

Study	Substrate	Duration (days)	Endpoint	Concentration µg/g OC	Comments
	Sand/UV		NOEC		Each Site station and the Reference Wood station had almost total mortality after 4 hours although mortality occurred more rapidly in Site stations. Only test organisms in Sand Reference survived for 4 hours. All endpoints except the 584 are from reference stations.
			LOEC		
	Wood/UV		NOEC		
			LOEC		
P. promelas	Elutriate Sand	7	NOEC	Aqueous concentration not measured.	These are aqueous exposures.
			LOEC		
	Elutriate Wood		NOEC		
			LOEC		
	Dilutions Sand		NOEC		
			LOEC		
	Dilutions Wood		NOEC		
			LOEC		

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																			
			SQT9-1			SQT9-2			SQT9-3			SQT9-4			SQT10-1				
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		
Naphthalene	128.19	3.36		23	0.0103	<	2.6	0.0012		14	0.0077		19	0.0085		16	0.0065		
1-Methylnaphthalene	142.2	3.84		5.6	0.0023	<	2.15	0.0009		4.1	0.0020		3.4	0.0014		3.1	0.0011		
1-Methylphenanthrene	192.26	5.04		19	0.0057		12	0.0038		15	0.0055		20	0.0060	<	2.9	0.0008		
2,3,5-Trimethylnaphthalene	170.26	4.86	<	4.3	0.0015	<	4.05	0.0014	<	2.7	0.0011	<	3.05	0.0010	<	2.05	0.0006		
2,6-Dimethylnaphthalene	156.23	4.37	<	8.5	0.0031	<	8	0.0031	<	5	0.0023	<	6	0.0022	<	4	0.0013		
2-Methylnaphthalene	142.2	3.86		10	0.0040	<	2.25	0.0010		5.7	0.0028		5.5	0.0022		6.5	0.0024		
Acenaphthene	154.21	4.01		9.3	0.0035	<	3.45	0.0014		6.2	0.0028		5.4	0.0020		5.9	0.0020		
Acenaphthylene	152.2	3.22	<	7	0.0026	<	6.5	0.0026	<	4.45	0.0021	<	4.95	0.0019	<	3.4	0.0012		
Anthracene	178.2	4.53		42	0.0135	<	6.5	0.0022	<	4.2	0.0017	<	4.7	0.0015	<	3.2	0.0009		
Fluorene	166.2	4.21		13	0.0045	<	3.95	0.0014		5.4	0.0023	<	2.95	0.0010	<	2	0.0006		
Phenanthrene	178.2	4.57		110	0.0355		60	0.0204		62	0.0245		66	0.0213		79	0.0231		
Total LMW PAHs				251.7	0.0865		111.45	0.0394		128.75	0.0547		140.95	0.0490		128.05	0.0406		
Benzo(a)anthracene	228.29	6.71		17	0.0043	<	7.5	0.0020	<	5	0.0015	<	5.5	0.0014	<	3.9	0.0009		
Benzo(a)pyrene	252.31	6.11	<	9	0.0021	<	8.5	0.0020	<	6	0.0017	<	6.5	0.0015	<	4.4	0.0009		
Benzo(b)fluoranthene	252.32	6.27	<	7.5	0.0017	<	7	0.0017	<	4.65	0.0013	<	5	0.0011		7.2	0.0015		
Benzo(e)pyrene	252.31	6.14	<	6.5	0.0015	<	6	0.0014	<	4.15	0.0012	<	4.65	0.0011		7.2	0.0015		
Benzo(ghi)perylene	276.34	6.51	<	7	0.0015	<	7	0.0015	<	4.55	0.0012	<	5	0.0010		7.6	0.0014		
Benzo(k)fluoranthene	252.32	6.29	<	6	0.0014	<	5.5	0.0013		80	0.0223		41	0.0093		7.5	0.0015		
Chrysene	228.29	5.71	<	6.5	0.0016	<	6.5	0.0017	<	4.2	0.0013	<	4.75	0.0012		11	0.0025		
Dibenz(a,h)anthracene	278.35	6.71		14	0.0029	<	6.5	0.0014	<	4.3	0.0011	<	4.8	0.0010	<	3.3	0.0006		
Fluoranthene	202.26	5.08		39	0.0111	<	6	0.0018		10	0.0035		10	0.0028		24	0.0062		
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	7	0.0015	<	6.5	0.0014	<	4.35	0.0011	<	4.85	0.0010	<	3.3	0.0006		
Perylene	252.31	6.14		31	0.0071	<	12	0.0029		59	0.0165		24	0.0055	<	6	0.0012		
Pyrene	202.26	4.92		30	0.0085	<	7	0.0021	<	4.6	0.0016	<	5	0.0014		20	0.0052		
Total HMW PAHs				180.5	0.0450		86	0.0214		190.8	0.0542		121.05	0.0284		105.4	0.0241		
Total PAHs				432.2	0.1315		197.45	0.0608		319.55	0.1090		262	0.0774		233.45	0.0646		
Dibenzofuran + VOCs				13.40	0.0041		6.12	0.0019		9.91	0.0034		8.12	0.0024		7.24	0.0020		
Total PAHs + VOCs				445.60	0.1356		203.57	0.0627		329.46	0.1123		270.12	0.0798		240.69	0.0666		
% Lipids				1.74			1.65			1.42			1.74			1.92			
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79		
Hazard Quotient					0.04			0.02			0.03			0.02			0.02		

Notes:
1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.
ug/kg = micrograms per kilogram, wet weight
NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																		
			SQT10-2			SQT10-3			SQT10-4			SQT11-1&2			SQT11-3&4			
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid	
Naphthalene	128.19	3.36		17	0.0081		19	0.0095		5.8	0.0905		17	0.0379		13	0.0052	
1-Methylnaphthalene	142.2	3.84		3.2	0.0014		3.5	0.0016	<	1.7	0.0239	<	2.15	0.0043	<	2	0.0007	
1-Methylphenanthrene	192.26	5.04	<	3.7	0.0012	<	3.7	0.0012	<	4.6	0.0479	<	6	0.0089	<	5.5	0.0015	
2,3,5-Trimethylnaphthalene	170.26	4.86	<	2.6	0.0009	<	2.65	0.0010	<	3.25	0.0382	<	4.1	0.0069	<	3.85	0.0012	
2,6-Dimethylnaphthalene	156.23	4.37	<	5	0.0020	<	5	0.0021	<	6.5	0.0832	<	8	0.0146	<	7.5	0.0025	
2-Methylnaphthalene	142.2	3.86		6.2	0.0027		6.9	0.0031	<	1.8	0.0253		7.3	0.0147		5.0	0.0018	
Acenaphthene	154.21	4.01		6.6	0.0026		7.2	0.0030	<	2.75	0.0357		7.8	0.0145	<	3.25	0.0011	
Acenaphthylene	152.2	3.22	<	4.3	0.0017	<	4.35	0.0018	<	5.5	0.0723	<	6.5	0.0122	<	6.5	0.0022	
Anthracene	178.2	4.53	<	4.05	0.0014	<	4.1	0.0015	<	5	0.0561	<	6.5	0.0104	<	6	0.0017	
Fluorene	166.2	4.21		5.1	0.0019	<	2.55	0.0010	<	3.15	0.0379		8.6	0.0148	<	3.7	0.0011	
Phenanthrene	178.2	4.57		75	0.0258		82	0.0295	<	4.55	0.0511		100	0.1603		71	0.0204	
Total LMW PAHs				132.75	0.0497		140.95	0.0553		44.6	0.5620		173.95	0.2995		127.3	0.039384992	
Benzo(a)anthracene	228.29	6.71	<	4.95	0.0013	<	5	0.0014	<	6	0.0526	<	7.5	0.0094	<	7.5	0.0017	
Benzo(a)pyrene	252.31	6.11	<	5.5	0.0013	<	5.5	0.0014	<	7	0.0555	<	8.5	0.0096	<	8	0.0016	
Benzo(b)fluoranthene	252.32	6.27	<	4.45	0.0011	<	4.5	0.0011	<	5.5	0.0436	<	7	0.0079	<	6.5	0.0013	
Benzo(e)pyrene	252.31	6.14	<	4	0.0010	<	4.05	0.0010	<	5	0.0396	<	6.5	0.0074	<	6	0.0012	
Benzo(ghi)perylene	276.34	6.51	<	4.4	0.0010	<	4.45	0.0010	<	5.5	0.0398	<	7	0.0072	<	6.5	0.0012	
Benzo(k)fluoranthene	252.32	6.29	<	3.6	0.0009	<	3.6	0.0009	<	4.45	0.0353		17	0.0192		59	0.0120	
Chrysene	228.29	5.71		9.9	0.0027		9.4	0.0026	<	5	0.0438	<	6.5	0.0081		12	0.0027	
Dibenz(a,h)anthracene	278.35	6.71	<	4.15	0.0009	<	4.2	0.0010	<	5	0.0359	<	6.5	0.0067	<	6	0.0011	
Fluoranthene	202.26	5.08		21	0.0064		24	0.0076	<	4.9	0.0485		33	0.0466		31	0.0079	
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	4.2	0.0009	<	4.25	0.0010	<	5	0.0362	<	6.5	0.0067	<	6	0.0011	
Perylene	252.31	6.14	<	7.5	0.0018	<	7.5	0.0019	<	9.5	0.0753		37	0.0419		36	0.0073	
Pyrene	202.26	4.92		17	0.0052		18	0.0057	<	5.5	0.0544		23	0.0325		30	0.0076	
Total HMW PAHs				90.65	0.0244		94.45	0.0267		68.35	0.5604		166	0.2033		214.5	0.0467	
Total PAHs				223.4	0.074160529		235.4	0.0820		112.95	1.1224		339.95	0.5028		341.8	0.086131624	
Dibenzofuran + VOCs				6.93	0.0023		7.30	0.0025		3.50	0.0348		10.54	0.0156		10.60	0.0027	
Total PAHs + VOCs				230.33	0.0765		242.70	0.0845		116.45	1.1572		350.49	0.5184		352.40	0.0888	
% Lipids				1.63			1.56			0.05			0.35			1.95		
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79	
Hazard Quotient					0.02			0.02			0.31			0.14			0.02	

Notes:
1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.
ug/kg = micrograms per kilogram, wet weight
NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																	
			SQT12-1			SQT12-2			SQT12-3			SQT12-4			SQT2-1		
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid
Naphthalene	128.19	3.36		15	0.0080		16	0.0075		15	0.0073		14	0.0069		22	0.0077
1-Methylnaphthalene	142.2	3.84	<	1.55	0.0007	<	2	0.0008		3.6	0.0016		2.8	0.0012		8	0.0025
1-Methylphenanthrene	192.26	5.04	<	4.2	0.0015	<	5.5	0.0017	<	4.05	0.0013	<	3.4	0.0011		19	0.0044
2,3,5-Trimethylnaphthalene	170.26	4.86	<	2.95	0.0012	<	3.8	0.0013	<	2.9	0.0011	<	2.4	0.0009	<	5.5	0.0014
2,6-Dimethylnaphthalene	156.23	4.37	<	6	0.0026	<	7.5	0.0029	<	5.5	0.0022	<	4.7	0.0019	<	10.5	0.0030
2-Methylnaphthalene	142.2	3.86		6.0	0.0029		6.2	0.0026		6.4	0.0028		5.8	0.0026		9.1	0.0029
Acenaphthene	154.21	4.01		6.6	0.0029	<	3.2	0.0013		7.0	0.0028		5.6	0.0023	<	4.45	0.0013
Acenaphthylene	152.2	3.22	<	4.85	0.0022	<	6	0.0024		13	0.0053	<	3.95	0.0016	<	8.5	0.0025
Anthracene	178.2	4.53	<	4.6	0.0018	<	6	0.0020	<	4.5	0.0016	<	3.75	0.0013	<	8	0.0020
Fluorene	166.2	4.21		8.8	0.0036	<	3.65	0.0013		8.8	0.0033	<	2.35	0.0009	<	5	0.0013
Phenanthrene	178.2	4.57		89	0.0342		100	0.0338		76	0.0265		76	0.0268		120	0.0302
Total LMW PAHs				149.55	0.0617		159.85	0.0577		146.75	0.0557		124.75	0.0475		220.05	0.0593
Benzo(a)anthracene	228.29	6.71		12	0.0036	<	7	0.0018	<	5.5	0.0015		9.7	0.0027		51	0.0100
Benzo(a)pyrene	252.31	6.11	<	6.5	0.0018	<	8	0.0019	<	6	0.0015	<	5	0.0012		36	0.0064
Benzo(b)fluoranthene	252.32	6.27		14	0.0038	<	6.5	0.0016	<	4.95	0.0012		13	0.0032		30	0.0053
Benzo(e)pyrene	252.31	6.14		14	0.0038	<	6	0.0014		13	0.0032		11	0.0027		41	0.0073
Benzo(ghi)perylene	276.34	6.51	<	5	0.0012	<	6.5	0.0014	<	4.85	0.0011	<	4.05	0.0009		32	0.0052
Benzo(k)fluoranthene	252.32	6.29		12	0.0033		26	0.0062		95	0.0234		8.3	0.0021		66	0.0117
Chrysene	228.29	5.71		20	0.0060		15	0.0040		16	0.0044		16	0.0044		61	0.0120
Dibenz(a,h)anthracene	278.35	6.71	<	4.7	0.0012	<	6	0.0013	<	4.6	0.0010	<	3.85	0.0009	<	8.5	0.0014
Fluoranthene	202.26	5.08		32	0.0108		22	0.0066		21	0.0064		21	0.0065		67	0.0149
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	4.75	0.0012	<	6	0.0013	<	4.6	0.0010	<	3.9	0.0009	<	8.5	0.0014
Perylene	252.31	6.14		28	0.0076		73	0.0174		61	0.0150		14	0.0035	<	15.5	0.0028
Pyrene	202.26	4.92		24	0.0081		13	0.0039		13	0.0040		14	0.0044		77	0.0171
Total HMW PAHs				176.95	0.0524		195	0.0488		249.5	0.0637		123.8	0.0334		493.5	0.0954
Total PAHs				326.5	0.1140		354.85	0.1065		396.25	0.1194		248.55	0.0809		713.55	0.1547
Dibenzofuran + VOCs				10.12	0.0035		11.00	0.0033		12.28	0.0037		7.71	0.0025		22.12	0.0048
Total PAHs + VOCs				336.62	0.1176		365.85	0.1098		408.53	0.1231		256.26	0.0835		735.67	0.1595
% Lipids				1.46			1.66			1.61			1.59			2.23	
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79
Hazard Quotient					0.03			0.03			0.03			0.02			0.04

Notes:

1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.

ug/kg = micrograms per kilogram, wet weight

NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																				
			SQT2-2			SQT2-3			SQT2-4			SQT4-1			SQT4-2&4			SQT4-3	
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid
Naphthalene	128.19	3.36		23	0.0111		18	0.0062		18	0.0067		20	0.0136		16	0.0067		15	0.0054
1-Methylnaphthalene	142.2	3.84		9.3	0.0040	<	3.05	0.0010		4.1	0.0014	<	2.25	0.0014		4.1	0.0016		4.4	0.0014
1-Methylphenanthrene	192.26	5.04		17	0.0055	<	8	0.0018		26	0.0065		41	0.0185		44	0.0123		57	0.0137
2,3,5-Trimethylnaphthalene	170.26	4.86	<	6	0.0022	<	6	0.0016	<	3.75	0.0011	<	4.25	0.0022		6.1	0.0019		12	0.0032
2,6-Dimethylnaphthalene	156.23	4.37	<	11.5	0.0045	<	11	0.0031	<	7	0.0021	<	8.5	0.0047	<	5.5	0.0019	<	5.5	0.0016
2-Methylnaphthalene	142.2	3.86		8.8	0.0038	<	3.2	0.0010		7.4	0.0025		8.4	0.0051		8.3	0.0031		7.1	0.0023
Acenaphthene	154.21	4.01	<	4.95	0.0020	<	4.9	0.0014		7.7	0.0024	<	3.6	0.0020		11	0.0038		8.0	0.0024
Acenaphthylene	152.2	3.22	<	9.5	0.0039	<	9.5	0.0028	<	6	0.0019		17	0.0097		65	0.0230		52	0.0157
Anthracene	178.2	4.53	<	9	0.0031	<	9	0.0022	<	6	0.0016		20	0.0098		33	0.0100		41	0.0106
Fluorene	166.2	4.21	<	5.5	0.0020	<	5.5	0.0015		10	0.0029	<	4.15	0.0022		13	0.0042		8.4	0.0023
Phenanthrene	178.2	4.57		110	0.0381		65	0.0162		79	0.0212		110	0.0537		120	0.0362		130	0.0336
Total LMW PAHs				214.55	0.0802		143.15	0.0389		174.95	0.0502		239.15	0.1229		326	0.10468336		340.4	0.09233709
Benzo(a)anthracene	228.29	6.71		47	0.0127		31	0.0060		58	0.0122		310	0.1181		440	0.1036		450	0.0908
Benzo(a)pyrene	252.31	6.11		38	0.0093	<	12.5	0.0022		46	0.0087	<	9	0.0031		380	0.0810		380	0.0694
Benzo(b)fluoranthene	252.32	6.27		27	0.0066	<	10	0.0018		34	0.0064		170	0.0586		260	0.0554		290	0.0530
Benzo(e)pyrene	252.31	6.14		37	0.0091		23	0.0041		44	0.0083		190	0.0655		250	0.0533		260	0.0475
Benzo(ghi)perylene	276.34	6.51		29	0.0065	<	9.5	0.0015		30	0.0052		62	0.0195		96	0.0187		96	0.0160
Benzo(k)fluoranthene	252.32	6.29		130	0.0318		33	0.0058		47	0.0089		260	0.0896		310	0.0661		300	0.0548
Chrysene	228.29	5.71		52	0.0141		38	0.0074		67	0.0140		330	0.1257		400	0.0942		410	0.0828
Dibenz(a,h)anthracene	278.35	6.71	<	9.5	0.0021	<	9	0.0014	<	6	0.0010		14	0.0044		20	0.0039		20	0.0033
Fluoranthene	202.26	5.08		61	0.0186		41	0.0090		72	0.0170		290	0.1247		350	0.0930		400	0.0911
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	9.5	0.0021	<	9.5	0.0015	<	6	0.0010		44	0.0138		65	0.0126		66	0.0110
Perylene	252.31	6.14	<	17	0.0042	<	17	0.0030		30	0.0057	<	12.5	0.0043	<	8.5	0.0018		50	0.0091
Pyrene	202.26	4.92		89	0.0272		72	0.0158		130	0.0308		410	0.1763		640	0.1701		710	0.1618
Total HMW PAHs				546	0.1442		305.5	0.0596		570	0.1194		2101.5	0.8035		3219.5	0.7537		3432	0.6906
Total PAHs				760.55	0.2244		448.65	0.0984		744.95	0.1696		2340.65	0.9264		3545.5	0.8584		3772.4	0.7829
Dibenzofuran + VOCs				23.58	0.0070		13.91	0.0031		23.09	0.0053		72.56	0.0287		109.91	0.0266		116.94	0.0243
Total PAHs + VOCs				784.13	0.2313		462.56	0.1015		768.04	0.1749		2413.21	0.9551		3655.41	0.8850		3889.34	0.8072
% Lipids				1.62			2.25			2.09			1.15			1.86			2.17	
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79			3.79
Hazard Quotient					0.06			0.03			0.05			0.25			0.23			0.21

Notes:

1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.

ug/kg = micrograms per kilogram, wet weight

NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*															
			SQT3-1			SQT3-2			SQT3-3&4			SQT5-1			SQT5-2&3&4	
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid	ug/kg[1]	umol/g lipid
Naphthalene	128.19	3.36		19	0.0274		24	0.0347		15	0.0094		22	0.0114	19	0.0099
1-Methylnaphthalene	142.2	3.84	<	2.8	0.0036	<	2.85	0.0037	<	2.05	0.0012		5.5	0.0026	5.9	0.0028
1-Methylphenanthrene	192.26	5.04		68	0.0655		67	0.0645		59	0.0247		230	0.0798	160	0.0555
2,3,5-Trimethylnaphthalene	170.26	4.86		14	0.0152	<	5.5	0.0060		10	0.0047		81	0.0317	46	0.0180
2,6-Dimethylnaphthalene	156.23	4.37	<	10.5	0.0124	<	10.5	0.0124	<	7.5	0.0039		34	0.0145	18	0.0077
2-Methylnaphthalene	142.2	3.86		8.4	0.0109		14	0.0182		6.9	0.0039		13	0.0061	12	0.0056
Acenaphthene	154.21	4.01	<	4.5	0.0054		9.1	0.0109	<	3.25	0.0017		28	0.0121	16	0.0069
Acenaphthylene	152.2	3.22		59	0.0718		54	0.0657		51	0.0270		200	0.0876	150	0.0657
Anthracene	178.2	4.53		48	0.0499		53	0.0551		42	0.0190		230	0.0860	140	0.0524
Fluorene	166.2	4.21	<	5	0.0056		11	0.0123	<	3.75	0.0018		51	0.0205	30	0.0120
Phenanthrene	178.2	4.57	<	65	0.0675		120	0.1247		120	0.0543		560	0.2095	350	0.1309
Total LMW PAHs				304.2	0.3354		370.95	0.4082		320.45	0.1517		1454.5	0.5618	946.9	0.3674
Benzo(a)anthracene	228.29	6.71		500	0.4056		520	0.4218		500	0.1766		1500	0.4380	1300	0.3796
Benzo(a)pyrene	252.31	6.11		460	0.3376		480	0.3523		470	0.1502		1300	0.3435	190	0.0502
Benzo(b)fluoranthene	252.32	6.27		310	0.2275		290	0.2128		320	0.1023		840	0.2219	710	0.1876
Benzo(e)pyrene	252.31	6.14		310	0.2275		300	0.2202		290	0.0927		770	0.2035	640	0.1691
Benzo(ghi)perylene	276.34	6.51		130	0.0871		120	0.0804		120	0.0350		350	0.0844	310	0.0748
Benzo(k)fluoranthene	252.32	6.29		380	0.2789		360	0.2642		340	0.1087		970	0.2563	810	0.2140
Chrysene	228.29	5.71		460	0.3731		470	0.3813		450	0.1590		1200	0.3504	960	0.2803
Dibenz(a,h)anthracene	278.35	6.71		29	0.0193		26	0.0173		25	0.0072		98	0.0235	92	0.0220
Fluoranthene	202.26	5.08		480	0.4395		500	0.4578		460	0.1834		1500	0.4944	1100	0.3626
Indeno(1,2,3-cd)pyrene	276.34	6.72		91	0.0610		87	0.0583		84	0.0245		290	0.0700	260	0.0627
Perylene	252.31	6.14		70	0.0514		60	0.0440		51	0.0163		190	0.0502	160	0.0423
Pyrene	202.26	4.92		810	0.7416		870	0.7966		790	0.3150		2600	0.8570	1900	0.6263
Total HMW PAHs				4030	3.2502		4083	3.3070		3900	1.3709		11608	3.3931	8432	2.4715
Total PAHs				4334.2	3.5856		4453.95	3.7153		4220.45	1.5227		13062.5	3.9549	9378.9	2.8390
Dibenzofuran + VOCs				134.36	0.1112		138.07	0.1152		130.83	0.0472		404.94	0.1226	290.75	0.0880
Total PAHs + VOCs				4468.56	3.6967		4592.02	3.8304		4351.28	1.5699		13467.44	4.0775	9669.65	2.9270
% Lipids				0.54			1.55			1.24			1.50		2.32	
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79		3.79
Hazard Quotient					0.98			1.01			0.41			1.08		0.77

Notes:
1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.
ug/kg = micrograms per kilogram, wet weight
NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																				
			SQT8-1&2			SQT8-3&4			SQT6-1			SQT6-2&4			SQT6-3					
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid			
Naphthalene	128.19	3.36		43	0.0182		27	0.0094		13	0.0075		14	0.0124		17	0.0086			
1-Methylnaphthalene	142.2	3.84		19	0.0073		9.5	0.0030	<	2.15	0.0011	<	2.1	0.0017	<	2.55	0.0012			
1-Methylphenanthrene	192.26	5.04		13	0.0037		15	0.0035	<	5.5	0.0021	<	5.5	0.0033	<	7	0.0023			
2,3,5-Trimethylnaphthalene	170.26	4.86		9.3	0.0030		11	0.0029	<	4.05	0.0017	<	4	0.0027	<	4.8	0.0018			
2,6-Dimethylnaphthalene	156.23	4.37		21	0.0073		18	0.0051	<	8	0.0038	<	8	0.0058	<	9.5	0.0039			
2-Methylnaphthalene	142.2	3.86		35	0.0134		15	0.0047		4.6	0.0024		5.0	0.0040		6.7	0.0030			
Acenaphthene	154.21	4.01		28	0.0099		29	0.0084		6.8	0.0032	<	3.4	0.0025	<	4.1	0.0017			
Acenaphthylene	152.2	3.22		71	0.0254		99	0.0290	<	6.5	0.0031	<	6.5	0.0049		19	0.0081			
Anthracene	178.2	4.53	<	7	0.0021		15	0.0038	<	6.5	0.0027	<	6.5	0.0041	<	7.5	0.0027			
Fluorene	166.2	4.21		16	0.0052		25	0.0067	<	3.9	0.0017	<	3.9	0.0027		10	0.0039			
Phenanthrene	178.2	4.57		120	0.0366		150	0.0376		76	0.0314		84	0.0536		96	0.0348			
Total LMW PAHs				382.3	0.1320		413.5	0.1141		137	0.0607		142.9	0.0976		184.15	0.0720			
Benzo(a)anthracene	228.29	6.71		34	0.0081		37	0.0072		66	0.0213		71	0.0353		84	0.0237			
Benzo(a)pyrene	252.31	6.11	<	9.5	0.0020		24	0.0042		72	0.0210		81	0.0365		100	0.0256			
Benzo(b)fluoranthene	252.32	6.27	<	7.5	0.0016		18	0.0032		52	0.0152		55	0.0248		67	0.0171			
Benzo(e)pyrene	252.31	6.14		20	0.0043		24	0.0042		62	0.0181		68	0.0306		80	0.0205			
Benzo(ghi)perylene	276.34	6.51	<	7.5	0.0015		16	0.0026		25	0.0067		28	0.0115		33	0.0077			
Benzo(k)fluoranthene	252.32	6.29		35	0.0075		100	0.0177		64	0.0187		71	0.0320		110	0.0281			
Chrysene	228.29	5.71		35	0.0083		40	0.0078		80	0.0258		84	0.0418		97	0.0274			
Dibenz(a,h)anthracene	278.35	6.71	<	7	0.0014	<	6	0.0010	<	6.5	0.0017	<	6.5	0.0027	<	7.5	0.0017			
Fluoranthene	202.26	5.08		55	0.0148		65	0.0143		58	0.0211		60	0.0337		71	0.0226			
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	7	0.0014	<	6	0.0010	<	6.5	0.0017		15	0.0062		17	0.0040			
Perylene	252.31	6.14	<	12.5	0.0027	<	11	0.0019		31	0.0090		97	0.0437	<	14	0.0036			
Pyrene	202.26	4.92		80	0.0215		92	0.0203		110	0.0400		110	0.0618		130	0.0415			
Total HMW PAHs				310	0.0751		439	0.0855		633	0.2001		746.5	0.3605		810.5	0.2235			
Total PAHs				692.3	0.2071		852.5	0.1996		770	0.2608		889.4	0.4581		994.65	0.2955			
Dibenzofuran + VOCs				21.46	0.0064		26.43	0.0062		23.87	0.0081		27.57	0.0142		30.83	0.0092			
Total PAHs + VOCs				713.76	0.2135		878.93	0.2058		793.87	0.2689		916.97	0.4723		1025.48	0.3047			
% Lipids				1.84			2.24			1.36			0.88			1.55				
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79			
Hazard Quotient					0.06			0.05			0.07			0.12			0.08			

Notes:
1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.
ug/kg = micrograms per kilogram, wet weight
NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for *L variegatus*																	
			FORM-1			FORM-2			FORM-3			FORM-4			W. Bear-1		
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid
Naphthalene	128.19	3.36		21	0.0084		17	0.0084		23	0.0085		14	0.0044		16	0.0095
1-Methylnaphthalene	142.2	3.84		4.2	0.0015		3.4	0.0015		5.0	0.0017		2.7	0.0008	<	2.4	0.0013
1-Methylphenanthrene	192.26	5.04	<	3.55	0.0009	<	3.55	0.0012	<	3.9	0.0010	<	3.5	0.0011	<	6.5	0.0026
2,3,5-Trimethylnaphthalene	170.26	4.86	<	2.5	0.0008	<	2.5	0.0009	<	2.8	0.0008	<	2.5	0.0008	<	4.6	0.0020
2,6-Dimethylnaphthalene	156.23	4.37	<	4.85	0.0016	<	4.85	0.0020	<	5.5	0.0017	<	4.8	0.0015	<	9	0.0044
2-Methylnaphthalene	142.2	3.86		8.1	0.0029		6.7	0.0030		7.2	0.0024		5.5	0.0017	<	2.55	0.0014
Acenaphthene	154.21	4.01		9.4	0.0031		7.3	0.0030		6.9	0.0021		5.9	0.0018	<	3.9	0.0019
Acenaphthylene	152.2	3.22		9.2	0.0031	<	4.1	0.0017		9.8	0.0031	<	4.05	0.0013	<	7.5	0.0037
Anthracene	178.2	4.53	<	3.9	0.0011	<	3.9	0.0014		37	0.0098	<	3.85	0.0012	<	7	0.0030
Fluorene	166.2	4.21		42	0.0130		17	0.0065		6.9	0.0020		16	0.0050	<	4.45	0.0020
Phenanthrene	178.2	4.57		100	0.0288		98	0.0350		83	0.0221		69	0.0215		56	0.0238
Total LMW PAHs				208.7	0.0652		168.3	0.0647		191	0.0550		131.8	0.0410		119.9	0.0555
Benzo(a)anthracene	228.29	6.71	<	4.75	0.0011	<	4.75	0.0013	<	5.5	0.0011	<	4.7	0.0015	<	8.5	0.0028
Benzo(a)pyrene	252.31	6.11	<	5.5	0.0011	<	5.5	0.0014	<	6	0.0011	<	5.5	0.0017	<	10	0.0030
Benzo(b)fluoranthene	252.32	6.27	<	4.3	0.0009	<	4.3	0.0011	<	4.75	0.0009	<	4.25	0.0013	<	8	0.0024
Benzo(e)pyrene	252.31	6.14	<	3.85	0.0008	<	3.85	0.0010	<	4.25	0.0008	<	3.8	0.0012	<	7	0.0021
Benzo(ghi)perylene	276.34	6.51	<	4.2	0.0008	<	4.2	0.0010	<	4.65	0.0008	<	4.15	0.0013	<	7.5	0.0021
Benzo(k)fluoranthene	252.32	6.29		89	0.0181	<	3.45	0.0009	<	3.8	0.0007	<	3.4	0.0011	<	6.5	0.0020
Chrysene	228.29	5.71	<	3.9	0.0009	<	3.9	0.0011	<	4.35	0.0009	<	3.85	0.0012	<	7	0.0023
Dibenz(a,h)anthracene	278.35	6.71	<	4	0.0007	<	4	0.0009	<	4.4	0.0007	<	3.95	0.0012	<	7.5	0.0020
Fluoranthene	202.26	5.08		32	0.0081		18	0.0057		25	0.0059		15	0.0047	<	7	0.0026
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	4	0.0007	<	4	0.0009	<	4.45	0.0008	<	3.95	0.0012	<	7.5	0.0021
Perylene	252.31	6.14	<	7.5	0.0015	<	7.5	0.0019	<	8	0.0015		16	0.0050	<	13.5	0.0041
Pyrene	202.26	4.92		13	0.0033	<	4.25	0.0013		11	0.0026	<	4.2	0.0013	<	8	0.0030
Total HMW PAHs				176	0.0380		67.7	0.0184		86.15	0.0178		72.75	0.0227		98	0.0304
Total PAHs				384.7	0.1032		236	0.0832		277.15	0.0729		204.55	0.0637		217.9	0.0860
Dibenzofuran + VOCs				*11.93*	*0.0032*		7.32	*0.0026*		8.59	0.0023		6.34	0.0020		6.75	0.0027
Total PAHs + VOCs				396.63	0.1064		243.32	0.0857		285.74	0.0751		210.89	0.0657		224.65	0.0886
% Lipids				1.95			1.57			2.11			2.59			1.32	
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79			3.79
Hazard Quotient					0.03			0.02			0.02			0.02			0.02

Notes:

1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.

ug/kg = micrograms per kilogram, wet weight

NEBR = No Effect Body Residue

Table 3.1.
Target Lipid Model for *L. variegatus*
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Target Lipid Model for L variegatus															
			W. Bear-2&3			W.Bear-4			Initial			Initial Duplicate			
Compound	MW	log Kow		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid		ug/kg[1]	umol/g lipid	
Naphthalene	128.19	3.36		17	0.0079		9.5	0.0072		15	0.0048		11	0.0035	
1-Methylnaphthalene	142.2	3.84		4.4	0.0018	<	2.15	0.0015		3.6	0.0010		2.6	0.0008	
1-Methylphenanthrene	192.26	5.04	<	5	0.0015	<	5.5	0.0028		2.8	0.0006		2.9	0.0006	
2,3,5-Trimethylnaphthalene	170.26	4.86	<	3.7	0.0013	<	4.05	0.0023		2.7	0.0006		2.5	0.0006	
2,6-Dimethylnaphthalene	156.23	4.37	<	7	0.0027	<	8	0.0050		1.7	0.0004		1.6	0.0004	
2-Methylnaphthalene	142.2	3.86		6.4	0.0027	<	2.25	0.0015		6.7	0.0019		5.3	0.0015	
Acenaphthene	154.21	4.01	<	3.1	0.0012	<	3.45	0.0022		6.1	0.0016		5.6	0.0015	
Acenaphthylene	152.2	3.22	<	6	0.0023	<	6.5	0.0041	<	0.55	0.0001	<	0.65	0.0002	
Anthracene	178.2	4.53	<	5.5	0.0018	<	6.5	0.0035		4.3	0.0010		3.2	0.0007	
Fluorene	166.2	4.21	<	3.55	0.0013		9.6	0.0056		4.2	0.0010		3.2	0.0008	
Phenanthrene	178.2	4.57		72	0.0241		57	0.0311		64	0.0147		65	0.0150	
Total LMW PAHs				133.65	0.0486		114.5	0.0668		111.65	0.0279		103.55	0.0257	
Benzo(a)anthracene	228.29	6.71	<	7	0.0018	<	7.5	0.0032		1.7	0.0003		1.5	0.0003	
Benzo(a)pyrene	252.31	6.11	<	8	0.0019	<	8.5	0.0033	<	0.35	0.0001	<	0.85	0.0001	
Benzo(b)fluoranthene	252.32	6.27	<	6.5	0.0015	<	7	0.0027	<	0.55	0.0001	<	0.65	0.0001	
Benzo(e)pyrene	252.31	6.14	<	5.5	0.0013	<	6	0.0023		1.8	0.0003		1.6	0.0003	
Benzo(ghi)perylene	276.34	6.51	<	6	0.0013	<	7	0.0025		1.7	0.0003		1.5	0.0002	
Benzo(k)fluoranthene	252.32	6.29	<	5	0.0012		42	0.0162	<	0.455	0.0001	<	0.55	0.0001	
Chrysene	228.29	5.71	<	5.5	0.0014	<	6.5	0.0028		3.4	0.0006		3.1	0.0006	
Dibenz(a,h)anthracene	278.35	6.71	<	6	0.0013	<	6.5	0.0023	<	0.55	0.0001	<	0.6	0.0001	
Fluoranthene	202.26	5.08	<	5.5	0.0016	<	6	0.0029		8.7	0.0018		9.2	0.0019	
Indeno(1,2,3-cd)pyrene	276.34	6.72	<	6	0.0013	<	6.5	0.0023	<	0.55	0.0001	<	0.6	0.0001	
Perylene	252.31	6.14	<	10.5	0.0025	<	12	0.0046	<	0.95	0.0002	<	1.1	0.0002	
Pyrene	202.26	4.92	<	6.5	0.0019	<	7	0.0034		7.9	0.0016		7.7	0.0016	
Total HMW PAHs				78	0.0190		122.5	0.0483		28.61	0.0053		28.95	0.0054	
Total PAHs				211.65	0.0677		237	0.1150		140.26	0.0332		132.5	0.0311	
Dibenzofuran + VOCs				6.56	0.0021		7.35	0.0036		4.35	0.0010		4.11	0.0010	
Total PAHs + VOCs				218.21	0.0698		244.35	0.1186		144.60	0.0342		136.61	0.0321	
% Lipids				1.68			1.03			2.45			2.43		
NEBR (umol/g lipid)					3.79			3.79			3.79			3.79	
Hazard Quotient					0.02			0.03			0.01			0.01	

Notes:

1, Concentrations of compounds that were less than (<) the detection limit are estimated as 50% of the detection limit.

ug/kg = micrograms per kilogram, wet weight

NEBR = No Effect Body Residue

APPENDICES

Appendix 1 - Bioassay Sediment Data SQT1-SQT12
Ashland/Norther States Power Lakefront Superfund SIte

Analyte	SQT1			SQT2			SQT3		
	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
METALS (mg/kg)									
Aluminum	900		900	1700		1700	2100		2100
Antimony	0.096	J	0.096	0.22	J	0.22	0.45		0.45
Arsenic	0.51		0.51	2.2		2.2	3.3		3.3
Barium	6.1		6.1	35		35	35		35
Beryllium	0.085		0.085	0.14		0.14	0.2		0.2
Cadmium	0.091	U	0.0455	0.57		0.57	0.55		0.55
Calcium	590		590	5900		5900	5400		5400
Chromium	2.4		2.4	7.3		7.3	7.3		7.3
Cobalt	1.1		1.1	1.9		1.9	3.4		3.4
Copper	3.4		3.4	47		47	43		43
Iron	2300		2300	4200		4200	5800		5800
Lead	3.6		3.6	11		11	20		20
Magnesium	520		520	880		880	1100		1100
Manganese	25		25	76		76	80		80
Mercury	0.029		0.029	0.049		0.049	0.11		0.11
Nickel	2.2		2.2	6.1		6.1	8.0		8.0
Potassium	90		90	270		270	240		240
Selenium	0.18	U	0.09	0.8	J	0.8	0.70	J	0.70
Silver	0.042	J	0.042	0.047	J	0.047	0.083	J	0.083
Sodium	16	J	16	49	J	49	49	J	49
Thallium	0.011	J	0.011	0.057	J	0.057	0.079		0.079
Vanadium	5		5	9.6		9.6	13		13
Zinc	6.5		6.5	35		35	50		50
Cyanide	0.066	U	0.033	0.15	U	0.075	0.16	U	0.08
PAHs (µg/kg)									
1-Methylnaphthalene	14000		14000	35	J	35	120		120
1-Methylphenanthrene	1600		1600	58		58	160		160
2,3,5-Trimethylnaphthalene	1100		1100	14	J	14	30	J	30
2,6-Dimethylnaphthalene	7200		7200	27	J	27	180		180
2-Methylnaphthalene	24000		24000	47	J	47	190		190
Acenaphthene	21000		21000	47	J	47	250		250
Acenaphthylene	1200		1200	96		96	580		580
Anthracene	8000	J	8000	71	J	71	440	J	440
Benzo(a)anthracene	4600		4600	340		340	1800		1800
Benzo(a)pyrene	4100	J	4100	370	J	370	2500	J	2500
Benzo(b)fluoranthene	1800		1800	200		200	1200		1200
Benzo(e)pyrene	2200		2200	190		190	1100		1100
Benzo(g,h,i)perylene	2300		2300	270		270	1400		1400
Benzo(k)fluoranthene	2400		2400	220		220	1300		1300
Chrysene	4200		4200	290		290	1600		1600
Dibenzo(a,h)anthracene	160		160	19	J	19	120		120
Fluoranthene	11000		11000	340		340	1500		1500
Fluorene	7800		7800	32	J	32	180		180
Indeno(1,2,3-cd)pyrene	1700		1700	180		180	1100		1100
Naphthalene	15000		15000	61	J	61	190		190
Perylene	580		580	58	J	58	320		320
Phenanthrene	31000		31000	230		230	800		800
Pyrene	18000		18000	510		510	3100		3100
Total PAHs(µg/kg)			166940			3195			17060
Total PAHS (µg/g)			166.94			3.195			17.06
Carbon Normalized (NOC) PAH (ug/gOC)			36291.30			7.61			42.65
TOC			4600	0		420000			400000

Appendix 1 - Bioassay Sediment Data SQT1-SQT12
Ashland/Norther States Power Lakefront Superfund SIte

Analyte	SQT4			SQT5			SQT6		
	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
METALS (mg/kg)									
Aluminum	1900	J	1900	1700		1700	8600		8600
Antimony	0.59		0.59	0.65		0.65	0.49		0.49
Arsenic	4.3		4.3	3.5		3.5	5.8		5.8
Barium	50		50	35		35	72		72
Beryllium	0.27		0.27	0.17		0.17	0.67		0.67
Cadmium	0.89		0.89	0.5		0.5	0.81		0.81
Calcium	9200	J	9200	6000		6000	3700		3700
Chromium	7		7	6.7		6.7	18		18
Cobalt	3.8		3.8	3.7		3.7	5.8		5.8
Copper	71		71	40		40	51		51
Iron	8200		8200	6200		6200	12000		12000
Lead	16		16	19		19	30		30
Magnesium	1200		1200	110		110	3500		3500
Manganese	140		140	78		78	180		180
Mercury	0.18		0.18	0.15		0.15	0.14		0.14
Nickel	7.7		7.7	7.7		7.7	14		14
Potassium	250		250	200		200	1300		1300
Selenium	1.4	J	1.4	0.86	J	0.86	1.1	J	1.1
Silver	0.11	J	0.11	0.094	J	0.094	0.28		0.28
Sodium	56	J	56	47	J	47	110		110
Thallium	0.1		0.1	0.099		0.099	0.13		0.13
Vanadium	13		13	11		11	29		29
Zinc	69		69	54		54	78		78
Cyanide	0.20	U	0.10	0.17	U	0.085	0.14	U	0.07
PAHs (µg/kg)									
1-Methylnaphthalene	100		100	290		290	15	J	15
1-Methylphenanthrene	120		120	410		410	16		16
2,3,5-Trimethylnaphthalene	47		47	180		180	6.2	J	6.2
2,6-Dimethylnaphthalene	120		120	450		450	12	J	12
2-Methylnaphthalene	160		160	410		410	24		24
Acenaphthene	180		180	790		790	12	J	12
Acenaphthylene	440		440	890		890	98		98
Anthracene	290	J	290	1100	J	1100	42	J	42
Benzo(a)anthracene	1700		1700	3300		3300	230		230
Benzo(a)pyrene	2100	J	2100	3700	J	3700	280	J	280
Benzo(b)fluoranthene	970		970	1900		1900	180		180
Benzo(e)pyrene	950		950	1700		1700	170		170
Benzo(g,h,i)perylene	990		990	2000		2000	210		210
Benzo(k)fluoranthene	1100		1100	2100		2100	190		190
Chrysene	1500		1500	2800		2800	210		210
Dibenzo(a,h)anthracene	91		91	160		160	18		18
Fluoranthene	1200		1200	3400		3400	220		220
Fluorene	110		110	490		490	14	J	14
Indeno(1,2,3-cd)pyrene	860		860	1600		1600	160		160
Naphthalene	170		170	400		400	18	J	18
Perylene	280		280	480		480	52		52
Phenanthrene	620		620	2700		2700	120		120
Pyrene	2900		2900	6400		6400	310		310
Total PAHs(µg/kg)			14098			31250			2297.2
Total PAHS (µg/g)			14.098			31.25			2.2972
Carbon Normalized (NOC) PAH (ug/gOC)			33.57			125.00			24.18
TOC			420000			250000			95000

Appendix 1 - Bioassay Sediment Data SQT1-SQT12
Ashland/Norther States Power Lakefront Superfund SIte

Analyte	SQT7			SQT7 DUP			SQT8		
	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
METALS (mg/kg)									
Aluminum	1100		1100	1100		1100	1800		1800
Antimony	0.077	J	0.077	0.09	J	0.09	0.18	J	0.18
Arsenic	0.49		0.49	0.41		0.41	1.5		1.5
Barium	6.4		6.4	5.7		5.7	28	J	28
Beryllium	0.084		0.084	0.078		0.078	0.14		0.14
Cadmium	0.055	U	0.0275	0.058	U	0.029	0.35		0.35
Calcium	570		570	520		520	4200		4200
Chromium	3.4		3.4	3.7		3.7	6.2		6.2
Cobalt	1		1	1.1		1.1	1.9		1.9
Copper	2.9		2.9	2.7		2.7	23		23
Iron	2500		2500	2600		2600	3800		3800
Lead	2.3		2.3	1.9		1.9	9.4		9.4
Magnesium	510		510	720		720	800		800
Manganese	26		26	27		27	69		69
Mercury	0.025	J	0.025	0.014	J	0.014	0.019	J	0.019
Nickel	2.2		2.2	2.2		2.2	4.7		4.7
Potassium	160		160	120		120	240		240
Selenium	0.19	U	0.095	0.18	U	0.09	0.45	J	0.45
Silver	0.036	J	0.036	0.047	J	0.047	0.035	U	0.0175
Sodium	29	J	29	17	J	17	33	J	33
Thallium	0.0085	U	0.00425	0.0079	U	0.00395	0.038	J	0.038
Vanadium	7.1		7.1	6.2		6.2	9.0		9.0
Zinc	8.8		8.8	6.8		6.8	35		35
Cyanide	0.063	U	0.031	0.07	U	0.035	0.16	U	0.08
PAHs (µg/kg)									
1-Methylnaphthalene	540		540	400		400	16000		16000
1-Methylphenanthrene	440		440	400		400	93		93
2,3,5-Trimethylnaphthalene	180		180	160		160	200		200
2,6-Dimethylnaphthalene	830		830	700		700	2200		2200
2-Methylnaphthalene	690		690	480		480	19000		19000
Acenaphthene	1700		1700	1800		1800	7300		7300
Acenaphthylene	290		290	300		300	160		160
Anthracene	1400	J	1400	1300	J	1300	300	J	300
Benzo(a)anthracene	1300		1300	1500		1500	260		260
Benzo(a)pyrene	1500	J	1500	1500	J	1500	250	J	250
Benzo(b)fluoranthene	620		620	640		640	160		160
Benzo(e)pyrene	670		670	710		710	140		140
Benzo(g,h,i)perylene	760		760	760		760	190		190
Benzo(k)fluoranthene	770		770	770		770	170		170
Chrysene	1200		1200	1300		1300	250		250
Dibenzo(a,h)anthracene	50		50	46		46	15	J	15
Fluoranthene	2900		2900	3300		3300	340		340
Fluorene	1100		1100	1100		1100	1900		1900
Indeno(1,2,3-cd)pyrene	570		570	570		570	140		140
Naphthalene	110	J	110	55	J	55	19000		19000
Perylene	190		190	190		190	46	J	46
Phenanthrene	4700		4700	5700		5700	1800		1800
Pyrene	4300		4300	4900		4900	650		650
Total PAHs(µg/kg)			22510			23681			69914
Total PAHS (µg/g)			22.51			23.681			69.914
Carbon Normalized (NOC) PAH (ug/gOC)			6083.78			7176.06			249.69
TOC			3700			3300			280000

Appendix 1 - Bioassay Sediment Data SQT1-SQT12
Ashland/Norther States Power Lakefront Superfund SIte

Analyte	SQT8 DUP			SQT9			SQT10			
	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result
METALS (mg/kg)										
Aluminum	2000		2000	680		680	310		310	870
Antimony	0.36	J	0.36	0.086	U	0.043	0.065	U	0.0325	0.20
Arsenic	2.3		2.3	0.49		0.49	0.34		0.34	1.7
Barium	54	J	54	7.7		7.7	2.7		2.7	22
Beryllium	0.21		0.21	0.041	J	0.041	0.032	J	0.032	0.084
Cadmium	0.38		0.38	0.08	U	0.04	0.054	U	0.027	0.44
Calcium	4300		4300	1300		1300	190		190	4600
Chromium	7.6		7.6	2		2	0.86		0.86	4.3
Cobalt	2.0		2.0	0.4		0.4	0.28		0.28	0.84
Copper	15		15	2.3		2.3	1.3	U	0.65	8.4
Iron	4500		4500	1100		1100	640		640	2300
Lead	13		13	2		2	1.1		1.1	5.1
Magnesium	870		870	280		280	140		140	470
Manganese	77		77	18		18	12		12	49
Mercury	0.044	J	0.044	0.0067	J	0.0067	0.0023	J	0.0023	0.015
Nickel	5.6		5.6	1.3		1.3	0.66		0.66	2.7
Potassium	250		250	120		120	61		61	150
Selenium	0.82	J	0.82	0.28	U	0.14	0.19	U	0.095	0.62
Silver	0.038	J	0.038	0.025	U	0.0125	0.019	U	0.0095	0.04
Sodium	46	J	46	19	J	19	10	U	5	46
Thallium	0.096	J	0.096	0.012	U	0.006	0.0083	U	0.00415	0.019
Vanadium	11		11	3.8		3.8	1.5		1.5	6.3
Zinc	35		35	7.3		7.3	3.1		3.1	23
Cyanide	0.19	U	0.095	0.12	U	0.06	0.07	U	0.035	0.16
PAHs (µg/kg)										
1-Methylnaphthalene	11000		11000	2.4	J	2.4	0.79	J	0.79	30
1-Methylphenanthrene	85		85	39		39	0.23	U	0.115	82
2,3,5-Trimethylnaphthalene	150		150	0.75	U	0.375	0.37	U	0.185	26
2,6-Dimethylnaphthalene	1600		1600	0.99	U	0.495	0.48	U	0.24	25
2-Methylnaphthalene	13000		13000	3.3	J	3.3	1.1	J	1.1	35
Acenaphthene	5500		5500	1.5	J	1.5	0.55	J	0.55	14
Acenaphthylene	110		110	2.9		2.9	0.42	U	0.21	56
Anthracene	310	J	310	0.81	UJ	0.405	0.58	J	0.58	120
Benzo(a)anthracene	210		210	0.99	U	0.495	1.7	J	1.7	380
Benzo(a)pyrene	190	J	190	1.3	UJ	0.65	2	J	2	310
Benzo(b)fluoranthene	110		110	2.8		2.8	1.5		1.5	200
Benzo(e)pyrene	100		100	0.49	U	0.245	1.1		1.1	150
Benzo(g,h,i)perylene	140		140	0.6	U	0.3	4.3		4.3	180
Benzo(k)fluoranthene	130		130	2.4		2.4	1.3		1.3	230
Chrysene	200		200	2.4		2.4	1.9		1.9	330
Dibenzo(a,h)anthracene	12	J	12	0.54	U	0.27	0.36	J	0.36	17
Fluoranthene	290		290	5.2		5.2	2.7		2.7	600
Fluorene	1500		1500	1.5	J	1.5	0.51		0.51	74
Indeno(1,2,3-cd)pyrene	96		96	0.5	U	0.25	1.3		1.3	170
Naphthalene	12000		12000	7.2		7.2	1.1		1.1	41
Perylene	27	J	27	1.5	U	0.75	1.2		1.2	58
Phenanthrene	1600		1600	8.1		8.1	3.0	U	1.5	670
Pyrene	570		570	0.76	U	0.38	5.6		5.6	720
Total PAHs(µg/kg)			48360			82.935			26.24	
Total PAHS (µg/g)			48.36			0.082935			0.02624	
Carbon Normalized (NOC) PAH (ug/gOC)			98.69			1.43			20.18	
TOC			490000			58000			1300	

Appendix 1 - Bioassay Sediment Data SQT1-SQT12
Ashland/Norther States Power Lakefront Superfund SIte

Analyte	SQT11		SQT12		
	Flag	Risk Result	Result	Flag	Risk Result
METALS (mg/kg)					
Aluminum		870	690		690
Antimony	J	0.20	0.058	U	0.029
Arsenic		1.7	0.49		0.49
Barium		22	6.4		6.4
Beryllium	J	0.084	0.056		0.056
Cadmium		0.44	0.052	U	0.026
Calcium		4600	420		420
Chromium		4.3	1.9		1.9
Cobalt		0.84	0.68		0.68
Copper		8.4	1.9	U	0.95
Iron		2300	1700		1700
Lead		5.1	1.2		1.2
Magnesium		470	420		420
Manganese		49	17		17
Mercury		0.015	0.0015	U	0.0007
Nickel		2.7	1.8		1.8
Potassium		150	87		87
Selenium	J	0.62	0.18	U	0.09
Silver	U	0.02	0.017	U	0.0085
Sodium	J	46	12	J	12
Thallium	U	0.0095	0.008	U	0.004
Vanadium		6.3	4.6		4.6
Zinc		23	6.7		6.7
Cyanide	U	0.08	0.071	U	0.035
PAHs (µg/kg)					
1-Methylnaphthalene		30	0.65	U	0.325
1-Methylphenanthrene		82	0.31	U	0.155
2,3,5-Trimethylnaphthalene		26	0.49	U	0.245
2,6-Dimethylnaphthalene	J	25	0.64	U	0.32
2-Methylnaphthalene		35	0.68	U	0.34
Acenaphthene	J	14	0.54	U	0.27
Acenaphthylene		56	0.55	U	0.275
Anthracene	J	120	0.52	UJ	0.26
Benzo(a)anthracene		380	0.64	U	0.32
Benzo(a)pyrene	J	310	0.81	UJ	0.405
Benzo(b)fluoranthene		200	0.51	U	0.255
Benzo(e)pyrene		150	0.32	U	0.16
Benzo(g,h,i)perylene		180	0.39	U	0.195
Benzo(k)fluoranthene		230	0.4	U	0.2
Chrysene		330	0.32	U	0.16
Dibenzo(a,h)anthracene		17	0.35	U	0.175
Fluoranthene		600	1.5		1.5
Fluorene		74	0.46	U	0.23
Indeno(1,2,3-cd)pyrene		170	0.32	U	0.16
Naphthalene		41	0.72	U	0.36
Perylene		58	0.96	U	0.48
Phenanthrene		670	1.5		1.5
Pyrene		720	1.4	J	1.4
Total PAHs(µg/kg)		3798			8.29
Total PAHS (µg/g)		3.798			0.00829
Carbon Normalized (NOC) PAH (ug/gOC)		13.56			25.91
TOC		280000			320

Appendix 2
LSRI Report

EVALUATION OF SEDIMENTS FROM THE ASHLAND HARBOR LAKEFRONT SITE FOR TOXICTY TO *HYALELLA AZTECA, PIMEPHALES PROMELAS, CHIRONOMUS DILUTUS,* AND *LUMBRICULUS VARIEGATUS* EXPOSED IN A VARIETY OF BIOASSAYS

By

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FINAL REPORT

To

URS
10200 Innovation Drive, Suite 500
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April 2006

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INTRODUCTION

The University of Wisconsin-Superior's Lake Superior Research Institute (LSRI) contracted with URS to evaluate sediments from the Ashland Lakefront site for toxicity toward several species of benthic invertebrates and one species of fish. Sediment samples were collected from a total of six reference stations and eight Site stations. The contaminated sediment from one of the sites was diluted with dilution sediment to obtain a concentration gradient. The following tests were conducted: a 28-day exposure of *Hyalella azteca*, a 21-day exposure of *Hyalella azteca* to reference sediment only, a 28-day exposure of *Hyalella azteca* to new reference sediment and previous non-reference sediment, a ten-day exposure of *Hyalella azteca* to a sediment dilution series under laboratory and ultraviolet light conditions with some treatments containing detritus, one seven-day solid phase fathead minnow exposure, one seven-day solid phase fathead minnow exposure under ultraviolet light, an early life stage *Chironomus dilutus* exposure, a *Lumbriculus variegatus* bioaccumulation study, and finally a sediment polycyclic aromatic hydrocarbon (PAH) equilibrium partitioning study. The endpoints of survival and growth were determined for most studies except for the bioaccumulation study and PAH equilibrium study. Only survival was used as an endpoint for the 21-day exposure of *Hyalella azteca* to the newly collected reference sediment.

METHODS

Sediment Collection, Preparation and Chemical Analysis

Sediment was collected by staff from URS between the dates of 18 June 2005 and 24 June 2005 and placed in plastic two-gallon pails with minimal head space. Two new reference (SQT13 and SQT14) sediment samples were collected on September 27, 2006. The sediment was picked up from the Ashland Harbor site by LSRI staff and transported back to the lab on ice, or in the case of the September samples, dropped off by URS at the LSRI laboratory. The samples were stored at 4.0 °C until they were homogenized. The samples were designated as having been collected from a reference station, a Site station and the general substrate type noted. Table 1 describes the treatments and includes performance controls.

Table 1. Sediment Identification, Designation, and Substrate Type.

Treatment Identification	Designation	Substrate Type
Silica Sand	Performance control	Sand
West Bearskin	Performance control	Sand
Formulated Sediment	Performance control	Sand
SQT9	Reference	Wood
SQT10	Reference	Sand
SQT11	Reference	Wood
SQT12	Reference	Sand
SQT13	Reference	Sand
SQT14	Reference	Sand
SQT1	Non-reference	Sand
SQT2	Non-reference	Wood
SQT3	Non-reference	Sand
SQT4	Non-reference	Wood
SQT5	Non-reference	Wood
SQT6	Non-reference	Sand
SQT7	Non-reference	Sand

Prior to testing, the sediment was homogenized for 15 minutes using a commercial drill equipped with a stainless steel mortar paddle. At 5-minute intervals, the sediment was briefly stirred manually to ensure further homogeneity. After homogenization, all sediment was immediately placed into the test beakers. Between homogenization of sediments, all equipment was cleaned with a lab soap solution, lab water, 10% nitric acid, deionized water, acetone, and deionized water. Samples were collected from each sediment for the following determinations: PAHs, TAL metals, TOC, total sulfide, total cyanide, and grain size (sieve only). The samples were sent to Pace Analytical, Green Bay, WI for analysis and results transmitted to URS.

Solid Phase Sediment Toxicity Tests

Solid phase sediment toxicity tests were performed with the following four freshwater species: the crustacean *Hyalella azteca*, the insect *Chironomus dilutus*, the oligochaete *Lumbriculus variegatus*, and the fish *Pimephales promelas* (fathead minnow). The objectives of each of the tests were slightly different and will be discussed below. In general, the objective was to determine whether the contaminants in the sediment were harmful to the test organisms.

The LSRI test protocols: "Conducting a 28-d Sediment Toxicity Test with *Hyalella azteca"* (SOP AT/34); "Conducting a 28-d Bioaccumulation Sediment Toxicity Test with the Oligochaete, *Lumbriculus variegatus*" (SOP AT/19); and "Conducting a 7-d Sediment Renewal Toxicity Test with *Pimephales promelas*" (SOP AT/33) are based upon EPA-developed methods (U.S. EPA, 2000). Conducting an Early Life Stage Sediment Renewal Toxicity Test with *Chironomus dilutus* is also based upon the EPA-developed method (U.S. EPA, 2000). Briefly, the tests were initiated with juvenile life-stages in the cases of *H. azteca* (7-8 days old), *C. dilutus* (less than 4.0 hours old), *P. promelas* (7 days old), and adult *L.variegatus* organisms. The tests were performed at water temperatures of 23.0 ±2.0 °C, and the overlying water was regularly exchanged within the aquaria containing the screened beakers approximately two times daily at a rate of 32.0 ± 2.0 mL/min for approximately 1.0 hour. A 16L:8D photoperiod was maintained.

Test	Method	Conditions	Fed	Age of Organism at test initiation	Endpoint
28-d H. azteca	USEPA 2000, LSRI SOP AT/34	Sediment from 8 site stations and 4 reference stations	1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids.	7-8 d	Mortality, weight
21-d H. azteca	USEPA 2000, LSRI SOP AT/34	Sediment from 1 site station and 2 reference stations	1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids.	7-8 d	Mortality
28-d H. azteca	USEPA 2000, LSRI SOP AT/34	Sediment from 8 site stations and 2 "old" and 2 "new" reference stations	1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids.	7-8 d	Mortality, weight
10-d H. azteca	USEPA 2000, LSRI SOP AT/34	Sediment from 4 site stations, a dilution series (SQT1), and 2 reference stations	1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids.	7-8 d	Mortality, weight
10-d H. azteca	USEPA 2000, LSRI SOP AT/34	Sediment from 4 site stations, a dilution series (SQT1), and 2 reference stations. Exposed to UV light	1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids.	7-8 d	Mortality, weight
7-d P. promelas	USEPA 2000, LSRI SOP AT/33	Sediment from 8 site stations and 4 reference stations	0.15 g (1000-1500 nauplii) of newly hatched (less than 24-h old) brine shrimp nauplii (2x daily)	7 d	Mortality, weight
7-d P. promelas	USEPA 2000, LSRI SOP AT/33	Sediment from 8 site stations and 4 reference stations. Exposed to UV light	0.15 g (1000-1500 nauplii) of newly hatched (less than 24-h old) brine shrimp nauplii (2x daily)	7 d	Mortality, weight
10-d C. dilutus	USEPA 2000	Sediment from 8 site stations and 4 reference stations	1.0 mL daily of a 4.0 g/L Tetrafin® suspension	< 4.0 hr	Mortality, weight
28-d L. variegates	USEPA 2000, LSRI SOP AT/19	Sediment from 6 site stations and 4 reference stations	No feeding	Adult	Bioaccumulation

Approximately 100 mL of homogenized sediment was placed into each 300-mL beaker containing two screened holes about two-thirds of the distance up the beaker walls to allow for water exchange between the beaker and the aquarium in which it was placed. Each aquarium contained eight replicate beakers for each species and sediment type tested. A set of eight replicate beakers was placed into a glass aquarium, which received the renewal water. The aquaria were then placed within the larger water baths set to maintain the desired test temperature (23.0 °C). Sediment was added one day prior to the addition of the test animals to allow the sediment to settle and overlying water to clear. Observations of the bioassay beakers showed that particulates remained suspended for at least several days in tests with sandy and woody sediments (Appendix 22, Photos). Ten organisms were added to each replicate for all species except for the *C. dilutus* which had twelve organisms added. The replicate beakers were fed equal volumes of food. *H. azteca* received 1.0 mL daily of a yeast, Cerophyll®, and trout chow mixture containing 1800 mg/L total suspended solids. *C. dilutus* was fed 1.0 mL daily of a 4.0 g/L Tetrafin® suspension. Fathead minnows were fed twice daily, six hours apart, 0.15 g (1000-1500 nauplii) of newly hatched (less than 24-h old) brine shrimp nauplii. The *L. variegatus* test organisms were not fed during the test. At the end of the appropriate exposure period, sediment from each beaker was sieved through a 425µm mesh sieve, rinsed into a clear Pyrex® pan, placed over a light table, and the surviving organisms retrieved. The *H. azteca* and *P. promelas* organisms were placed into dried, pre-weighed aluminum pans and dried at approximately 60°C for 24 hours to obtain dry weight measurements. Ash-free dry weights were also determined on the *C. dilutus* by placing the previously ashed and weighed pans containing the animals in a muffle furnace at 550 °C for approximately 2.0 hours. The *L. variegatus* were placed in clean lab water and allowed to depurate overnight. Wet-weights were determined on *L. variegatus* before placing them in amber vials and freezing prior to body residue analysis. Weights were determined to 0.1 mg for all survivors.

During the tests, twice daily measurements were made of dissolved oxygen and temperature. pH and conductivity was measured several times throughout an exposure period. Total alkalinity, total hardness, ammonia, and non-purgeable organic carbon (NPOC) was measured at the beginning and end of the exposure period.

Dilution Sediment Test

Based upon the results of the initial *H. azteca* 28 day test there was no survival in Station SQT1 (a sand station) and low survival (6%) in SQT7 (a sand station). In order to verify this result and to better establish an effects threshold it was decided to make a serial dilution (100, 50, 25, 12.5%) of SQT1 volumetrically. It was decided not to dilute a woody site as toxicity was not observed. It was decided to make a serial dilution (100, 50, 25, 12.5%) of SQT1 volumetrically. Rather than dilute STQ1 with reference sediment because of the low reference stations survival, it was decided to make dilution sediment with a mixture of West Bearskin (WBS) and silica sand. The diluent tests were calculated as follows:

West Bearskin: 19.2 % solids, 7.0 % TOC
SQT1: 81.5% solids, 0.46% TOC

Therefore, the diluent sediment should contain 0.46% TOC and 81.5% solids. On a kg basis:

1000g (0.46%) = (X g) (7.0%)
X = 65.7 g dry WBS.

Therefore, silica sand = 1000g – 65.7 g= 934 g dry weight.

However, the WBS sediment exists as wet weight, so

65.7 g dry X (100g wet/19.2 g dry) = 342 g wet WBS

So, 934 g silica sand was mixed with 342 g wet WBS to yield a diluent containing 0.46% TOC on dry wt basis and 78.4% solids. The percent solids are lower unless we remove water from the WBS. This did not matter as when the sediment is placed into the beaker water was added. SQT1 and the dilution sediment were measured volumetrically into a mixing container where it was mixed and placed into the testing system as described above. *H. azteca* were the only organisms exposed to this dilution series. No additional time for equilibration between the SQT1 sediment and the diluent sediments was provided.

Ultraviolet (UV) Light Enhancement Toxicity Tests

Both *H. azteca* and *P. promelas* were exposed to UV light in a regime designed to replicate field conditions.

Field measurements of UV light

Prior to the UV-light exposure, UV-A (315-400 nm) and UV-B (280-315 nm) measurements were made at the Ashland harbor sites using an IL1700 International Light Research Radiometer/Photometer. Appropriate detectors, filters, and calibration factors corresponding to UV-A and UV-B wavelengths were used. The UV-light levels in Ashland Harbor were measured on 3 August 2005, which was a cloudy day and turbid water conditions were present. The second collection period, 31 August 2005, represented the clear sky day. On both sampling days measurements were taken at five different times (08:00, 10:00, 14:00, 16:00, 18:00 hrs), at the surface and three different depths (2 cm below the surface, mid-depth, and bottom) and at two different locations SQT1 (7.6 feet deep) and SQT2 (10.1 feet deep) at the Ashland site. UVA and UVB measurements were made at 10.0 cm intervals at one site to determine a rate of attenuation. Attempts to place the detector surface in the nepheloid layer were unsuccessful, so that the deepest readings were made slightly above the sediment-water interface. The results are summarized in Appendix Table 23. These data were submitted to URS who conferred with staff from the USEPA-Duluth laboratory (Dr. David Mount)

to decide on an appropriate UV light regime. Since these UV measurements were made after the summer solstice and did not include solar noon, they were adjusted as recommended by Dr. Mount. Readings from the near bottom were selected for testing with *H. azteca* and mid-water readings were selected for testing with *P. promelas*. After significant discussion between URS and EPA-Duluth personnel, it was agreed to conduct a 10-day bioassay for *H. azteca* at 45 $\mu W/cm^2$ UVA and 0.4 $\mu W/cm^2$ UVB and a 7-day bioassay for the fatheads at a mid-depth exposure of 248 $\mu W/cm^2$ UVA and 6 $\mu W/cm^2$ UVB (Appendix 1).

Laboratory Regime

In the laboratory UV light bulbs (UV-A 340 bulbs, Q-panel Co.) were used to simulate field conditions. Measurements were taken at the beginning and the end of each UV exposure bioassay using the same meter as in the field and under the same exposure conditions (i.e., beakers present, overlying water present, glass covers present) as in the actual bioassay. Mean initial UVA and UVB readings for the *H.* azteca 10-d test were 44.9 $\mu W/cm^2$ and 3.79 $\mu W/cm^2$, respectively. The UVA lab exposure was very close to the desired field exposure condition. The UVB was higher than the desired exposure condition and likely due to spectral overlap between UVA and UVB. At the end of the 10-d *H. azteca* test the grand average for UVA was 42.4 $\mu W/cm^2$ and the grand average for UVB was 3.03 $\mu W/cm^2$. For the 7-d fathead exposure the following are the mean UVA and UVB intensities at the beginning of the exposure 238.0 $\mu W/cm^2$ and 18.2 $\mu W/cm^2$. Measurements were not taken at the end of the exposure. We used a constant intensity and a 16:8 light dark cycle. See Appendix 1 for rationale on UV bioassay exposure.

To determine the effect that avoidance behavior of UV light had on toxicity 4-5 1.0 cm leaf plugs were added to each beaker during the UV light exposure. Leafs were collected from the litter layer at Wisconsin Point Forest. One centimeter plugs were cut out of the leaves and allowed to soak in de-ionized water for four weeks. The water was changed weekly. The leaf plugs were autoclaved prior to addition to the exposure beakers.

Statistical Analysis

Data were analyzed using the SigmaStat® program (Jandel Corporration, 1995). Data analyses included: normality (Komogorov-Smirnov) testing, equal variance testing, one way analysis of variance (ANOVA), and a suite of tests for comparison between treatment means. Non-normal survival and weight data, when possible, were transformed using the arc sine-square root transformation (U.S. EPA 2000) to normalize the data. In some instances, data would not normalize after using different transformations. These data were analyzed using a non-parametric (Kruskal-Wallis or Dunn's Method) analysis of ranks. Data that passed the equal variance test used Tukey's test for all pairwise comparison tests. Mean percent survival and mean dry weight values for laboratory control sediments and the appropriate reference sediment were analyzed with a statistical significance level of 0.05. Abbott's formula for adjusting test mortality to control or

reference mortality was employed to compare normal light and the UV light exposures. Statistical analyses raw data files are kept on file at the Lake Superior Research Institute and are available upon request.

Quality Assurance/Quality Control

Toxicity tests were initiated with healthy, vigorous animals. Reference toxicant tests were performed with all test species prior to the start of the definitive test. Control charts are available upon request. In the sediment toxicity tests, percent survival and dry weights of survivors in sand performance controls were compared to published test acceptability criteria (U.S.EPA, 2000) to determine the overall performance of the animals and the test system. Empty aluminum drying pans along with Class I standardized weights were used as a check for the organism drying process and the performance of the balance. Test conditions were monitored twice daily for parameters that might affect the outcome of the test (i.e., temperature, and dissolved oxygen). Daily and weekly calibration of test meters ensured optimal performance. Reference standards and duplicate samples were used in the analysis of ammonia, alkalinity, and hardness. The LSRI quality assurance and quality control manager performed inspections of logbooks, recorded measurements, and instrumentation used during the tests. Any deviations were discussed with the principal investigator and documented in the study logbook. The sediment studies were conducted with a high degree of quality assurance/quality control criteria.

RESULTS

Lumbriculus variegatus Bioaccumulation Study. A 96-hour toxicity screening was conducted prior to the start of the 28-d bioaccumulation study. The results from the 96-hour screening showed that sediments SQT7 and SQT1 were acutely toxic. These sediments were not used in the bioassay exposure. *L. variegatus* tissue was sent to Pace Analytical for PAH and lipid analysis. Summary results are reported in Appendix Table 2. A complete set of data with level four quality assurance and quality control has been previously submitted to URS. All tissue date are reported as µg/g wet weight.

Polycyclic aromatic hydrocarbon water concentration equilibrium study. A time series sampling of overlying water over fourteen days was used to determine partitioning and equilibration of PAHs from the sediment into the overlying water. Samples were collected and sent to Pace Analytical for analysis. Summary results are reported in two parts in Appendix Table 3 and 3.1. A complete set of data with level four quality assurance and quality control has been previously submitted to URS.

Hyalella azteca 28-d test (29 June to 27 July 2005). Mean percent survival (80.0-95.0 %) over the 28 days of exposure was high for animals exposed in the performance control sediments (silica sand, West Bearskin, and formulated sediment, Table 2). Reference sites SQT9 and SQT11 also had high mean percent survival (80.0-90.0, Table 2). Reference sites SQT10 and SQT12 had mean percent survivals of 40.0 ± 12.0 and 48.8 ± 29.5, respectively. Treatment sites ranged from 0.0 – 91.3 mean percent survival.

Treatments SQT1 and SQT7 mean percent survivals (0.0 and 6.3 ± 5.2, respectively) were significantly ($p < 0.05$) reduced when compared to the performance controls and reference sites SQT9 and SQT11 (Table 2). SQT3 mean percent survival (72.5 ± 8.9) was significantly ($p < 0.05$) reduced when compared to the performance controls of silica sand and West Bearskin. Statistical comparison was made using the reference sites SQT10 and SQT12. SQT1 and SQT7 were significantly ($p < 0.05$) reduced when compared to the reference sites of SQT10 and SQT12. The rest of the treatment sites had significantly great survival when compared to the reference sites SQT10 and SQT12. Individual survival counts are presented in Appendix Table 4.

Mean dry weight per individual ranged from 0.24 ± 0.05 mg to 0.49 ± 0.25 mg in the reference sediment and performance control treatments (Table 2). Average dry weight ranged from 0.26 ±0.04 mg to 0.42 ± 0.08 mg in the treatment sediments (Table 2). No significance difference at any Site station was detected at 95.0 % confidence. Individual growth measurements are presented in Appendix Table 4.

The mean percent survival of the performance control organisms (80.0-95.0 %) met test acceptability criteria of, where the criterion for acceptability is a mean survival level of 80.0 percent (U.S. EPA, 2000). The final mean values for the dry weights of the performance control (0.24-0.49 mg) for *H. azteca* are greater then the recommended value of 0.15 mg from several round robin tests (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 5.

Hyalella azteca 21-d test (12 August to 2 September 2005). A 21-day *H.azteca* test conducted as a repeat exposure to reference sites SQT10 and SQT12 which had experienced significant mortality in the initial *H. azteca* test. The 21-day test had acceptable survival (97.5 ± 4.6) in silica sand performance control (Table 3). Sand reference stations SQT10 and SQT12 had mean percent survivals of 50.0 ±18.5 and 76.3 ± 18.5, respectively (Table 3). These results were similar to the previous 28-d *H. azteca* test. Individual survival counts are presented in Appendix Table 6). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 7.

Hyalella azteca 28-d test (7 October to 4 November 2005). Because of low survival in the sand reference stations (SQT10 and SQT12) in the initial 28-day *H. azteca* bioassay, the bioassay was conducted again using sediments from two new sand reference stations (SQT13 and SQT14) collected in September. Mean percent survival ranged from 20.0 – 88.8 over the 10 days of exposure for animals exposed in the performance control sediments (silica sand, West Bearskin, and formulated sediment, Table 4). Traditionally at LSRI we have had low survival in the formulated sediment recommended by USEPA. Reference wood stations SQT9 and SQT11 had mean percent survivals of 65.0-85.0 (Table 4). New reference sand stations SQT13 and SQT14 had

mean percent survivals of 37.5 ± 21.9 and 52.5 ± 26.6, respectively (Table 4). Treatment sites ranged from 0.0 – 90.0 mean percent survival. Treatments SQT1 and SQT7 mean percent survivals (0.0 and 17.5, respectively) were significantly ($p < 0.05$) reduced when compared to the performance controls of silica sand and West Bearskin and reference sites SQT9 and SQT11 (Table 4). Statistical comparison was made using the reference sites SQT13 and SQT14 and the other treatments. All treatments sites with the exception of SQT1 and SQT7 had significantly greater survival. SQT1 and SQT7 were significantly ($p < 0.05$) reduced when compared to reference sites SQT13 and SQT14. Individual survival counts are presented in Appendix Table 8.

Mean dry weight per individual ranged from 0.24 ± 0.04 mg to 0.85 ± 0.14 mg in the reference sediment and performance control treatments (Table 4). Average dry weight ranged from 0.24 ±0.05 mg to 0.41 ± 0.18 mg in the treatment sediments (Table 4). SQT6 growth was significantly reduced ($p < 0.05$) when compared to the silica sand performance control. Individual growth measurements are presented in Appendix Table 8.

The mean percent survival of the performance control organisms (87.5-88.8) met the test acceptability criterion of 80.0 percent (U.S. EPA, 2000). The formulated performance control sediment was not used in determining test acceptability. The final mean values for the dry weights of the performance control (0.24-0.48 mg) for *H. azteca* are greater then the recommend value of 0.15 mg from several round robin tests (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 9.

Hyalella azteca 10-d test (3 January to 13 January 2006). These test results are from the sediment dilution of SQT1 and are the control (laboratory light) for the concurrently conducted UV light test. Mean percent survival ranged from 97.5 -100.0 over the 28 days of exposure for animals exposed in the performance control sediments (silica sand and West Bearskin Table 5). Reference sites SQT9 and SQT11 also had high mean percent survival (97.5 and 93.8, Table 5). The sediment used to dilute the sediment from SQT1 had 101.3 percent survival, Table 5. Treatment sites ranged from 0.0 – 97.5 mean percent survival. Treatments SQT1 had 0.0 percent survival which was significantly ($p < 0.05$) reduced when compared to the performance controls of silica sand and West Bearskin and reference sites SQT9, SQT11, and the dilution sediment (Table 5). The 50% dilution of SQT1 was also significantly ($p < 0.05$) reduced when compared to all of the performance controls and reference sediments (Table 5). No significant difference was detected in survival in the rest of the dilution (25% and 12.5%) of SQT1. SQT8 survival was also significantly ($p < 0.05$) reduced when compared to the silica sand and dilution sediment controls (Table 5). Individual survival counts are presented in Appendix Table 10.

Mean dry weight per individual ranged from 0.11 ± 0.01 mg to 0.18 ± 0.02 mg in the reference sediment and performance control treatments (Table 5). Average dry

weight ranged from 0.10 ±0.01 mg to 0.19 ± 0.04 mg in the treatment sediments (Table 5). Only the 25% dilution of SQT1 had significantly reduced growth. Individual growth measurements are presented in Appendix Table 10.

The mean percent survival of the performance control organisms (97.5 – 100.0) met test acceptability of 80.0 percent (U.S. EPA, 2000). The final mean values for the dry weights of the performance control (0.11-0.15 mg) for *H. azteca* are very similar to the recommend value of 0.15 mg from several 28-d round robin tests (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 11.

Hyalella azteca 10-d test UV light (3 January to 13 January 2006). These test results are from the sediment dilution of SQT1 and are exposed to UV light. In an additional treatment, beakers containing the same dilution sediment series also had 4-5 1.0 cm leaf plugs added to act as a form of detritus and provide refugia to the organisms. Mean percent survival ranged from 91.3 - 98.8 over the 10 days of exposure for animals exposed in the performance control sediments (silica sand, silica sand with leaf plugs, and West Bearskin Table 6). Reference sites SQT9 and SQT11 also had high mean percent survival (91.3 and 78.8, Table 6). The sediment used to dilute SQT1 sediment had 97.5 percent survival, Table 6. Treatment sites ranged from 0.0 – 95.0 mean percent survival. Treatments SQT1, 50% SQT1 with and with out leaf plugs, and 25% SQT1 with and with out leaf plugs were significantly ($p < 0.05$) reduced when compared to the performance controls of silica sand, silica sand with leaf plugs, West Bearskin and reference sites SQT9, SQT11, and the dilution sediment (Table 6). No significant difference was detected in survival in 12.5% SQT1 with and with out leaf plugs when compared to the performance controls and reference sites. SQT5 survival 40.0 ± 20.0 was also significantly ($p < 0.05$) reduced when compared to all of the performance control and reference sediments (Table 6). SQT4 survival (71.3 ± 12.5) was significantly ($p < 0.05$) reduced when compared to the silica sand with and with out leaf plugs and the dilution sediment (Table 6). Individual survival counts are presented in Appendix Table 12.

After applying Abbot's formula to correct for percent mortality in the silica sand control for both the UV and laboratory light the results are as follows: The 12.5% SQT1 with laboratory light and 12.5% SQT1 with UV light are significantly ($p < 0.05$) different from each other in the respects of survival, whereas, the 12.5 % SQT1 with laboratory light and 12.5% SQT1 with UV light and with leaf plugs are not significantly different. The 25.0 % SQT1 under UV light when compared to 25.0% SQT1 under laboratory light has significantly ($p < 0.05$) reduced survival. The 25% SQT1 with leaf plugs under UV light is significantly ($p < 0.05$) reduced when compared to the 25% SQT1 under laboratory light. However, the 25% SQT1 with leaf plugs had significantly greater survival when compared to the 25 % SQT1 without leaf plugs while both are exposed under UV light. The 50% SQT1 with and with out leaf plugs has significantly ($p < 0.05$) reduced survival when compared to the 50% SQT1 laboratory light exposed.

Mean dry weight per individual ranged from 0.11 ± 0.01 mg to 0.17 ± 0.03 mg in the reference sediment and performance control treatments (Table 6). Average dry weight ranged from 0.11 ±0.01 mg to 0.16 ± 0.03 mg in the treatment sediments (Table 6). Significant ($p < 0.05$) difference was detected in growth in treatments 12.5 % SQT1, 25 % SQT1, 25%SQT 1 with leaf plugs, SQT2, SQT4, and SQT5 (Table 6). Individual growth measurements are presented in Appendix Table 12.

The mean percent survival of the performance control organisms (91.3– 98.8) met test acceptability criterion of 80.0 percent (U.S. EPA, 2000). Currently there are no guidelines for test acceptability for a ten-day test The final mean values for the dry weights of the performance control (0.11-0.17 mg) for *H. azteca* are very similar to the recommend value of 0.15 mg from several 28-d round robin tests (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 13.

Pimephales promelas 7-d test (July 8-15, 2005). Mean percent survival ranged from 82.5 – 95.0 over the 7 days of exposure for animals exposed in the performance control sediments (silica sand, formulated sediment, and West Bearskin, Table 7). Reference sites SQT9, SQT10, SQT11, and SQT12 also had high mean percent survival (70.0-96.3, Table 7). No significant reduction in survival was detected over the 7 days of exposure. Individual survival counts are presented in Appendix Table 14.

Mean dry weight per individual ranged from 0.58 ± 0.07 mg to 0.75 ± 0.16 mg in the reference sediments and performance control treatments (Table 7). Average dry weight ranged from 0.47 ±0.06 mg to 0.71 ± 0.09 mg in the treatment sediments (Table 7). Significant ($p < 0.05$) decrease was detected in growth in treatment SQT1 relative to the silica sand performance control and the reference sediment SQT10, but not to the other control and reference sediments (Table 7). Individual growth measurements are presented in Appendix Table 14.

The mean percent survival of the performance control organisms (82.5 – 95.0) met test acceptability criterion of 80.0 percent (U.S. EPA, 2000). The final mean values for the dry weights of the performance control (0.58-0.71 mg), and all other treatments for *P. promelas* are greater than the recommended value of 0.25 mg (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 15.

Pimephales promelas 7-d test UV light (27 January 2006 – 2 February 2006). Mean percent survival ranged from 73.8 – 87.5 over the 7 days of exposure for animals exposed in the performance control sediments (silica sand, formulated sediment, and West Bearskin Table 8). Reference sites SQT9, SQT10, SQT11, and SQT12 also had high mean percent survival (73.8-82.5, Table 8). Treatments SQT7 and SQT1 had

significant ($p < 0.05$) reduction in survival (28.8 ±2.2 and 0.0, respectively) when compared to all of the performance controls and reference sediments (Table 8). Individual survival counts are presented in Appendix Table 16.

The survival data was corrected for percent mortality in the silica sand controls. The comparison was then made between survival of the laboratory light and UV light exposed bioassays. Treatment sites SQT7 and SQT1 exposed to UV light were significantly ($p < 0.05$) reduced when compared to the laboratory light exposed treatments.

Mean dry weight per individual ranged from 0.54 ± 0.09 mg to 0.59 ± 0.16 mg in the reference sediments and performance control treatments (Table 8). Average dry weight ranged from 0.45 ±0.11 mg to 0.63 ± 0.18 mg in the treatment sediments (Table 8). No significant ($p < 0.05$) difference was detected in growth in treatments relative to the performance controls and the reference sediments (Table 8). Individual growth measurements are presented in Appendix Table 16.

The mean percent survival (81.3 and 87.5) of the performance control organisms in the silica sand and West Bearskin sediment met test acceptability criterion of 80.0 percent (U.S. EPA, 2000). The formulated sediment survival (73.8) is slightly below the U.S. EPA criterion of 80% (2000).The final mean values for the dry weights of the performance control (0.58-0.59 mg) and all treatments except SQT1 ( ) for *P. promelas* are greater than the recommended value of 0.25 mg (U.S. EPA, 2000). The measured values for the water quality characteristics indicate that the quality of the overlying water with regard to these characteristics was acceptable for tests with this species (U.S. EPA, 2000). Individual water characteristic measurements are presented in Appendix Table 17.

Chironomus dilutus early life stage test (10 February 2006 to 3 March 2006). Mean percent survival for animals exposed in the performance controls of silica sand and West Bearskin were 100.0 and 97.2, respectively (Table 9). Formulated sediment mean percent survival was 30.0 ± 20.0. The reference sediments SQT9, SQT11, SQT13, and SQT14 mean percent survival ranged from 3.0-30.0 (Table 9). Treatment SQT6 had a high mean percent survival of 96.0 (Table 9). The other treatments mean percent survivals ranged from 0.0-13.0 (Table 9). Statistical comparisons were made (Table 9). Individual survival counts are presented in Appendix Table 18.

Mean ash free dry weight was calculated and reported in Table 9. No statistical significance was detected due to the high variability in survival affecting the growth results. Individual growth measurements are presented in Appendix Table 19.

CONCLUSIONS

The Lake Superior Research Institute (LSRI) contracted with URS to evaluate the toxicity of sediments collected from several sites in Ashland Harbor, Ashland Wisconsin. The survival of *H. azteca* in the 29 June 2005 28 day experiment showed no survival in

sites SQT1 and 6.3 percent survival in SQT7. These are both significantly reduced when compared to the performance control. There was less than 50 percent survival in two of the reference sediments (SQT10 and SQT12) provided. Data indicates that the low survival was not from experimental methods as the performance controls and other treatment sediment had high survival (> 80.0 %). Observations were made during homogenization of the sediment that a strong odor of decaying organic matter was detected. These stations both had slightly elevated levels of ammonia (Appendix Table 11). Both sediments also had the presence of snail shells noted during the homogenization. A repeat exposure of *H. azteca* to the same reference sediment was conducted to determine if the results were repeatable. The survival was very similar to the previous test. No significant difference was detected in growth in the original 28-d. *H. azteca* test. Due to the poor survival in reference sediments SQT10 and SQT12, new reference sediment was collected by URS staff.

After the collection of the new reference sediment (SQT13 and SQT14), another *H. azteca* 28-d test was conducted. Again, there was no survival in SQT1 and the survival in SQT7 was 17.5% which was significantly reduced when compared to the performance controls and reference sediments. The reference sediments SQT13 and SQT14 had low survival 37.5 and 52.5%, respectively. The test met acceptable performance criteria. Treatment survival results are very similar when compared to the first 28-d *H. azteca*. No differences in growth were detected when compared to the controls.

After examining the survival results of the *H. azteca* tests and the sediment chemistry it was decided by URS that a threshold level of total PAHs and mortality needed to be determined. This was accomplished by diluting SQT1, which had complete mortality, with non-toxic sediment. Table 5 shows that the highest SQT1 dilution (12.5%) had a 97.5% mean survival while the 50% dilution had 15.0 % mean survival. The 50% SQT1 and SQT1 had significant reduction in survival when compared to the performance and reference sediments. Based on the data in Table 5 the threshold value of survival lies somewhere between the 25% and 50% of sediment SQT1.

The same dilution regime as above was used in a bioassay along with UV light exposure. Some of the treatments also contained leaf plugs that provided potential refuge from the UV light (Table 6). Treatments 25% SQT1 with out and with leaf plugs, 50% SQT1 with out and with leaf plugs, 100% SQT1 with out and with leaf plugs, and SQT5 show a significant reduction in survival when compared to the performance controls and reference sediments. The general trend with the dilution series as mentioned above applies here also, as the SQT1 sediment percentage increases, survival decreases. It should also be noted that the survival in treatments 12.5% SQT1, 25% SQT1, 50% SQT1, SQT4 and SQT5 when exposed to UV light is reduced when compared to their non-UV exposed counterparts. It appears that leaf plugs do provide some protection from the UV light. Survival (78.8%) was reduced in 12.5% SQT1 without leaf plugs and was 95% in 12.5% SQT1 with leaf plugs. The same trend held true for the 25% SQT1 concentration. However, the 50% SQT1 concentration with and with out leaf plugs had 0.0 % survival.

FINAL REPORT

BASELINE ECOLOGICAL RISK ASSESSMENT - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

VOLUME II: APPENDICES A - I

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January 2007

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Appendices A – I

Appendices

Appendix A Screening for Contaminants of Potential Concern

Appendix B Sediment Quality Triad Study

Appendix C Fish Tissue Investigation

Appendix D Surface Water Investigation

Appendix E Characterization Of Wetlands And Terrestrial Habitats

Appendix F Description of Food Web Modeling

Appendix G Data Quality Objectives (DQOs)

Appendix H Toxicological Reference Values and Benchmarks

Appendix I Exposure and Risk Estimates

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS[2]

µg/g	Micrograms per gram (parts per million)
µg/kg	Micrograms per kilogram (parts per billion)
µg/L	Micrograms per liter (parts per billion)
$\mu W/cm^2$	Microwatt per square centimeter
ACR	Acute to chronic ratio
ADD	Average daily dose
Ag	Silver
AH	Aromatic hydrocarbons
ANCOVA	Analysis of covariance
AOI	Area of interest
ARARs	Applicable or relevant and appropriate requirements
As	Arsenic
ATSDR	Agency for Toxic Substances and Disease Registry
AUF	Area use factor
AVS	Acid volatile sulfides
AWQC	Ambient water quality criteria
BAF	Bioaccumulation factor
BaP	Benzo(a)pyrene
BERA	Baseline Ecological Risk Assessment
BSAF	Biota sediment accumulation factors
BTEX	Benzene, toluene, ethylbenzene, and xylene
BW	Body weight
CBR	Critical body residue
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
COC	Chemical of concern
COPC	Chemical of Potential Concern
CS	Contaminated sand
CSM	Conceptual Site Model
Cu	Copper
CW	Contaminated wood
DBH	Diameter breast height
DNA	Deoxyribonucleic acid
DOC	Dissolved organic carbon
DQO	Data Quality Objective
ECOSAR	Ecological Structure Activity Relationships
ECO-SSL	Ecological Screening Level
EC_{20}	Effective concentration – 20 percent response
EC_{50}	Effective concentration – 50 percent response
ED_{20}	Effective dose – 20 percent response
ED_{50}	Effective dose – 50 percent response

[2] This list includes acronyms, abbreviations, and definitions used in the BERA text and appendices.

USEPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERA	Ecological Risk Assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERED	Environmental Residue Effects Database
ER-L	Effects range-low
ER-M	Effects range-median
ESA	Endangered Species Act
ESL	Ecological Screening Level
ETO	Ephemeropter, trichoptera, odonata
FS	Feasibility Study
GPS	Global Positioning System
ha	Hectare
Hg	Mercury
HHRA	Human health risk assessment
HMW-PAHs	High molecular weight polycyclic aromatic hydrocarbons
HOMO	Highest occupied molecular orbit
HQ	Hazard Quotient
IR	Ingestion rate
Kow	Octanol-water partition coefficient
LMW-PAHs	Low molecular weight polycyclic aromatic hydrocarbons
LOAEC	Lowest observed adverse effect concentration
LOAEL	Lowest observed adverse effects level
LOEC	Lowest observed effects concentration
LSRI	Lake Superior Research Institute
LUMO	Lowest unoccupied molecular orbit
MD	Maryland
MDR	Minimum daily requirement
mg/kg	Milligrams per kilogram (parts per million)
mg/kg/d	Milligrams per kilogram per day
mg/kg BW/d	Milligrams per kilogram body weight per day
mg/L	Milligrams per Liter (parts per million)
MGP	Manufactured gas plant
MI	Michigan
MSL	Mean sea level
NA	Not applicable
NC	Not calculated
NCP	National Contingency Plan
NE	Not established
NEBR	No effect body residue
NOAA	National Oceanic and Atmospheric Administration
NOAEC	No observed adverse effect concentration
NOAEL	No observed adverse effects level
NOC-PAH	PAH concentration normalized to organic carbon
NOEC	No observed effects concentration
NOEL	No observed effects level

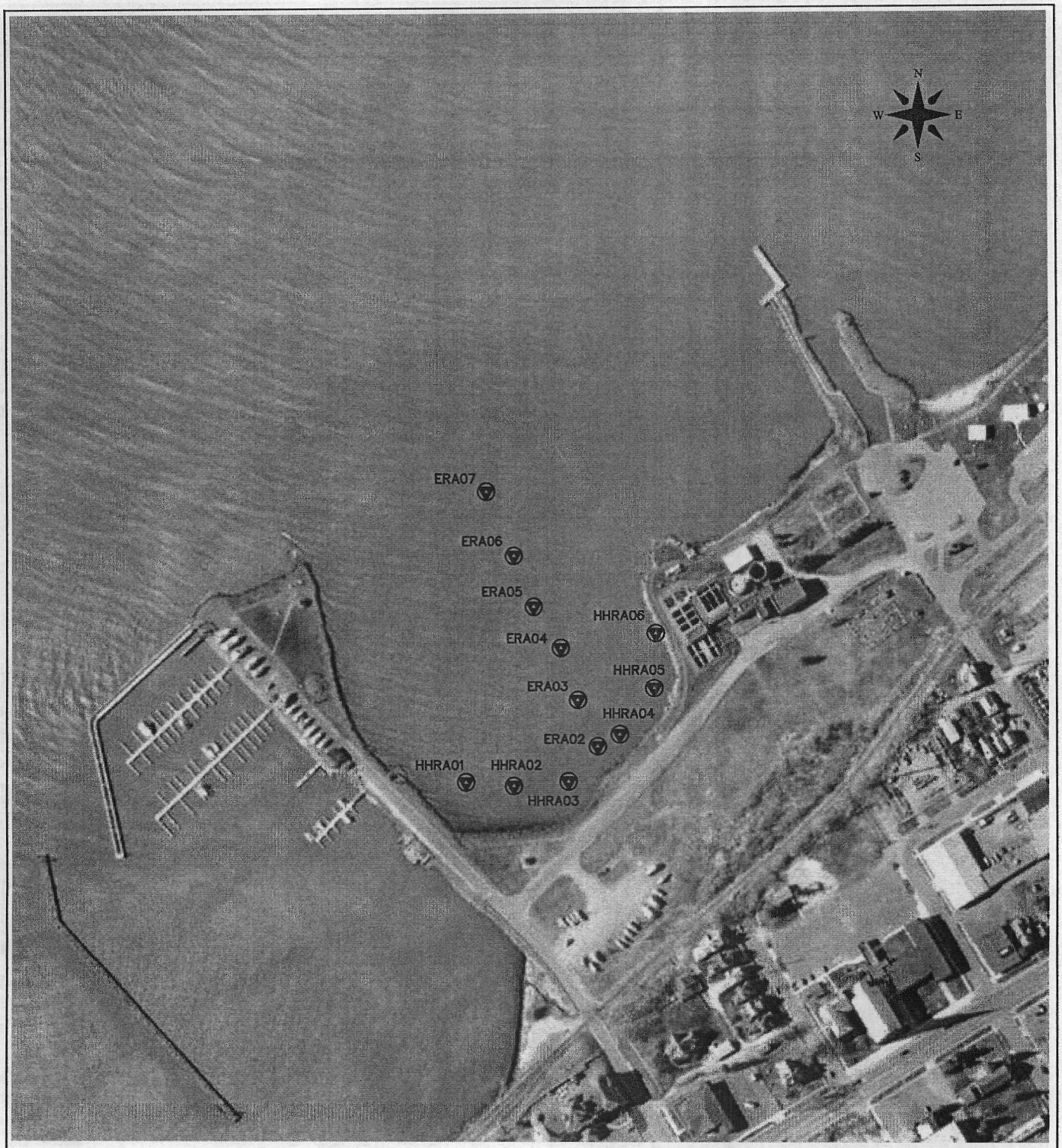
NRDA	Natural Resource Damage Assessment
NRWQC	National Recommended Water Quality Criteria
NSP	Northern States Power
NWI	National Wetland Inventory
OC	Organic carbon
ORNL	Oak Ridge National Laboratory
PAH	Polycyclic aromatic hydrocarbon
Pb	Lead
PCBs	Polychlorinated biphenysl
PEC	Probable effects concentration
PER	Photoenzymatic repair
POM	Particulate organic matter
ppm	Parts per million
ppb	Parts per billion
PRG	Preliminary Remedial Goal
QA	Quality assurance
QAPP	Quality assurance project plan
QSARs	Quantitative structure-activity relationships
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROC	Receptor of concern
SLERA	Screening Level Risk Assessment
SEM	Simultaneously extractable metals
SMDP	Scientific Management Decision Point
SQUIRT	NOAA Screening Quick Reference Table
SQT	Sediment Quality Triad
SVOC	Semivolatile organic compound
SW	Surface Water
T&E	Threatened and endangered
TEC	Threshold effect concentration
TEL	Threshold Effects Level
TLM	Target Lipid Model
TOC	Total organic carbon
TPAH	Total polycyclic aromatic hydrocarbons
TRV	Toxicity Reference Value
TU	Toxic unit
UCL	Upper Confidence Limit
UPL	Upper Prediction Limit
USACE	U.S. Army Corp. of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UV	Ultraviolet light
UVA	Ultraviolet light (340-400 nm)
UVB	Ultraviolet light (280-320 nm)
UVC	Ultraviolet light (200-280 nm)

VOC	Volatile organic compound
WCMP	Wisconsin Coastal Management Program
WDNR	Wisconsin Department of Natural Resources
WI	Wisconsin
WPBCO	Weathered Prudhoe Bay crude oil
WWTP	Waste water treatment plant
Zn	Zinc

Appendix A
Contaminant Screening

Data for screening of contaminants in surface water was taken from stations sampled during the RI investigation (Figure A-1).

Data for screening of contaminants in sediment (Figure A-2) and soil (Figure A-3) was taken from historical data collection activities as well as data collected during the RI. For sediment, data from sampling depths 0-6" was used when available, however, if data from that depth interval was unavailable in areas of the Site, data from the depth interval 0-2' was used. Figure A-2 shows the depth intervals for each station.



LEGEND:

SURFACE WATER SAMPLE STATION

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SURFACE WATER SAMPLE STATIONS

DRAWN BY:	FS	SCALE:	1" = 300'	PROJECT:	25688375
CHECKED BY:	WSB	DATE:	17.MAY.2006	SHEET:	A-1
APPROVED BY:	WSB				

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

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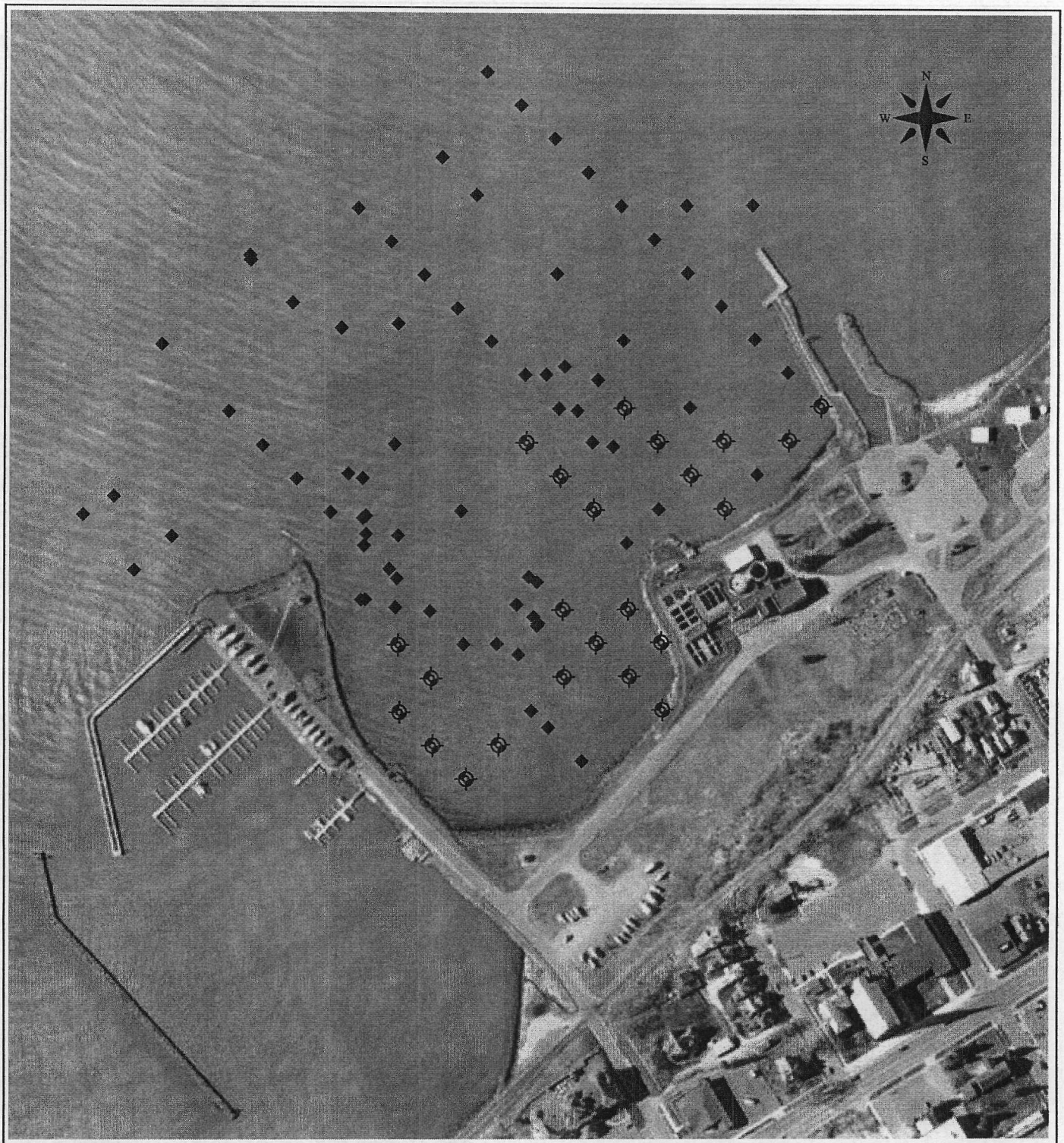

LEGEND:

SEDIMENT SAMPLE STATION

◆ SAMPLE DEPTH = 0–0.5'

⊙ SAMPLE DEPTH = 0–2'

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SEDIMENT SAMPLE STATIONS

DRAWN BY:	FS	SCALE:	1" = 300'	PROJECT:	25688375
CHECKED BY:	WSB	DATE:	17.MAY.2006	SHEET:	A–2
APPROVED BY:	WSB				

URS
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MILWAUKEE, WISCONSIN 53226
414–831–4100

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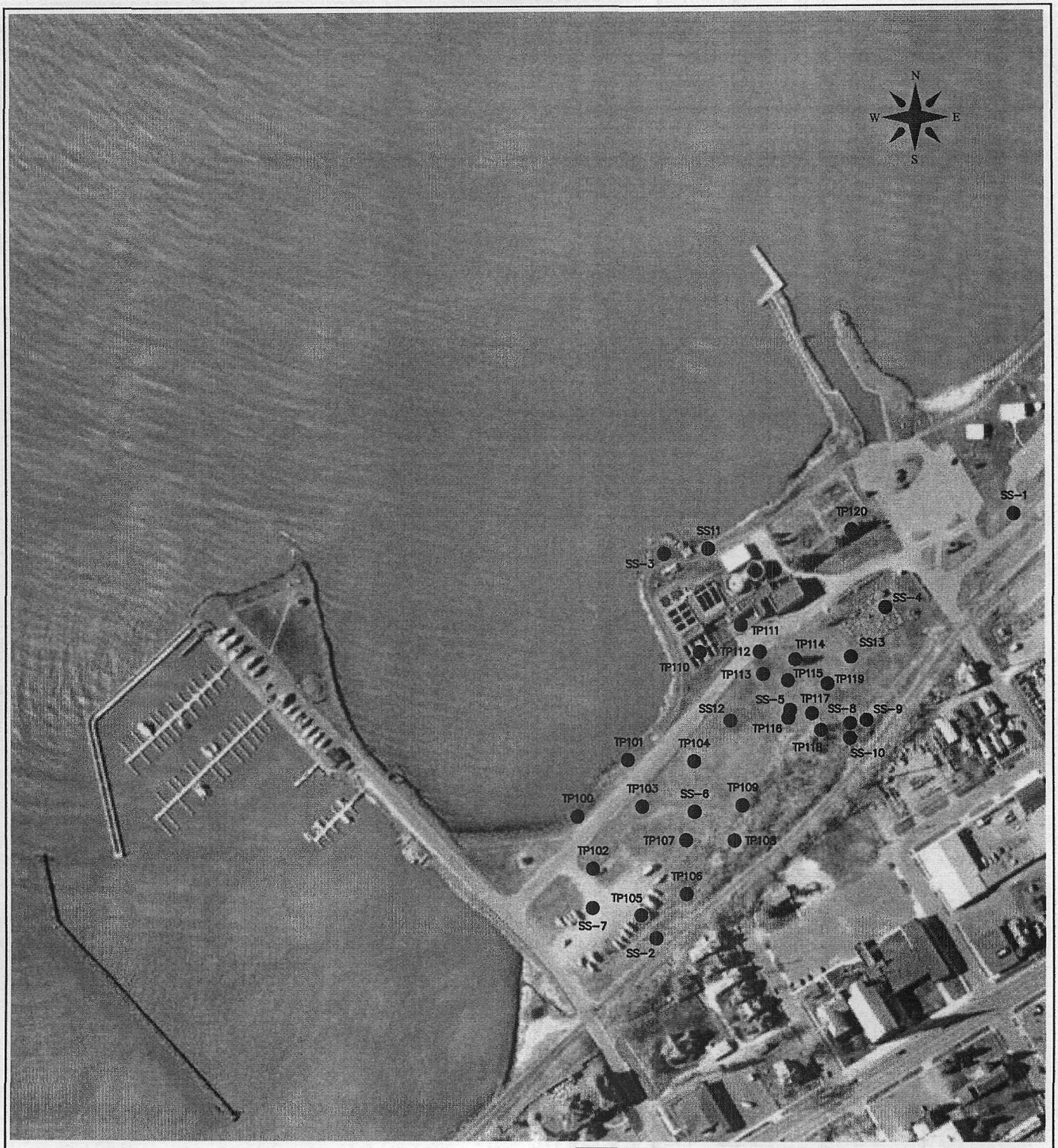

LEGEND:

● SOIL SAMPLE STATION

0 300 600

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: SOIL SAMPLE STATIONS

DRAWN BY:	FS	SCALE:	1" = 300'	PROJECT:	25688375
CHECKED BY:	WSB	DATE:	17.MAY.2006	SHEET:	A-3
APPROVED BY:	WSB				

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Table A-1
Surface Water Data Summary - Low Energy Event
Human Health Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Low Energy	VOC	Benzene	ug/L	6	2	33	0.26	0.28	0.14	non-parametric	Jackknife	0.22
Low Energy	VOC	Toluene	ug/L	6	4	67	0.26	0.34	0.25	normal	Student's-t	0.33
Low Energy	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	6	100	1.3	2.7	1.93	normal	Student's-t	2.31

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. 95% UCL = 95% Upper Confidence Limit
4. Table includes data from surface water sampling stations HHRA01, HHRA02, HHRA03, HHRA04, HHRA05 and HHRA06
5. Only consitutents detected at least once were evaluated
6. Data shown is for total fraction (unfiltered samples)
7. Low energy event sampling conducted in June 2005

Data Distribution and 95% UCL:

Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-2
Surface Water Data Summary - High Energy Event
Human Health Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
High Energy	VOC	1,2,4-Trimethylbenzene	ug/L	6	1	17	0.17	0.17	0.10	*non-parametric*	Jackknife	0.13
High Energy	VOC	Benzene	ug/L	6	5	83	0.15	0.74	0.27	gamma	Standard Bootstrap	0.42
High Energy	VOC	Ethylbenzene	ug/L	6	6	100	0.19	0.48	0.36	normal	Student's-t	0.44
High Energy	VOC	m & p-Xylenes	ug/L	6	2	33	0.39	0.44	0.26	non-parametric	Jackknife	0.36
High Energy	VOC	Toluene	ug/L	6	2	33	0.29	0.31	0.18	non-parametric	Jackknife	0.26
High Energy	PAH	1-Methylnaphthalene	ug/L	6	2	33	1.1	1.1	0.73	non-parametric	Jackknife	0.97
High Energy	PAH	2-Methylnaphthalene	ug/L	6	2	33	1.1	1.2	0.75	non-parametric	Jackknife	1.01
High Energy	PAH	Acenaphthene	ug/L	6	1	17	1.1	1.1	0.64	non-parametric	Jackknife	0.83
High Energy	PAH	Naphthalene	ug/L	6	5	83	1.1	1.8	1.38	normal	Student's-t	1.78
High Energy	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	5	83	0.63	2.1	1.06	normal	Student's-t	1.59

Notes:

1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. 95% UCL = 95% Upper Confidence Limit
4. COC = Constituent of Concern
5. Table includes data from surface water sampling stations HHRA01, HHRA02, HHRA03, HHRA04, HHRA05 and HHRA06
6. Only consitutents detected at least once were evaluated
7. Data shown is for total fraction (unfiltered samples)
8. High energy event sampling conducted in November 2005

Data Distribution and 95% UCL:

Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-3
Surface Water Data Summary and Screening - Low Energy Event
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Sample Depth	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	HQ	COC Decision
Low Energy	Mid	VOC	Benzene	ug/L	6	2	33	0.15	0.35	0.13	non-parametric	Jackknife	0.22	11.4	3.07E-02	No
Low Energy	Mid	VOC	Toluene	ug/L	6	6	100	0.3	0.51	0.38	normal	Student's-t	0.44	253	2.02E-03	No
Low Energy	Mid	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	6	100	1.3	2.2	1.53	gamma	Jackknife	1.83	NE	NC	NA
Low Energy	Near Bottom	VOC	Benzene	ug/L	5	1	20	0.37	0.37	0.13	non-parametric	Jackknife	0.26	11.4	3.25E-02	No
Low Energy	Near Bottom	VOC	Toluene	ug/L	5	3	60	0.31	0.49	0.28	normal	Student's-t	0.44	253	1.94E-03	No
Low Energy	Near Bottom	OTHER	Dissolved Organic Carbon (DOC)	mg/L	5	5	100	1.1	1.8	1.48	normal	Student's-t	1.79	NE	NC	NA

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Table includes data from surface water sampling stations ERA02, ERA03, ERA04, ERA05, ERA06 and ERA07; dissolved fraction
10. Only detected consitutents were evaluated
11. Low energy event sampling conducted in June 2005
12. HQ calculated as follows: HQ = Maximum Detected Concentration/Criteria

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-4
Surface Water Data Summary and Screening - High Energy Event
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Sampling Event	Sample Depth	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	HQ	COC Decision
High Energy	Mid	VOC	Benzene	ug/L	6	2	33	0.15	0.19	0.10	non-parametric	Jackknife	0.15	11.4	1.67E-02	No
High Energy	Mid	VOC	Ethylbenzene	ug/L	6	1	17	0.22	0.22	0.11	non-parametric	Jackknife	0.15	14	1.57E-02	No
High Energy	Mid	VOC	Toluene	ug/L	6	4	67	0.3	0.41	0.30	normal	Student's-t	0.39	253	1.62E-03	No
High Energy	Mid	PAH	Naphthalene	ug/L	6	2	33	1.6	2.2	1.00	non-parametric	Jackknife	1.59	13	1.69E-01	No
High Energy	Mid	OTHER	Dissolved Organic Carbon (DOC)	mg/L	6	3	50	1.8	2.2	1.14	non-parametric	Jackknife	1.92	NE	NC	NA
High Energy	Near Bottom	VOC	Benzene	ug/L	5	5	100	0.14	0.33	0.21	normal	Student's-t	0.29	11.4	2.89E-02	No
High Energy	Near Bottom	VOC	Ethylbenzene	ug/L	5	1	20	0.21	0.21	0.11	non-parametric	Jackknife	0.16	14	1.50E-02	No
High Energy	Near Bottom	VOC	Toluene	ug/L	5	4	80	0.27	0.57	0.42	normal	Student's-t	0.55	253	2.25E-03	No
High Energy	Near Bottom	PAH	Naphthalene	ug/L	5	2	40	1.1	2	0.95	lognormal	Jackknife	1.55	13	1.54E-01	No
High Energy	Near Bottom	OTHER	Dissolved Organic Carbon (DOC)	mg/L	5	4	80	0.75	2.6	1.58	normal	Student's-t	2.55	NE	NC	NA

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to *non-detected results*.
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Table includes data from surface water sampling stations ERA02, ERA03, ERA04, ERA05, ERA06 and ERA07; dissolved fraction
10. Only detected consitutents were evaluated
11. High energy event sampling conducted in November 2005
12. HQ calculated as follows: HQ = Maximum Detected Concentration/Criteria

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004).
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed,
the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Table A-5
Sediment Data Summary and Screening (Carbon Adjusted Data)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	TEC	PEC	Source	HQ (Max Hit/TEC)	COC Decision	HQ (Max Hit/PEC)	COC Decision	HQ (95% UCL/TEC)	COC Decision	HQ (95% UCL/PEC)	COC Decision
Chequamegon Bay	CYANIDE	Cyanide	mg/kg	72	1	1	0.61	0.61	1.35	non-parametric	Standard Bootstrap	0.61	0.1	NE	Reg V	6.10E+00	Yes	NC	NA	6.10E+00	Yes	NC	NA
Chequamegon Bay	METALS	Aluminum	mg/kg	72	72	100	980	13000	3709.17	non-parametric	Standard Bootstrap	6373.99	25500	NE	SQuiRT	5.10E-01	No	NC	NA	1.72E-01	No	NC	NA
Chequamegon Bay	METALS	Antimony	mg/kg	72	22	31	1.65	4.2	1.68	non-parametric	Standard Bootstrap	1.82	2	25	WDNR 2003	2.10E+00	Yes	1.68E-01	No	9.12E-01	No	7.30E-02	No
Chequamegon Bay	METALS	Arsenic	mg/kg	72	61	85	1.4	30	6.20	non-parametric	Standard Bootstrap	8.01	9.8	33	WDNR 2003	3.06E+00	Yes	9.09E-01	No	8.18E-01	No	2.43E-01	No
Chequamegon Bay	METALS	Barium	mg/kg	72	72	100	5.3	180	46.83	normal	Student's-t	52.63	48	NE	OR	3.75E+00	Yes	NC	NA	1.10E+00	Yes	NC	NA
Chequamegon Bay	METALS	Beryllium	mg/kg	72	66	92	0.041	2.6	0.39	gamma	Standard Bootstrap	0.46	122	NE	OR	2.13E-02	No	NC	NA	3.75E-03	No	NC	NA
Chequamegon Bay	METALS	Cadmium	mg/kg	72	26	36	0.13	1.1	0.38	lognormal	Standard Bootstrap	0.43	0.99	5	WDNR 2003	1.11E+00	Yes	2.20E-01	No	4.34E-01	No	8.60E-02	No
Chequamegon Bay	METALS	Chromium	mg/kg	72	68	94	2	31	10.04	non-parametric	Standard Bootstrap	11.55	43	110	WDNR 2003	7.21E-01	No	2.82E-01	No	2.71E-01	No	1.06E-01	No
Chequamegon Bay	METALS	Chromium (III)	mg/kg	23	23	100	3	28	10.22	lognormal	Standard Bootstrap	12.57	43	110	WDNR 2003	6.51E-01	No	2.55E-01	No	2.92E-01	No	1.14E-01	No
Chequamegon Bay	METALS	Chromium (VI)	mg/kg	23	16	70	2.3	9.5	5.50	normal	Student's-t	6.13	43	110	WDNR 2003	2.21E-01	No	8.64E-02	No	1.43E-01	No	5.57E-02	No
Chequamegon Bay	METALS	Cobalt	mg/kg	72	72	100	1.3	16	4.51	gamma	Standard Bootstrap	5.17	43.4	NE	Reg V	3.69E-01	No	NC	NA	1.19E-01	No	NC	NA
Chequamegon Bay	METALS	Copper	mg/kg	72	72	100	1.8	700	73.48	gamma	Standard Bootstrap	91.38	32	150	WDNR 2003	2.19E+01	Yes	4.67E+00	Yes	2.86E+00	Yes	6.09E-01	No
Chequamegon Bay	METALS	Iron	mg/kg	72	72	100	3100	93000	11720.83	non-parametric	Standard Bootstrap	13938.74	20000	40000	WDNR 2003	4.65E+00	Yes	2.33E+00	Yes	6.97E-01	No	3.48E-01	No
Chequamegon Bay	METALS	Lead	mg/kg	72	49	68	4.2	200	24.43	gamma	Standard Bootstrap	29.56	36	130	WDNR 2003	5.56E+00	Yes	1.54E+00	Yes	8.21E-01	No	2.27E-01	No
Chequamegon Bay	METALS	Manganese	mg/kg	72	71	100	34	460	158.40	gamma	Standard Bootstrap	167.96	460	1100	WDNR 2003	1.00E+00	Yes	4.18E-01	No	3.65E-01	No	1.53E-01	No
Chequamegon Bay	METALS	Mercury	mg/kg	72	36	50	0.029	1.2	0.18	non-parametric	Standard Bootstrap	0.13	0.18	1.1	WDNR 2003	6.67E+00	Yes	1.09E+00	Yes	7.22E-01	No	1.18E-01	No
Chequamegon Bay	METALS	Nickel	mg/kg	72	63	88	1.4	52	9.21	gamma	Standard Bootstrap	10.74	23	49	WDNR 2003	2.26E+00	Yes	1.06E+00	Yes	4.67E-01	No	2.19E-01	No
Chequamegon Bay	METALS	Selenium	mg/kg	72	21	29	0.83	16	1.63	non-parametric	Standard Bootstrap	1.99	1	NE	SQuiRT	1.60E+01	Yes	NC	NA	1.97E+00	Yes	NC	NA
Chequamegon Bay	METALS	Silver	mg/kg	72	8	11	0.33	2.5	0.55	non-parametric	Standard Bootstrap	0.61	1.6	2.2	WDNR 2003	1.56E+00	Yes	1.14E+00	Yes	3.84E-01	No	2.75E-01	No
Chequamegon Bay	METALS	Thallium	mg/kg	72	14	19	0.7	4.1	1.47	non-parametric	Standard Bootstrap	1.60	0.7	NE	OR	5.86E+00	Yes	NC	NA	2.29E+00	Yes	NC	NA
Chequamegon Bay	METALS	Vanadium	mg/kg	72	71	99	8.3	60	20.15	non-parametric	Standard Bootstrap	22.61	57	NE	SQuiRT	1.05E+00	Yes	NC	NA	3.97E-01	No	NC	NA
Chequamegon Bay	METALS	Zinc	mg/kg	72	72	100	7.3	140	60.95	non-parametric	Standard Bootstrap	67.13	120	460	WDNR 2003	1.17E+00	Yes	3.04E-01	No	5.59E-01	No	1.46E-01	No
Chequamegon Bay	PAH	1-Methylnaphthalene	ug/kg	127	81	64	12	48000	5529.75	non-parametric	Standard Bootstrap	5466.80	NE	NE	TSO	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	1-Methylphenanthrene	ug/kg	65	28	43	150	14000	781.89	non-parametric	Standard Bootstrap	1218.71	NE	NE	TSO	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	2,3,5-Trimethylnaphthalene	ug/kg OC	65	20	31	190.909	3333333.33	93525.93	non-parametric	Standard Bootstrap	181097.50	988	NE	TLM	3.37E+03	Yes	NC	NA	1.83E+02	Yes	NC	NA
Chequamegon Bay	PAH	2,6-Dimethylnaphthalene	ug/kg	65	26	40	54	56000	2315.13	non-parametric	Standard Bootstrap	4127.43	NE	NE	TSO	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	2-Methylnaphthalene	ug/kg	149	99	66	12	2380000	48394.27	non-parametric	Standard Bootstrap	85754.45	NE	240	BC	NC	NA	9.92E+03	Yes	NC	NA	3.57E+02	Yes
Chequamegon Bay	PAH	Acenaphthene	ug/kg dw @ 1%TOC	150	103	69	0.85	1233333.3	30284.81	non-parametric	Standard Bootstrap	50813.16	6.7	89	WDNR 2003	1.84E+05	Yes	1.39E+04	Yes	7.58E+03	Yes	5.71E+02	Yes
Chequamegon Bay	PAH	Acenaphthylene	ug/kg dw @ 1%TOC	147	90	61	0.77	75000	2470.57	non-parametric	Standard Bootstrap	3803.62	5.9	128	WDNR 2003	1.27E+04	Yes	5.86E+02	Yes	6.45E+02	Yes	2.97E+01	Yes
Chequamegon Bay	PAH	Anthracene	ug/kg dw @ 1%TOC	150	98	65	1.39	366666.7	10843.61	non-parametric	Standard Bootstrap	17523.27	57.2	845	WDNR 2003	6.41E+03	Yes	4.34E+02	Yes	3.06E+02	Yes	2.07E+01	Yes
Chequamegon Bay	PAH	Benzo(a)anthracene	ug/kg dw @ 1%TOC	152	129	85	6.77	236666.7	6263.33	non-parametric	Standard Bootstrap	9793.06	108	1050	WDNR 2003	2.19E+03	Yes	2.25E+02	Yes	9.07E+01	Yes	9.33E+00	Yes
Chequamegon Bay	PAH	Benzo(a)pyrene	ug/kg dw @ 1%TOC	155	130	84	3.77	206666.7	5199.29	non-parametric	Standard Bootstrap	7947.04	150	1450	WDNR 2003	1.38E+03	Yes	1.43E+02	Yes	5.30E+01	Yes	5.48E+00	Yes
Chequamegon Bay	PAH	Benzo(b)fluoranthene	ug/kg dw @ 1%TOC	151	123	83	1.98	93333.3	2844.98	non-parametric	Standard Bootstrap	4149.58	240	13400	WDNR 2003	3.89E+02	Yes	6.97E+00	Yes	1.73E+01	Yes	3.10E-01	No
Chequamegon Bay	PAH	Benzo(e)pyrene	ug/kg dw @ 1%TOC	121	100	83	3.62	113333.3	1819.38	non-parametric	Standard Bootstrap	3337.69	150	1450	WDNR 2003	7.56E+02	Yes	7.82E+01	Yes	2.23E+01	Yes	2.30E+00	Yes
Chequamegon Bay	PAH	Benzo(g,h,i)perylene	ug/kg dw @ 1%TOC	150	101	67	0.55	100000	2449.51	lognormal	Standard Bootstrap	3700.98	170	3200	WDNR 2003	5.88E+02	Yes	3.13E+01	Yes	2.18E+01	Yes	1.16E+00	Yes
Chequamegon Bay	PAH	Benzo(k)fluoranthene	ug/kg dw @ 1%TOC	151	102	68	1.98	123333.3	3109.15	lognormal	Standard Bootstrap	4773.51	240	13400	WDNR 2003	5.14E+02	Yes	9.20E+00	Yes	1.99E+01	Yes	3.56E-01	No
Chequamegon Bay	PAH	Biphenyl	ug/Kg	65	23	35	49	15000	1058.54	non-parametric	Standard Bootstrap	1666.39	NE	NE	TSO	NC	NA	NC	NA	NC	NA	NC	NA
Chequamegon Bay	PAH	Chrysene	ug/kg dw @ 1%TOC	152	131	86	5.08	210000	5686.46	non-parametric	Standard Bootstrap	8746.02	166	1290	WDNR 2003	1.27E+03	Yes	1.63E+02	Yes	5.27E+01	Yes	6.78E+00	Yes
Chequamegon Bay	PAH	Dibenz(a,h)anthracene	ug/kg dw @ 1%TOC	145	60	41	0.55	19000	1159.98	non-parametric	Standard Bootstrap	1613.56	33	135	WDNR 2003	5.76E+02	Yes	1.41E+02	Yes	4.89E+01	Yes	1.20E+01	Yes
Chequamegon Bay	PAH	Fluoranthene	ug/kg dw @ 1%TOC	152	134	88	7.28	533333.3	13605.71	non-parametric	Standard Bootstrap	20929.75	423	2230	WDNR 2003	1.26E+03	Yes	2.39E+02	Yes	4.95E+01	Yes	9.39E+00	Yes
Chequamegon Bay	PAH	Fluorene	ug/kg dw @ 1%TOC	148	91	61	0.52	500000	12084.04	non-parametric	Standard Bootstrap	20192.02	77.4	536	WDNR 2003	6.46E+03	Yes	9.33E+02	Yes	2.61E+02	Yes	3.77E+01	Yes
Chequamegon Bay	PAH	Indeno(1,2,3-cd)pyrene	ug/kg dw @ 1%TOC	150	94	63	0.55	96666.7	2277.64	non-parametric	Standard Bootstrap	3491.95	200	3200	WDNR 2003	4.83E+02	Yes	3.02E+01	Yes	1.75E+01	Yes	1.09E+00	Yes
Chequamegon Bay	PAH	Naphthalene	ug/kg dw @ 1%TOC	178	126	71	1.67	2710000	77245.64	non-parametric	Standard Bootstrap	119526.42	176	561	WDNR 2003	1.54E+04	Yes	4.83E+03	Yes	6.79E+02	Yes	2.13E+02	Yes
Chequamegon Bay	PAH	Perylene	ug/kg OC	65	19	29	463.536	3033333.33	76168.38	non-parametric	Standard Bootstrap	151070.85	813	NE	[illegible]	3.74E+03	Yes	NC	NA	1.86E+02	Yes	NC	NA

Table A-5
Sediment Data Summary and Screening (Carbon Adjusted Data)
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	TEC	PEC	Source	HQ (Max Hit/TEC)	COC Decision	HQ (Max Hit/PEC)	COC Decision	HQ (95% UCL/TEC)	COC Decision	HQ (95% UCL/PEC)	COC Decision
Chequamegon Bay	PAH	Phenanthrene	ug/kg dw (d)	155	122	79	3.03	1833333.3	38877.17	non-parametric	Standard Bootstrap	61952.03	204	1170	WDNR 2003	8.99E+03	Yes	1.57E+03	Yes	3.13E+02	Yes	5.47E+01	Yes
Chequamegon Bay	PAH	Pyrene	ug/kg dw (d)	155	135	87	12.02	1000000	20118.60	non-parametric	Standard Bootstrap	32502.93	195	1520	WDNR 2003	5.13E+03	Yes	6.58E+02	Yes	1.67E+02	Yes	2.14E+01	Yes
Chequamegon Bay	SVOC	Dibenzofuran	ug/kg dw (d)	106	57	54	0.54	40000	545.59	non-parametric	Standard Bootstrap	1170.73	150	580	WDNR 2003	2.67E+02	Yes	6.90E+01	Yes	7.80E+00	Yes	2.02E+00	Yes
Chequamegon Bay	SVOC	m & p-cresols	ug/kg	65	16	25	8.5	670	268.44	non-parametric	Standard Bootstrap	376.00	52.4	NE	Reg V	1.28E+01	Yes	NC	NA	7.18E+00	Yes	NC	NA
Chequamegon Bay	SVOC	o-Cresol	ug/kg	106	25	24	1.2	64	70.70	non-parametric	Standard Bootstrap	64.00	55.4	NE	Reg V	1.16E+00	Yes	NC	NA	1.16E+00	Yes	NC	NA
Chequamegon Bay	SVOC	p-Cresol	ug/kg	41	25	61	13	1100	78.13	non-parametric	Standard Bootstrap	121.60	52.4	NE	Reg V	2.10E+01	Yes	NC	NA	2.32E+00	Yes	NC	NA
Chequamegon Bay	SVOC	Phenol	ug/kg dw (d)	106	26	25	0.53	333.33	76.19	non-parametric	Standard Bootstrap	118.30	420	12000	WDNR 2003	7.94E-02	No	2.78E-02	No	2.82E-02	No	9.86E-03	No
Chequamegon Bay	TOTAL PAH	Total PAH	ug/kg dw (f)	155	148	95	70.45	11646000	293125.63	non-parametric	Standard Bootstrap	477331.36	1610	22800	WDNR 2003	7.23E+03	Yes	5.11E+02	Yes	2.96E+03	Yes	2.09E+01	Yes
Chequamegon Bay	VOC	1,2,4-Trimethylbenzene	ug/kg OC	115	32	28	16.66667	1790000.00	10479296	non-parametric	Standard Bootstrap	169351.18	1147	NE	TLM	1.56E+03	Yes	NC	NA	1.48E+02	Yes	NC	NA
Chequamegon Bay	VOC	1,3,5-Trimethylbenzene	ug/kg OC	115	21	18	16.6667	88400.00	8348999	non-parametric	Standard Bootstrap	88400.00	1147	NE	TLM	7.71E+01	Yes	NC	NA	7.71E+01	Yes	NC	NA
Chequamegon Bay	VOC	Benzene	ug/kg dw (g)	124	18	15	0.227	317.65	761.16	non-parametric	Standard Bootstrap	317.65	57	110	WDNR 2003	5.57E+00	Yes	2.89E+00	Yes	5.57E+00	Yes	2.89E+00	Yes
Chequamegon Bay	VOC	Ethylbenzene	ug/kg	124	28	23	5	31900	1447.89	non-parametric	Standard Bootstrap	2324.12	175	NE	Reg V	1.82E+02	Yes	NC	NA	1.33E+01	Yes	NC	NA
Chequamegon Bay	VOC	sec-Butyl benzene	ug/kg dw (d)	112	10	9	0.167	1.94	841.32	non-parametric	Standard Bootstrap	1.94	25	90	WDNR 2003	7.74E-02	No	3.87E-02	No	7.74E-02	No	3.87E-02	No
Chequamegon Bay	VOC	Styrene	ug/kg	112	9	8	5	10	839.43	non-parametric	Standard Bootstrap	10.00	254	NE	Reg V	3.94E-02	No	NC	NA	3.94E-02	No	NC	NA
Chequamegon Bay	VOC	Toluene	ug/kg dw (d)	124	70	56	0.167	14000	905.33	non-parametric	Standard Bootstrap	1472.03	890	1800	WDNR 2003	1.57E-01	Yes	7.78E+00	Yes	1.65E+00	Yes	8.18E-01	No
Chequamegon Bay	VOC	Xylenes (total)	ug/kg dw (g)	75	19	25	0.167	35000	2703.19	non-parametric	Standard Bootstrap	4364.84	25	50	WDNR 2003	1.40E+03	Yes	7.00E+02	Yes	1.75E+02	Yes	8.73E+01	Yes

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Only detected constituents were evaluated
10. TEC = Threshold Effect Concentration (
11. PEC = Probable Effect Concentration

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004)
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jackknife UCL was selected

Criteria sources:
CBR for baseline narcosis is 6.94 umol/g lipid
CBR for PAHs is 3.79 umol/g lipid
WDNR 2003 = WDNR 2003 Consensus-Based Sediment Quality Guidelines Recommendations for Use & Application Interim Guidance
ESL=Region V Ecological Screening Levels
Region IV WQS=EPA Region IV Water Management Division Screening List from ACQUIRE
TLM=Target Lipid Model (DiToro and McGrath 2000-See text)
T50 =Logistic model point estimate of T50 concentrations (concentration at which 50% of samples are predicted to be toxic; Field et al. 2002)
SQuiRT=NOAA, Screening Quick Reference Tables
BC= Criteria for Managing Contaminated Sediment in British Columbia MWLAP 2004
OSWER Tier II=ORNL Tier 2 value
Field, L.J., D.D. MacDonald, S.B. Norton, C.G. Ingersoll, C.G. Severn, D.E. Smorong, and R.A. Lindskoog. 2002
Predicting amphipod toxicity from sediment chemistry using logistic regression models. Environmental Toxicology and Chemistry 21(9) 1993-2005

Table A-6
Sediment Data Summary
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Chequamegon Bay	CYANIDE	Cyanide	mg/kg	72	1	1	0.61	0.61	1.35	non-parametric	Standard Bootstrap	0.61
Chequamegon Bay	METALS	Aluminum	mg/kg	72	72	100	980	13000	3709.17	non-parametric	Standard Bootstrap	4373.99
Chequamegon Bay	METALS	Antimony	mg/kg	72	22	31	1.45	4.2	1.68	non-parametric	Standard Bootstrap	1.82
Chequamegon Bay	METALS	Arsenic	mg/kg	72	61	85	1.4	30	4.20	non-parametric	Standard Bootstrap	4.91
Chequamegon Bay	METALS	Barium	mg/kg	72	72	100	5.3	180	46.83	normal	Student's-t	52.63
Chequamegon Bay	METALS	Beryllium	mg/kg	72	66	92	0.041	2.6	0.39	gamma	Standard Bootstrap	0.46
Chequamegon Bay	METALS	Cadmium	mg/kg	72	26	36	0.13	1.1	0.38	lognormal	Standard Bootstrap	0.43
Chequamegon Bay	METALS	Chromium	mg/kg	72	68	94	2	31	10.04	non-parametric	Standard Bootstrap	11.65
Chequamegon Bay	METALS	Chromium (III)	mg/kg	23	23	100	3	28	10.22	lognormal	Standard Bootstrap	12.57
Chequamegon Bay	METALS	Chromium (VI)	mg/kg	23	16	70	2.5	9.5	5.50	normal	Student's-t	6.13
Chequamegon Bay	METALS	Cobalt	mg/kg	72	72	100	1.1	16	4.51	gamma	Standard Bootstrap	5.17
Chequamegon Bay	METALS	Copper	mg/kg	72	72	100	1.8	700	72.48	gamma	Standard Bootstrap	91.38
Chequamegon Bay	METALS	Iron	mg/kg	72	72	100	3100	93000	11720.83	non-parametric	Standard Bootstrap	13938.74
Chequamegon Bay	METALS	Lead	mg/kg	72	49	68	6.2	200	24.43	gamma	Standard Bootstrap	29.56
Chequamegon Bay	METALS	Manganese	mg/kg	72	72	100	34	460	148.40	gamma	Standard Bootstrap	167.96
Chequamegon Bay	METALS	Mercury	mg/kg	72	36	50	0.029	1.2	0.10	non-parametric	Standard Bootstrap	0.13
Chequamegon Bay	METALS	Nickel	mg/kg	72	63	88	1.4	52	9.21	gamma	Standard Bootstrap	10.74
Chequamegon Bay	METALS	Selenium	mg/kg	72	21	29	0.83	16	1.63	non-parametric	Standard Bootstrap	1.99
Chequamegon Bay	METALS	Silver	mg/kg	72	8	11	0.35	2.5	0.55	non-parametric	Standard Bootstrap	0.61
Chequamegon Bay	METALS	Thallium	mg/kg	72	14	19	0.7	4.1	1.47	non-parametric	Standard Bootstrap	1.60
Chequamegon Bay	METALS	Vanadium	mg/kg	72	71	99	8.3	60	20.15	non-parametric	Standard Bootstrap	22.62
Chequamegon Bay	METALS	Zinc	mg/kg	72	72	100	7.3	140	60.95	non-parametric	Standard Bootstrap	67.13
Chequamegon Bay	PAH	1-Methylnaphthalene	ug/kg	127	81	64	12	98000	3579.75	non-parametric	Standard Bootstrap	5486.80
Chequamegon Bay	PAH	1-Methylphenanthrene	ug/kg	65	28	43	150	14000	781.89	non-parametric	Standard Bootstrap	1218.71
Chequamegon Bay	PAH	2,3,5-Trimethylnaphthalene	ug/Kg	65	20	31	21	6700	333.65	non-parametric	Standard Bootstrap	559.04
Chequamegon Bay	PAH	2,6-Dimethylnaphthalene	ug/kg	65	26	40	54	56000	2314.12	non-parametric	Standard Bootstrap	4127.43
Chequamegon Bay	PAH	2-Methylnaphthalene	ug/kg	149	99	66	12	2380000	48394.27	non-parametric	Standard Bootstrap	85754.45
Chequamegon Bay	PAH	Acenaphthene	ug/kg	150	103	69	4.9	1020000	22005.86	non-parametric	Standard Bootstrap	37622.62
Chequamegon Bay	PAH	Acenaphthylene	ug/kg	147	90	61	10.0	75000	2304.64	non-parametric	Standard Bootstrap	3558.12
Chequamegon Bay	PAH	Anthracene	ug/kg	150	98	65	6.6	360000	8343.66	non-parametric	Standard Bootstrap	13835.00
Chequamegon Bay	PAH	Benzo(a)anthracene	ug/kg	152	129	85	13.0	150000	5322.40	lognormal	Standard Bootstrap	7735.40
Chequamegon Bay	PAH	Benzo(a)pyrene	ug/kg	155	130	84	14.0	100000	4624.58	lognormal	Standard Bootstrap	6269.37
Chequamegon Bay	PAH	Benzo(b)fluoranthene	ug/kg	151	125	83	12.0	50000	2817.47	lognormal	Standard Bootstrap	3681.96
Chequamegon Bay	PAH	Benzo(e)pyrene	ug/kg	121	100	83	47.0	11000	1323.63	lognormal	Standard Bootstrap	1635.84
Chequamegon Bay	PAH	Benzo(g,h,i)perylene	ug/kg	150	101	67	16.5	37000	2079.95	lognormal	Standard Bootstrap	2700.87
Chequamegon Bay	PAH	Benzo(k)fluoranthene	ug/kg	151	102	68	13.0	71000	2759.87	non-parametric	Standard Bootstrap	3895.77
Chequamegon Bay	PAH	Biphenyl	ug/Kg	65	23	35	49	25000	1058.54	non-parametric	Standard Bootstrap	1846.39
Chequamegon Bay	PAH	Chrysene	ug/kg	152	131	86	16.0	130000	4954.06	lognormal	Standard Bootstrap	7063.66
Chequamegon Bay	PAH	Dibenzo(a,h)anthracene	ug/kg	145	60	41	15	3259	1087.75	non-parametric	Standard Bootstrap	1489.27
Chequamegon Bay	PAH	Fluoranthene	ug/kg	152	134	88	31	330000	10241.12	lognormal	Standard Bootstrap	15426.23
Chequamegon Bay	PAH	Fluorene	ug/kg	148	91	61	5.80	500000	9522.09	non-parametric	Standard Bootstrap	16609.75
Chequamegon Bay	PAH	Indeno(1,2,3-cd)pyrene	ug/kg	150	94	63	6.7	39000.0	1875.43	non-parametric	Standard Bootstrap	2496.77
Chequamegon Bay	PAH	Naphthalene	ug/kg	178	126	71	30	2710000	68265.49	non-parametric	Standard Bootstrap	107468.76
Chequamegon Bay	PAH	Perylene	ug/Kg	65	19	29	43	910.00	310.71	non-parametric	Standard Bootstrap	416.24
Chequamegon Bay	PAH	Phenanthrene	ug/kg	155	122	79	23	1200000	26234.33	non-parametric	Standard Bootstrap	43329.29
Chequamegon Bay	PAH	Pyrene	ug/kg	155	135	87	45	439000	14318.95	lognormal	Standard Bootstrap	21300.94

Table A-6
Sediment Data Summary
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Chequamegon Bay	SVOC	Dibenzofuran	ug/kg	106	57	54	9.20	5100	208.16	non-parametric	Standard Bootstrap	303.32
Chequamegon Bay	SVOC	m & p-cresols	ug/Kg	65	16	25	8.5	670	268.44	non-parametric	Standard Bootstrap	376.00
Chequamegon Bay	SVOC	o-Cresol	ug/kg	106	25	24	1.2	64	70.70	non-parametric	Standard Bootstrap	64.00
Chequamegon Bay	SVOC	p-Cresol	ug/kg	41	25	61	13	1100	78.13	non-parametric	Standard Bootstrap	121.60
Chequamegon Bay	SVOC	Phenol	ug/kg	106	26	25	3	240	86.10	non-parametric	Standard Bootstrap	118.94
Chequamegon Bay	TOTAL PAH	Total PAH	ug/kg	155	148	95	358	9079000	224802.67	non-parametric	Standard Bootstrap	364018.51
Chequamegon Bay	VOC	1,2,4-Trimethylbenzene	ug/kg	115	32	28	5	17900	1144.72	non-parametric	Standard Bootstrap	1798.44
Chequamegon Bay	VOC	1,3,5-Trimethylbenzene	ug/kg	115	21	18	5	1300	856.91	non-parametric	Standard Bootstrap	1300.00
Chequamegon Bay	VOC	Benzene	ug/kg	124	18	15	5	540	775.09	non-parametric	Standard Bootstrap	540.00
Chequamegon Bay	VOC	Ethylbenzene	ug/kg	124	28	23	5	31900	1447.89	non-parametric	Standard Bootstrap	2324.12
Chequamegon Bay	VOC	sec-Butyl benzene	ug/kg	112	10	9	5	10.00	840.26	non-parametric	Standard Bootstrap	10.00
Chequamegon Bay	VOC	Styrene	ug/kg	112	9	8	5	10	839.43	non-parametric	Standard Bootstrap	10.00
Chequamegon Bay	VOC	Toluene	ug/kg	124	70	56	5	14000	999.40	non-parametric	Standard Bootstrap	1569.67
Chequamegon Bay	VOC	Xylenes (total)	ug/kg	75	19	25	5	35000	2712.99	non-parametric	Standard Bootstrap	4365.68

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results.

Table A-7
Soil Data Summary and Screening
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Domain	Analysis	Constituent	Units	Number of Samples	Number of Detections	Detection Rate (%)	Minimum Detected Concentration	Maximum Detected Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL	Criteria	Criteria Source	HQ (Max Hit/Criteria)	COC Decision	HQ (95% UCL/Criteria)	COC Decision
Kreher Park	CYANIDE	Cyanide	mg/kg	25	11	44	0.12	1.4	0.25	Non-parametric	Standard Bootstrap	0.36	1.33	EPA 2003a	1.05E+00	Yes	2.71E-01	No
Kreher Park	METALS	Aluminum	mg/Kg	24	24	100	870	14000	8561.25	Normal	Student's-t	9584.38	NE	NA	NC	NA	NC	NA
Kreher Park	METALS	Antimony	mg/Kg	24	4	17	1.4	2.1	0.95	Non-parametric	Standard Bootstrap	1.10	0.27	EPA 2005	7.78E+00	Yes	4.07E+00	Yes
Kreher Park	METALS	Arsenic	mg/kg	34	31	91	1.3	13.9	4.37	lognormal	Standard Bootstrap	5.38	18	EPA 2005	7.72E-01	No	2.99E-01	No
Kreher Park	METALS	Barium	mg/Kg	24	24	100	10	420	114.58	gamma	Standard Bootstrap	140.60	330	EPA 2005	1.27E+00	Yes	4.26E-01	No
Kreher Park	METALS	Beryllium	mg/Kg	24	23	96	0.1	8.3	1.12	Non-parametric	Standard Bootstrap	1.65	21	EPA 2005	3.95E-01	No	7.86E-02	No
Kreher Park	METALS	Cadmium	mg/Kg	34	18	53	0.143	12	0.75	Non-parametric	Standard Bootstrap	1.31	0.36	EPA 2005	3.33E+01	Yes	3.64E+00	Yes
Kreher Park	METALS	Chromium	mg/kg	34	34	100	2.4	29	17.35	Normal	Student's-t	19.18	26	EPA 2005	1.12E+00	Yes	7.38E-01	No
Kreher Park	METALS	Chromium (III)	mg/Kg	24	24	100	2.1	29	19.34	Normal	Student's-t	21.40	26	EPA 2005	1.12E+00	Yes	8.23E-01	No
Kreher Park	METALS	Chromium (VI)	mg/Kg	24	20	83	0.17	0.62	0.27	Normal	Student's-t	0.31	26	EPA 2005	2.38E-02	No	1.19E-02	No
Kreher Park	METALS	Cobalt	mg/Kg	24	24	100	0.91	12	7.03	Non-parametric	Standard Bootstrap	7.65	13	EPA 2005	9.23E-01	No	5.88E-01	No
Kreher Park	METALS	Copper	mg/kg	34	34	100	2.2	120	43.43	gamma	Standard Bootstrap	51.62	54	EPA 2003b	2.22E+00	Yes	9.56E-01	No
Kreher Park	METALS	Iron	mg/kg	34	34	100	4100	94000	20887.65	Non-parametric	Standard Bootstrap	25072.46	NE	NA	NC	NA	NC	NA
Kreher Park	METALS	Lead	mg/kg	34	33	97	5.19	950	104.13	gamma	Standard Bootstrap	153.26	11	EPA 2005	8.64E+01	Yes	1.39E+01	Yes
Kreher Park	METALS	Manganese	mg/Kg	24	24	100	100	670	311.25	Non-parametric	Standard Bootstrap	348.15	152	EPA 2003b	4.41E+00	Yes	2.29E+00	Yes
Kreher Park	METALS	Mercury	mg/kg	34	15	44	0.075	0.8	0.14	Non-parametric	Standard Bootstrap	0.20	0.1	Reg V ESL	8.00E+00	Yes	2.00E+00	Yes
Kreher Park	METALS	Nickel	mg/Kg	24	24	100	2	33	16.41	Non-parametric	Standard Bootstrap	18.10	48	EPA 2003b	6.88E-01	No	3.77E-01	No
Kreher Park	METALS	Selenium	mg/Kg	24	3	13	1.4	2.1	0.83	Non-parametric	Standard Bootstrap	0.95	0.028	EPA 2003b	7.50E+01	Yes	3.39E+01	Yes
Kreher Park	METALS	Silver	mg/Kg	24	6	25	0.72	7.6	0.97	Non-parametric	Standard Bootstrap	1.55	4.04	Reg V ESL	1.88E+00	Yes	3.84E-01	No
Kreher Park	METALS	Thallium	mg/Kg	24	1	4	2.4	2.4	0.93	Non-parametric	Standard Bootstrap	1.04	0.057	Reg V ESL	4.21E+01	Yes	1.82E+01	Yes
Kreher Park	METALS	Vanadium	mg/Kg	24	24	100	8.9	63	33.37	Non-parametric	Standard Bootstrap	36.44	78	EPA 2005	8.08E-01	No	4.67E-01	No
Kreher Park	METALS	Zinc	mg/kg	34	34	100	4.3	4100	253.99	lognormal	Standard Bootstrap	445.94	120	EPA 2003b	3.42E+01	Yes	3.72E+00	Yes
Kreher Park	PAH	Acenaphthene	ug/Kg	24	1	4	490	490	327.83	Non-parametric	Standard Bootstrap	490	682000	EPA 2003a	7.18E-04	No	7.18E-04	No
Kreher Park	PAH	Acenaphthylene	ug/Kg	25	6	24	190	27000	1623.86	Non-parametric	Standard Bootstrap	3367.61	682000	EPA 2003a	3.96E-02	No	4.94E-03	No
Kreher Park	PAH	Anthracene	ug/Kg	24	1	4	1600	1600	631.33	Non-parametric	Standard Bootstrap	704.01	1480000	EPA 2003a	1.08E-03	No	4.76E-04	No
Kreher Park	PAH	Benzo(a)anthracene	ug/kg	27	14	52	240	25000	2095.22	lognormal	Standard Bootstrap	3676.16	5210	EPA 2003a	4.80E+00	Yes	7.06E-01	No
Kreher Park	PAH	Benzo(a)pyrene	ug/kg	34	16	47	290	68000	3518.12	Non-parametric	Standard Bootstrap	6823.35	1520	EPA 2003a	4.47E+01	Yes	4.49E+00	Yes
Kreher Park	PAH	Benzo(b)fluoranthene	ug/kg	27	16	59	330	53000	3651.56	lognormal	Standard Bootstrap	6824.57	59800	EPA 2003a	8.86E-01	No	1.14E-01	No
Kreher Park	PAH	Benzo(e)pyrene	ug/Kg	24	10	42	250	49000	2648.00	lognormal	Standard Bootstrap	5976.66	1520	BaP surrogate	3.22E+01	Yes	3.93E+00	Yes
Kreher Park	PAH	Benzo(g,h,i)perylene	ug/kg	27	8	30	210	57000	3724.61	Non-parametric	Standard Bootstrap	7287.91	119000	EPA 2003a	4.79E-01	No	6.12E-02	No
Kreher Park	PAH	Benzo(k)fluoranthene	ug/Kg	24	3	13	460	15000	932.17	Non-parametric	Standard Bootstrap	1937.21	148000	EPA 2003a	1.01E-01	No	1.31E-02	No
Kreher Park	PAH	Chrysene	ug/kg	27	13	48	270	32000	2321.26	lognormal	Standard Bootstrap	4276.34	4730	EPA 2003a	6.77E+00	Yes	9.04E-01	No
Kreher Park	PAH	Fluoranthene	ug/kg	27	15	56	250	25000	2392.61	gamma	Standard Bootstrap	4003.47	122000	EPA 2003a	2.05E-01	No	3.28E-02	No
Kreher Park	PAH	Fluorene	ug/Kg	24	1	4	570	570	331.17	Non-parametric	Standard Bootstrap	547.68	122000	EPA 2003a	4.67E-03	No	4.49E-03	No
Kreher Park	PAH	Indeno(1,2,3-cd)pyrene	ug/kg	27	7	26	190	33000	2543.76	Non-parametric	Standard Bootstrap	4703.07	109000	EPA 2003a	3.03E-01	No	4.31E-02	No
Kreher Park	PAH	Naphthalene	ug/kg	34	7	21	40	2144	333.46	Non-parametric	Standard Bootstrap	512.72	99.4	EPA 2003a	2.16E+01	Yes	5.16E+00	Yes
Kreher Park	PAH	Phenanthrene	ug/kg	34	5	15	410	6800	524.13	Non-parametric	Standard Bootstrap	876.98	45700	EPA 2003a	1.49E-01	No	1.92E-02	No
Kreher Park	PAH	Pyrene	ug/kg	34	17	50	220	52000	3366.59	Non-parametric	Standard Bootstrap	5945.49	78500	EPA 2003a	6.62E-01	No	7.57E-02	No
Kreher Park	PAH	Total PAH	ug/kg	34	21	62	40	462700	26180.01	gamma	Standard Bootstrap	49343.72	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	1,2,4-Trimethylbenzene	ug/kg	24	1	4	19	19	7.98	Non-parametric	Jackknife	8.80	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	1,3,5-Trimethylbenzene	ug/kg	26	2	8	77	114	14.73	Non-parametric	Jackknife	22.89	NE	NA	NC	NA	NC	NA
Kreher Park	VOC	Benzene	ug/kg	34	3	9	23	495	29.69	Non-parametric	Standard Bootstrap	56.05	255	EPA 2003a	1.94E+00	Yes	2.20E-01	No
Kreher Park	VOC	Ethylbenzene	ug/kg	34	4	12	25	301	21.41	Non-parametric	Standard Bootstrap	37.45	5160	EPA 2003a	5.83E-02	No	7.26E-03	No
Kreher Park	VOC	Toluene	ug/kg	34	17	50	12	405	34.04	Non-parametric	Standard Bootstrap	55.40	5450	EPA 2003a	7.43E-02	No	1.02E-02	No
Kreher Park	VOC	Xylenes (total)	ug/kg	10	7	70	29	1104	220.95	gamma	Standard Bootstrap	409.73	10000	EPA 2003a	1.10E-01	No	4.10E-02	No

Notes:
1. The 95% Upper Confidence Limit (95% UCL) was set equal to the maximum detected concentration when either the 95% UCL was not calculated (standard deviation of zero), or when the calculated 95% UCL was greater than the maximum detected concentration.
2. Average concentration and standard deviation were calculated by assigning a value of one-half of the detection limit to non-detected results
3. NE = Not Established
4. NC = Not Calculated
5. NA = Not Applicable
6. HQ = Hazard Quotient
7. 95% UCL = 95% Upper Confidence Limit
8. COC = Constituent of Concern
9. Only detected consitutents were evaluated

Criteria sources:
EPA 2003a = EPA Region 5 Ecological Screening Levels table (August 22, 2003)
EPA 2005 = Ecological soil screening levels (ECO-SSLs), OSWER, Washington, D.C.
EPA 2003b = Draft Ecological Soil Screening Levels (ECO-SSLs). In: Kapustka, L., W. Clements, L. Zicardi, P. Paquin, M. Sprenger, and D. Wall 2004. Issue Paper on Ecological Effects of Metals. Submitted to U.S. EPA Risk Assessment Forum, Washington,
Reg V ESL = EPA Region V Ecological Screening Levels

Data Distribution and 95% UCL:
Data distribution and 95% UCL were evaluated using ProUCL (EPA, April 2004)
For normally distributed data, the Student's-t UCL was selected. For data that were not normally distributed, the Standard Bootstrap UCL was selected. If the Standard Bootstrap UCL was not available, then the Jacknife UCL was selected.

Appendix B
Sediment Quality Triad Report

FINAL REPORT

SEDIMENT QUALITY TRIAD INVESTIGATION - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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Attachment 2 Overview of Sediment Bioassays

Attachment 3 Benthic Macroinvertebrate Community Investigation

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

µg/g	Micrograms per gram (parts per million)
BSAF	Biota-sediment accumulation factor
BERA	Baseline Ecological Risk Assessment
BSAF	Biota sediment accumulation factors
COPC	Chemical of Potential Concern
USEPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
LOEC	Lowest observed effects concentration
NOC-PAH	Organic carbon normalized PAH.
NOEC	No observed effects concentration
PAH	Polycyclic aromatic hydrocarbon
PEC	Probable effects concentration
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
TEC	Threshold Effects Concentration
UCL	Upper Confidence Limit
WDNR	Wisconsin Department of Natural Resources

In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site) (URS 2005) a Sediment Quality Triad Investigation (Triad) was conducted to evaluate the potential for toxicity of Site sediment to sediment-dwelling invertebrates. The Triad approach evaluates sediment quality by integrating spatially and temporally matched sediment chemistry, biological, and toxicological information (Long and Chapman 1985; Chapman et al. 1987). Benthic invertebrate community analysis and sediment toxicity testing provide site-specific information regarding potential ecological effects of exposure of ecological receptors to COPCs in the Site sediment. These additional lines of evidence supplement traditional bulk sediment chemistry data to provide a more relevant, site-specific assessment of risks.

The Triad approach was originally developed for estuarine systems, namely Puget Sound and San Francisco Bay (Long and Chapman 1985; Chapman et al. 1987). However, numerous freshwater sediment investigations, including those conducted in the Great Lakes region, have utilized the Triad approach. For instance, as part of the Great Lakes National Program of USEPA, Rediske et al. (2001) and Rediske et al. (2002) have used the Triad approach to investigate the extent of sediment contamination in Manistee and Muskegon Lakes, respectively.

The objective of the Triad approach for the Ashland site is to incorporate site-specific ecological effects information to determine whether COPC concentrations in sediment have adverse effects on benthic invertebrate communities or indirectly on fish and wildlife that depend upon these organisms. The conclusions developed from this Triad study will be used to support the baseline ecological risk assessment (BERA) for the Site.

As part of the approved RI/FS Work Plan, a sampling design was developed to optimize the utility of the information being developed from these studies. One of the key objectives of the sampling design was to ensure that the number of and spatial coverage of the Triad samples reflected a gradient of total PAH concentrations in sediment as well as controlled for any potentially confounding variables which may have affected the results of the studies (URS 2005). Potentially confounding variables that were considered in selecting sampling locations in the sediment area included the presence of wood waste in the sediment, substrate grain size, and water depth (using water depth as a variable incorporates other variables including energy regime and light penetration). Information obtained from previous investigations of Chequamegon Bay sediments (SEH 1998a, 2002) was considered in the sampling location selection process.

During the development of the RI/FS Work Plan data from the SEH (1998a) benthic community study was used as the basis for a power analysis to compute the number of benthic samples required to detect differences amongst stations. For this study alpha, the probability of rejecting a null hypothesis when it is actually true, was set at 0.05. Beta, the probability of failing to reject a null hypothesis when it is actually false was set at 0.2; thus the power (1 – beta), the probability of rejecting a false null hypothesis, was set at 0.8.

Attachment 1 (Sediment Investigation) describes how Site Triad stations and Reference stations were selected and sampled for bulk sediment chemistry, sediment toxicity testing and benthic community analysis. Figures showing the locations and tables summarizing the coordinates of the Triad stations are also provided in Attachment 1.

Attachment 2 (Sediment Toxicity Investigation) describes how the sediment toxicity testing was conducted and presents the results.

Attachment 3 (Benthic Macroinvertebrate Community Investigation) presents the results of the benthic community analysis and describes how environmental variables, including differences in sediment chemistry, influenced the structure of the benthic macroinvertebrate community at the Site.

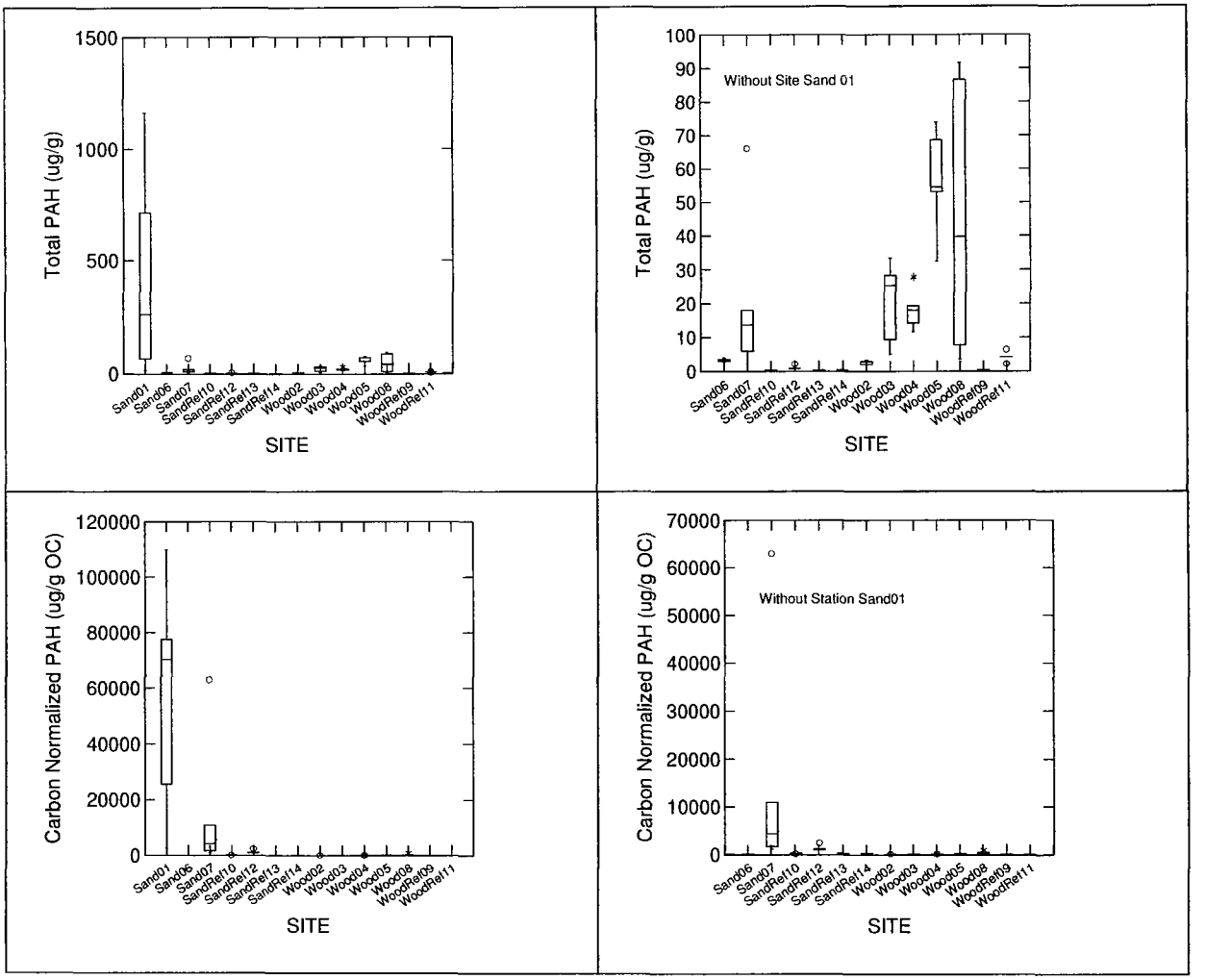
This Triad report integrates these three lines of evidence for use in the BERA.

3.1 SEDIMENT INVESTIGATION

The results of the bulk sediment analysis indicated that several chemicals in Site sediment exceeded WDNR threshold effects concentrations (TEC) and probable effects concentrations (PEC) (WDNR 2003). In particular, a number of polycyclic aromatic hydrocarbon compounds (PAHs) as well as total PAHs (TPAHs) exceeded the PEC at several of the SQT stations. Total PAHs exceeded its TEC at all Triad stations and exceeded its PEC at Stations SQT1, 3, 4, 5, 7 and 8. Copper, lead and mercury exceeded their TEC in several samples. Copper and mercury exceeded their PEC in one sample each, SQT5 and SQT8 respectively. Several VOCs exceeded their TEC in several samples and benzene and total xylenes exceeded their PECs. Figure 3.1 are box and whisker plots[1] of PAH and carbon normalized PAHs (NOC-PAH) at the SQT stations.[2] Considering PAHs on a dry weight basis, Station SQT1 had the highest levels of PAHs followed by Stations SQT 3, 4, 5, 7 and 8. On a NOC-PAH basis, Station SQT1 again had the highest level, followed by Station SQT7.

[1] Box and whisker plots show the maximum, minimum, upper and lower quartile, and median values for all replicates at a station.
[2] Detailed sediment chemistry data is in Attachment 1.

Figure 3.1. Levels of PAHs (in dry weight and organic carbon normalized units) at SQT Stations.



3.2 SEDIMENT BIOASSAYS

Sediment bioassays to evaluate toxicity of Site sediments were conducted using the amphipod, *Hyalella azteca*, the midge, *Chironomus dilutus*, and larvae of the fathead minnow, *Pimephales promelas*. The endpoints measured were survival and growth. *H. azteca* and *P. promelas* bioassays were conducted under both laboratory light and UV light. In addition a bioaccumulation bioassay was conducted with the oligochaete worm, *Lumbriculus variegatus*. The results of the bioassays indicated that sediments at some stations were toxic to these laboratory organisms and that UV light resulted in some incremental effects.[3] High mortality in all Reference Sand stations during several *H. azteca* bioassays indicated that there were effects from other unmeasured environmental stressors.

[3] The relevance of using UV light in laboratory bioassays in discussed in Attachment 2 to this report and the BERA.

Only the results from the sand substrate stations were used to draw conclusions regarding effects thresholds since the carbon normalized values for wood substrate stations are confounded by the form of wood in the sample. Several relatively large pieces of wood in a sample could result in a high organic carbon content and a correspondingly low organic carbon normalized PAH concentrations. As an example Site Wood station SQT8 had a dry weight concentration of 69.9 µg/g but with 28% total organic carbon it resulted in a carbon normalized concentration of only 249.7 µg PAH/gOC. While large pieces of wood debris were removed from the composite sample used for the bioassays, pieces less than ½ inch in size were left in the sample and remained in it for the bioassay. These large pieces of wood would significantly overstate the surface binding capacity of the organic carbon in the sample. This same sample at 1% organic carbon would have had a substantially greater carbon normalized concentration.

The concentrations of total PAHs in the bioassay treatments are summarized in Table 3.1.

Table 3.1. Concentration of Total PAHs in Composite Sediment Samples Used for Bioassays

SQT Station	Substrate Matrix	Total Organic Carbon (%)	Total PAH (µg/g)	Carbon Normalized PAH (µg/g OC)
SQT1	Sand	0.46	166.94	36291.3
SQT1 (50%)	Sand	~0.46	~83.47	~18145.65
SQT1 (25%)	Sand	~0.46	~41.74	~9072.93
SQT1 (12.5%)	Sand	~0.46	~20.87	~4536.41
SQT2	Wood	42	3.20	7.61
SQT3	Sand	40	17.06	42.65
SQT4	Wood	42	14.10	33.57
SQT5	Wood	25	31.25	125.00
SQT6	Sand	9.5	2.30	24.18
SQT7	Sand	0.37	22.51	6083.8
SQT8	Wood	28	69.91	249.69
SQT9	Wood	5.8	.08	1.43#
SQT10	Sand	0.13	.03	20.18#
SQT11	Wood	28	3.80	13.56#
SQT12	Sand	0.03	0.008	25.91#
SQT13*	Sand	0.28	.426	152.14#
SQT14*	Sand	0.39	.426	109.23#

~Estimated based upon dilution, not measured.

*Based upon the average of the five replicate samples collected from these stations for bulk sediment chemistry analysis.

NOC-PAH levels in reference station sediments may be misleading because many PAH compounds were not detected and hence given a value of 1/2DL. For detailed information on PAH composition see the Sediment Investigations report accompanying this report (Attachment 1 to the Sediment Quality Triad Investigation)

3.2.1 *Hyalella azteca* Bioassay

In the first bioassay under laboratory light conditions there was significant mortality at Stations SQT1 and SQT7, compared to the controls, West Bearskin Reference and Wood Reference stations. Results at Station SQT3 were significantly different from the two laboratory controls but not any reference stations. Reference Sand stations SQT10 and SQT12 were also significantly different from the controls, West Bearskin Reference and Wood Reference stations. Only Reference Wood Station SQT11 showed any significant growth effects and that was only compared to the formulated sand control.

A second bioassay with *H. azteca* using two new Reference Sand stations SQT13 and SQT14 was conducted under laboratory light. There was significant mortality in both SQT1 and SQT7 compared to the silica sand control, West Bearskin reference and the Reference Sand stations. However, the results at these two stations were not significantly different from the formulated sand control. SQT6 had significant growth effects but only compared to the silica sand control. The absence of growth effects in the survivors at Station SQT7 where there was significant mortality in both tests and the fact that the West Bearskin Reference had comparable results suggests the significance of the SQT6 growth result is questionable. Unlike the first test there was no significant mortality in SQT3.

A third bioassay was conducted with *H. azteca* in an attempt to identify an effects threshold. It was conducted for 10 days and used a dilution series of 50%, 25% and 12.5% of SQT1 sediment. This sediment was mixed to have the approximate organic carbon content as the original SQT1 as described in Attachment 2. No other Site Sand stations were included in this test. Table 3.1 summarizes the approximate PAH concentration in these treatments. There was significant mortality in SQT1 and the 50% dilution of SQT1 compared to all controls and the Reference Wood stations. Site Wood station SQT8 had significant mortality compared to the silica sand control and the dilution sediment. However, the results for SWT8 were not significantly different from any of the reference stations including West Bearskin. There were significant growth effects in the 25% dilution of SQT1 compared to the Reference Wood station SQT9 however there were no significant growth differences in the 50% dilution compared to any reference stations.

A fourth bioassay was conducted under the same conditions as the third but under UV light. The results of this test indicated significant mortality in Stations SQT1 and all dilutions of SQT1, except the 12.5% dilution, compared to all controls and the Reference Wood stations. In addition Site Wood stations SQT4, SQT5 and SQT8 had significant mortality compared to one or more controls. However, only Site Wood Station SQT5 was different from the Reference Wood stations.

A parallel test to this fourth bioassay provided leaf plugs in the treatment vessels for potential refugia. Survival in the leaf plug treatment was greater than in the no leaf treatment suggesting some moderating effect due to the availability of this refugia. There were growth effects at most stations in the UV bioassay compared to a control but no differences from the Reference Wood results.

3.2.2 *Pimephales promelas* Bioassay

The first bioassay conducted with *Pimephales promelas* was under laboratory light. There was no significant mortality at any stations in this test. There was significantly less growth, however, in SQT1 compared to the silica sand control and to SQT10, a Reference Sand station. There were no significant differences between growth in SQT1 and growth in any other reference stations including West Bearskin.

In the *P. promelas* bioassay conducted under UV light, there was significant mortality in SQT1 and SQT7 compared to all controls and reference stations. There was no significant growth effects at any station compared to the sand control where there were survivors.

3.2.3 *Chironomus dilutus* early life stage Bioassay

There were two attempts at conducting this test, however, in each attempt there was substantial mortality in one or more controls and all of the Reference Wood and Sand stations. While LRSI speculated that the early life stage larvae may have avoided the sediment and remained planktonic and were subsequently flushed from the bioassay vessel, the bottom line is that the results of this test cannot be used as the basis for any conclusions as to the relative toxicity of Site sediments compared to sediments in the region unaffected by Site contaminants.

3.2.4 *Lumbriculus variegatus* Bioaccumulation Bioassay

Bioaccumulation assays were conducted using the worm, *Lumbriculus variegatus*. Prior to conducting the 28-day bioaccumulation test a 4-day screening test was conducted to ensure that the test organisms could survive for the 28 day duration of the test. All worms died at Site Sand stations SQT1 and SQT7 in the screening test so these stations were not used in the 28 day bioaccumulation test.

At the culmination of the 28 day bioaccumulation test levels of PAHs were measured in the worms. These data were used in the BERA.

3.3 BENTHIC MACROINVERTEBRATE COMMUNITY INVESTIGATION

Dominant taxa comprising the benthic macroinvertebrate communities at both Site and Reference stations were chironomids which made up an average 32.6% of the abundance in each sample. Sand Reference Station SQT12 had a range from 84 to 91% chironomids in the five replicate samples. In all, 58 taxa of chironomids were identified. The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa),* oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai),* amphipods (including *Gammarus fasciatus*), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals (See Appendix 1 to Attachment 3). Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

The results of the benthic macroinvertebrate investigation indicated very few patterns in the distribution of these taxa that could be related to levels of PAHs in the sediment. Several

measures of community structure, e.g. percent dominance, percent non-insects and percent gatherers, were positively related to TPAH, while percent chironomids and diversity were negatively related to TPAH. There was also a negative relationship between NOC-PAH and the number of Ephemeroptera/Trichoptera/Odonata (ETO) taxa and with the abundance ratio of ETO/ETO+chironomids. This suggests there may be increasing stress with increased NOC-PAHs. However, there is no consistent pattern that could be related to the Site as Reference Sand stations SQT10 and SQT12 had the lowest abundance ratio of ETO/ETO+chironomids.

Likewise review of the box and whisker plots and cluster diagrams did not identify any consistent trends in station similarity, i.e., there was substantial variability in benthic community structure that couldn't be explained consistently by station category (whether sand or wood substrate), or whether it was a Site or Reference station (Attachment 3).

While levels of PAHs in Site sediments couldn't explain any variation in the benthic community, grain size and substrate type were significant explanatory factors for the variation in the benthic community. For most of the benthic community measures, the finer grain sizes were associated with lower values. Six substrate category effects were significant including:

1) Higher percent non insects, crustacea+mollusca, filter-feeders, and predators at Reference Wood than at Site Wood stations.
2) Lower percent parasites at Reference Wood than at Site Wood stations.
3) Lower percent facultative species at Reference Sand than at Site Sand stations.

However, these six significant results don't support a conclusion that Site stations, whether sand or wood, negatively influence benthic community metrics.

The results of the MANOVA based upon some metrics, e.g., suggested there was some separation of Site Sand from Reference Sand stations and Site Wood from Reference Wood stations (Figure 1.4, 1.5 and 1.6), however these results were not consistent for all metrics and as discussed previously, the ANCOVA provided little evidence that this separation could be explained by the levels of PAH (either as TPAH or NOC-PAH).

The three lines of evidence considered in this Sediment Quality Triad Investigation, i.e. sediment chemistry, sediment bioassays and the benthic macroinvertebrate investigation, did not result in a consistent conclusion. Some bioassay results[4] including the following:

1) Significant mortality at SQT1 and SQT7 in the *H. azteca* in the 28 day test under laboratory light;
2) Significant mortality at SQT1 and the 50% dilution of SQT1 in the 10 day test under laboratory light;
3) Significantly lower growth at SQT1 for *P. promelas* under laboratory light; and
4) Mortality to all *L.variegatus* in SQT1 and SQT7 in the bioaccumulation screening test,

were consistent with what bulk sediment chemistry would predict, i.e., effects were associated with those sediments in which levels of NOC-PAH were highest (See Table 3.1). However, there was considerable variability in benthic community measures that couldn't be related to different levels of PAHs. Rather, differences in the benthic macroinvertebrate structure appeared to be related more to substrate type, either wood or sand and grain size differences.

Based upon the results of the sediment bioassays the no effects concentration (NOEC) for *H. azteca* from both the bioassays conducted by URS during 2005 and 2006 (Table 4.1) and those conducted by SEH in 2001 (Table 4.2) are in the range of 4,500 – 10,000 µg PAH/g organic carbon (OC). For *P. promelas* the NOECs were also fairly similar, 6,084 µg PAH/gOC in 2005-2006 and 3996 µg PAH/gOC in 2001. Because the *C. dilutus* failed in 2005-2006 only the NOEC from 2001 of 735 µg PAH/gOC is available.

Table 4.1. Effects Endpoints for Bioassays Conducted 2005-2006.

Summary of Normal Light Bioassay Results with Three Species for URS 2005-2006				
Organism	NOEC		LOEC	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	20.9	4,536	22.5	6,084
P. promelas	22.5	6,084	166.9	36,291
C. dilutus	NA	NA	NA	NA

[4] The bioassays under UV light and the *C. dilutus* bioassays are not used in these comparisons for reasons discussed in Attachment 2 and in the BERA.

Table 4.2. Effects Endpoints for Bioassays Conducted in 2001.

Summary of Normal Light Bioassay Results with Three Species Conducted for SEH 2001				
Organism	NOEC[1]		LOEC[1]	
	Total PAHs µg/g	Total PAHs µg/gOC	Total PAHs µg/g	Total PAHs µg/gOC
H. azteca	249.4	9,978	823.1	4842 or 14396[2]
P. promelas	79.9	3,996	249.4	9978
C. tentans	16.2	735	79.9	3996

1) SEH reports that the NOEC and LOEC are for lowest of either mortality or growth endpoints (reduced growth or mortality > 20%

2) The first value is suspect due to apparent problems with TOC analyses. The second value assumes that the true TOC lies between adjacent higher and lower values.

These results must be also considered in light of the significant mortality experienced in the Reference Sand stations during the 2005-2006 bioassays. Considering that *H. azteca* is a relatively sensitive test organism and one that is continually in contact with the sediment, the mortality in the Reference Sand stations suggests the presence of some unmeasured stressor in the sediment in many parts of Chequamegon Bay. If this is so, then the possibility exists that the cause of mortality in SQT1 and SQT7 is not due exclusively to PAH levels in the sediment. Factors responsible for mortality in the Reference Sand stations could have been responsible for the mortality at the Site Sand stations.[5] The other bioassays conducted with *P. promelas* or *C. dilutus* don't help in interpretation of these results. There was no mortality in any stations with *P. promelas* and the bioassays with *C. dilutus* were inconclusive because of significant mortality (or loss) in control as well as reference stations in addition to the site stations.

While levels of PAHs in Site sediments didn't consistently explain any variation in the benthic community, grain size and substrate type were significant explanatory factors. For most of the benthic community measures the finer grain sizes were associated with lower values. The overall results for the benthic community investigation suggest that PAH levels (whether TPAH or NOC-PAH) are playing only a minor role in structuring communities, overshadowed by other substrate effects (e.g., grain size and whether the substrate category was wood or sand). Perhaps this is not surprising as it was expected that a benthic community inhabiting an area with a wood mulch substrate would differ from that inhabiting a sand substrate. It has also been well-established that grain size and substrate type is often a significant explanatory factor of differences in benthic community structure.

In conclusion, bulk sediment chemistry suggests that compared to WDNR sediment quality guideline (WDNR 2003) there should be an no effects threshold between 1.6 and 22.8 µg/g in sediment with 1% organic carbon (@1%OC). These concentrations are the Threshold Effects Concentrations and the Probable Effects Concentrations, respectively. The results of sediment

[5] It should be noted that of the Site Sand stations three of the four Site Sand stations had significant mortality in the first 28-day test and two of the Site Sand stations had significant mortality in the second 28-d test. While two stations in both tests, SQT1 and SQT7 had elevated levels of carbon normalized PAHs, a third Site Sand station, SQT3 also had significant mortality in the first 28-d test. SQT3 had only 42.7 µgPAH/g OC and also had approximately 40% TOC. Total PAH on a non-normalized basis at this station was 17 µg/g. While there was no significant mortality at Sand Station SQT3 in the second 28-d test, there is insufficient consistent information to support a conclusion of whether the same variable that apparently affected the reference stations did or did not affect some or all of the Site Sand stations.

bioassays indicate that there is a no effects threshold for benthic invertebrates such as *H. azteca* in the range of 4,000 to 10,000 µg PAH/gOC. These levels are equivalent to 40 to 100 µg/g @1%OC. For benthic invertebrates like *C. tentans* no effects are predicted at about 735 µg PAH/gOC (or 7.35 @1%OC). The low effects thresholds for these benthic organisms range from about 4,800 to 14,000 µg PAH/gOC (or 48 to 140 @1%OC).

However, no significant effects appear to be manifested at the benthic community level of organization even in areas where PAH levels from benthic samples were greater than in the range of 40,000 to 80,000 µg PAH/gOC (400 to 800 µg/g@1%OC) seen in some of the replicates from Station SQT1 (Figure 3.1). This could be due to a variety of factors such as adaptation of the organisms that actually live in Site sediment or selection of species throughout Chequamegon Bay that are tolerant of a wide range of conditions. It could also be explained by the fact that the levels of PAHs in a six inch (15cm) deep sediment sample are not the exposure medium for the majority of the small benthic epifaunal and infaunal species that constitute the benthic community at the Site and in Chequamegon Bay that may be primarily exposed to the top two to three inches. It is likely that the levels of Site chemicals in the top two to three inches are less than a composite sample of the top six inches.[6] If this is the situation, then comparing the levels of PAHs in the top six inches to the results of grab samples that may have all the benthic organisms in the top two or three inches of the grab effectively separates cause (PAH level) from potential effect (impairment of benthic community).

Lastly, these results could reflect the fact that the species populations that make up benthic communities in Chequamegon Bay are limited by factors other than contaminants in the sediment. Any effects exerted at the individual level, as suggested by the bioassays, are overshadowed by limiting factors such as predation, niche availability (including substrate type and grain size) or food supply. If this is true the reproductive potential of these opportunistic benthic species is sufficient to sustain a benthic community throughout Chequamegon Bay that is fairly similar but has small scale heterogeneity as the result of substrate characteristics. In this scenario, the levels of contaminants in the Site sediment do not have a significant influence on benthic community structure.

[6] Note that the original RI/FS Work Plan recommended sampling only the top four inches (10cm).

Chapman P.M., Dexter, R.N., and E.R. Long. 1987. Synoptic Measures of Sediment Contamination, Toxicity, and Infaunal Community Composition (The Sediment Quality Triad) In San Francisco Bay. Mar. Ecol. Prog. Series 37:75-96

Long, E.R. and P.M. Chapman. 1985. A Sediment Quality Triad: Measures Of Sediment Contamination, Toxicity, And Infaunal Community Composition In Puget Sound. Marine Pollution Bulletin. 16:405-415.

Rediske, R., Gabrosek, J., Thompson, C., Bertin, C., Blunt, J., and P. Meier. 2001. Preliminary Investigation of the Extent of Sediment Contamination in Manistee Lake. Great Lakes national Program Office, U.S. Environmental Protection Agency.

Rediske, R., Thompson, C., Schelske, C., Gabrosek, J., Nalepa, T. and G. Peaslee. 2002. Preliminary investigation of the extent of sediment contamination in Muskegon Lake. Great Lakes national Program Office, U.S. Environmental Protection Agency.

WDNR 2003. Consensus-Based Sediment Quality Guidelines. Recommendations for Use and Application. Interim Guidance. WT-732 2003.

ATTACHMENT 1

SEDIMENT INVESTIGATION - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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January 2007

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Figure 2.6 Locations of Cores Collected for SEDFLUME Analysis, June 13 – 25, 2005

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Appendices

Appendix A May 2005 Sediment Chemistry Results

In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site), sediment samples were collected from the Ashland, WI area and analyzed for semi-volatile organic compounds (SVOCs) including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs) and metals. The results of these analyses were used to support environmental impact studies and ecological and human health risk assessments for the Site.

Three separate field efforts were conducted. A reconnaissance survey to identify reference stations was conducted in May 2005. In June 2005 sediment samples and benthic community samples were collected from both Site and Reference Stations. Two supplemental Reference Stations were sampled in September 2005.

Three types of sediment samples were collected during the June 2005 sampling event to support on-going investigations at the Site:

- Supplemental sediment: Surface sediment samples (0-6 inch depth) were collected for chemical analyses at 14 locations to supplement the existing surface sediment database;
- Sediment Quality Triad (SQT): Temporally and spatially matched surface sediment samples (0-6 inch depth) were collected for benthic invertebrate community analyses, sediment bioassays, and bulk sediment chemical analyses; and
- Sediment cores:
  - Sediment flume (SEDFLUME) cores were collected by the subcontractor Sea Engineering Inc. to support sediment stability studies; and
  - Vertically stratified cores were collected to support age-dating studies.

In addition to collection of the sediment samples, various surveys and other data collection activities were conducted to characterize hydrography and sediment bed morphology in the Site area, including:

- Collection of current, wave and suspended sediment data using in-situ instrumentation;
- Bathymetric survey;
- Side scan sonar survey;
- Subbottom profiling; and
- Underwater videography of bottom morphology.

The results of these investigations are presented in the following reports:

Sampling Program	Data collected	Report
Supplemental Sediment Sampling	Bulk sediment chemistry	This report
Sediment Quality Triad	Bulk sediment chemistry	This report and sediment quality triad report
	Sediment bioassays	Sediment bioassay report and sediment quality triad report
	Benthic community	Sediment quality triad report
Sedflume Cores	Sediment erosion thresholds	"Sedflume Analysis of Ashland, WI Cores" by Sea Engineering Inc. and Sediment Stability Assessment
Vertically stratified cores	Age-dating	Sediment Stability Assessment
In situ monitoring	Wave, current and suspended sediment	Sediment Stability Assessment; and "Instrument Deployment, Sediment Sampling, and Remote Sensing Surveys, Ashland/NSP Lakefront Superfund Site" by OSI
Bathymetric, side scan, subbottom profiling and underwater videography	Sediment morphology	Sediment Stability Assessment; and "Instrument Deployment, Sediment Sampling, and Remote Sensing Surveys, Ashland/NSP Lakefront Superfund Site" by OSI

This field work was conducted during three field efforts between May and September 2005. In May of 2005, URS conducted a reconnaissance survey to locate potential SQT sampling locations at the Site as well as SQT reference sediment stations in other areas of Chequamegon Bay outside of potential Site influence. In situ instrumentation was also deployed in May (See

Table 2 Average survival and dry weight of *Hyalella azteca* following 28 days of exposure to sediments from Ashland Harbor, 29 June 2005 to 27 July 2005. Standard deviations are in ( ).

Treatment	Average percent survival	Average dry weight (mg)
Silica Sand	95.0 (7.6)	0.49 (0.25)
Formulated Sediment	80.0 (10.7)	0.46 (0.07)
West Bearskin	95.0 (10.7)	0.24 (0.05)
SQT9	80.0 (16.9)	0.38 (0.08)
SQT10	40.0 (12.0) [abcde]	0.49 (0.07)
SQT11	90.0 (10.7)	0.23 (0.06)[b]
SQT12	48.8 (29.5) [abcde]	0.45 (0.23)
SQT6	91.3 (6.4)	0.28 (0.05)
SQT2	91.3 (15.5)	0.31 (0.06)
SQT7	6.3 (5.2) [abcdefg]	0.40 (0.34)
SQT4	95.0 (5.3)	0.26 (0.04)
SQT3	72.5 (8.9) [ac]	0.42 (0.08)
SQT5	91.3 (8.3)	0.33 (0.04)
SQT1	0.0 (0.0) [abcdefg]	0.00 (0.00)
SQT8	77.5 (17.5)	0.33 (0.06)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[e] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Kruskal-Wallis analysis of variance on ranks.

[f] Survival significantly reduced relative to the SQT10 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[g] Survival significantly reduced relative to the SQT12 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 3. Average survival and dry weight of *Hyalella azteca* following 21 days of exposure to reference sediments from Ashland Harbor, 12 August 2005 to 2 September 2005. Standard deviations are in ( ).

Treatment	Average percent survival
Silica Sand	97.5 (4.6)
SQT10	50.0 (18.5)[acd]
SQT12	76.3 (18.5)
SQT5	81.3 (18.1)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[c]Survival significantly reduced relative to the SQT12 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d]Survival significantly reduced relative to the SQT5 sediment by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 4. Average survival and dry weight of *Hyalella azteca* following 28 days of exposure to sediments from Ashland Harbor, 7 October 2005 to 4 November 2005. Standard deviations are in ( ).

Treatment	Average percent survival	Average dry weight (mg)
Silica Sand	87.5 (8.9)	0.48 (0.09)
Formulated Sediment	20.0 (12.0)	0.85 (0.14)
West Bearskin	88.8 (15.5)	0.24 (0.04)
SQT9	65.0 (16.9)	0.37 (0.10)
SQT13	37.5 (21.9)	0.43 (0.09)
SQT11	85.0 (7.6)	0.26 (0.05)
SQT14	52.5 (26.6)	0.34 (0.12)
SQT6	90.0 (10.7)	0.24 (0.05)[a]
SQT2	83.8 (13.0)	0.31 (0.09)
SQT7	17.5 (16.7)[acdefg]	0.41 (0.18)
SQT4	90.0 (14.1)	0.26 (0.04)
SQT3	87.5 (10.4)	0.27 (0.02)
SQT5	81.3 (12.5)	0.26 (0.05)
SQT1	0.0 (0.0)[acdefg]	
SQT8	85.0 (9.3)	0.26 (0.04)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[e] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method analysis of variance.

[f] Survival significantly reduced relative to the SQT13 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

[g] Survival significantly reduced relative to the SQT14 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses

Table 5. Average survival and dry weight of *Hyalella azteca* following 10 days of exposure to sediments from Ashland Harbor, 3 January 2006 to 13 January 2006. Standard deviations are in ( ).

Treatment	Average percent survival	Average dry weight (mg)
Silica Sand	100 (0.0)	0.15 (0.02)
West Bearskin	97.5 (7.1)	0.11 (0.01)
Dilution Sediment	101.3 (8.3)	0.11 (0.02)
SQT9	97.5 (4.6)	0.18 (0.02)
SQT11	93.8 (7.4)	0.13 (0.01)
12.5% SQT1	97.5 (4.6)	0.12 (0.02)
25 % SQT1	82.5 (34.5)	0.10 (0.01)[d]
50% SQT1	15.0 (10.7)[abcde]	0.12 (0.07)
SQT1	0.0 (0.0)[abcde]	
SQT2	92.5 (7.1)	0.13 (0.02)
SQT4	93.8 (5.2)	0.18 (0.02)
SQT5	92.5 (10.4)	0.18 (0.03)
SQT8	73.8 (32.0)[ac]	0.19 (0.04)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[c] Survival significantly reduced relative to the dilution sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by Dunn's Method of analysis of variance.

[e] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 6. Average survival and dry weight of *Hyalella azteca* following 10 days of exposure to sediments from Ashland Harbor and UV light, 3 January 2006 to 13 January 2006. Standard deviations are in ( ).

Treatment	Average percent survival	Average dry weight (mg)
Silica Sand	98.8 (9.9)	0.12 (0.02)
Silica Sand and Leaf Plugs	98.8 (9.9)	0.17 (0.03)
West Bearskin	91.3 (6.4)	0.11 (0.01)
Dilution Sediment	97.5 (4.6)	0.11 (0.01)
SQT9	91.3 (11.3)	0.16 (0.03)
SQT11	78.8 (12.5)	0.12 (0.02)
12.5% SQT1	78.8 (21.0)	0.12 (0.04)[b]
12.5% SQT1and Leaf Plugs	95.0 (7.6)	0.16 (0.02)
25 % SQT1	11.3 (14.6)[abcdef]	0.11 (0.03)[b]
25% SQT1 and Leaf Plugs	55.0 (17.7)[abcdef]	0.12 (0.03)[b]
50% SQT1	0.0 (0.0)[abcdef]	
50% SQT1 and Leaf Plugs	0.0 (0.0)[abcdef]	
SQT1	0.0 (0.0)[abcdef]	
SQT1 and Leaf Plugs	0.0 (0.0)[abcdef]	
SQT2	91.3 (8.3)	0.12 (0.02)[b]
SQT4	71.3 (12.5)[abd]	0.11 (0.02)[be]
SQT5	40.0 (20.0)[abcdef]	0.12 (0.03)[b]
SQT8	86.3 (16.0)[a]	0.16 (0.03)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the silica sand and leaf plug control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d] Survival significantly reduced relative to the dilution sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[e] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses or mean growth significantly reduced by one-way ANOVA and Dunn's Method of analysis of variance.

[f] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 7. Average survival and dry weight of *Pimephales promelas* following 7 days of exposure to sediments from Ashland Harbor, July 8-15, 2005. Standard deviations are in ( ).

Treatment	Average percent survival	Average dry weight (mg)
Silica Sand	95.0 (7.6)	0.71 (0.13)
Formulated Sediment	91.3 (6.4)	0.58 (0.07)
West Bearskin	82.5 (16.7)	0.67 (0.31)
SQT9	70.0(27.3)[abg]	0.67 (0.19)
SQT10	96.3 (5.2)	0.75 (0.16)
SQT11	90.0 (7.6)	0.61 (0.06)
SQT12	93.8 (5.2)	0.63 (0.06)
SQT6	93.8 (7.4)	0.57 (0.13)
SQT2	90.0 (10.7)	0.67 (0.10)
SQT7	90.0 (7.6)	0.54 (0.10)
SQT4	91.3 (8.3)	0.54 (0.06)
SQT3	82.5 (14.9)	0.63 (0.16)
SQT5	93.8 (9.2)	0.71 (0.09)
SQT1	76.3 (13.0)	0.47 (0.06)[ae]
SQT8	93.8 (7.4)	0.68 (0.07)

[a] Survival or growth significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[c] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[e] Survival or growth significantly reduced relative to the SQT10 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[f] Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[g] Survival significantly reduced relative to the SQT12 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 8. Average survival and dry weight of *Pimephales promelas* exposure to sediments from Ashland Harbor and UV light, 27 January 2006 to 2 February 2006. Standard deviations are in ( ).

Treatment	Average percent survival	Average ash free dry weight (mg)
Silica Sand	81.3 (1.2)	0.54 (0.09)
Formulated Sediment	73.8 (1.9)	0.57 (0.07)
West Bearskin	87.5 (0.9)	0.59 (0.16)
SQT9	82.5 (1.7)	0.68 (0.10)
SQT13	78.8 (1.2)	0.54 (0.15)
SQT11	73.8 (1.2)	0.64 (0.13)
SQT14	81.3 (2.0)	0.67 (0.04)
SQT6	77.5 (1.8)	0.62 (0.09)
SQT2	75.0 (1.9)	0.56 (0.07)
SQT7	38.8 (2.2)[abcdefg]	0.63 (0.18
SQT4	61.3 (1.5)	0.50 (0.11)
SQT3	68.8 (2.9)	0.45 (0.11)
SQT5	60.0 (1.5)	0.58 (0.09)
SQT1	0.0 (0.0)[abcdefg]	
SQT8	71.3 (1.4)	0.61 (0.08)

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the formulated sediment control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

c Survival significantly reduced relative to the West Bearskin reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[d] Survival significantly reduced relative to the SQT9 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[e] Survival significantly reduced relative to the SQT13 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

f Survival significantly reduced relative to the SQT11 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

g Survival significantly reduced relative to the SQT14 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

Table 9. Average survival and ash free dry weight of *Chironomus dilutus* early life stage exposure to sediments from Ashland Harbor, 10 February 2006 to 3 March 2006. Standard deviations are in ( ).

Treatment	Average percent survival	Average ash free dry weight (mg)
Silica Sand	100 (17.7)	0.86 (0.14)
Formulated Sediment	30 (20.0)	1.50 (0.81)
West Bearskin	97 (9.2)	1.23 (0.07)
SQT9	17 (27.8)	2.50 (1.56)
SQT13	23 (28)	2.44 (0.54)
SQT11	3 (7.4)	1.50
SQT14	30 (28.2)	2.58 (0.80)
SQT6	96 (16.0)	1.23 (0.12)
SQT2	0 (0)[abc]	
SQT7	4 (10.7)[abc]	2.90
SQT4	7 (9.9)[ab]	2.50 (0.26)
SQT3	13 (12.0)[ab]	3.37 (0.73)
SQT5	6 (11.7)[abc]	
SQT1	1 (3.5)[abc]	
SQT8	1 (3.5)[abc]	

[a] Survival significantly reduced relative to the silica sand control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

[b] Survival significantly reduced relative to the West Bearskin control by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

c Survival significantly reduced relative to the SQT14 reference by one-way ANOVA and Tukey's pairwise comparisons of the mean responses.

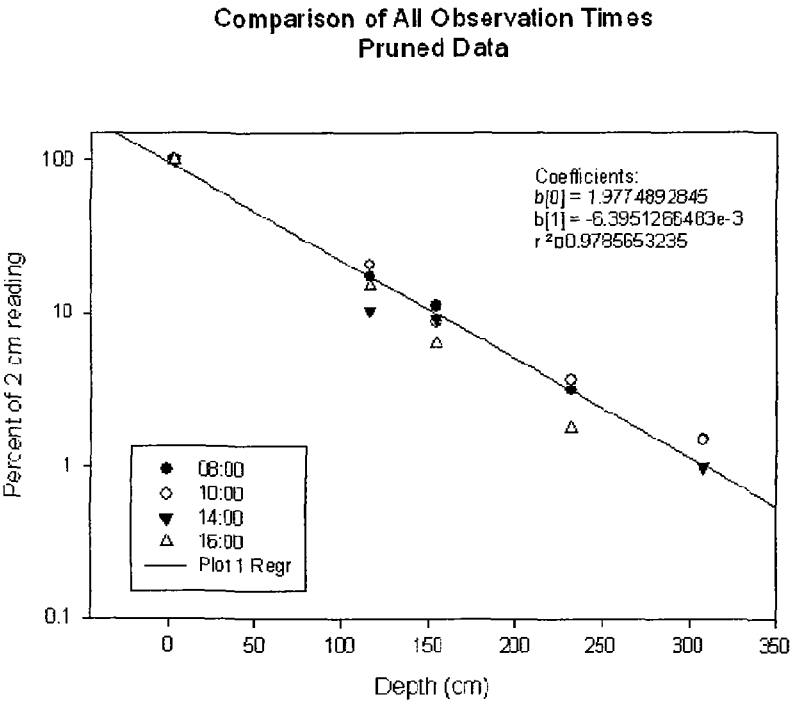
APPENDICES

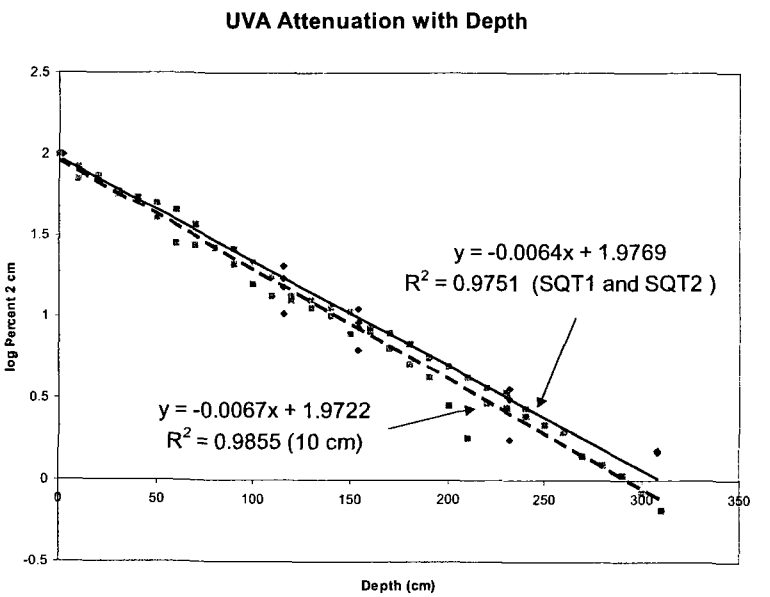
APPENDIX 1

UV Exposure for Ashland Sediment Tests

UV Exposure for Ashland Sediment Tests

Following your suggestion, here is what we did. First of all we compared your censured attenuation curve (from your 12.15.05 memo) to our data from 10 cm intervals.



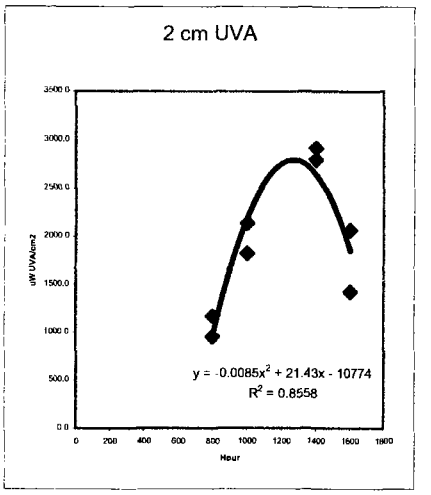


Presumably, the minor differences from your regression of the censured SQT1 and SQT2 you had in your memo likely results from us using Excel. The fact that the rate of attenuation in the 10 cm readings is similar to what you calculated provides some validation of the approach you used.

We then re-visited the data, censured some of the data you discussed and again fitted them to a parabolic curve. Here is what Darrel got.

4 data sets only (no 1800 data)

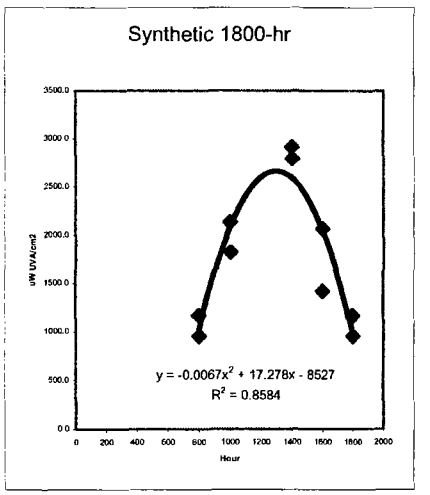
	Time	2 cm
SQT1	800	1166.8
	1000	1822.8
	1400	2795.0
	1600	1419.3
SQT2	800	954.3
	1000	2136.8
	1400	2914.5
	1600	2066.8



As you suggested we then set the 1800 data equal to the 0800 data (note that we can't be sure the anomalies you point out in the 1800 data are not real since the same results were seen in the cloudy day data. Could this reflect the low angle of the sun?). Nevertheless we did this, fit it to a curve and estimated a mean irradiance at 2cm depth over a 16 hour period.

with 1800-hr data=0800-hr data

	Time	2 cm
SQT1	800	1166.8
	1000	1822.8
	1400	2795.0
	1600	1419.3
	1800	1166.8
SQT2	800	954.3
	1000	2136.8
	1400	2914.5
	1600	2066.8
	1800	954.3



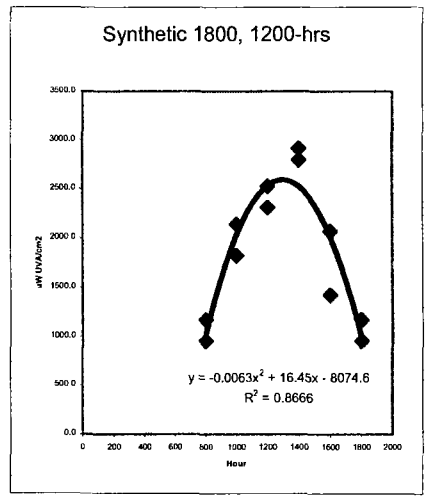
Using the resulting equation, we then estimated UVA over a 16-hour period. Where negative values were predicted, we entered zeros, and calculated the average irradiance.

Hours	Time	uW UVA/cm^2	uW UVA/cm^2
0	600	-572.2	0
2	800	1007.4	1007.4
4	1000	2051	2051
6	1200	2558.6	2558.6
8	1400	2530.2	2530.2
10	1600	1965.8	1965.8
12	1800	865.4	865.4
14	2000	-771	0
16			0
		average=	1372.3

For comparison we also "plugged" an estimated 1200 value using the of the 1000 and 1400 data (assumes a symmetrical curve). This resulted in somewhat greater average irradiance.

with 1200-hr data=average 1000+1400-hr

	Time	2 cm
SQT1	800	1166.8
	1000	1822.8
	1200	2308.9
	1400	2795.0
	1600	1419.3
SQT2	1800	1166.8
	800	954.3
	1000	2136.8
	1200	2525.6
	1400	2914.5
	1600	2066.8
	1800	954.3



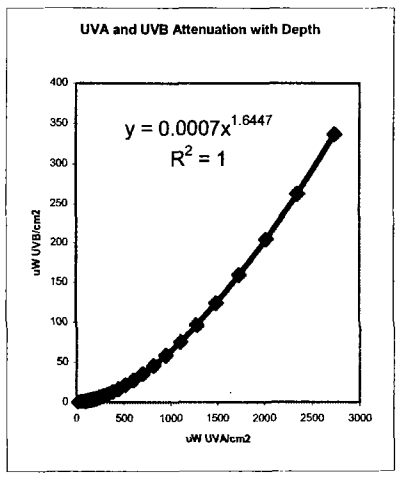
We then recalculated the 16-hr. average irradiance as before.

	uW UVA/cm^2	uW UVA/cm^2
600	-472.6	0
800	1053.4	1053.4
1000	2075.4	2075.4
1200	2593.4	2593.4
1400	2607.4	2607.4
1600	2117.4	2117.4
1800	1123.4	1123.4
2000	-374.6	0
		0
	average=	1446.3

Using this and the attenuation regression equation, the following results for the mid-depth and bottom of SQT1 (the shallowest station) were obtained:

Depth	uW UVA/cm^2		uW UVA/cm^2	
cm	2 cm	% 2 cm	Mid	Bottom
115.8	1446.3	17.2	249	
231.6	1446.3	3.1		45

We also collected UVB data at 10 cm intervals at the Site and, as shown below, we calculated an equation by which we could estimate UVB from UVA light at different depths.



Using this equation, the values for UVB were calculated at the SQT1 mid and bottom depths.

Depth	Mid		Bottom	
cm	uW UVA/cm^2	uW UVB/cm^2	uW UVA/cm^2	uW UVB/cm^2
115.8	249	6		
231.6			45	0.4

These results were then adjusted for Summer Solstice using the 33% higher irradiance expected on that day. This resulted in the following estimates:

Depth	Mid		Bottom	
cm	uW UVA/cm^2	uW UVB/cm^2	uW UVA/cm^2	uW UVB/cm^2
115.8	331	8		
231.6			60	0.5

Following your proposal we then adjusted these "clear sky" estimates for partly cloudy weather using the 75% adjustment factor you proposed.

Depth	Mid		Bottom	
cm	uW UVA/cm^2	uW UVB/cm^2	uW UVA/cm^2	uW UVB/cm^2
115.8	248	6		
231.6			45	0.4

Assuming you agree with what we have done this, I gather from your memo you are proposing that we could conduct the UV bioassays for 10-days with mid depth exposure of 248 $\mu W/cm^2$ UVA and 6 $\mu W/cm^2$ UVB. The *Hyalella* test will be conducted at 45 $\mu W/cm^2$ UVA and 0.4 $\mu W/cm^2$ UVB. It would be our intention to use a constant intensity and a 16:8 light dark cycle.

I will discuss the "depth-indexing" once more with Xcel on Thursday before we finalize the UV regime. I will recommend we simulate conditions at Station SQT 1.

APPENDIX 2

PAH Concentrations in *L. variegatus* From Ashland Sediment Bioaccumulation Study

PAH Concentrations in *Lumbriculus variegatus* from Ashland Sediment Bioaccumulation Study

Compound	SQT9-1	SQT9-2	SQT9-3	SQT9-4	SQT10-1	SQT10-2	SQT10-3	SQT10-4	SQT11-1&2	SQT11-3&4
1-Methylnaphthalene	5.6	<4.3	4.1	3.4	3.1	3.2	3.5	<3.4	<4.3	<4.0
1-Methylphenanthrene	19	12	15	20	<5.8	<7.4	<7.4	<9.2	<12	<11
2,3,5-Trimethylnaphthalene	<8.6	<8.1	<5.4	<6.1	<4.1	<5.2	<5.3	<6.5	<8.2	<7.7
2,6-Dimethylnaphthalene	<17	<16	<10	<12	<8.0	<10	<10	<13	<16	<15
2-Methylnaphthalene	10	<4.5	5.7	5.5	6.5	6.2	6.9	<3.6	7.3	5.0
Acenaphthene	9.3	<6.9	6.2	5.4	5.9	6.6	7.2	<5.5	7.8	<6.5
Acenaphthylene	<14	<13	<8.9	<9.9	<6.8	<8.6	<8.7	<11	<13	<13
Anthracene	42	<13	<8.4	<9.4	<6.4	<8.1	<8.2	<10	<13	<12
Benzo(a)anthracene	17	<15	<10	<11	<7.8	<9.9	<10	<12	<15	<15
Benzo(a)pyrene	<18	<17	<12	<13	<8.8	<11	<11	<14	<17	<16
Benzo(b)fluoranthene	<15	<14	<9.3	<10	7.2	<8.9	<9.0	<11	<14	<13
Benzo(e)pyrene	<13	<12	<8.3	<9.3	7.2	<8.0	<8.1	<10	<13	<12
Benzo(ghi)perylene	<14	<14	<9.1	<10	7.6	<8.8	<8.9	<11	<14	<13
Benzo(k)fluoranthene	<12	<11	80	41	7.5	<7.2	<7.2	<8.9	17	59
Chrysene	<13	<13	<8.4	<9.5	11	9.9	9.4	<10	<13	12
Dibenz(a,h)anthracene	<14	<13	<8.6	<9.6	<6.6	<8.3	<8.4	<10	<13	<12
Fluoranthene	39	<12	10	10	24	21	24	<9.8	33	31
Fluorene	13	<7.9	5.4	<5.9	<4.0	<5.1	<5.1	<6.3	8.6	<7.4
Indeno(1,2,3-cd)pyrene	<14	<13	<8.7	<9.7	<6.6	<8.4	<8.5	<10	<13	<12
Naphthalene	23	<5.2	14	19	16	17	19	5.8	17	13
Perylene	31	<24	59	24	<12	<15	<15	<19	37	36
Phenanthrene	110	60	62	66	79	75	82	<9.1	100	71
Pyrene	30	<14	<9.2	<10	20	17	18	<11	23	30
% Lipids	1.74	1.65	1.42	1.74	1.92	1.63	1.56	0.05	0.35	1.95

PAH Concentrations in *Lumbriculus variegatus* from Ashland Sediment Bioaccumulation Study

Compound	SQT12-1	SQT12-2	SQT12-3	SQT12-4	SQT2-1	SQT2-2	SQT2-3	SQT2-4	SQT4-1	SQT4-2&4	SQT4-3
1-Methylnaphthalene	<3.1	<4.0	3.6	2.8	8	9.3	<6.1	4.1	<4.5	4.1	4.4
1-Methylphenanthrene	<8.4	<11	<8.1	<6.8	19	17	<16	26	41	44	57
2,3,5-Trimethylnaphthalene	<5.9	<7.6	<5.8	<4.8	<11	<12	<12	<7.5	<8.5	6.1	12
2,6-Dimethylnaphthalene	<12	<15	<11	<9.4	<21	<23	<22	<15	<17	<11	<11
2-Methylnaphthalene	6.0	6.2	6.4	5.8	9.1	8.8	<6.4	7.4	8.4	8.3	7.1
Acenaphthene	6.6	<6.4	7.0	5.6	<8.9	<9.9	<9.8	7.7	<7.2	11	8.0
Acenaphthylene	<9.7	<12	13	<7.9	<17	<19	<19	<12	17	65	52
Anthracene	<9.2	<12	<9.0	<7.5	<16	<18	<18	<12	20	33	41
Benzo(a)anthracene	12	<14	<11	9.7	51	47	31	58	310	440	450
Benzo(a)pyrene	<13	<16	<12	<10	36	38	<25	46	<18	380	380
Benzo(b)fluoranthene	14	<13	<9.9	13	30	27	<20	34	170	260	290
Benzo(e)pyrene	14	<12	13	11	41	37	23	44	190	250	260
Benzo(ghi)perylene	<10	<13	<9.7	<8.1	32	29	<19	30	62	96	96
Benzo(k)fluoranthene	12	26	95	8.3	66	130	33	47	260	310	300
Chrysene	20	15	16	16	61	52	38	67	330	400	410
Dibenz(a,h)anthracene	<9.4	<12	<9.2	<7.7	<17	<19	<18	<12	14	20	20
Fluoranthene	32	22	21	21	67	61	41	72	290	350	400
Fluorene	8.8	<7.3	8.8	<4.7	<10	<11	<11	10	<8.3	13	8.4
Indeno(1,2,3-cd)pyrene	<9.5	<12	<9.2	<7.8	<17	<19	<19	<12	44	65	66
Naphthalene	15	16	15	14	22	23	18	18	20	16	15
Perylene	28	73	61	<14	<31	<34	<34	30	<25	<17	50
Phenanthrene	89	100	76	76	120	110	65	79	110	120	130
Pyrene	24	13	13	14	77	89	72	130	410	640	710
% Lipids	1.46	1.66	1.61	1.59	2.23	1.62	2.25	2.09	1.15	1.86	2.17

PAH Concentrations in *Lumbriculus variegatus* from Ashland Sediment Bioaccumulation Study

Compound	SQT3-1	SQT3-2	SQT3-3&4	SQT5-1	SQT5-2&3&4	SQT8-1&2	SQT8-3&4	SQT6-1	SQT6-2&4	SQT6-3
1-Methylnaphthalene	<5.6	<5.7	<4.1	5.5	5.9	19	9.5	<4.3	<4.2	<5.1
1-Methylphenanthrene	68	67	59	230	160	13	15	<11	<11	<14
2,3,5-Trimethylnaphthalene	14	<11	10	81	46	9.3	11	<8.1	<8.0	<9.6
2,6-Dimethylnaphthalene	<21	<21	<15	34	18	21	18	<16	<16	<19
2-Methylnaphthalene	8.4	14	6.9	13	12	35	15	4.6	5.0	6.7
Acenaphthene	<9.0	<9.1	<6.5	28	16	28	29	<6.8	<6.8	<8.2
Acenaphthylene	59	54	51	200	150	71	99	<13	<13	19
Anthracene	48	53	42	230	140	<14	15	<13	<13	<15
Benzo(a)anthracene	500	520	500	1500	1300	34	37	66	71	84
Benzo(a)pyrene	460	480	470	1300	190	<19	24	72	81	100
Benzo(b)fluoranthene	310	290	320	840	710	<15	18	52	55	67
Benzo(e)pyrene	310	300	290	770	640	20	24	62	68	80
Benzo(ghi)perylene	130	120	120	350	310	<15	16	25	28	33
Benzo(k)fluoranthene	380	360	340	970	810	35	100	64	71	110
Chrysene	460	470	450	1200	960	35	40	80	84	97
Dibenz(a,h)anthracene	29	26	25	98	92	<14	<12	<13	<13	<15
Fluoranthene	480	500	460	1500	1100	55	65	58	60	71
Fluorene	<10	11	<7.5	51	30	16	25	<7.8	<7.8	10
Indeno(1,2,3-cd)pyrene	91	87	84	290	260	<14	<12	<13	15	17
Naphthalene	19	24	15	22	19	43	27	13	14	17
Perylene	70	60	51	190	160	<25	<22	31	97	<28
Phenanthrene	130	120	120	560	350	120	150	76	84	96
Pyrene	810	870	790	2600	1900	80	92	110	110	130
% Lipids	0.54	1.55	1.24	1.50	2.32	1.84	2.24	1.36	0.88	1.55

PAH Concentrations in *Lumbriculus variegatus* from Ashland Sediment Bioaccumulation Study

Compound	FORM-1	FORM-2	FORM-3	FORM-4	W. Bear-1	W. Bear-2&3	W.Bear-4	Initial	Initial Duplicate
1-Methylnaphthalene	4.2	3.4	5.0	2.7	<4.8	4.4	<4.3	3.6	2.6
1-Methylphenanthrene	<7.1	<7.1	<7.8	<7.0	<13	<10	<11	2.8	2.9
2,3,5-Trimethylnaphthalene	<5.0	<5.0	<5.6	<5.0	<9.2	<7.4	<8.1	2.7	2.5
2,6-Dimethylnaphthalene	<9.7	<9.7	<11	<9.6	<18	<14	<16	1.7	1.6
2-Methylnaphthalene	8.1	6.7	7.2	5.5	<5.1	6.4	<4.5	6.7	5.3
Acenaphthene	9.4	7.3	6.9	5.9	<7.8	<6.2	<6.9	6.1	5.6
Acenaphthylene	9.2	<8.2	9.8	<8.1	<15	<12	<13	<1.1	<1.3
Anthracene	<7.8	<7.8	37	<7.7	<14	<11	<13	4.3	3.2
Benzo(a)anthracene	<9.5	<9.5	<11	<9.4	<17	<14	<15	1.7	1.5
Benzo(a)pyrene	<11	<11	<12	<11	<20	<16	<17	<1.4	<1.7
Benzo(b)fluoranthene	<8.6	<8.6	<9.5	<8.5	<16	<13	<14	<1.1	<1.3
Benzo(e)pyrene	<7.7	<7.7	<8.5	<7.6	<14	<11	<12	1.8	1.6
Benzo(ghi)perylene	<8.4	<8.4	<9.3	<8.3	<15	<12	<14	1.7	1.5
Benzo(k)fluoranthene	89	<6.9	<7.6	<6.8	<13	<10	42	<0.91	<1.1
Chrysene	<7.8	<7.8	<8.7	<7.7	<14	<11	<13	3.4	3.1
Dibenz(a,h)anthracene	<8.0	<8.0	<8.8	<7.9	<15	<12	<13	<1.1	<1.2
Fluoranthene	32	18	25	15	<14	<11	<12	8.7	9.2
Fluorene	42	17	6.9	16	<8.9	<7.1	9.6	4.2	3.2
Indeno(1,2,3-cd)pyrene	<8.0	<8.0	<8.9	<7.9	<15	<12	<13	<1.1	<1.2
Naphthalene	21	17	23	14	16	17	9.5	15	11
Perylene	<15	<15	<16	16	<27	<21	<24	<1.9	<2.2
Phenanthrene	100	98	83	69	56	72	57	64	65
Pyrene	13	<8.5	11	<8.4	<16	<13	<14	7.9	7.7
% Lipids	1.95	1.57	2.11	2.59	1.32	1.68	1.03	2.45	2.43

APPENDIX 3

Pace Analytical Report
PAH Water Only Equilibrium Study

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 48 HR

Matrix Type : WATER
Collection Date : 08/04/05
Report Date : 08/23/05
Lab Sample Number : 862425-001

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.8	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.1	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		5.5	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 48 HR

Matrix Type : WATER
Collection Date : 08/04/05
Report Date : 08/23/05
Lab Sample Number : 862425-002

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.9	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		4.7	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 48 HR

Matrix Type : WATER
Collection Date : 08/04/05
Report Date : 08/23/05
Lab Sample Number : 862425-003

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		6.7	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - 48 HR

Matrix Type : WATER
Collection Date : 08/04/05
Report Date : 08/23/05
Lab Sample Number : 862425-004

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		5.7	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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920-469-2436

Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - DAY 4

Matrix Type : WATER
Collection Date : 08/06/05
Report Date : 08/23/05
Lab Sample Number : 862425-005

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene		2.0	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.1	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		5.8	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

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Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - DAY 4

Matrix Type : WATER
Collection Date : 08/06/05
Report Date : 08/23/05
Lab Sample Number : 862425-006

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene		2.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.8	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene		2.2	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene		1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.8	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene		1.9	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.7	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		7.1	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene		4.2	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene		2.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
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Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - DAY 4

Matrix Type : WATER
Collection Date : 08/06/05
Report Date : 08/23/05
Lab Sample Number : 862425-007

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		5.7	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
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Analytical Report Number: 862425

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - DAY 4

Matrix Type : WATER
Collection Date : 08/06/05
Report Date : 08/23/05
Lab Sample Number : 862425-008

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/11/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.2	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.2	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Naphthalene		7.0	1.7	1	ug/L	B&	08/14/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/14/05	SW846 3510C	8270C-SIM
Phenanthrene		1.7	1.7	1	ug/L	&*	08/14/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 0HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-001

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		8.3	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene		1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene		1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		8.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		13	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 0HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-002

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		7.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		8.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		13	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

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1241 Bellevue Street
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 0HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-003

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - 0HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-004

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene		2.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 2HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-005

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		3.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		5.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		7.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 2HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-006

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		4.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		6.4	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		8.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		4.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		8.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 2HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-007

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		2.3	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - 2HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-008

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 4HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-009

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		3.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.3	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		5.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 4HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-010

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		7.4	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		3.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		6.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		11	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 4HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-011

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - 4 HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-012

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		7.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 8HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-013

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		2.4	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene		1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		4.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		7.4	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 8HR

Matrix Type : WATER
Collection Date : 08/02/05
Report Date : 08/23/05
Lab Sample Number : 862259-014

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene		6.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		3.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		6.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		11	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc. **Analytical Report Number: 862259** 1241 Bellevue Street Green Bay, WI 54302 920-469-2436

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J - 24HR

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-017

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		2.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : J DUP - 24HR

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-018

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene		1.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		1.9	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		5.0	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene		3.6	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 24HR

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-019

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.4	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.3	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.3	1.7	1	ug/L	&N	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		3.5	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
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920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 24HRMS

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-020

SEMIVOLATILES - SPECIAL LIST - SIM **Prep Date:** 08/09/05

Analyte	Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	45	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	51	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	53	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	46	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	49	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	46	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	48	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Anthracene	62	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	67	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	72	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	68	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	56	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	60	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	59	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Chrysene	55	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	60	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	72	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Fluorene	56	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	58	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Naphthalene	48	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Perylene	56	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Phenanthrene	60	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM
Pyrene	72	1.7	1	ug/L		08/13/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O - 24HRMSD

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-021

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte	Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	38	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	51	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	44	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	38	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	41	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Acenaphthene	38	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Acenaphthylene	38	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Anthracene	57	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene	65	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	75	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	71	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	58	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	62	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	61	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Chrysene	57	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene	65	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluoranthene	73	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Fluorene	46	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene	62	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Naphthalene	42	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Perylene	58	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Phenanthrene	56	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM
Pyrene	72	1.7	1	ug/L		08/14/05	SW846 3510C	8270C-SIM

Pace Analytical Services, Inc.

1241 Bellevue Street
Green Bay, WI 54302
920-469-2436

Analytical Report Number: 862259

Client : LAKE SUPERIOR RESEARCH INSTITUTE
Project Name : ASHLAND - PAH EQUILIBRIUM
Project Number :
Field ID : O DUP - 24HR

Matrix Type : WATER
Collection Date : 08/03/05
Report Date : 08/23/05
Lab Sample Number : 862259-022

SEMIVOLATILES - SPECIAL LIST - SIM

Prep Date: 08/09/05

Analyte		Result	EQL	Dilution	Units	Code	Anl Date	Prep Method	Anl Method
1-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
1-Methylphenanthrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,3,5-Trimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2,6-Dimethylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
2-Methylnaphthalene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Acenaphthylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Anthracene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)anthracene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(a)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(b)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(e)pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(ghi)perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Benzo(k)fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Chrysene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Dibenz(a,h)anthracene		2.2	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluoranthene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Fluorene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Indeno(1,2,3-cd)pyrene		2.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Naphthalene		6.1	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Perylene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Phenanthrene		2.8	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM
Pyrene	<	1.7	1.7	1	ug/L	&	08/13/05	SW846 3510C	8270C-SIM

APPENDIX 4

Survival and Growth of *H. azteca*
Following 28-d of Exposure to Ashland Harbor Sediments,
29 June 2005 to 27 July 2005

Appendix Table 4. Survival and Growth of *H. azteca* following 28-d of Exposure to Ashland Harbor Sediments, 29 June 2005 to 27 July 2005.

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Total Dry wt (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
A	Silica Sand	1	9			2.7	0.30		
A	Silica Sand	2	11			6.0	0.55		
A	Silica Sand	3	9			3.7	0.41		
A	Silica Sand	4	9			4.1	0.46		
A	Silica Sand	5	10			3.6	0.36		
A	Silica Sand	6	10			4.1	0.41		
A	Silica Sand	7	9			9.8	1.09		
A	Silica Sand	8	9	95.0	7.6	3.0	0.33	0.49	0.25
B	Form. Sediment	1	7			2.9	0.41		
B	Form. Sediment	2	9			3.9	0.43		
B	Form. Sediment	3	9			4.1	0.46		
B	Form. Sediment	4	8			4.5	0.56		
B	Form. Sediment	5	8			3.1	0.39		
B	Form. Sediment	6	8			4.2	0.53		
B	Form. Sediment	7	6			*			
B	Form. Sediment	8	9	80.0	10.7	*		0.46	0.07
C	W. Bearskin	1	10			2.8	0.28		
C	W. Bearskin	2	9			2.2	0.24		
C	W. Bearskin	3	10			2.1	0.21		
C	W. Bearskin	4	10			2.3	0.23		
C	W. Bearskin	5	10			2.2	0.22		
C	W. Bearskin	6	7			2.2	0.31		
C	W. Bearskin	7	10			1.5	0.15		
C	W. Bearskin	8	10	95.0	10.7	2.9	0.29	0.24	0.05
D	SQT9	1	7			3.2	0.46		
D	SQT9	2	5			2.7	0.54		
D	SQT9	3	8			2.6	0.33		
D	SQT9	4	10			3.3	0.33		
D	SQT9	5	7			2.6	0.37		
D	SQT9	6	8			2.5	0.31		
D	SQT9	7	9			3.7	0.41		
D	SQT9	8	10	80.0	16.9	3.2	0.32	0.38	0.08
E	SQT10	1	5			2.5	0.50		
E	SQT10	2	3			1.6	0.53		
E	SQT10	3	3			1.6	0.53		
E	SQT10	4	4			2.1	0.53		
E	SQT10	5	5			1.9	0.38		
E	SQT10	6	6			2.4	0.40		
E	SQT10	7	3			1.4	0.47		
E	SQT10	8	3	40.0	12.0	1.7	0.57	0.49	0.07
F	SQT11	1	10			2.2	0.22		
F	SQT11	2	7			1.9	0.27		
F	SQT11	3	9			1.7	0.19		
F	SQT11	4	9			1.9	0.21		
F	SQT11	5	10			1.4	0.14		
F	SQT11	6	8			2.8	0.35		
F	SQT11	7	9			2.1	0.23		
F	SQT11	8	10	90.0	10.7	2.2	0.22	0.23	0.06
G	SQT12	1	5			2.9	0.58		
G	SQT12	2	0			0.0	0.00		
G	SQT12	3	8			3.0	0.38		
G	SQT12	4	6			2.1	0.35		
G	SQT12	5	5			2.6	0.52		
G	SQT12	6	8			3.6	0.45		
G	SQT12	7	1			0.8	0.80		
G	SQT12	8	6	48.8	29.5	3.1	0.52	0.45	0.23

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Total Dry wt (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
H	*SQT6*	*1*	*10*			2.3	0.23		
H	SQT6	2	9			2.3	0.26		
H	SQT6	3	9			3.0	0.33		
H	SQT6	4	8			1.8	0.23		
H	SQT6	5	9			2.1	0.23		
H	SQT6	6	9			2.8	0.31		
H	SQT6	7	9			3.0	0.33		
H	SQT6	8	10	91.3	6.4	2.8	0.28	0.28	0.05
I	SQT2	1	9			2.5	0.28		
I	SQT2	2	9			2.0	0.22		
I	SQT2	3	8			2.8	0.35		
I	SQT2	4	10			3.6	0.36		
I	SQT2	5	10			3.1	0.31		
I	SQT2	6	6			2.2	0.37		
I	SQT2	7	11			2.5	0.23		
I	SQT2	8	10	91.3	15.5	3.8	0.38	0.31	0.06
J	SQT7	1	0			0.0	0.00		
J	SQT7	2	0			0.0	0.00		
J	SQT7	3	1			0.7	0.70		
J	SQT7	4	0			0.0	0.00		
J	SQT7	5	1			0.6	0.60		
J	SQT7	6	1			0.7	0.70		
J	SQT7	7	1			0.5	0.50		
J	SQT7	8	1	6.3	5.2	0.7	0.70	0.40	0.34
K	SQT4	1	9			2.6	0.29		
K	SQT4	2	10			2.2	0.22		
K	SQT4	3	9			2.0	0.22		
K	SQT4	4	10			2.4	0.24		
K	SQT4	5	10			2.7	0.27		
K	SQT4	6	9			2.9	0.32		
K	SQT4	7	9			2.1	0.23		
K	SQT4	8	10	95.0	5.3	2.5	0.25	0.26	0.04
L	SQT3	1	7			3.0	0.43		
L	SQT3	2	8			2.4	0.30		
L	SQT3	3	8			2.6	0.33		
L	SQT3	4	8			3.3	0.41		
L	SQT3	5	6			3.1	0.52		
L	SQT3	6	6			3.1	0.52		
L	SQT3	7	7			3.0	0.43		
L	SQT3	8	8	72.5	8.9	3.6	0.45	0.42	0.08
M	SQT5	1	9			3.5	0.39		
M	SQT5	2	10			3.4	0.34		
M	SQT5	3	9			3.1	0.34		
M	SQT5	4	9			3.2	0.36		
M	SQT5	5	8			2.8	0.35		
M	SQT5	6	8			2.7	0.34		
M	SQT5	7	10			2.8	0.28		
M	SQT5	8	10	91.3	8.3	2.7	0.27	0.33	0.04
N	SQT1	1	0			0.0	0.00		
N	SQT1	2	0			0.0	0.00		
N	SQT1	3	0			0.0	0.00		
N	SQT1	4	0			0.0	0.00		
N	SQT1	5	0			0.0	0.00		
N	SQT1	6	0			0.0	0.00		
N	SQT1	7	0			0.0	0.00		
N	SQT1	8	0	0.0	0.0	0.0	0.00	0.00	0.00

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Total Dry wt (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
O	SQT8	1	9			3.2	0.36		
O	SQT8	2	8			2.9	0.36		
O	SQT8	3	10			2.6	0.26		
O	SQT8	4	8			3.6	0.45		
O	SQT8	5	7			2.2	0.31		
O	SQT8	6	8			2.1	0.26		
O	SQT8	7	8			2.7	0.34		
O	SQT8	8	4	77.5	17.5	1.3	0.33	0.33	0.06

* Lab accident. Organisms lost in handling pan.

APPENDIX 5

Water Chemistry Parameters of *H. azteca*
28-d Test Exposed to Sediments from Ashland Harbor,
29 June 2005 to 27 July 2005

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Temperature (° C)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	23.7	23.9	23.9	23.6	23.5	23.3	23.4	23.7	23.7	23.6	23.4	23.7	23.6	23.6	23.5
29-Jun-05	0	7:50	2	23.7	23.8	24.0	23.5	23.7	23.5	23.4	23.9	23.8	23.6	23.4	23.7	23.8	23.8	23.5
29-Jun-05	0	7:50	3	23.7	23.9	23.9	23.8	23.5	23.5	23.3	23.9	23.7	23.5	23.8	23.5	23.7	23.8	23.5
29-Jun-05	0	7:50	4	23.8	23.9	23.9	23.9	23.6	23.4	23.4	23.9	23.8	23.8	23.3	23.7	23.8	23.8	23.4
29-Jun-05	0	7:50	5	23.6	24.0	23.9	23.8	23.7	23.4	23.5	23.5	23.7	23.8	23.5	23.7	23.6	23.7	23.5
29-Jun-05	0	7:50	6	23.7	24.0	23.8	23.8	23.7	23.1	23.3	23.9	23.6	23.7	23.1	23.6	23.8	23.8	23.6
29-Jun-05	0	7:50	7	23.7	23.9	23.8	23.2	23.6	23.3	23.4	23.9	23.6	23.7	23.4	23.6	23.7	23.8	23.4
29-Jun-05	0	7:50	8	23.7	23.9	23.9	23.7	23.6	23.4	23.5	23.8	23.6	23.8	23.2	23.8	23.7	23.8	23.5
29-Jun-05	0	4:20	1	23.9	23.7	23.6	23.6	23.6	23.4	23.4	23.6	23.5	23.6	23.3	23.6	23.7	23.5	23.5
29-Jun-05	0	4:20	4	23.8	23.7	23.8	23.8	23.6	23.4	23.5	23.6	23.6	23.6	23.4	23.7	23.5	23.4	23.4
30-Jun-05	1	7:00	4	23.6	23.4	23.7	23.5	23.3	23.3	23.4	23.3	23.5	23.4	23.2	23.3	23.1	23.3	23.4
30-Jun-05	1	7:00	6	23.5	23.4	23.7	23.5	23.4	23.3	23.3	23.4	23.2	23.4	23.2	23.4	23.0	23.3	23.4
30-Jun-05	1	15:45	4	24.0	23.8	23.7	23.8	23.8	23.7	23.8	23.8	23.6	23.6	23.7	23.8	23.8	23.9	23.5
30-Jun-05	1	15:45	8	23.8	23.8	23.8	23.8	23.8	23.7	23.7	23.9	23.4	23.7	23.7	23.8	23.8	23.9	23.2
1-Jul-05	2	8:00	4	23.1	23.7	23.7	23.7	23.1	23.5	23.0	23.7	23.6	23.5	22.8	23.5	23.5	23.7	23.3
1-Jul-05	2	8:00	5	23.1	23.9	23.8	23.8	23.2	23.6	23.0	23.7	23.4	23.5	22.9	23.5	23.5	23.8	23.3
1-Jul-05	2	15:15	2	23.2	23.9	23.9	23.7	23.1	23.0	23.0	23.6	23.4	23.6	23.0	23.6	23.6	23.9	23.5
1-Jul-05	2	15:15	4	23.2	23.9	23.8	23.9	23.1	23.0	23.1	23.6	23.5	23.5	23.0	23.5	23.6	23.8	23.6
2-Jul-05	3	8:15	4	23.2	23.8	23.7	23.4	22.8	22.8	22.9	23.4	23.0	23.4	22.8	23.6	23.5	23.6	23.2
2-Jul-05	3	8:15	7	23.2	23.9	23.7	23.8	22.9	22.9	22.9	23.6	23.1	23.5	22.9	23.6	23.6	23.6	23.1
2-Jul-05	3	16:30	3	23.4	22.9	23.9	22.7	23.3	23.2	23.1	23.0	23.4	23.9	23.1	23.8	22.9	22.8	23.6
2-Jul-05	3	16:30	4	23.4	22.9	24.0	22.9	23.4	23.2	23.2	22.9	23.8	23.8	23.1	23.9	22.9	22.9	23.8
3-Jul-05	4	8:10	1	23.5	22.5	24.0	22.1	23.3	23.2	23.3	22.1	23.7	23.1	23.2	23.8	22.7	22.7	23.6
3-Jul-05	4	8:10	4	23.4	22.5	23.9	22.6	23.3	23.2	23.3	22.5	23.7	23.8	23.2	23.9	22.8	22.8	23.7
3-Jul-05	4	16:00	3	24.2	25.1	24.3	24.9	23.0	24.0	23.8	24.8	24.2	24.3	24.0	24.2	24.8	24.8	24.1
3-Jul-05	4	16:00	4	24.1	25.0	24.4	25.0	24.1	24.0	23.9	24.8	24.2	24.3	23.5	24.2	24.8	24.8	24.2
4-Jul-05	5	8:00	4	22.9	21.7	23.7	21.7	22.8	22.8	22.7	21.7	23.1	23.7	22.7	23.6	22.2	21.8	23.4
4-Jul-05	5	8:00	6	22.9	21.8	23.7	21.8	22.8	22.8	22.7	21.6	23.6	23.7	22.7	23.7	22.1	21.9	23.7
4-Jul-05	5	16:15	4	23.5	24.6	23.9	24.6	23.4	23.2	23.2	24.6	23.7	23.8	23.2	23.8	24.6	24.4	23.7
4-Jul-05	5	16:15	8	23.4	24.4	23.9	24.6	23.4	23.3	23.2	24.6	23.8	23.8	23.2	23.9	24.6	24.5	23.7
5-Jul-06	6	6:30	4	23.0	22.8	23.2	21.7	22.8	22.6	22.2	21.5	23.4	23.4	22.5	23.3	21.6	21.4	23.3
5-Jul-06	6	6:30	5	22.6	21.7	23.3	21.6	22.7	22.7	22.7	21.6	23.3	23.4	22.3	23.2	21.6	21.4	23.4
5-Jul-06	6	14:30	2	23.0	23.4	23.6	23.2	22.8	22.7	22.7	23.5	23.4	23.4	22.7	23.4	23.5	23.0	23.3
5-Jul-06	6	14:30	4	22.9	23.4	23.5	23.3	22.8	22.8	22.8	23.4	23.5	23.4	22.7	23.3	23.6	23.1	23.4
6-Jul-05	7	7:20	4	22.6	23.0	22.7	22.9	22.3	22.6	22.7	23.3	23.1	22.9	22.1	23.1	23.2	23.0	23.1
6-Jul-05	7	7:20	7	22.5	22.7	22.5	23.1	22.4	22.4	22.9	23.1	23.1	22.9	22.3	23.0	23.3	23.1	23.1
6-Jul-05	7	15:30	3	23.1	23.6	23.3	23.7	23.1	23.0	23.2	23.7	23.1	23.3	22.8	23.2	23.5	23.5	23.3
6-Jul-05	7	15:30	4	23.1	23.6	23.3	23.7	23.2	23.0	23.1	23.6	23.3	23.4	23.0	23.2	23.6	23.6	23.3
7-Jul-05	8	6:30	4	23.0	23.3	23.4	23.1	22.6	22.7	22.8	23.2	22.4	23.3	22.8	23.2	23.0	22.9	23.0
7-Jul-05	8	6:30	6	23.0	23.2	22.4	23.1	22.8	22.7	22.7	22.4	23.2	22.9	23.2	23.4	23.1	23.0	23.2
7-Jul-05	8	15:15	4	23.0	23.0	23.5	23.1	22.6	22.9	22.8	23.0	23.6	23.2	22.7	23.3	23.1	22.9	23.3
7-Jul-05	8	15:15	8	22.9	23.0	23.4	23.5	22.7	22.7	22.6	23.1	23.3	23.4	22.7	23.3	23.1	22.8	23.4
8-Jul-08	9	6:45	4	23.0	23.2	23.5	23.0	22.7	22.7	22.9	22.9	23.3	23.4	22.7	23.1	23.0	23.0	23.3
8-Jul-08	9	6:45	7	22.8	23.1	23.3	23.2	22.9	22.5	22.6	22.7	23.3	23.5	22.9	23.2	22.9	23.2	23.0
8-Jul-08	9	15:15	1	22.9	23.1	23.6	23.1	23.0	22.9	22.9	23.2	23.2	23.4	22.8	23.4	23.2	22.9	23.4
8-Jul-08	9	15:15	4	23.1	23.1	23.6	23.1	23.1	23.0	22.8	23.2	23.4	23.5	22.8	23.4	23.2	22.8	23.3
9-Jul-05	10	8:00	4	23.1	22.9	23.0	23.2	22.7	22.6	23.0	22.8	23.3	23.3	22.9	23.3	23.2	23.2	23.2
9-Jul-05	10	8:00	5	23.2	22.9	23.1	23.2	22.7	22.5	23.0	22.8	23.3	23.2	22.9	23.0	23.2	23.2	23.3
9-Jul-05	10	17:30	2	23.4	23.3	23.6	23.4	23.2	23.3	23.3	23.4	23.4	23.7	23.4	23.6	23.4	23.4	23.6
9-Jul-05	10	17:30	4	23.4	23.3	23.6	23.3	23.3	23.3	23.4	23.4	23.6	23.6	23.4	23.6	23.4	23.4	23.6
10-Jul-05	11	8:00	4	23.3	23.5	23.6	23.6	23.2	23.1	23.2	23.3	23.3	23.3	23.1	23.4	23.3	23.4	23.3
10-Jul-05	11	8:00	7	23.3	23.5	23.6	23.5	22.9	23.2	23.1	23.3	23.3	23.3	23.1	23.4	23.3	23.4	23.3
10-Jul-05	11	18:20	3	23.7	23.8	23.8	23.7	23.7	23.6	23.6	23.9	23.9	23.9	23.7	23.8	23.9	23.9	23.7
10-Jul-05	11	18:20	4	23.7	23.8	23.8	23.8	23.8	23.7	23.7	23.9	24.0	23.9	23.7	23.9	23.9	23.9	23.8

Date	Day	Time	Rep	Sillca Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
11-Jul-05	12	6:00	1	23.3	23.2	23.5	23.3	23.2	23.2	23.2	23.4	23.4	23.6	23.1	23.4	23.5	23.4	23.3
11-Jul-05	12	6:00	4	23.3	23.3	23.5	23.4	23.3	23.3	23.4	23.5	23.4	23.8	23.3	23.6	23.4	23.4	23.4
11-Jul-05	12	15:15	4	23.8	23.7	24.0	23.6	23.8	23.6	23.5	23.8	24.0	24.1	23.5	24.0	24.0	23.8	24.1
11-Jul-05	12	15:15	5	23.7	23.7	24.1	23.7	23.7	23.5	23.5	23.8	24.0	24.2	23.5	24.0	24.0	23.9	24.2
12-Jul-05	13	8:00	4	23.1	23.2	23.5	23.4	23.1	23.4	23.4	23.4	23.6	23.6	23.0	23.7	23.5	23.3	23.7
12-Jul-05	13	8:00	6	23.1	23.1	23.4	23.6	23.0	23.4	23.3	23.2	23.6	23.6	23.0	23.5	23.4	22.9	23.7
12-Jul-05	13	15:00	4	23.4	23.8	24.5	23.9	23.8	23.7	23.6	23.9	24.5	24.5	23.7	24.4	23.9	23.9	24.6
12-Jul-05	13	15:00	8	23.8	23.8	24.5	23.9	23.8	23.7	23.6	23.9	24.5	24.5	23.7	24.5	23.9	23.9	24.6
13-Jul-05	14	8:30	4	24.4	24.6	24.9	24.6	24.4	24.2	24.1	24.6	24.8	24.9	24.2	24.8	24.7	24.5	25.0
13-Jul-05	14	8:30	5	24.4	24.7	24.9	24.7	24.4	24.2	24.1	24.7	24.8	24.9	24.2	24.7	24.7	24.5	25.0
13-Jul-05	14	14:50	2	23.4	23.6	24.0	23.6	23.7	23.4	23.4	23.7	24.1	24.0	23.5	24.0	23.8	23.7	24.1
13-Jul-05	14	14:50	4	23.5	23.6	23.4	23.6	23.7	23.4	23.4	23.7	24.1	24.0	23.4	24.0	23.8	23.6	24.1
14-Jul-05	15	8:00	4	23.5	23.5	23.6	23.5	23.5	23.3	23.3	23.5	23.6	23.6	23.3	23.6	23.6	23.5	23.7
14-Jul-05	15	8:00	7	23.5	23.6	23.7	23.5	23.5	23.3	23.3	23.5	23.7	23.7	23.3	23.6	23.6	23.4	23.7
14-Jul-05	15	15:00	3	23.0	23.5	23.7	23.3	23.0	22.9	22.8	23.6	23.8	23.8	22.9	23.6	23.7	23.4	23.8
14-Jul-05	15	15:00	4	23.0	23.5	23.7	23.5	23.0	22.8	22.8	23.6	23.7	23.8	22.9	23.7	23.7	23.5	23.8
15-Jul-05	16	6:30	1	22.5	22.8	23.3	22.6	22.3	22.0	22.0	22.7	23.2	23.2	22.0	22.5	22.8	22.4	23.1
15-Jul-05	16	6:30	4	22.5	22.8	23.3	22.7	22.4	22.0	22.0	22.8	23.2	23.2	22.0	23.0	22.7	22.4	23.0
15-Jul-05	16	16:00	4	22.9	23.0	23.5	22.9	22.8	22.7	22.5	22.9	23.5	23.5	22.8	23.2	22.9	22.9	23.5
15-Jul-05	16	16:00	8	22.8	23.1	23.0	22.9	22.8	22.8	22.5	23.0	23.6	23.4	22.7	23.3	22.8	22.9	23.5
16-Jul-05	17	5:30	4	22.9	23.1	23.1	23.0	22.9	22.9	22.7	22.7	23.1	23.3	22.7	23.2	22.9	22.8	23.3
16-Jul-05	17	5:30	6	23.0	22.9	23.0	23.1	22.8	22.7	22.7	22.8	23.1	23.1	22.8	23.3	22.8	22.7	23.4
16-Jul-05	17	14:45	4	22.9	23.3	23.5	23.1	22.8	22.8	22.9	22.8	23.5	23.6	23.4	23.4	23.3	23.2	23.6
16-Jul-05	17	14:45	8	22.8	23.2	23.4	23.0	22.7	22.9	22.8	22.9	23.4	23.4	23.3	23.3	23.4	23.3	23.5
17-Jul-05	18	9:45	4	22.8	23.1	23.4	23.1	22.9	22.7	22.6	23.1	23.5	23.5	22.8	23.3	23.1	23.0	23.5
17-Jul-05	18	9:45	5	22.8	23.1	23.4	23.1	22.8	22.8	22.6	23.1	23.5	23.5	22.8	23.3	23.1	23.0	23.5
17-Jul-05	18	15:00	2	23.3	23.5	23.5	23.5	23.3	23.4	23.3	23.3	23.5	23.6	23.2	23.4	23.6	23.4	23.4
17-Jul-05	18	15:00	4	23.1	23.4	23.5	23.5	23.2	23.3	23.4	23.4	23.4	23.6	23.1	23.5	23.5	23.5	23.5
18-Jul-05	19	7:00	4	23.1	22.4	23.2	22.4	22.9	23.0	22.8	22.4	23.2	23.2	23.1	23.1	22.5	22.3	23.2
18-Jul-05	19	7:00	7	23.3	22.4	23.3	22.4	22.8	23.0	22.7	22.5	23.2	23.3	23.1	23.0	22.4	22.3	23.3
18-Jul-05	19	16:00	3	23.2	23.1	23.1	23.1	23.2	23.4	23.3	23.0	23.2	23.3	23.4	23.0	23.0	23.1	23.1
18-Jul-05	19	16:00	4	23.3	23.1	23.1	23.2	23.2	23.3	23.4	23.0	23.3	23.3	23.4	23.2	23.0	23.2	23.1
19-Jul-05	20	7:30	1	21.3	21.6	21.9	21.6	21.3	21.4	21.3	21.6	22.0	21.9	21.5	21.7	21.7	21.7	21.9
19-Jul-05	20	7:30	4	21.3	21.6	21.8	21.7	21.3	21.4	21.3	21.7	22.0	21.9	21.5	21.8	21.7	21.7	21.9
19-Jul-05	20	15:20	2	22.1	22.2	22.2	22.4	22.0	22.1	22.0	22.3	22.3	22.3	22.1	22.1	22.3	22.4	22.3
19-Jul-05	20	15:20	4	22.1	22.2	22.2	22.4	22.0	22.1	22.0	22.3	22.3	22.3	22.2	22.2	22.3	22.4	22.3
20-Jul-05	21	6:30	4	23.3	23.4	23.4	23.6	23.4	23.5	23.3	23.4	23.4	23.4	23.3	23.2	23.5	23.5	23.3
20-Jul-05	21	6:30	6	23.3	23.5	23.4	23.6	23.2	23.4	23.3	23.4	23.4	23.5	23.4	23.3	23.5	23.5	23.3
20-Jul-05	21	16:00	4	23.7	23.8	23.7	23.8	23.4	23.4	23.3	23.6	23.8	23.5	23.5	23.4	23.6	23.7	23.7
20-Jul-05	21	16:00	8	23.6	23.8	23.7	23.8	23.5	23.4	23.3	23.7	23.7	23.7	23.5	23.4	23.6	23.7	23.7
21-Jul-05	22	8:00	4	22.6	22.9	22.9	23.0	22.3	22.3	22.8	22.7	22.9	22.9	22.4	22.9	22.6	22.5	23.1
21-Jul-05	22	8:00	5	22.5	22.9	23.0	22.9	22.4	22.3	22.3	22.8	23.1	23.1	21.9	23.1	22.7	22.9	23.1
21-Jul-05	22	15:30	2	22.9	22.6	23.3	22.7	22.9	22.0	22.8	22.7	23.2	23.3	22.9	23.0	22.7	22.7	23.1
21-Jul-05	22	15:30	4	22.9	22.5	23.3	22.7	22.9	23.0	22.8	22.6	23.0	23.3	22.9	23.1	22.7	22.7	23.2
22-Jul-05	23	7:30	4	23.4	23.7	23.6	23.7	23.4	23.5	23.4	23.7	23.6	23.6	23.5	23.5	23.8	23.7	23.4
22-Jul-05	23	7:30	7	23.4	23.7	23.5	23.8	23.4	23.5	23.4	23.8	23.5	23.7	23.6	23.5	23.8	23.7	23.5
22-Jul-05	23	14:30	3	23.4	23.4	23.6	23.3	23.3	23.4	23.4	23.6	23.6	23.6	23.4	23.4	23.7	23.4	23.5
22-Jul-05	23	14:30	4	23.4	23.4	23.6	23.5	23.3	23.5	23.4	23.6	23.6	23.6	23.5	23.4	23.7	23.5	23.6
23-Jul-05	24	8:00	1	23.1	23.2	23.3	23.3	23.4	23.2	23.1	23.0	23.4	23.4	23.2	23.3	23.1	23.2	23.0
23-Jul-05	24	8:00	4	23.2	23.3	23.4	23.1	23.2	23.2	23.1	23.2	23.3	23.4	23.1	23.2	23.1	23.2	23.3
23-Jul-05	24	15:15	4	23.4	23.4	23.6	23.5	23.4	23.5	23.3	23.6	23.6	23.7	23.4	23.5	23.6	23.5	23.7
23-Jul-05	24	15:15	6	23.5	23.5	23.6	23.6	23.4	23.5	23.3	23.6	23.6	23.7	23.4	23.5	23.6	23.5	23.7
24-Jul-05	25	8:15	4	23.2	23.1	23.3	23.4	23.2	23.3	23.2	23.3	23.3	23.3	23.3	23.2	23.3	23.1	23.3
24-Jul-05	25	8:15	6	23.3	23.2	23.3	23.5	23.3	23.3	23.2	23.3	23.2	23.3	23.3	23.2	23.3	23.4	23.3
24-Jul-05	25	15:20	4	23.5	23.5	23.6	23.7	23.4	23.4	23.4	23.6	23.7	23.7	23.4	23.5	23.6	23.4	23.7
24-Jul-05	25	15:20	8	23.5	23.5	23.6	23.7	23.5	23.4	23.4	23.7	23.7	23.7	23.4	23.6	23.6	23.5	23.7

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
25-Jul-05	26	8:00	4	23.4	23.4	23.6	23.5	23.4	23.4	23.3	23.5	23.4	23.6	23.3	23.4	23.4	23.3	23.5
25-Jul-05	26	8:00	5	23.5	23.4	23.6	23.5	23.4	23.4	23.3	23.5	23.4	23.6	23.3	23.4	23.4	23.3	23.5
25-Jul-05	26	16:00	2	23.5	23.6	23.6	23.6	23.4	23.6	23.5	23.7	23.6	23.6	23.5	23.5	23.5	23.6	23.7
25-Jul-05	26	16:00	4	23.6	23.5	23.7	23.7	23.4	23.6	23.5	23.6	23.5	23.6	23.5	23.5	23.5	23.6	23.7
26-Jul-05	27	8:30	4	23.6	22.8	23.7	23.7	23.5	23.5	23.3	23.6	23.6	23.6	23.4	23.6	23.5	23.5	23.6
26-Jul-05	27	8:30	7	23.7	23.7	23.7	23.6	23.4	23.4	23.3	23.6	23.5	23.6	23.4	23.3	23.5	23.6	23.4
26-Jul-05	27	15:45	3	23.7	23.9	23.7	23.7	23.6	23.9	23.7	23.7	23.5	23.8	23.8	23.5	23.4	23.6	23.4
26-Jul-05	27	15:45	4	23.9	23.8	23.8	23.8	23.7	23.9	23.7	23.7	23.7	23.8	23.8	23.5	23.4	23.7	23.5
27-Jul-05	28	6:00	1	22.8	22.9	23.0	23.1	23.0	23.1	22.9	22.9	23.0	23.0	22.9	22.8	22.8	22.9	22.9
27-Jul-05	28	6:00	2	22.9	23.0	23.1	23.0	23.1	23.0	22.9	22.9	23.0	23.1	23.0	22.9	22.8	22.9	22.9
27-Jul-05	28	6:00	3	23.0	23.0	23.1	23.0	23.1	23.1	22.9	23.0	22.9	23.0	23.0	22.8	22.8	22.9	22.9
27-Jul-05	28	6:00	4	23.0	23.0	23.1	23.1	23.1	23.1	22.9	23.0	23.0	23.1	23.0	22.8	22.9	23.0	22.9
27-Jul-05	28	6:00	5	23.0	23.0	23.0	23.0	23.0	23.0	22.9	23.0	22.9	23.1	23.0	22.7	22.8	23.0	22.9
27-Jul-05	28	6:00	6	22.9	23.0	23.0	23.0	23.0	23.1	22.9	23.0	23.0	23.0	23.0	22.8	22.9	23.0	22.9
27-Jul-05	28	6:00	7	23.0	23.0	22.9	23.0	22.9	23.0	22.9	23.0	22.9	23.1	23.0	22.8	22.8	23.0	22.9
27-Jul-05	28	6:00	8	23.0	23.0	22.8	23.0	23.0	23.0	22.9	22.9	22.8	23.1	23.0	22.8	22.9	22.9	22.7
			Average	**23.2**	**23.3**	**23.5**	**23.3**	**23.2**	**23.1**	**23.1**	**23.3**	**23.4**	**23.5**	**23.1**	**23.4**	**23.3**	**23.3**	**23.4**
			Minimum	21.3	21.6	21.8	21.6	21.3	21.4	21.3	21.5	22.0	21.9	21.5	21.7	21.6	21.4	21.9
			Maximum	24.4	25.1	24.9	25.0	24.4	24.2	24.1	24.8	24.8	24.9	24.2	24.8	24.8	24.8	25.0

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	6.9	6.6	6.8	6.6	2.6	6.6	5.5	7.0	5.8	7.6	6.3	7.5	7.1	7.4	4.3
29-Jun-05	0	7:50	2	6.9	6.8	6.8	6.7	6.6	7.3	6.6	7.2	6.9	6.7	7.3	7.5	7.3	5.9	4.5
29-Jun-05	0	7:50	3	6.7	6.8	5.8	7.0	2.8	7.0	5.2	7.1	7.0	6.2	6.4	7.8	7.4	5.6	3.3
29-Jun-05	0	7:50	4	6.8	6.8	6.5	7.3	3.9	7.2	7.0	7.2	7.2	5.7	7.2	7.9	7.3	6.9	3.9
29-Jun-05	0	7:50	5	7.0	6.8	6.3	6.8	6.1	6.6	6.9	7.1	7.1	7.3	7.5	7.8	7.5	7.6	5.2
29-Jun-05	0	7:50	6	6.7	6.9	6.0	5.5	6.3	6.6	6.6	6.6	6.8	7.3	5.6	7.9	5.9	7.6	6.6
29-Jun-05	0	7:50	7	7.0	6.8	6.8	5.6	6.3	6.9	6.4	6.7	7.0	7.3	7.0	8.0	7.4	7.2	3.6
29-Jun-05	0	7:50	8	6.9	6.9	6.6	6.3	5.9	6.1	7.0	6.3	7.0	7.3	6.8	8.1	7.7	7.5	4.0
29-Jun-05	0	4:20	1	6.9	7.0	6.9	5.7	4.6	5.8	7.9	7.2	5.4	7.1	4.6	5.8	6.2	6.8	5.2
29-Jun-05	0	4:20	4	7.4	7.0	6.9	6.0	4.6	7.8	8.0	8.1	4.1	6.2	8.0	5.8	8.0	5.2	4.2
30-Jun-05	1	7:00	4	6.8	6.9	7.3	6.8	6.7	6.9	7.7	7.8	5.1	7.8	7.5	5.4	7.7	5.2	4.3
30-Jun-05	1	7:00	6	6.7	7.1	7.4	7.4	6.8	5.7	7.1	7.6	5.4	7.6	6.0	6.0	6.6	6.7	7.4
30-Jun-05	1	15:45	4	6.9	6.0	6.6	5.0	5.5	6.4	7.2	6.6	7.2	6.5	7.4	6.3	6.8	6.7	6.2
30-Jun-05	1	15:45	8	7.1	6.6	6.6	6.9	6.6	6.8	7.1	6.4	3.9	6.8	6.0	6.8	6.4	7.0	4.6
1-Jul-05	2	8:00	4	7.5	7.3	7.3	5.1	5.3	6.8	6.9	7.6	7.4	7.4	7.5	7.7	7.4	7.2	6.2
1-Jul-05	2	0:00	5	7.3	7.2	7.2	6.2	6.3	6.6	6.9	7.6	7.3	7.1	7.5	6.7	7.4	6.1	7.3
1-Jul-05	2	15:15	2	6.1	6.5	5.2	4.8	4.7	6.6	7.0	7.4	7.1	7.4	6.6	6.7	6.0	4.7	4.1
1-Jul-05	2	15:15	4	7.0	5.9	6.0	7.2	5.2	6.7	7.3	7.0	6.3	7.0	7.1	5.9	6.5	6.1	4.2
2-Jul-05	3	8:15	4	6.9	6.0	6.0	6.8	7.1	7.2	7.3	7.0	6.8	6.7	7.2	6.6	7.3	5.7	7.3
2-Jul-05	3	8:15	7	6.8	6.7	7.2	5.7	4.1	7.2	7.2	7.3	7.2	7.3	6.5	7.0	7.5	6.6	5.3
2-Jul-05	3	16:30	3	7.0	6.9	6.9	6.6	5.6	7.1	6.4	6.1	4.8	5.5	7.3	5.8	7.1	7.1	6.7
2-Jul-05	3	16:30	4	7.0	7.1	6.6	6.8	6.0	7.2	7.3	7.2	7.3	6.5	7.3	6.6	6.8	6.5	5.2
3-Jul-05	4	8:10	1	6.9	5.6	6.9	6.1	2.5	6.6	6.9	6.6	6.4	6.3	6.3	6.5	6.2	6.2	6.2
3-Jul-05	4	8:10	4	6.9	6.1	6.5	5.4	6.5	6.6	7.0	6.8	7.1	5.4	6.9	5.9	6.4	6.8	6.1
3-Jul-05	4	16:00	3	6.5	5.5	5.1	5.2	4.2	6.3	5.9	6.8	5.0	5.7	6.7	4.8	6.6	6.6	6.7
3-Jul-05	4	16:00	4	6.4	6.6	4.9	4.7	6.6	6.5	6.9	7.0	6.2	6.3	6.4	5.0	6.2	6.7	5.7
4-Jul-05	5	8:00	4	6.8	6.9	6.8	6.8	6.5	7.2	7.3	7.3	7.3	7.3	7.2	7.0	7.3	7.2	6.1
4-Jul-05	5	8:00	6	6.7	6.7	7.1	7.3	6.4	6.8	6.7	7.3	6.6	7.3	6.9	4.9	5.2	7.4	7.3
4-Jul-05	5	16:15	4	6.9	7.0	6.0	7.1	7.4	6.2	7.6	7.5	6.2	7.0	7.2	6.5	7.2	7.2	5.4
4-Jul-05	5	16:15	8	7.3	6.9	6.1	7.3	6.9	6.9	7.4	6.4	7.2	6.9	7.1	6.6	7.0	6.6	3.4
5-Jul-06	6	6:30	4	7.7	7.1	7.2	6.9	7.2	7.3	7.4	7.2	7.3	6.6	6.9	6.1	7.3	7.5	5.8
5-Jul-06	6	6:30	5	7.7	6.5	6.6	7.2	7.1	6.6	7.6	7.2	5.9	6.5	7.2	3.0	4.7	6.9	6.9
5-Jul-06	6	14:30	2	6.6	5.9	5.6	7.3	7.0	7.5	7.6	7.7	7.3	6.5	7.7	6.9	6.2	6.1	5.7
5-Jul-06	6	14:30	4	7.7	6.6	6.7	7.5	7.2	6.5	7.5	7.7	7.6	7.0	7.5	7.0	6.5	6.6	5.9
6-Jul-05	7	7:20	4	7.8	6.7	7.1	7.2	6.3	7.4	6.9	7.4	7.9	6.9	7.0	6.0	6.1	7.2	6.2
6-Jul-05	7	7:20	7	6.9	6.5	6.5	6.6	7.6	7.1	7.1	7.6	6.9	7.5	6.7	6.8	7.1	6.4	7.0
6-Jul-05	7	15:30	3	6.9	7.3	6.0	7.5	6.4	7.7	5.6	7.6	6.1	7.7	6.7	6.9	7.7	7.3	6.9
6-Jul-05	7	15:30	4	7.1	6.9	5.4	7.4	6.8	7.6	7.7	7.7	7.6	7.9	6.9	7.2	7.2	7.3	7.0
7-Jul-05	8	6:30	4	7.3	6.4	6.6	7.1	6.3	6.5	7.5	7.3	6.7	7.2	7.3	7.0	7.1	6.0	7.0
7-Jul-05	8	6:30	6	7.5	6.3	6.5	6.4	5.9	7.5	7.0	7.0	6.4	6.9	7.1	7.2	6.4	6.0	7.1
7-Jul-05	8	15:15	4	7.1	6.7	6.5	4.9	6.8	7.3	6.8	4.7	2.3	6.6	7.3	7.6	6.5	7.5	6.7
7-Jul-05	8	15:15	8	7.4	6.6	7.2	7.3	6.5	7.8	7.4	7.4	6.3	7.3	7.4	6.6	7.6	7.4	7.7
8-Jul-08	9	6:45	4	6.4	6.6	6.9	7.0	6.4	7.2	6.7	7.1	7.4	7.2	7.6	6.9	7.1	6.4	6.6
8-Jul-08	9	6:45	7	6.7	6.5	7.2	6.6	6.7	6.9	7.1	6.8	7.4	7.0	7.4	6.7	6.9	7.2	6.9
8-Jul-08	9	15:15	1	6.6	6.9	6.6	5.7	6.8	7.2	7.2	6.9	4.5	5.3	6.3	5.0	6.3	6.4	7.1
8-Jul-08	9	15:15	4	7.6	7.0	6.2	6.3	6.9	7.1	7.0	7.2	7.3	5.0	6.8	6.5	6.7	6.7	6.9
9-Jul-05	10	8:00	4	6.2	5.9	6.9	6.0	4.9	6.3	6.8	6.9	6.3	6.4	5.6	6.6	6.8	5.8	6.1
9-Jul-05	10	8:00	5	6.1	5.8	5.9	6.3	5.0	6.2	6.8	6.2	5.6	5.4	5.9	5.4	5.8	5.3	6.4
9-Jul-05	10	17:30	2	6.6	6.5	6.2	3.5	6.5	6.6	6.7	5.9	6.6	6.2	6.1	6.4	6.1	5.9	6.3
9-Jul-05	10	17:30	4	6.6	5.9	6.6	3.6	6.5	6.3	6.8	6.4	6.6	5.6	6.6	6.5	4.9	5.8	5.7
10-Jul-05	11	8:00	4	6.4	5.8	6.4	5.9	5.0	6.3	6.2	6.2	6.3	5.2	6.4	5.8	5.3	5.3	6.2
10-Jul-05	11	8:00	7	5.9	4.4	6.0	6.2	4.4	5.9	5.0	6.2	6.2	5.9	6.1	5.5	5.9	6.1	6.6
10-Jul-05	11	18:20	3	6.7	6.0	5.0	6.7	4.9	6.2	6.6	6.5	4.2	4.8	5.4	5.9	5.8	5.0	5.0
10-Jul-05	11	18:20	4	6.5	6.5	6.4	6.6	6.5	6.3	6.6	6.6	6.4	5.1	5.4	6.3	4.9	5.4	5.6

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
11-Jul-05	12	6:00	1	6.4	4.4	5.5	6.1	6.1	5.0	6.4	6.0	4.7	5.4	5.9	4.1	5.3	4.7	5.9
11-Jul-05	12	6:00	4	6.7	5.9	6.6	6.6	6.4	6.1	6.9	6.4	6.7	5.2	6.1	5.9	5.0	5.1	6.1
11-Jul-05	12	15:15	4	6.4	5.8	6.3	6.5	4.4	5.4	6.7	6.6	5.6	5.0	6.6	4.4	5.3	5.1	5.5
11-Jul-05	12	15:15	5	6.0	5.4	6.3	6.6	4.8	6.6	5.6	6.3	5.4	4.8	5.5	3.3	4.2	4.6	5.5
12-Jul-05	13	8:00	4	6.3	6.4	6.3	6.1	5.1	5.6	6.4	6.4	6.9	6.0	6.9	5.8	6.4	6.7	4.7
12-Jul-05	13	8:00	6	5.9	6.0	6.0	6.4	5.3	5.9	5.7	6.8	6.3	6.3	6.5	6.5	6.4	5.3	6.4
12-Jul-05	13	15:00	4	6.4	5.6	4.9	4.8	6.1	6.2	6.2	5.9	6.0	5.1	6.3	5.3	6.3	6.2	4.3
12-Jul-05	13	15:00	8	6.3	5.5	6.2	6.0	6.1	6.1	5.6	5.6	4.5	5.7	6.2	6.0	5.9	3.9	5.9
13-Jul-05	14	8:30	4	6.6	5.8	6.5	5.7	5.5	6.4	6.4	6.0	6.2	6.3	6.3	6.1	6.4	6.4	4.9
13-Jul-05	14	8:30	5	6.3	5.9	6.1	6.3	5.2	6.0	6.4	6.1	5.2	6.1	6.0	4.8	5.2	5.7	5.2
13-Jul-05	14	14:50	2	6.7	6.2	6.3	5.8	6.0	6.4	6.3	6.3	6.1	6.4	6.5	6.0	6.1	6.2	5.5
13-Jul-05	14	14:50	4	6.6	6.6	6.4	5.5	5.9	6.2	6.4	6.1	6.3	6.1	5.9	5.1	6.3	6.3	5.9
14-Jul-05	15	8:00	4	6.4	6.1	6.2	5.9	4.8	6.1	5.0	6.4	6.3	6.1	6.4	6.0	6.2	6.3	5.2
14-Jul-05	15	8:00	7	6.2	4.2	6.2	5.9	6.2	6.4	6.5	6.5	6.1	6.3	6.5	6.1	6.0	5.6	6.0
14-Jul-05	15	15:00	3	6.7	5.1	6.2	4.6	5.0	6.3	6.4	6.3	3.9	5.3	6.0	4.6	6.2	5.9	6.1
14-Jul-05	15	15:00	4	6.6	5.2	6.0	4.2	6.1	6.3	6.3	6.1	6.2	5.9	6.1	5.0	6.1	6.2	5.0
15-Jul-05	16	6:30	1	6.2	3.3	5.1	3.0	3.7	5.8	6.6	6.7	5.2	6.5	6.6	6.0	6.2	6.5	6.8
15-Jul-05	16	6:30	4	6.8	6.1	5.8	4.4	5.1	6.6	6.4	6.8	6.5	6.4	5.8	6.0	6.4	6.8	6.6
15-Jul-05	16	16:00	4	6.6	6.1	6.3	6.7	5.5	6.3	6.8	7.0	6.5	6.7	6.4	6.2	7.0	6.6	6.4
15-Jul-05	16	16:00	8	6.7	6.4	4.9	6.6	6.4	6.4	6.0	7.1	4.2	6.8	6.5	6.0	6.7	6.2	6.6
16-Jul-05	17	5:30	4	6.4	4.2	5.8	4.8	5.3	5.2	6.1	6.4	6.3	6.1	6.2	5.4	6.4	6.6	6.2
16-Jul-05	17	5:30	6	6.0	5.7	6.2	4.1	5.6	6.2	6.3	5.9	6.4	6.9	6.6	6.1	6.7	5.4	6.7
16-Jul-05	17	14:45	4	6.1	5.0	6.1	6.3	4.2	6.3	6.4	6.6	6.6	5.6	5.4	5.4	4.1	5.4	5.6
16-Jul-05	17	14:45	8	6.4	6.1	5.7	5.4	5.7	6.4	5.8	7.3	5.1	6.2	5.9	5.9	6.3	5.7	5.9
17-Jul-05	18	9:45	4	6.4	3.4	6.4	6.3	6.0	6.1	6.5	6.7	6.3	6.0	6.1	4.3	6.5	6.1	6.1
17-Jul-05	18	9:45	5	6.4	2.4	6.1	6.4	5.6	6.1	6.6	6.5	4.4	6.2	5.8	5.9	6.1	5.6	6.5
17-Jul-05	18	15:00	2	6.6	3.9	6.2	5.9	3.7	5.0	6.0	6.6	6.0	5.9	6.2	5.7	5.3	5.9	5.4
17-Jul-05	18	15:00	4	6.1	5.8	6.1	6.1	5.3	5.4	6.4	6.4	6.4	6.0	6.0	4.9	6.4	6.3	6.1
18-Jul-05	19	7:00	4	6.1	6.3	6.3	5.9	5.4	5.7	6.1	6.2	6.3	5.9	5.3	5.1	6.1	6.1	5.7
18-Jul-05	19	7:00	7	6.3	5.2	5.9	6.3	5.7	5.7	5.7	5.9	5.7	6.1	5.9	5.5	5.6	6.2	6.3
18-Jul-05	19	16:00	3	6.2	5.8	6.2	5.8	4.6	6.0	6.0	6.1	5.4	5.0	5.5	4.4	6.0	4.4	5.7
18-Jul-05	19	16:00	4	6.1	5.2	6.2	6.0	4.9	5.9	5.8	6.0	6.3	5.9	5.6	5.6	5.3	5.6	5.5
19-Jul-05	20	7:30	1	6.4	5.1	6.5	6.4	5.6	6.0	6.1	6.4	5.1	6.5	6.2	5.3	5.8	6.1	6.6
19-Jul-05	20	7:30	4	6.3	6.0	6.4	6.0	5.5	6.0	6.2	6.3	6.4	6.3	6.6	5.7	6.3	6.0	6.1
19-Jul-05	20	15:20	2	6.9	5.4	6.2	6.0	3.9	5.2	5.8	6.2	6.0	5.9	6.1	6.2	5.5	5.7	4.5
19-Jul-05	20	15:20	4	6.3	6.0	6.2	6.1	4.1	5.2	6.2	6.2	4.8	5.1	5.4	5.8	5.8	6.0	4.5
20-Jul-05	21	6:30	4	6.7	5.0	6.3	6.1	4.1	5.9	6.1	6.1	6.1	5.9	5.7	5.7	5.9	5.3	4.0
20-Jul-05	21	6:30	6	6.3	5.9	6.2	6.1	5.7	5.9	4.7	6.1	5.1	6.0	5.8	5.3	5.4	5.2	5.7
20-Jul-05	21	16:00	4	6.6	5.0	6.9	7.1	6.0	6.3	7.0	7.2	5.1	5.9	6.9	6.5	6.3	6.2	5.2
20-Jul-05	21	16:00	8	7.2	7.0	6.8	6.9	7.3	6.8	7.2	7.0	6.5	7.2	7.3	6.7	6.7	4.3	7.0
21-Jul-05	22	8:00	4	7.7	4.5	7.0	5.4	7.3	7.2	7.2	8.0	7.4	7.5	6.8	7.7	7.9	7.6	7.3
21-Jul-05	22	8:00	5	7.5	5.6	6.9	6.8	7.7	7.2	6.9	7.9	6.0	6.8	8.0	7.6	7.6	7.0	7.7
21-Jul-05	22	15:30	2	8.1	4.5	7.3	7.4	6.0	4.8	7.1	7.1	7.2	6.6	6.5	7.5	5.6	6.1	5.5
21-Jul-05	22	15:30	4	7.7	5.2	7.5	7.4	6.6	6.3	7.1	7.1	5.0	5.6	6.7	7.2	7.0	5.9	6.1
22-Jul-05	23	7:30	4	7.7	1.9	6.6	7.0	7.1	7.0	6.7	7.5	6.9	7.2	7.1	7.0	7.2	6.0	5.4
22-Jul-05	23	7:30	7	7.4	2.5	7.2	6.9	5.7	7.1	6.5	7.4	6.9	7.0	6.7	7.1	7.2	4.8	7.2
22-Jul-05	23	14:30	3	8.0	4.5	7.0	6.7	5.9	6.8	7.0	7.5	4.7	7.5	7.3	4.8	7.0	4.1	7.4
22-Jul-05	23	14:30	4	7.8	5.2	6.0	7.3	7.3	7.2	7.4	7.3	5.8	7.0	6.8	7.2	7.4	6.1	5.6
23-Jul-05	24	8:00	1	7.8	1.9	7.5	6.9	6.6	5.9	6.0	7.7	7.4	7.5	7.5	5.3	6.1	7.3	7.0
23-Jul-05	24	8:00	4	8.0	6.5	7.4	7.4	6.2	7.4	7.7	7.3	7.8	7.9	6.8	7.3	7.1	7.0	6.3
23-Jul-05	24	15:15	4	7.8	6.9	7.4	7.7	6.4	6.7	7.5	7.6	7.5	7.2	7.0	7.4	7.4	6.5	6.1
23-Jul-05	24	15:15	6	7.8	4.6	7.4	7.6	6.1	7.1	6.9	7.7	5.6	7.3	7.5	7.0	7.4	7.2	7.4
24-Jul-05	25	8:15	4	7.8	7.8	7.9	7.1	6.2	7.0	7.2	7.6	7.4	6.3	7.1	7.4	7.0	7.5	6.6
24-Jul-05	25	8:15	6	7.9	6.8	7.5	7.5	6.3	7.0	6.8	7.8	6.4	7.6	7.6	7.0	7.5	7.1	7.6
24-Jul-05	25	15:20	4	8.2	5.2	7.4	5.7	6.4	7.1	7.3	7.6	7.3	6.9	7.2	7.1	7.2	7.2	5.5
24-Jul-05	25	15:20	8	8.0	7.2	7.1	7.2	6.8	7.2	7.0	7.3	4.6	6.8	7.3	6.3	7.2	4.6	7.3

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
25-Jul-05	26	8:00	4	8.0	5.5	7.3	7.1	7.0	6.6	7.3	7.4	7.3	7.1	7.3	3.7	7.4	7.2	6.1
25-Jul-05	26	8:00	5	7.7	5.8	7.4	7.1	7.2	6.3	7.2	7.4	6.1	6.8	7.2	6.6	7.0	6.4	7.4
25-Jul-05	26	16:00	2	8.3	6.2	7.5	6.2	5.1	4.3	6.7	7.3	6.8	6.3	5.5	6.9	6.3	7.1	6.3
25-Jul-05	26	16:00	4	8.5	4.5	7.2	5.7	4.5	6.0	7.1	7.2	7.0	7.1	4.9	6.8	7.0	6.9	6.0
26-Jul-05	27	8:30	4	8.2	3.8	7.5	6.7	6.1	7.0	7.7	8.0	7.9	7.8	7.2	6.6	8.0	8.0	7.2
26-Jul-05	27	8:30	7	7.2	5.3	7.7	7.1	5.1	7.7	7.7	7.9	7.4	7.8	7.7	8.1	8.2	7.4	7.5
26-Jul-05	27	15:45	3	7.5	4.9	7.6	7.3	3.9	7.0	7.2	7.6	5.9	7.3	7.5	6.6	7.2	7.3	5.8
26-Jul-05	27	15:45	4	9.2	5.0	7.3	7.3	4.9	5.9	6.9	7.3	7.2	7.7	6.7	6.8	7.2	7.3	6.0
27-Jul-05	28	6:00	1	7.6	3.5	7.5	7.1	6.3	5.3	7.2	7.7	6.2	6.7	6.6	6.5	7.2	7.7	7.5
27-Jul-05	28	6:00	2	6.1	7.0	7.5	6.9	6.7	5.6	6.7	7.6	7.0	7.1	6.8	6.8	6.9	7.8	7.2
27-Jul-05	28	6:00	3	7.4	6.1	7.5	7.1	6.1	7.2	7.4	7.5	6.4	7.3	7.0	6.8	7.2	7.0	6.9
27-Jul-05	28	6:00	4	7.1	6.9	7.4	7.3	6.9	7.1	7.5	7.6	7.3	7.5	6.7	7.2	7.4	7.2	7.2
27-Jul-05	28	6:00	5	7.3	5.7	7.3	6.9	7.3	6.2	7.5	7.4	6.3	7.5	7.0	7.5	7.5	6.5	6.1
27-Jul-05	28	6:00	6	7.3	6.8	7.4	7.0	6.7	6.5	7.2	7.6	6.6	7.7	7.2	7.3	7.4	7.2	7.3
27-Jul-05	28	6:00	7	7.4	4.0	7.3	6.9	6.0	6.7	7.4	7.9	7.1	7.6	6.8	7.5	7.7	6.3	7.4
27-Jul-05	28	6:00	8	7.3	6.6	7.5	7.0	7.0	5.9	7.5	7.9	6.0	7.6	6.9	7.5	7.5	6.0	7.5
			Average	**7.0**	**5.9**	**6.6**	**6.3**	**5.8**	**6.5**	**6.7**	**6.9**	**6.3**	**6.6**	**6.6**	**6.3**	**6.6**	**6.3**	**6.0**
			Minimum	5.9	1.9	4.9	3.0	2.5	4.3	4.7	4.7	2.3	4.8	4.6	3.0	4.1	3.9	3.3
			Maximum	9.2	7.8	7.9	7.7	7.7	7.8	8.0	8.1	7.9	7.9	8.0	8.1	8.2	8.0	7.7

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
pH

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	8.00	7.57	7.79	7.50	6.96	7.57	7.58	7.85	7.70	7.97	7.08	7.67	7.43	7.70	7.00
29-Jun-05	0	7:50	4	8.10	7.75	7.95	7.90	6.79	7.73	7.93	7.97	7.88	7.48	7.53	7.97	7.95	7.62	6.88
29-Jun-05	0	7:50	5	8.10	7.98	7.70	7.93	7.43	7.63	7.77	7.93	7.76	7.90	7.89	8.00	7.55	7.88	7.19
29-Jun-05	0	7:50	8	8.10	7.90	7.83	7.25	7.53	7.40	7.96	8.01	7.68	7.93	7.24	8.02	7.89	7.93	6.94
2-Jul-05	3	8:15	4	7.71	7.50	7.54	7.34	7.85	7.66	7.93	7.78	7.60	7.56	7.84	7.64	7.77	7.45	7.50
2-Jul-05	3	8:15	7	7.68	7.82	7.73	7.84	7.21	7.73	7.92	7.80	7.71	7.85	7.72	7.90	7.88	7.65	7.83
5-Jul-06	6	6:30	4	7.92	7.88	7.84	7.77	7.68	7.77	7.98	7.84	7.95	8.01	7.93	7.58	7.91	7.84	7.60
5-Jul-06	6	6:30	5	7.85	7.68	7.70	7.68	7.89	7.80	7.90	7.89	7.49	7.91	7.91	7.17	7.41	7.90	7.71
7-Jul-05	8	6:30	4	8.45	7.77	7.77	7.61	7.68	7.80	7.90	7.78	7.83	7.83	7.87	7.58	7.89	7.87	7.69
7-Jul-05	8	6:30	6	8.01	7.84	7.83	7.73	7.85	7.81	7.80	7.82	7.52	7.82	7.68	7.75	7.60	7.92	7.95
9-Jul-05	10	8:00	4	7.97	8.01	7.78	7.63	7.59	7.89	8.04	7.94	7.98	7.92	7.60	7.85	7.80	7.70	7.86
9-Jul-05	10	8:00	5	8.06	7.90	7.92	7.87	7.35	7.76	8.01	8.01	7.61	7.66	7.68	7.45	7.67	7.65	7.94
12-Jul-05	13	8:00	4	8.21	7.84	7.96	7.97	7.84	7.86	7.96	7.96	7.98	8.06	7.98	7.85	8.03	7.96	7.51
12-Jul-05	13	8:00	6	8.13	7.92	7.86	7.94	7.85	7.81	8.05	7.96	7.99	8.01	8.01	7.98	7.85	7.73	7.58
14-Jul-05	15	8:00	4	8.06	7.92	7.88	7.74	7.59	7.70	7.66	8.06	7.98	8.09	8.00	8.08	8.10	8.08	7.67
14-Jul-05	15	8:00	7	8.07	6.81	7.99	7.80	7.97	7.84	8.02	8.07	7.72	8.08	7.68	8.11	8.01	7.81	8.04
16-Jul-05	17	5:30	4	8.00	8.06	7.62	7.62	7.51	7.56	7.60	7.97	7.92	7.92	8.06	8.00	8.12	8.06	7.51
16-Jul-05	17	5:30	6	8.10	7.81	7.59	7.67	7.82	7.81	7.57	7.99	7.72	7.97	8.04	7.99	8.06	7.93	7.62
19-Jul-05	20	7:30	1	8.09	7.58	8.00	7.84	7.84	7.74	8.07	8.09	7.59	7.92	8.10	7.76	7.95	7.98	8.03
19-Jul-05	20	7:30	4	8.10	7.57	8.09	7.82	7.75	7.70	8.07	8.11	7.98	8.14	8.06	7.82	8.10	7.99	7.95
21-Jul-05	22	8:00	4	8.09	6.80	7.94	7.30	7.79	7.59	7.99	8.10	7.97	8.06	7.80	7.92	7.96	7.93	7.66
21-Jul-05	22	8:00	5	8.11	6.97	7.96	6.76	7.93	7.61	7.86	8.11	7.81	8.00	8.02	7.50	7.88	7.89	7.92
23-Jul-05	24	8:00	1	8.11	6.92	8.05	7.98	7.72	7.18	7.76	8.20	7.63	8.17	8.03	7.55	7.63	7.68	7.84
23-Jul-05	24	8:00	4	8.17	8.12	7.78	8.00	7.93	7.64	8.08	8.18	8.07	8.08	7.92	7.99	8.08	7.86	7.50
27-Jul-05	28	6:00	1	8.50	6.96	8.02	8.00	7.66	7.22	7.97	8.21	6.99	8.17	8.00	7.86	8.07	8.06	7.83
27-Jul-05	28	6:00	4	8.12	7.71	8.06	8.00	7.83	7.60	8.03	8.20	7.96	8.12	7.83	8.05	8.16	7.95	7.84
27-Jul-05	28	6:00	5	8.14	7.27	8.08	7.90	7.85	7.67	8.05	8.13	7.51	8.00	7.80	7.99	8.05	7.84	8.08
27-Jul-05	28	6:00	8	8.15	7.76	8.10	7.92	7.90	7.48	8.09	8.22	7.43	8.07	7.92	8.14	8.08		8.08
			Average	**8.08**	**7.63**	**7.87**	**7.73**	**7.66**	**7.66**	**7.91**	**8.01**	**7.75**	**7.95**	**7.83**	**7.83**	**7.89**	**7.85**	**7.67**
			Minimum	7.68	6.80	7.54	6.76	6.79	7.18	7.57	7.78	6.99	7.48	7.08	7.17	7.41	7.45	6.88
			Maximum	8.50	8.12	8.10	8.00	7.97	7.89	8.09	8.22	8.07	8.17	8.10	8.14	8.16	8.08	8.08

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	163	161	138	133	188	133	143	139	129	139	138	139	131	141	122
29-Jun-05	0	7:50	8	150	148	135	134	144	135	143	138	131	138	133	140	134	139	124
5-Jul-05	6	6:30	4	130	142	126	126	138	124	134	129	131	132	130	135	127	128	130
5-Jul-05	6	6:30	5	130	144	127	126	136	124	132	128	130	130	129	143	129	127	129
12-Jul-05	13	8:00	4	112	127	111	112	119	105	118	116	113	113	115	117	117	117	117
12-Jul-05	13	8:00	6	113	126	111	112	121	105	123	115	112	112	115	117	117	117	116
19-Jul-05	20	7:30	1	159	183	160	166	156	137	153	155	146	152	151	158	154	153	147
19-Jul-05	20	7:30	4	154	197	155	148	156	137	153	155	147	152	152	157	154	153	147
27-Jul-05	28	6:00	1	138	172	130	130	131	116	130	133	129	130	134	133	130	127	129
27-Jul-05	28	6:00	8	130	152	129	131	130	120	130	133	130	130	132	133	130	128	128
			Average	**137.9**	**155.1**	**132.3**	**131.9**	**141.9**	**123.4**	**136.0**	**134.2**	**129.9**	**132.9**	**132.8**	**137.2**	**132.4**	**132.9**	**129.0**
			Minimum	112	126	111	112	119	105	118	115	112	112	115	117	117	117	116
			Maximum	163	197	160	166	188	137	153	155	147	152	152	158	154	153	147

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Ammonia (ppm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	<0.063	<0.063	0.112	<0.063	0.788	<0.063	0.208	0.101	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
29-Jun-05	0	7:50	8	<0.063	<0.063	0.107	<0.063	0.201	<0.063	0.137	0.084	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
27-Jul-05	28	6:00	1	<0.063	<0.063	<0.063	<0.063	0.066	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
27-Jul-05	28	6:00	8	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063		<0.063
			Average	**<0.063**	**<0.063**	**0.073**	**<0.063**	**0.272**	**<0.063**	**0.102**	**<0.063**	**<0.063**	**<0.063**	**<0.063**	**<0.063**	**<0.063**	**<0.063**	**<0.063**
			Minimum	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	<0.063	<0.063	0.112	<0.063	0.788	<0.063	0.208	0.101	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
DOC (ppm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	1	3.7	4.7	5.5	5.2		6.1	5.6	3.5	9.2	4.8	10.8	6.3	7.1	6.2	13.4
29-Jun-05	0	7:50	8	3.5	7.6	3.6		5.6	6.0	4.2	4.0	7.6	4.8	10.3	5.4	6.4	5.1	11.8
27-Jul-05	28	6:00	1	4.4	10.9	1.8	2.2	2.1	2.7	1.8	2.6	2.1	1.9	1.9	2.3	2.0	2.1	2.0
27-Jul-05	28	6:00	8	1.9	11.1	1.8	1.9	1.7	1.9	1.8	1.9	2.1	1.8	1.8	4.9	2.0	2.0	2.0
			Average	**3.4**	**8.6**	**3.2**	**3.1**	**3.1**	**4.2**	**3.4**	**3.0**	**5.3**	**3.3**	**6.2**	**4.7**	**4.4**	**3.9**	**7.3**
			Minimum	1.9	4.7	1.8	1.9	1.7	1.9	1.8	1.9	2.1	1.8	1.8	2.3	2.0	2.0	2.0
			Maximum	4.4	11.1	5.5	5.2	5.6	6.1	5.6	4.0	9.2	4.8	10.8	6.3	7.1	6.2	13.4

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	3	38.8	51.2	51.6	55.2	60.0	52.8	53.2	50.8	55.6	62.4	54.8	53.6	54.0	54.0	56.8
29-Jun-05	0	7:50	7	54.4	50.0	52.4	52.8	63.2	50.8	53.2	50.8	56.4	53.6	56.8	53.2	53.6	52.0	57.6
27-Jul-05	28	6:00	3	48.0	61.2	48.0	46.8	48.8	44.4	48.0	50.8	48.8	47.6	49.2	51.2	50.4	50.0	48.0
27-Jul-05	28	6:00	7	47.6	67.6	47.2	48.8	48.8	44.8	48.4	49.6	48.8	50.0	50.4	52.8	51.2	48.8	49.6
			Average	**47.2**	**57.5**	**49.8**	**50.9**	**55.2**	**48.2**	**50.7**	**50.5**	**52.4**	**53.4**	**52.8**	**52.7**	**52.3**	**51.2**	**53.0**
			Minimum	38.8	50.0	47.2	46.8	48.8	44.4	48.0	49.6	48.8	47.6	49.2	51.2	50.4	48.8	48.0
			Maximum	54.4	67.6	52.4	55.2	63.2	52.8	53.2	50.8	56.4	62.4	56.8	53.6	54.0	54.0	57.6

Appendix Table 5. Water Chemistry Parameters fo *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 29 June 2005 to 27 July 2005.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
29-Jun-05	0	7:50	2	51.2	50.0	46.8	50.8	52.8	47.6	48.0	48.4	50.8	45.6	47.6	50.0	51.2	51.6	51.2
29-Jun-05	0	7:50	6	49.6	46.4	48.8	44.4	51.6	48.0	51.2	48.8	48.8	53.2	53.2	49.2	48.4	50.0	47.2
27-Jul-05	28	6:00	2	53.2	64.4	50.8	50.8	54.4	46.8	53.6	55.2	52.4	51.6	55.6	54.4	56.4	53.6	51.6
27-Jul-05	28	6:00	6	53.6	64.8	50.8	50.8	52.4	49.2	52.4	54.0	52.8	52.4	53.6	53.6	54.8	53.2	51.6
			Average	**51.9**	**56.4**	**49.3**	**49.2**	**52.8**	**47.9**	**51.3**	**51.6**	**51.2**	**50.7**	**52.5**	**51.8**	**52.7**	**52.1**	**50.4**
			Minimum	49.6	46.4	46.8	44.4	51.6	46.8	48.0	48.4	48.8	45.6	47.6	49.2	48.4	50.0	47.2
			Maximum	53.6	64.8	50.8	50.8	54.4	49.2	53.6	55.2	52.8	53.2	55.6	54.4	56.4	53.6	51.6

APPENDIX 6

Survival and Growth of *H. azteca* following 21-d of Exposure to Ashland Harbor Reference Sediments, 12 August 2005 to 2 September 2005

Appendix Table 6. Survival and Growth of *H. azteca* following 21-d od Exposure to Ashland Harbor Reference Sediments, 12 August 2005 to 2 September 2005.

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Devivation
A	Silica Sand	1	9		
A	Silica Sand	2	10		
A	Silica Sand	3	10		
A	Silica Sand	4	10		
A	Silica Sand	5	10		
A	Silica Sand	6	10		
A	Silica Sand	7	9		
A	Silica Sand	8	10	97.5	4.6
E	SQT10	1	3		
E	SQT10	2	8		
E	SQT10	3	5		
E	SQT10	4	6		
E	SQT10	5	3		
E	SQT10	6	4		
E	SQT10	7	4		
E	SQT10	8	7	50.0	18.5
G	SQT12	1	6		
G	SQT12	2	7		
G	SQT12	3	10		
G	SQT12	4	7		
G	SQT12	5	9		
G	SQT12	6	5		
G	SQT12	7	7		
G	SQT12	8	10	76.3	18.5
M	SQT5	1	9		
M	SQT5	2	5		
M	SQT5	3	10		
M	SQT5	4	6		
M	SQT5	5	8		
M	SQT5	6	10		
M	SQT5	7	8		
M	SQT5	8	9	81.3	18.1

APPENDIX 7

Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005. Temperature (° C)

Date	*Day*	*Time*	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	1	23.4	23.5	23.3	23.7
12-Aug-05	0	6:35	2	23.4	23.4	23.2	23.7
12-Aug-05	0	6:35	3	23.4	23.4	23.3	23.7
12-Aug-05	0	6:35	4	23.4	23.4	23.3	23.8
12-Aug-05	0	6:35	5	23.4	23.3	23.4	23.7
12-Aug-05	0	6:35	6	23.4	23.4	23.3	23.8
12-Aug-05	0	6:35	7	23.4	23.2	23.3	23.7
12-Aug-05	0	6:35	8	23.4	23.4	23.4	23.7
12-Aug-05	0	14:15	1	23.1	23.4	22.9	23.4
12-Aug-05	0	14:15	4	23.1	23.5	23.0	23.5
13-Aug-05	1	9:00	4	22.3	22.2	22.3	23.4
13-Aug-05	1	9:00	6	22.3	22.2	22.2	23.3
13-Aug-05	1	16:15	4	22.1	22.5	22.5	23.5
13-Aug-05	1	16:15	8	22.3	22.4	22.3	23.5
14-Aug-05	2	8:00	4	20.5	20.6	20.4	21.5
14-Aug-05	2	8:00	5	20.5	20.6	20.5	21.5
14-Aug-05	2	15:15	2	21.4	21.4	21.5	22.2
14-Aug-05	2	15:15	4	21.3	21.5	21.4	22.3
15-Aug-05	3	8:15	4	22.5	22.4	22.4	23.0
15-Aug-05	3	8:15	7	22.4	22.5	22.4	23.0
15-Aug-05	3	15:00	3	23.1	23.2	22.9	23.3
15-Aug-05	3	15:00	4	23.1	23.3	22.9	23.3
16-Aug-05	4	7:20	1	22.9	23.0	22.5	23.3
16-Aug-05	4	7:20	4	22.8	23.0	22.9	23.3
16-Aug-05	4	15:45	3	23.4	23.4	23.2	23.5
16-Aug-05	4	15:45	4	23.3	23.5	23.2	23.5
17-Aug-06	5	8:10	4	23.0	23.1	23.1	23.5
17-Aug-06	5	8:10	6	23.1	23.2	23.1	23.5
17-Aug-06	5	15:00	4	23.4	23.6	23.4	23.8
17-Aug-06	5	15:00	8	23.5	23.6	23.2	23.8
18-Aug-05	6	7:20	4	23.0	23.0	23.3	23.3
18-Aug-05	6	7:20	5	23.2	23.0	23.2	23.2
18-Aug-05	6	15:45	2	22.6	22.6	22.5	23.2
18-Aug-05	6	15:45	4	22.6	22.7	22.5	23.2

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
19-Aug-05	7	8:00	4	22.8	22.8	22.7	23.3
19-Aug-05	7	8:00	7	22.7	22.8	22.5	23.2
19-Aug-05	7	15:30	3	23.4	23.4	23.2	23.6
19-Aug-05	7	15:30	4	23.4	23.4	23.2	23.6
20-Aug-05	8	8:30	4	22.5	22.6	22.4	23.1
20-Aug-05	8	8:30	6	22.5	22.6	22.4	23.1
20-Aug-05	8	15:00	4	22.9	22.9	22.8	23.2
20-Aug-05	8	15:00	8	22.8	23.0	22.7	23.3
21-Aug-05	9	8:45	4	22.4	22.4	22.2	23.0
21-Aug-05	9	8:45	7	22.4	22.5	22.3	23.1
21-Aug-05	9	15:30	1	22.5	22.8	22.5	23.3
21-Aug-05	9	15:30	4	22.6	22.7	22.5	23.3
22-Aug-05	10	8:00	4	22.5	22.6	22.4	22.9
22-Aug-05	10	8:00	5	22.5	22.5	22.4	23.0
22-Aug-05	10	14:45	2	23.3	23.3	23.1	23.3
22-Aug-05	10	14:45	4	23.3	23.3	23.1	23.3
23-Aug-05	11	8:00	4	23.0	23.0	23.0	23.0
23-Aug-05	11	8:00	7	23.1	23.2	22.8	23.1
23-Aug-05	11	14:45	3	23.5	23.5	23.4	23.3
23-Aug-05	11	14:45	4	23.5	23.5	23.2	23.4
24-Aug-05	12	8:30	1	23.2	23.4	23.3	23.2
24-Aug-05	12	8:30	4	23.2	23.4	23.3	23.2
24-Aug-05	12	15:15	4	23.0	23.2	23.0	23.5
24-Aug-05	12	15:15	5	22.9	23.2	23.0	23.5
25-Aug-05	13	8:15	4	23.0	22.8	22.9	23.3
25-Aug-05	13	8:15	6	22.9	22.9	23.1	23.2
25-Aug-05	13	15:15	4	23.3	23.2	23.0	23.2
25-Aug-05	13	15:15	7	23.3	23.0	23.0	23.3
26-Aug-05	14	8:20	4	22.9	23.1	23.0	23.4
26-Aug-05	14	8:20	5	23.0	23.1	23.0	23.4
26-Aug-05	14	15:00	2	23.2	23.1	23.2	23.4
26-Aug-05	14	15:00	4	23.1	23.0	23.0	23.3
27-Aug-05	15	9:15	4	22.6	22.3	22.2	22.7
27-Aug-05	15	9:15	7	22.2	22.4	22.3	22.7
27-Aug-05	15	15:00	3	22.5	22.7	22.4	22.9
27-Aug-05	15	15:00	4	22.6	22.7	22.5	22.8

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
28-Aug-05	16	9:00	1	22.5	22.7	22.2	22.9
28-Aug-05	16	9:00	4	22.5	22.6	22.3	22.9
28-Aug-05	16	15:30	4	22.8	22.9	22.6	23.1
28-Aug-05	16	15:30	7	22.8	22.9	22.6	23.1
29-Aug-05	17	8:00	4	22.7	22.7	22.7	22.7
29-Aug-05	17	8:00	6	22.9	22.9	22.9	22.7
29-Aug-05	17	15:20	4	23.3	23.2	23.3	23.2
29-Aug-05	17	15:20	8	23.3	23.2	23.3	23.1
30-Aug-05	18	8:00	4	22.9	22.9	22.8	22.7
30-Aug-05	18	8:00	5	22.9	22.9	22.8	22.8
30-Aug-05	18	15:00	2	21.0	21.0	20.8	21.4
30-Aug-05	18	15:00	4	21.0	21.0	20.9	21.4
31-Aug-05	19	9:15	4	22.4	22.9	22.4	22.9
31-Aug-05	19	9:15	7	22.4	22.5	22.4	22.9
31-Aug-05	19	15:00	3	22.9	22.9	22.8	23.2
31-Aug-05	19	15:00	4	22.9	22.4	22.8	23.2
1-Sep-05	20	7:00	1	22.7	22.9	22.4	22.9
1-Sep-05	20	7:00	4	22.5	23.0	22.5	23.2
1-Sep-05	20	15:00	1	22.8	22.9	22.8	23.2
1-Sep-05	20	15:00	4	22.9	22.9	22.8	23.2
2-Sep-05	21	7:45	1	22.5	22.6	22.5	23.0
2-Sep-05	21	7:45	2	22.6	22.6	22.5	23.0
2-Sep-05	21	7:45	3	22.6	22.6	22.5	23.0
2-Sep-05	21	7:45	4	22.5	22.6	22.5	23.0
2-Sep-05	21	7:45	5	22.5	22.6	22.6	23.0
2-Sep-05	21	7:45	6	22.5	22.7	22.6	23.0
2-Sep-05	21	7:45	7	22.5	22.7	22.6	23.0
2-Sep-05	21	7:45	8	22.5	22.7	22.2	23.0
			Average	**22.8**	**22.8**	**22.7**	**23.1**
			Minimum	20.5	20.6	20.4	21.4
			Maximum	23.5	23.6	23.4	23.8

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	1	7.2	3.0	6.9	6.8
12-Aug-05	0	6:35	2	7.0	4.2	4.9	2.8
12-Aug-05	0	6:35	3	7.2	6.3	6.8	6.7
12-Aug-05	0	6:35	4	7.2	7.2	5.4	6.1
12-Aug-05	0	6:35	5	7.3	4.3	4.7	6.8
12-Aug-05	0	6:35	6	7.4	6.1	3.0	6.5
12-Aug-05	0	6:35	7	7.1	4.3	4.4	4.3
12-Aug-05	0	6:35	8	7.2	4.4	6.7	4.0
12-Aug-05	0	14:15	1	6.9	3.7	6.3	6.0
12-Aug-05	0	14:15	4	6.8	5.6	5.4	6.0
13-Aug-05	1	9:00	4	7.5	7.3	6.1	6.2
13-Aug-05	1	9:00	6	7.6	7.4	5.0	6.6
13-Aug-05	1	16:15	4	7.2	5.9	5.8	6.4
13-Aug-05	1	16:15	8	7.0	4.9	6.4	4.4
14-Aug-05	2	8:00	4	7.7	5.4	7.1	5.5
14-Aug-05	2	8:00	5	7.7	2.5	7.0	4.8
14-Aug-05	2	15:15	2	6.9	3.4	5.1	4.0
14-Aug-05	2	15:15	4	7.1	5.8	6.4	6.5
15-Aug-05	3	8:15	4	7.5	4.8	7.0	6.8
15-Aug-05	3	8:15	7	7.4	5.5	7.1	6.9
15-Aug-05	3	15:00	3	7.5	5.1	6.8	6.1
15-Aug-05	3	15:00	4	7.5	6.1	7.0	6.8
16-Aug-05	4	7:20	1	7.4	4.4	5.9	7.5
16-Aug-05	4	7:20	4	7.5	6.4	6.7	7.6
16-Aug-05	4	15:45	3	7.0	4.2	6.9	7.4
16-Aug-05	4	15:45	4	6.6	4.1	7.0	5.6
17-Aug-06	5	8:10	4	7.5	5.0	6.7	5.9
17-Aug-06	5	8:10	6	7.3	4.6	6.7	6.2
17-Aug-06	5	15:00	4	6.8	5.8	7.1	5.5
17-Aug-06	5	15:00	8	6.9	3.8	5.8	4.9
18-Aug-05	6	7:20	4	6.9	5.9	7.4	5.2
18-Aug-05	6	7:20	5	7.4	4.6	6.6	5.9
18-Aug-05	6	15:45	2	7.4	9.4	7.7	7.0
18-Aug-05	6	15:45	4	7.6	6.9	7.4	6.3

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
19-Aug-05	7	8:00	4	7.4	2.1	7.4	5.7
19-Aug-05	7	8:00	7	7.4	5.5	7.5	5.8
19-Aug-05	7	15:30	3	7.2	7.0	7.3	5.5
19-Aug-05	7	15:30	4	7.2	7.2	7.2	5.9
20-Aug-05	8	8:30	4	7.8	7.3	7.8	7.3
20-Aug-05	8	8:30	6	7.3	5.6	7.8	7.0
20-Aug-05	8	15:00	4	7.8	7.6	7.9	6.7
20-Aug-05	8	15:00	8	7.8	6.6	7.5	6.0
21-Aug-05	9	8:45	4	7.6	6.9	7.4	7.3
21-Aug-05	9	8:45	7	7.9	7.1	7.1	7.1
21-Aug-05	9	15:30	1	8.0	6.4	8.2	5.0
21-Aug-05	9	15:30	4	8.2	7.6	8.3	6.7
22-Aug-05	10	8:00	4	7.8	7.1	7.8	7.9
22-Aug-05	10	8:00	5	7.8	6.8	8.1	7.6
22-Aug-05	10	14:45	2	7.3	6.8	6.8	6.9
22-Aug-05	10	14:45	4	7.1	6.0	6.7	7.0
23-Aug-05	11	8:00	4	6.8	6.4	7.2	7.1
23-Aug-05	11	8:00	7	7.4	6.9	6.6	7.3
23-Aug-05	11	14:45	3	7.5	5.3	7.2	8.0
23-Aug-05	11	14:45	4	7.4	5.3	7.1	7.4
24-Aug-05	12	8:30	1	7.5	7.2	6.6	7.0
24-Aug-05	12	8:30	4	7.7	4.8	7.0	7.2
24-Aug-05	12	15:15	4	7.6	7.7	7.3	6.1
24-Aug-05	12	15:15	5	7.5	4.0	7.0	5.3
25-Aug-05	13	8:15	4	7.4	6.9	7.6	6.6
25-Aug-05	13	8:15	6	7.0	6.9	7.9	7.4
25-Aug-05	13	15:15	4	7.2	7.4	7.6	6.3
25-Aug-05	13	15:15	7	6.9	7.2	7.2	6.7
26-Aug-05	14	8:20	4	7.6	6.1	7.1	5.6
26-Aug-05	14	8:20	5	7.6	4.3	6.2	5.2
26-Aug-05	14	15:00	2	7.6	6.9	7.4	6.9
26-Aug-05	14	15:00	4	7.4	7.1	7.3	6.1
27-Aug-05	15	9:15	4	7.0	6.3	8.0	5.9
27-Aug-05	15	9:15	7	6.9	8.0	8.1	6.5
27-Aug-05	15	15:00	3	7.6	6.0	7.8	7.1
27-Aug-05	15	15:00	4	7.4	4.1	7.3	7.1

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
28-Aug-05	16	9:00	1	7.4	5.5	7.3	7.4
28-Aug-05	16	9:00	4	7.6	5.6	7.4	6.8
28-Aug-05	16	15:30	4	8.1	7.0	7.3	6.9
28-Aug-05	16	15:30	7	8.0	6.7	6.7	5.6
29-Aug-05	17	8:00	4	7.5	6.7	6.7	6.2
29-Aug-05	17	8:00	6	7.4	7.6	8.0	7.1
29-Aug-05	17	15:20	4	7.6	5.3	7.0	5.7
29-Aug-05	17	15:20	8	7.8	6.0	6.5	4.8
30-Aug-05	18	8:00	4	8.2	6.1	8.0	7.3
30-Aug-05	18	8:00	5	7.7	4.4	7.7	6.7
30-Aug-05	18	15:00	2	8.7	7.4	7.7	7.6
30-Aug-05	18	15:00	4	8.4	6.1	7.7	7.7
31-Aug-05	19	9:15	4	8.0	6.9	7.8	6.6
31-Aug-05	19	9:15	7	7.8	7.4	7.6	7.3
31-Aug-05	19	15:00	3	7.5	7.1	7.1	6.1
31-Aug-05	19	15:00	4	7.7	6.2	6.7	5.4
1-Sep-05	20	7:00	1	7.2	6.9	7.4	6.9
1-Sep-05	20	7:00	4	7.6	7.2	6.1	6.0
1-Sep-05	20	15:00	1	8.4	9.7	6.2	7.8
1-Sep-05	20	15:00	4	8.4	6.9	6.7	7.6
2-Sep-05	21	7:45	1	8.1	6.0	7.4	7.4
2-Sep-05	21	7:45	2	7.8	3.7	7.0	6.9
2-Sep-05	21	7:45	3	7.8	5.4	7.4	7.3
2-Sep-05	21	7:45	4	8.0	7.3	7.2	6.9
2-Sep-05	21	7:45	5	7.8	6.6	7.6	7.0
2-Sep-05	21	7:45	6	8.1	7.4	7.0	7.4
2-Sep-05	21	7:45	7	7.7	7.0	7.2	7.6
2-Sep-05	21	7:45	8	7.9	7.4	7.6	6.2
			Average	**7.5**	**6.0**	**7.0**	**6.4**
			Minimum	6.6	2.1	3.0	2.8
			Maximum	8.7	9.7	8.3	8.0

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005.
pH

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	1	8.12	7.54	7.93	7.91
12-Aug-05	0	6:35	4	8.11	7.85	7.90	7.88
12-Aug-05	0	6:35	5	8.12	7.45	7.88	7.88
12-Aug-05	0	6:35	8	8.16	7.35	7.97	7.20
15-Aug-05	3	8:00	4	8.10	7.67	8.03	7.99
15-Aug-05	3	8:00	7	8.13	8.10	7.97	7.97
18-Aug-05	6	7:20	4	8.10	7.50	8.06	7.96
18-Aug-05	6	7:20	5	8.19	7.46	8.11	7.97
20-Aug-05	8	8:30	4	8.17	8.03	8.04	7.87
20-Aug-05	8	8:30	6	8.16	7.83	8.04	7.86
22-Aug-05	10	8:00	4	8.06	7.90	8.02	8.01
22-Aug-05	10	8:00	5	8.08	7.60	8.12	8.01
25-Aug-05	13	8:15	4	8.01	7.96	8.00	7.96
25-Aug-05	13	8:15	6	8.03	7.81	8.04	8.00
27-Aug-05	15	9:15	4	8.20	7.73	8.07	7.64
27-Aug-05	15	9:15	7	*	7.99	8.02	7.73
29-Aug-05	17	8:00	4	8.31	7.32	8.12	7.96
29-Aug-05	17	8:00	6	8.22	7.16	8.00	7.81
1-Sep-05	20	7:00	1	8.06	8.00	8.27	7.91
1-Sep-05	20	7:00	4	8.12	7.97	8.19	7.97
2-Sep-05	21	7:45	1	8.27	7.73	8.06	8.09
2-Sep-05	21	7:45	4	8.24	7.98	7.97	7.95
2-Sep-05	21	7:45	5	8.27	7.95	8.08	8.10
2-Sep-05	21	7:45	8	8.24	7.96	8.10	8.03
			Average	**8.15**	**7.74**	**8.04**	**7.90**
			Minimum	8.01	7.16	7.88	7.20
			Maximum	8.31	8.10	8.27	8.10

* Data point not recorded

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005. Conductivity (µmhos/cm)

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	1	122	144	125	129
12-Aug-05	0	6:35	8	122	157	125	140
18-Aug-05	6	7:20	4	113	126	119	115
18-Aug-05	6	7:20	5	114	128	118	116
25-Aug-05	13	8:15	4	111	132	115	116
25-Aug-05	13	8:15	6	113	126	117	112
1-Sep-05	20	7:00	1	117	117	112	117
1-Sep-05	20	7:00	4	114	117	113	117
2-Sep-05	21	7:45	1	128	131	132	130
2-Sep-05	21	7:45	8	128	133	129	130
			Average	**118**	**131**	**120**	**122**
			Minimum	111	117	112	112
			Maximum	128	157	132	140

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 Aug
mmonia (ppm)

Date	Day	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	1	0.077	0.884	0.486	<0.063
12-Aug-05	0	8	0.073	2.608	0.399	<0.063
13-Aug-05	1	1	0.102	1.804	0.691	<0.063
13-Aug-05	1	8	0.102	1.041	0.726	<0.063
14-Aug-05	2	1	1.95	1.343	0.801	<0.063
14-Aug-05	2	8	0.125	0.126	0.726	0.141
15-Aug-05	3	1	0.147	2.534	0.686	<0.063
15-Aug-05	3	8	0.158	1.531	0.694	<0.063
16-Aug-05	4	1	0.217	3.432	0.677	0.102
16-Aug-05	4	8	0.223	2.831	0.967	0.135
17-Aug-05	5	1	0.376	1.837	0.731	0.103
17-Aug-05	5	8	0.318	1.632	0.752	0.101
18-Aug-05	6	1	0.261	1.786	0.764	0.127
18-Aug-05	6	8	0.260	1.346	0.780	0.104
19-Aug-05	7	1	0.234	1.868	0.681	0.071
19-Aug-05	7	8	0.215	1.461	0.668	0.064
20-Aug-05	8	1	0.200	1.594	0.781	0.069
20-Aug-05	8	8	0.205	1.327	0.617	<0.063
21-Aug-05	9	1	0.174	1.311	0.578	<0.063
21-Aug-05	9	8	0.171	1.039	0.612	<0.063
22-Aug-05	10	1	0.166	1.295	0.491	0.085
22-Aug-05	10	8	0.169	1.022	0.513	<0.063
23-Aug-05	11	1	0.203	0.841	0.515	<0.063
23-Aug-05	11	8	0.222	0.958	0.503	0.068
24-Aug-05	12	1	0.188	0.912	0.535	0.076
24-Aug-05	12	8	0.208	0.868	0.59	0.088
25-Aug-05	13	1	0.169	0.696	0.321	0.126
25-Aug-05	13	8	0.184	0.866	0.265	<0.063
26-Aug-05	14	1	0.118	0.539	0.169	<0.063
26-Aug-05	14	8	0.127	0.621	0.278	0.068
29-Aug-05	17	1	0.091	0.38	0.078	<0.063
29-Aug-05	17	8	0.088	0.305	0.105	<0.063
31-Aug-05	19	1	0.121	0.242	<0.063	<0.063
31-Aug-05	19	8	0.099	0.236	0.103	<0.063
2-Sep-05	21	1	<0.063	0.235	<0.063	<0.063
2-Sep-05	21	8	<0.063	0.139	<0.063	<0.063
		Average	**0.217**	**1.21**	**0.511**	**<0.063**
		Minimum	<0.063	0.126	<0.063	<0.063
		Maximum	1.95	3.432	0.967	0.141

Appendix *Table 7.* Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005. Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	3	47.2	51.2	48	53.2
12-Aug-05	0	6:35	7	No sample	53.2	50.4	59.2
2-Sep-05	28	7:45	3	49.6	51.6	46.4	48
2-Sep-05	28	7:45	7	46.4	49.6	48.4	47.6
			Average	**47.7**	**51.4**	**48.3**	**52.0**
			Minimum	46.4	49.6	46.4	47.6
			Maximum	49.6	53.2	50.4	59.2

Appendix Table 7. Water Chemistry Parameters for *H. azteca* Exposed to Sediments from Ashland Harbor, 12 August 2005 to 2 September 2005. Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	SQT10	SQT12	SQT5
12-Aug-05	0	6:35	2	54	63.2	62.4	60
12-Aug-05	0	6:35	6	42	58.4	68.4	58
2-Sep-05	28	7:45	2	53.2	58	52.8	56.8
2-Sep-05	28	7:45	6	54.4	54.8	53.2	54
			Average	**50.9**	**58.6**	**59.2**	**57.2**
			Minimum	42.0	54.8	52.8	54.0
			Maximum	54.4	63.2	68.4	60.0

APPENDIX 8

Survival and Growth of *H. azteca* following 28-d of Exposure to Ashland Harbor Sediments, 7 October 2005 to 11 November 2005

Appendix Table 8. Survival and Growth of *H.azteca* following 28-d of Exposure to Ashland Harbor Sediments, 7 October 2005 to 4 November 2005.

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Number Weighed	Total Dry Wt (mg)	Individual Dry Wt (mg)	Average Dry Wt (mg)	Standard Deviation
A	Silica Sand	1	9			9	4.3	0.48		
A	Silica Sand	2	10			10	4.1	0.41		
A	Silica Sand	3	10			10	4.9	0.49		
A	Silica Sand	4	9			9	3.3	0.37		
A	Silica Sand	5	8			8	4.3	0.54		
A	Silica Sand	6	8			8	5.3	0.66		
A	Silica Sand	7	8			7	3.3	0.47		
A	Silica Sand	8	8	87.5	8.9	8	3.6	0.45	0.48	0.09
B	Form. Sediment	1	2			2	1.4	0.70		
B	Form. Sediment	2	0			0				
B	Form. Sediment	3	2			2	1.9	0.95		
B	Form. Sediment	4	1			1	0.9	0.90		
B	Form. Sediment	5	2			2	1.4	0.70		
B	Form. Sediment	6	2			2	2.2	1.10		
B	Form. Sediment	7	4			4	3.2	0.80		
B	Form. Sediment	8	3	20.0	12.0	3	2.4	0.80	0.85	0.14
C	W. Bearskin	1	9			8	1.7	0.21		
C	W. Bearskin	2	6			6	1.9	0.32		
C	W. Bearskin	3	10			10	1.9	0.19		
C	W. Bearskin	4	10			10	1.9	0.19		
C	W. Bearskin	5	7			7	2	0.29		
C	W. Bearskin	6	9			9	2.2	0.24		
C	W. Bearskin	7	10			9	2.2	0.24		
C	W. Bearskin	8	10	88.8	15.5	10	2.4	0.24	0.24	0.04
D	SQT9	1	9			9	2	0.22		
D	SQT9	2	5			5	1.9	0.38		
D	SQT9	3	5			5	1.7	0.34		
D	SQT9	4	8			8	2.4	0.30		
D	SQT9	5	5			5	2.7	0.54		
D	SQT9	6	5			5	2.3	0.46		
D	SQT9	7	8			8	2.8	0.35		
D	SQT9	8	7	65.0	16.9	7	2.3	0.33	0.37	0.10
E	SQT13	1	6			6	1.9	0.32		
E	SQT13	2	5			5	1.9	0.38		
E	SQT13	3	5			5	2.1	0.42		
E	SQT13	4	2			2	0.8	0.40		
E	SQT13	5	0			0				
E	SQT13	6	6			6	2.8	0.47		
E	SQT13	7	4			4	1.8	0.45		
E	SQT13	8	2	37.5	21.9	2	1.2	0.60	0.43	0.09
F	SQT11	1	8			8	2.3	0.29		
F	SQT11	2	8			8	2.2	0.28		
F	SQT11	3	9			9	1.7	0.19		
F	SQT11	4	10			10	1.8	0.18		
F	SQT11	5	9			9	2.3	0.26		
F	SQT11	6	8			8	2.7	0.34		
F	SQT11	7	8			8	2.3	0.29		
F	SQT11	8	8	85.0	7.6	8	1.9	0.24	0.26	0.05
G	SQT14	1	8			8	2.2	0.28		
G	SQT14	2	5			5	2	0.40		
G	SQT14	3	10			10	2.9	0.29		
G	SQT14	4	3			3	1.7	0.57		
G	SQT14	5	2			2	0.8	0.40		
G	SQT14	6	4			4	1.2	0.30		
G	SQT14	7	6			6	2.1	0.35		
G	SQT14	8	4	52.5	26.6	4	0.7	0.18	0.34	0.12

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Number Weighed	Total Dry Wt (mg)	Individual Dry Wt (mg)	Average Dry Wt (mg)	Standard Deviation
H	SQT6	1	8			8	1.5	0.19		
H	SQT6	2	9			9	1.9	0.21		
H	SQT6	3	10			10	2	0.20		
H	SQT6	4	9			9	1.9	0.21		
H	SQT6	5	9			9	2.7	0.30		
H	SQT6	6	10			10	2.4	0.24		
H	SQT6	7	7			7	2.3	0.33		
H	SQT6	8	10	90.0	10.7	8	1.8	0.23	0.24	0.05
I	SQT2	1	7			7	3.4	0.49		
I	SQT2	2	9			9	2.1	0.23		
I	SQT2	3	7			8	2.5	0.31		
I	SQT2	4	10			9	2.9	0.32		
I	SQT2	5	9			9	2.1	0.23		
I	SQT2	6	8			8	3.1	0.39		
I	SQT2	7	10			10	2.1	0.21		
I	SQT2	8	7	83.8	13.0	7	1.8	0.26	0.31	0.09
J	SQT7	1	2			2	1.2	0.60		
J	SQT7	2	2			2	0.9	0.45		
J	SQT7	3	0			0				
J	SQT7	4	0			0				
J	SQT7	5	4			4	1	0.25		
J	SQT7	6	2			2	1.1	0.55		
J	SQT7	7	0			0				
J	SQT7	8	4	17.5	16.7	4	0.8	0.20	0.41	0.18
K	SQT4	1	10			10	2.1	0.21		
K	SQT4	2	8			8	2.2	0.28		
K	SQT4	3	6			6	1.3	0.22		
K	SQT4	4	10			10	2.6	0.26		
K	SQT4	5	9			9	2.2	0.24		
K	SQT4	6	9			9	2.7	0.30		
K	SQT4	7	10			10	2.4	0.24		
K	SQT4	8	10	90.0	14.1	10	3.1	0.31	0.26	0.04
L	SQT3	1	8			8	2.3	0.29		
L	SQT3	2	8			8	2.3	0.29		
L	SQT3	3	9			9	2.2	0.24		
L	SQT3	4	9			10	2.6	0.26		
L	SQT3	5	9			9	2.4	0.27		
L	SQT3	6	10			10	2.3	0.23		
L	SQT3	7	10			10	2.5	0.25		
L	SQT3	8	7	87.5	10.4	6	1.8	0.30	0.27	0.02
M	SQT5	1	8			8	1.5	0.19		
M	SQT5	2	8			8	2.3	0.29		
M	SQT5	3	7			7	1.8	0.26		
M	SQT5	4	9			9	2.3	0.26		
M	SQT5	5	8			8	1.9	0.24		
M	SQT5	6	9			8	2.2	0.28		
M	SQT5	7	10			10	2.4	0.24		
M	SQT5	8	6	81.3	12.5	6	2.1	0.35	0.26	0.05
N	SQT 1	1	0			0				
N	SQT 1	2	0			0				
N	SQT 1	3	0			0				
N	SQT 1	4	0			0				
N	SQT 1	5	0			0				
N	SQT 1	6	0			0				
N	SQT 1	7	0			0				
N	SQT 1	8	0	0.0	0.0	0				

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Number Weighed	Total Dry Wt (mg)	Individual Dry Wt (mg)	Average Dry Wt (mg)	Standard Deviation
O	SQT8	1	8			8	1.9	0.24		
O	SQT8	2	10			10	2.9	0.29		
O	SQT8	3	9			9	2.3	0.26		
O	SQT8	4	8			8	2.1	0.26		
O	SQT8	5	9			9	3.1	0.34		
O	SQT8	6	7			7	1.7	0.24		
O	SQT8	7	8			8	1.8	0.23		
O	SQT8	8	9	85.0	9.3	9	2.2	0.24	0.26	0.04

APPENDIX 9

Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 11 November 2005

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Temperature (° C)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	23.0	23.0	23.1	22.8	22.8	22.8	23.1	22.8	22.7	22.9	22.9	22.9	22.4	22.9	22.4
7-Oct-05	0	7:00	2	23.1	23.2	23.1	22.8	22.8	22.7	23.0	23.0	22.9	23.0	22.8	23.0	22.7	23.0	22.7
7-Oct-05	0	7:00	3	23.1	23.0	23.2	23.0	22.9	22.9	22.9	23.1	22.7	22.8	22.8	22.9	22.5	23.0	22.5
7-Oct-05	0	7:00	4	23.1	23.1	23.1	23.1	22.9	22.9	22.9	23.2	22.9	22.8	22.9	22.9	22.6	23.1	22.7
7-Oct-05	0	7:00	5	23.0	23.1	23.0	22.9	22.9	22.9	22.9	22.9	22.8	22.8	23.0	22.9	22.5	22.8	22.9
7-Oct-05	0	7:00	6	23.0	23.1	23.0	23.0	23.0	22.9	22.9	22.8	22.8	22.8	23.1	22.9	22.6	22.8	22.9
7-Oct-05	0	7:00	7	23.1	23.1	23.0	22.8	22.9	22.8	23.0	22.8	22.7	22.8	22.9	22.8	22.6	23.0	22.6
7-Oct-05	0	7:00	8	23.0	23.1	23.0	23.0	22.9	22.8	22.8	22.7	22.6	22.8	23.0	22.9	22.6	22.8	22.7
7-Oct-05	0	15:30	1	23.2	23.3	23.3	23.2	23.2	23.1	23.3	23.4	23.2	23.3	23.3	23.2	23.0	23.2	23.0
7-Oct-05	0	15:30	4	23.2	23.3	23.4	23.3	23.3	23.2	23.2	23.4	23.3	23.3	23.2	23.3	23.2	23.3	23.1
8-Oct-05	1	9:30	4	22.0	22.5	22.2	22.4	22.0	21.9	21.9	22.4	22.4	22.3	22.0	22.1	22.2	22.3	22.4
8-Oct-05	1	9:30	6	22.0	22.4	22.2	22.4	22.1	21.9	21.9	22.4	22.4	22.3	22.0	22.5	22.4	22.0	22.4
8-Oct-05	1	16:15	4	22.2	22.4	22.3	22.6	22.2	22.2	22.1	22.6	22.6	22.4	22.4	22.5	22.3	22.1	22.6
8-Oct-05	1	16:15	8	22.3	22.4	22.4	22.6	22.3	22.0	21.8	22.6	22.6	22.4	22.3	22.5	22.1	22.1	22.5
9-Oct-05	2	9:30	4	22.3	22.4	22.5	22.4	22.4	22.3	22.1	22.4	22.4	22.4	22.3	22.5	22.3	22.3	22.4
9-Oct-05	2	9:30	5	22.4	22.3	22.4	22.3	22.4	22.2	22.3	22.3	22.3	22.3	22.4	22.4	22.4	22.4	22.4
9-Oct-05	2	17:30	2	22.2	22.4	22.6	22.5	22.6	22.3	22.2	22.1	22.2	22.5	22.1	22.3	22.0	22.6	22.4
9-Oct-05	2	17:30	4	22.3	22.6	22.6	22.4	22.4	22.1	22.3	22.4	22.4	22.6	22.3	22.4	22.4	22.4	22.4
10-Oct-05	3	9:00	4	22.0	22.2	22.4	22.4	22.0	21.8	22.0	22.2	22.2	22.1	21.8	22.0	22.0	22.2	22.2
10-Oct-05	3	9:00	7	22.0	22.5	22.6	22.1	21.8	22.0	21.9	22.1	22.1	22.0	21.9	22.0	22.0	22.1	22.1
10-Oct-05	3	15:30	3	22.3	23.4	22.6	22.5	22.2	22.2	22.2	22.6	22.5	22.6	22.3	22.4	22.4	22.5	22.4
10-Oct-05	3	15:30	4	22.3	22.5	22.6	22.5	22.2	22.2	22.2	22.6	22.6	22.6	22.3	22.6	22.1	22.5	22.5
11-Oct-05	4	8:40	1	22.3	22.4	22.6	22.4	22.0	22.1	22.1	22.4	22.5	22.4	22.2	22.6	22.3	22.4	22.4
11-Oct-05	4	8:40	4	22.3	22.5	22.5	22.6	22.1	22.0	22.2	22.4	22.5	22.5	22.1	22.5	22.4	22.4	22.4
11-Oct-05	4	15:00	3	22.7	22.7	22.8	22.7	22.6	22.6	22.7	22.8	22.5	22.5	22.6	22.7	22.4	22.7	22.4
11-Oct-05	4	15:00	4	22.8	22.7	22.8	22.7	22.6	22.6	22.7	22.8	22.6	22.5	22.7	22.7	22.7	22.7	22.6
12-Oct-05	5	9:30	4	22.7	22.6	22.7	22.7	22.6	22.5	22.6	22.7	22.6	22.6	22.6	22.6	22.5	22.6	22.6
12-Oct-05	5	9:30	6	22.8	22.7	22.7	22.7	22.7	22.5	22.7	22.6	22.6	22.5	22.6	22.5	22.4	22.6	22.6
12-Oct-05	5	15:45	4	22.8	22.7	22.8	22.8	22.7	22.7	22.7	22.8	22.7	22.6	22.6	22.7	22.6	22.7	22.5
12-Oct-05	5	15:45	8	22.8	22.8	22.8	22.7	22.7	22.6	22.6	22.8	22.7	22.6	22.7	22.7	22.5	22.7	22.6
13-Oct-05	6	8:40	4	22.7	22.6	22.7	22.6	22.5	22.5	22.6	22.8	22.8	22.6	22.7	22.6	22.7	22.7	22.5
13-Oct-05	6	8:40	5	22.7	22.7	22.7	22.6	22.5	22.5	22.5	22.8	22.7	22.6	22.7	22.6	22.4	22.7	22.2
13-Oct-05	6	15:20	2	22.9	22.9	22.9	22.8	22.8	22.8	22.9	22.9	23.0	22.9	22.9	22.9	22.8	22.9	22.9
13-Oct-05	6	15:20	4	22.9	22.9	22.8	22.9	22.9	22.8	22.9	22.9	23.0	22.9	22.8	22.9	22.8	22.9	22.9
14-Oct-05	7	8:15	4	22.6	22.5	22.8	22.6	22.6	22.5	22.6	22.8	22.8	22.7	22.6	22.8	22.6	22.6	22.6
14-Oct-05	7	8:15	7	22.7	22.7	22.8	22.7	22.6	22.6	22.6	22.8	22.8	22.8	22.7	22.8	22.6	22.6	22.6
14-Oct-05	7	15:15	3	22.9	22.8	22.9	22.9	22.8	22.7	22.8	22.8	22.8	22.6	22.8	23.0	22.7	22.8	22.8
14-Oct-05	7	15:15	4	23.0	22.8	22.9	22.9	22.8	22.8	22.8	22.9	22.8	22.7	22.8	22.9	22.8	22.9	22.9
15-Oct-05	8	8:15	4	22.4	22.6	22.7	22.5	22.4	22.4	22.4	22.6	22.5	22.5	22.4	22.6	22.4	22.4	22.4
15-Oct-05	8	8:15	6	22.8	22.6	22.6	22.5	22.4	22.2	22.4	22.6	22.5	22.5	22.5	22.6	22.3	22.0	22.4
15-Oct-05	8	15:30	4	22.7	22.6	22.6	22.7	22.5	22.5	22.6	22.6	22.7	22.6	22.4	22.5	22.5	22.6	22.7
15-Oct-05	8	15:30	8	22.7	22.6	22.7	22.7	22.5	22.4	22.5	22.7	22.6	22.6	22.5	22.6	22.6	22.7	22.8
16-Oct-05	9	9:30	4	22.5	22.5	22.5	22.6	22.3	22.3	22.3	22.5	22.5	22.4	22.3	22.4	22.4	22.6	22.5
16-Oct-05	9	9:30	7	22.6	22.6	22.5	22.5	22.5	22.3	22.4	22.5	22.5	22.4	22.4	22.5	22.4	22.6	22.4
16-Oct-05	9	17:30	1	22.9	22.5	22.5	22.6	22.9	22.8	22.8	22.5	22.5	22.7	22.7	22.6	22.5	22.6	22.6
16-Oct-05	9	17:30	4	22.9	22.5	22.6	22.4	22.8	22.8	22.7	22.6	22.6	22.7	23.0	22.6	22.6	22.7	22.6
17-Oct-05	10	8:00	4	22.9	22.4	22.6	22.6	22.8	22.4	22.9	22.6	22.6	22.4	22.9	22.6	22.4	22.7	22.5
17-Oct-05	10	8:00	5	22.9	22.6	22.7	22.5	22.8	22.6	23.0	22.4	22.5	22.3	22.8	22.5	22.4	22.5	22.5
17-Oct-05	10	15:50	2	22.5	22.6	22.6	22.5	22.6	22.7	22.6	22.7	22.6	22.5	22.6	22.6	22.5	22.7	22.3
17-Oct-05	10	15:50	4	22.5	22.6	22.6	22.6	22.6	22.5	22.7	22.6	22.5	22.4	22.6	22.6	22.5	22.7	22.3
18-Oct-05	11	8:30	4	22.6	22.4	22.7	22.6	22.5	22.3	22.3	22.2	22.5	22.5	22.5	22.5	22.3	22.6	22.1
18-Oct-05	11	8:30	7	22.5	22.4	22.6	22.4	22.5	22.3	22.5	22.3	22.3	22.5	22.5	22.5	22.0	22.4	22.6
18-Oct-05	11	15:20	3	22.7	22.8	22.7	22.7	22.7	22.4	22.6	22.8	22.6	22.6	22.7	22.6	22.5	22.5	22.5
18-Oct-05	11	15:20	4	22.7	22.7	22.7	22.7	22.5	22.6	22.7	22.7	22.7	22.6	22.7	22.7	22.5	22.6	22.5
19-Oct-05	12	8:15	1	22.6	22.4	22.5	22.3	22.3	22.2	22.3	22.4	22.3	22.4	22.2	22.4	22.4	22.4	22.3
19-Oct-05	12	8:15	4	22.6	22.3	22.6	22.4	22.3	22.3	22.3	22.4	22.5	22.4	22.3	22.5	22.3	22.4	22.5
19-Oct-05	12	15:20	4	22.7	22.6	22.6	22.7	22.6	22.6	22.6	22.7	22.7	22.4	22.6	22.6	22.5	22.7	22.3
19-Oct-05	12	15:20	5	22.7	22.6	22.6	22.6	22.6	22.5	22.6	22.6	22.6	22.4	22.7	22.5	22.3	22.5	22.5
20-Oct-05	13	8:15	4	22.6	22.4	22.5	22.4	22.2	22.3	22.3	22.3	22.3	22.3	22.2	22.3	22.2	22.3	22.3
20-Oct-05	13	8:15	6	22.6	22.3	22.5	22.4	22.2	22.2	22.4	22.4	22.3	22.3	22.2	22.3	22.4	22.2	22.3
20-Oct-05	13	15:25	4	22.8	22.7	22.7	22.7	22.6	22.6	22.6	22.7	22.6	22.5	22.5	22.6	22.5	22.6	22.4
20-Oct-05	13	15:25	8	22.8	22.7	22.6	22.8	22.6	22.6	22.6	22.7	22.5	22.5	22.6	22.6	22.3	22.6	22.4
21-Oct-05	14	8:15	4	22.5	22.4	22.5	22.4	22.4	22.2	22.4	22.3	22.4	22.4	22.5	22.4	22.2	22.2	22.3
21-Oct-05	14	8:15	5	22.6	22.4	22.6	22.4	22.4	22.2	22.4	22.3	22.4	22.4	22.5	22.4	22.2	22.3	22.3
21-Oct-05	14	15:15	2	22.7	22.5	22.5	22.4	22.4	22.4	22.4	22.4	22.3	22.2	22.4	22.5	22.2	22.3	22.3
21-Oct-05	14	15:15	4	22.6	22.5	22.6	22.4	22.4	22.4	22.4	22.4	22.3	22.2	22.4	22.4	22.2	22.2	22.3
22-Oct-05	15	9:00	4	22.3	22.2	22.3	22.2	22.1	22.0	22.1	22.2	22.1	22.0	22.1	22.4	22.1	22.6	21.9
22-Oct-05	15	9:00	7	22.3	22.1	22.4	22.1	22.2	22.1	22.1	22.2	22.1	22.1	22.2	22.1	21.9	21.9	22.1
22-Oct-05	15	18:00	3	22.3	22.2	22.4	22.3	22.2	22.2	22.3	22.3	22.2	22.0	22.3	22.1	21.8	22.1	21.9
22-Oct-05	15	18:00	4	22.4	22.2	22.4	22.2	22.2	22.3	22.4	22.3	22.3	22.1	22.3	21.9	22.0	22.1	22.0
23-Oct-05	16	9:00	1	22.2	22.2	22.4	22.1	22.1	21.9	21.9	22.1	22.1	22.2	22.0	22.2	22.1	22.1	22.0
23-Oct-05	16	9:00	4	22.1	22.3	22.5	22.2	22.1	21.9	22.0	22.1	22.3	22.1	22.1	22.2	22.1	22.2	22.1

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
24-Oct-05	17	8:15	4	22.3	22.1	22.4	22.3	22.0	22.1	22.1	22.2	22.1	22.1	21.9	21.9	22.0	21.7	22.0
24-Oct-05	17	8:15	6	22.2	22.1	22.2	22.3	22.0	21.9	22.0	22.2	22.2	22.1	21.9	22.1	22.0	21.9	22.0
24-Oct-05	17	16:25	4	22.7	22.7	22.9	22.8	22.5	22.5	22.5	22.7	22.9	22.6	22.5	22.8	22.6	22.8	22.6
24-Oct-05	17	16:25	8	22.7	22.7	22.9	22.7	22.5	22.6	22.5	22.7	22.7	22.7	22.7	22.8	22.6	22.8	22.6
25-Oct-05	18	6:00	4	22.4	22.5	22.7	22.7	22.4	22.4	22.4	22.5	22.7	22.7	22.3	22.6	22.4	22.4	22.4
25-Oct-05	18	6:00	5	22.6	22.5	22.6	22.7	22.5	22.4	22.3	22.5	22.7	22.6	22.4	22.6	22.3	22.4	22.5
25-Oct-05	18	15:00	2	22.4	22.5	22.5	22.4	22.5	22.5	22.3	22.4	22.5	22.5	22.5	22.4	22.5	22.4	22.4
25-Oct-05	18	15:00	4	22.5	22.6	22.5	22.5	22.4	22.5	22.5	22.5	22.5	22.5	22.4	22.5	22.3	22.5	22.4
26-Oct-05	19	8:00	4	22.4	22.3	22.4	22.2	22.0	22.0	22.2	22.4	22.3	22.2	22.2	22.3	22.3	22.1	22.2
26-Oct-05	19	8:00	7	22.4	22.3	22.5	22.3	22.1	22.0	22.2	22.5	22.3	22.3	22.3	22.4	22.3	22.2	22.3
26-Oct-05	19	15:30	3	22.4	22.4	22.5	23.5	22.3	22.3	22.3	22.4	22.5	22.5	22.5	22.5	22.4	22.7	22.4
26-Oct-05	19	15:30	4	22.5	22.6	22.6	22.6	22.4	22.3	22.3	22.6	22.7	22.4	22.5	22.6	22.5	22.7	22.6
27-Oct-05	20	8:00	1	22.3	22.4	22.5	22.5	22.3	22.3	22.3	22.4	22.3	22.1	22.3	22.3	22.2	22.3	22.4
27-Oct-05	20	8:00	4	22.4	22.5	22.5	22.4	22.4	22.2	22.1	22.4	22.4	22.2	22.1	22.4	22.3	22.2	22.2
27-Oct-05	20	15:00	2	22.4	22.4	22.5	22.6	22.5	22.2	22.4	22.5	22.5	22.4	22.4	22.3	22.4	22.5	22.4
27-Oct-05	20	15:00	4	22.5	22.4	22.6	22.6	22.4	22.2	22.5	22.6	22.5	22.2	22.3	22.5	22.5	22.8	22.4
28-Oct-05	21	8:00	4	22.4	22.6	22.5	22.4	22.4	22.4	22.1	22.4	22.4	22.0	22.2	22.3	22.3	22.4	22.4
28-Oct-05	21	8:00	6	22.5	22.4	22.5	22.4	22.3	22.4	22.0	22.4	22.3	22.4	22.2	22.1	22.2	22.3	22.3
28-Oct-05	21	14:30	4	22.4	22.4	22.4	22.5	22.4	22.3	22.3	22.1	22.4	22.2	22.1	22.4	22.2	22.2	22.2
28-Oct-05	21	14:30	8	22.4	22.3	22.4	22.5	22.3	22.1	22.2	22.6	22.3	22.3	22.2	22.2	22.2	22.4	22.1
29-Oct-05	22	8:30	4	22.9	22.9	23.0	22.9	22.6	22.7	22.6	22.8	22.9	22.7	22.7	22.8	22.6	22.8	22.7
29-Oct-05	22	8:30	5	23.0	23.0	23.0	22.9	22.8	22.7	22.6	22.8	22.7	22.8	22.5	22.6	22.6	22.6	22.8
29-Oct-05	22	17:00	2	22.5	22.6	22.6	22.6	22.4	22.3	22.1	22.5	22.5	22.4	22.4	22.6	22.4	22.5	22.3
29-Oct-05	22	17:00	4	22.6	22.6	22.6	22.5	22.4	22.3	22.2	22.6	22.6	22.4	22.4	22.5	22.4	22.5	22.5
30-Oct-05	23	7:00	4	22.3	22.4	22.4	22.4	22.3	22.2	22.3	22.5	22.5	22.3	22.3	22.5	22.4	22.4	22.5
30-Oct-05	23	7:00	7	22.3	22.4	22.4	22.5	22.3	22.1	22.3	22.4	22.5	22.3	22.2	22.5	22.5	22.4	22.6
30-Oct-05	23	18:00	3	22.5	22.4	22.7	22.5	22.4	22.2	22.5	22.6	22.5	22.4	22.5	22.5	22.4	22.5	22.5
30-Oct-05	23	18:00	4	22.5	22.6	22.6	22.5	22.5	22.4	22.5	22.6	22.6	22.5	22.4	22.5	22.4	22.6	22.6
31-Oct-05	24	7:00	1	22.4	22.4	22.5	22.5	22.3	22.1	22.2	22.5	22.5	22.3	22.3	22.2	22.4	22.3	22.3
31-Oct-05	24	7:00	4	22.4	22.4	22.6	22.6	22.3	22.2	22.3	22.6	22.5	22.4	22.2	22.3	22.4	22.4	22.5
31-Oct-05	24	15:30	4	22.4	22.4	22.4	22.3	22.2	22.3	22.2	22.6	22.6	22.5	22.2	22.4	22.5	22.4	22.6
31-Oct-05	24	15:30	6	22.4	22.4	22.4	22.2	22.3	22.3	22.1	22.7	22.6	22.6	22.3	22.6	22.4	22.5	22.6
1-Nov-05	25	8:30	4	22.2	22.2	22.4	22.2	21.8	21.7	21.9	22.1	22.2	22.0	21.5	22.0	22.0	22.0	22.3
1-Nov-05	25	8:30	6	22.1	22.3	22.3	22.2	22.0	21.7	21.9	22.2	22.1	22.0	21.8	22.2	22.0	22.0	22.3
1-Nov-05	25	16:20	4	22.5	22.4	22.5	22.5	22.4	22.2	22.3	22.4	22.6	22.3	22.2	22.3	22.3	22.3	22.2
1-Nov-05	25	16:20	8	22.5	22.5	22.6	22.5	22.3	22.2	22.1	22.6	22.4	22.3	22.3	22.4	22.4	22.3	22.3
2-Nov-05	26	8:15	4	22.3	20.1	22.2	20.0	22.0	22.0	22.0	20.0	22.1	22.0	22.0	21.9	20.0	20.0	21.7
2-Nov-05	26	8:15	5	22.3	20.1	22.3	20.1	22.1	22.1	22.1	20.0	22.0	22.2	22.0	22.0	20.0	20.0	22.0
2-Nov-05	26	15:00	2	22.6	22.5	22.7	22.3	22.6	22.4	22.3	22.5	22.3	22.4	22.4	22.6	22.6	22.4	22.5
2-Nov-05	26	15:00	4	22.6	22.3	22.7	22.4	22.6	22.4	22.5	22.5	22.5	22.4	22.5	22.6	22.6	22.4	22.5
3-Nov-05	27	8:15	4	22.3	22.8	22.3	22.7	22.2	22.1	22.1	23.0	22.3	22.3	22.1	22.0	22.7	22.5	22.0
3-Nov-05	27	8:15	7	22.2	22.8	22.2	22.7	22.2	22.0	22.1	22.9	22.3	22.3	22.1	22.2	22.5	22.6	21.3
3-Nov-05	27	15:00	3	22.4	23.1	22.6	23.1	22.4	22.3	22.2	23.2	22.4	22.4	22.2	22.4	23.0	23.0	22.5
3-Nov-05	27	15:00	4	22.5	23.1	22.6	23.1	22.4	22.3	22.3	23.2	22.6	22.4	22.3	22.6	22.9	22.9	22.5
4-Nov-05	28	7:10	1	22.1	22.4	22.0	22.4	22.1	21.8	21.8	22.6	22.0	22.1	21.9	22.0	22.6	22.7	22.2
4-Nov-05	28	7:10	2	22.3	22.7	22.6	22.6	22.0	21.9	21.8	22.7	22.0	22.2	22.0	33.1	22.6	22.7	22.2
4-Nov-05	28	7:10	3	22.1	22.7	22.0	22.4	22.0	21.9	22.8	22.7	22.0	22.0	22.0	22.1	22.7	22.7	22.1
4-Nov-05	28	7:10	4	22.1	22.7	22.2	22.6	22.0	21.9	21.9	22.7	22.1	22.1	22.0	22.0	22.6	22.8	22.1
4-Nov-05	28	7:10	5	22.2	22.5	22.1	22.6	22.0	21.9	21.9	22.7	22.0	22.1	22.0	22.0	22.6	22.6	22.2
4-Nov-05	28	7:10	6	22.2	22.6	22.0	22.6	22.0	21.9	21.9	22.8	22.0	22.1	22.0	22.1	22.6	22.6	22.1
4-Nov-05	28	7:10	7	22.2	22.5	22.1	22.6	21.9	21.8	21.9	22.8	22.1	22.2	22.0	22.1	22.6	22.6	21.9
4-Nov-05	28	7:10	8	22.1	22.5	22.1	22.7	21.9	21.8	21.9	22.8	22.0	22.2	22.0	22.1	22.6	22.6	22.0
			Average	**22.5**	**22.5**	**22.6**	**22.5**	**22.4**	**22.3**	**22.4**	**22.5**	**22.5**	**22.4**	**22.4**	**22.6**	**22.4**	**22.5**	**22.4**
			Minimum	22.0	20.1	22.0	20.0	21.8	21.7	21.8	20.0	22.0	22.0	21.5	21.9	20.0	20.0	21.3
			Maximum	23.2	23.4	23.4	23.5	23.3	23.2	23.3	23.4	23.3	23.3	23.3	33.1	23.2	23.3	23.1

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	7.1	7.0	7.0	3.3	5.9	3.2	6.1	5.3	3.6	4.7	6.0	5.7	4.4	6.6	5.0
7-Oct-05	0	7:00	2	6.9	7.0	6.9	2.5	5.0	4.9	5.1	6.9	6.3	6.6	2.8	4.2	3.1	4.6	4.8
7-Oct-05	0	7:00	3	7.2	7.0	6.8	7.2	5.8	5.1	7.0	7.1	3.6	4.9	4.5	6.0	3.5	5.4	5.1
7-Oct-05	0	7:00	4	7.1	7.3	5.6	5.2	7.5	5.4	4.6	5.0	3.4	4.6	6.2	4.7	3.1	4.0	6.5
7-Oct-05	0	7:00	5	7.1	7.1	5.7	3.3	7.1	6.9	6.6	4.7	4.6	4.0	4.6	5.9	5.8	2.6	4.6
7-Oct-05	0	7:00	6	7.4	6.6	5.0	7.1	4.7	4.1	5.6	4.4	3.9	2.7	6.4	4.7	3.4	3.9	7.2
7-Oct-05	0	7:00	7	7.2	7.1	6.6	3.2	5.4	6.3		4.7	6.0	4.9	7.1	5.1	6.0	4.0	5.9
7-Oct-05	0	7:00	8	7.2	6.8	6.6	6.8	5.1	5.5	5.2	4.8	4.9	4.4	7.1	5.5	4.0	4.6	5.4
7-Oct-05	0	15:30	1	7.5	6.9	6.8	6.7	5.3	3.5	7.8	7.7	4.0	6.2	7.9	6.5	7.0	7.1	5.4
7-Oct-05	0	15:30	4	7.5	7.1	7.4	7.0	4.1	7.2	3.8	7.8	4.7	7.4	7.8	6.5	4.7	7.1	7.1
8-Oct-05	1	9:30	4	7.6	7.6	8.4	7.5	5.4	8.0	4.6	8.2	6.7	7.1	7.7	8.4	6.3	6.9	8.0
8-Oct-05	1	9:30	6	8.0	6.7	7.0	7.6	4.8	8.2	5.3	7.8	6.4	7.1	7.5	7.3	5.2	6.6	8.0
8-Oct-05	1	16:15	4	7.1	7.5	8.3	7.7	5.2	7.2	4.0	7.4	7.0	7.4	8.1	8.2	8.1	4.8	6.7
8-Oct-05	1	16:15	8	7.3	6.9	6.2	7.6	5.3	7.1	3.9	6.6	6.9	7.5	8.1	8.1	7.3	2.4	6.8
9-Oct-05	2	9:30	4	6.9	6.8	6.9	5.7	6.1	7.0	6.3	7.1	4.8	6.3	7.6	6.9	5.9	5.4	6.9
9-Oct-05	2	9:30	5	6.7	7.4	6.3	6.6	5.9	6.9	6.9	6.4	5.6	7.0	7.4	7.0	6.1	6.2	7.6
9-Oct-05	2	17:30	2	6.3	5.6	6.6	5.9	6.6	6.7	6.6	6.4	5.9	5.3	5.0	5.7	4.9	5.9	5.9
9-Oct-05	2	17:30	4	7.2	7.2	7.1	5.9	6.4	7.0	6.1	7.4	4.0	6.6	7.1	7.3	6.3	6.2	6.8
10-Oct-05	3	9:00	4	7.6	6.8	7.0	6.9	6.0	7.0	6.1	7.2	4.7	6.7	7.0	6.2	6.3	6.1	6.6
10-Oct-05	3	9:00	7	7.7	6.3	7.1	6.3	6.2	6.3	6.0	6.6	5.6	5.2	6.1	5.6	6.6	6.7	7.0
10-Oct-05	3	15:30	3	7.0	6.4	7.0	7.4	5.6	7.1	7.0	6.9	6.0	6.9	6.8	6.7	6.6	5.4	6.2
10-Oct-05	3	15:30	4	7.1	7.0	6.9	7.1	5.0	7.0	6.9	6.8	6.4	7.3	6.7	5.8	6.8	4.8	6.8
11-Oct-05	4	8:40	1	7.7	6.5	7.3	7.4	4.6	7.3	6.5	7.3	6.1	7.9	7.3	7.7	7.0	7.3	8.3
11-Oct-05	4	8:40	4	7.9	7.8	7.9	8.0	4.3	7.8	6.2	7.8	6.7	8.2	8.0	6.4	7.1	6.5	7.6
11-Oct-05	4	15:00	3	7.4	7.1	7.4	8.0	6.2	7.9	7.9	7.3	6.9	6.9	7.4	7.0	6.6	7.4	7.0
11-Oct-05	4	15:00	4	7.1	6.6	7.7	7.8	6.9	7.8	7.6	7.3	5.8	7.8	7.7	6.9	7.3	7.1	7.8
12-Oct-05	5	9:30	4	7.2	5.8	7.8	7.8	4.1	7.7	6.4	7.6	6.1	7.9	7.4	7.2	6.2	7.7	7.9
12-Oct-05	5	9:30	6	7.4	5.7	6.8	6.2	6.1	5.8	7.5	7.8	6.4	6.9	7.4	7.3	7.3	7.1	7.9
12-Oct-05	5	15:45	4	6.7	5.4	7.3	7.8	6.5	7.5	7.3	6.0	7.2	7.9	7.5	6.2	5.5	7.4	7.2
12-Oct-05	5	15:45	8	6.8	5.8	6.8	4.6	6.9	7.3	3.4	7.4	7.3	7.0	7.0	6.3	7.4	5.8	7.4
13-Oct-05	6	8:40	4	7.5	7.0	7.9	8.4	7.4	7.8	6.5	7.3	7.8	7.6	7.2	7.0	7.2	6.5	7.9
13-Oct-05	6	8:40	5	7.6	7.5	7.8	5.2	5.7	7.4	5.7	7.6	7.6	7.0	7.1	4.2	7.5	4.1	6.5
13-Oct-05	6	15:20	2	6.4	3.4	7.2	5.4	6.6	7.4	5.6	5.9	7.2	7.3	7.4	6.8	6.8	5.6	6.5
13-Oct-05	6	15:20	4	7.2	4.7	7.6	7.5	7.4	7.1	6.9	6.3	6.6	7.0	6.4	5.3	6.9	6.5	7.2
14-Oct-05	7	8:15	4	7.9	6.8	7.5	8.6	7.5	8.1	8.3	8.3	5.7	7.2	7.6	7.2	7.1	7.8	6.6
14-Oct-05	7	8:15	7	7.3	6.3	7.1	7.4	7.1	8.4	7.2	8.0	7.2	7.3	7.5	7.4	7.7	7.3	6.9
14-Oct-05	7	15:15	3	7.0	7.3	7.2	7.7	5.7	7.4	6.9	7.0	6.1	8.0	7.3	7.0	6.6	8.0	7.3
14-Oct-05	7	15:15	4	6.8	6.9	7.6	7.7	7.1	7.5	7.4	7.5	4.0	7.6	6.9	7.4	7.2	7.4	7.7
15-Oct-05	8	8:15	4	7.3	6.5	7.3	8.0	8.3	7.6	6.8	7.4	4.9	7.1	6.8	6.8	6.3	7.8	7.6
15-Oct-05	8	8:15	6	7.4	4.3	6.2	5.2	8.3	7.7	3.4	7.5	5.7	7.3	7.0	7.0	6.5	7.8	7.7
15-Oct-05	8	15:30	4	6.6	5.9	8.3	8.1	8.5	7.8	7.7	7.4	5.1	8.0	7.2	6.6	6.9	7.7	8.0
15-Oct-05	8	15:30	8	6.6	6.2	7.0	6.9	8.2	7.6	4.7	7.1	6.1	8.1	6.5	5.5	7.1	6.0	6.8
16-Oct-05	9	9:30	4	7.6	7.4	7.9	7.6	7.5	7.9	8.4	8.6	5.1	8.5	7.5	8.8	5.8	7.6	8.7
16-Oct-05	9	9:30	7	7.4	7.7	8.1	7.4	7.2	8.1	6.1	7.8	7.2	8.3	7.8	8.9	7.1	6.7	7.8
16-Oct-05	9	17:30	1	7.1	7.2	8.6	8.8	8.6	6.1	6.4	8.5	7.1	7.7	8.2	7.1	7.5	7.2	7.2
16-Oct-05	9	17:30	4	7.2	8.6	8.3	8.6	7.6	5.9	8.4	8.4	4.9	7.9	7.0	7.3	6.1	7.6	7.4
17-Oct-05	10	8:00	4	7.0	6.1	8.3	7.1	6.5	7.6	6.3	6.7	4.5	7.4	7.2	7.2	6.3	7.1	7.6
17-Oct-05	10	8:00	5	7.1	7.1	7.5	6.2	6.5	6.6	5.7	6.9	7.1	6.7	6.8	6.1	5.1	5.5	5.4
17-Oct-05	10	15:50	2	7.4	6.6	7.2	6.8	4.5	6.9	6.7	7.2	6.7	6.4	6.8	5.2	5.3	53.9	6.1
17-Oct-05	10	15:50	4	7.3	6.6	7.3	7.7	4.4	7.2	6.1	6.8	6.7	7.1	6.4	5.5	6.8	6.5	7.5
18-Oct-05	11	8:30	4	7.4	7.3	6.8	7.8	6.9	7.3	7.3	7.0	7.7	6.3	6.3	6.3	5.9	5.9	7.2
18-Oct-05	11	8:30	7	7.0	6.9	7.2	6.1	7.3	7.7	7.9	7.9	7.4	6.8	7.0	6.2	6.9	5.5	7.2
18-Oct-05	11	15:20	3	7.6	7.5	7.0	7.7	6.9	7.3	6.6	7.5	5.0	5.7	7.2	7.4	7.0	6.8	6.8
18-Oct-05	11	15:20	4	7.4	5.7	7.8	7.7	6.8	7.3	7.2	7.9	7.8	6.4	7.0	5.9	7.0	6.1	7.5

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
19-Oct-05	12	8:15	1	7.4	7.4	7.0	8.0	8.0	6.4	6.1	8.4	5.4	7.9	8.8	7.3	8.3	6.4	7.9
19-Oct-05	12	8:15	4	7.3	7.0	7.3	8.5	8.6	7.5	6.6	8.3	7.3	7.8	8.6	7.0	7.3	7.1	8.0
19-Oct-05	12	15:20	4	8.2	6.9	8.1	7.6	7.3	7.8	7.3	7.5	6.8	6.5	7.0	6.7	7.6	7.3	7.4
19-Oct-05	12	15:20	5	8.0	8.0	7.9	6.2	6.3	5.7	7.4	6.9	6.4	7.5	7.7	5.8	7.1	5.0	7.3
20-Oct-05	13	8:15	4	7.3	6.5	7.0	6.9	7.3	7.4	6.5	7.1	7.3	7.1	8.3	7.7	7.3	8.0	7.4
20-Oct-05	13	8:15	6	7.6	5.2	7.2	6.9	8.3	6.8	6.5	8.3	4.7	7.6	7.5	8.2	7.6	6.9	7.0
20-Oct-05	13	15:25	4	7.1	7.2	7.6	7.2	6.9	6.9	6.9	7.2	7.6	5.8	7.2	6.4	7.3	6.8	7.4
20-Oct-05	13	15:25	8	6.8	7.3	7.5	5.8	6.1	7.1	6.3	6.8	6.9	7.4	7.0	7.5	7.0	7.3	7.1
21-Oct-05	14	8:15	4	7.5	7.8	8.4	8.6	7.4	8.0	6.9	6.1	8.1	6.7	6.2	6.9	6.8	8.3	7.4
21-Oct-05	14	8:15	5	7.4	7.7	8.0	7.9	7.2	7.1	7.6	5.9	8.2	7.6	6.5	6.9	7.2	7.8	7.2
21-Oct-05	14	15:15	2	7.5	7.1	7.3	7.4	6.6	7.2	4.6	6.3	8.4	5.2	7.0	6.4	7.8	7.7	6.7
21-Oct-05	14	15:15	4	7.2	7.0	7.3	7.6	6.2	7.4	5.1	6.7	7.7	5.1	7.2	6.9	8.1	8.0	7.2
22-Oct-05	15	9:00	4	7.7	7.3	7.3	7.5	6.8	6.9	6.4	7.3	8.1	5.7	7.0	6.6	7.4	7.4	7.3
22-Oct-05	15	9:00	7	7.8	7.1	7.4	7.6	6.7	7.8	5.3	7.6	6.6	7.7	8.2	6.9	7.5	6.9	7.0
22-Oct-05	15	18:00	3	7.6	7.7	7.3	7.5	7.3	7.0	6.2	7.2	7.7	6.0	8.0	7.1	8.3	7.5	7.9
22-Oct-05	15	18:00	4	7.3	7.4	7.3	7.1	7.6	7.8	5.7	7.3	7.0	4.9	5.5	7.6	7.8	7.8	8.0
23-Oct-05	16	9:00	1	7.9	7.9	7.1	7.1	6.9	6.4	7.0	7.8	6.5	6.4	7.5	7.8	7.0	6.9	7.8
23-Oct-05	16	9:00	4	7.7	7.5	7.3	7.8	7.0	7.9	7.1	8.5	7.0	6.8	6.4	7.7	7.3	7.0	8.4
24-Oct-05	17	8:00	4	7.8	8.7	7.2	7.6	6.6	7.2	6.3	7.6	8.1	6.1	7.4	7.2	7.3	8.5	8.9
24-Oct-05	17	8:00	6	8.1	7.4	7.3	5.9	6.7	5.9	6.2	7.1	6.2	7.7	7.6	7.8	7.1	6.9	8.4
24-Oct-05	17	16:25	4	7.6	7.0	7.1	6.7	6.4	7.0	6.9	7.0	6.9	4.8	7.1	6.9	7.2	6.7	7.0
24-Oct-05	17	16:25	8	7.5	8.2	6.9	6.4	6.8	7.1	5.7	6.1	5.5	7.3	7.2	7.2	7.0	6.4	7.0
25-Oct-05	18	6:00	4	7.4	7.4	7.0	6.9	6.6	7.4	6.4	7.2	7.4	5.4	6.4	7.2	7.4	6.9	4.2
25-Oct-05	18	6:00	5	7.6	7.8	7.9	7.6	7.0	6.8	6.9	6.0	7.3	6.8	7.1	6.6	6.7	7.2	7.3
25-Oct-05	18	15:00	2	7.8	6.9	7.4	7.3	6.9	6.8	6.9	6.7	7.6	6.1	7.1	6.7	7.9	8.1	6.6
25-Oct-05	18	15:00	4	8.0	7.6	7.8	7.1	6.7	7.6	6.6	7.8	7.0	6.6	6.4	7.4	7.6	7.1	5.9
26-Oct-05	19	8:00	4	8.3	8.5	7.7	8.3	7.1	7.8	6.2	7.4	8.2	7.4	7.9	8.4	7.3	8.5	9.0
26-Oct-05	19	8:00	7	8.6	8.2	7.7	7.8	7.1	7.6	6.9	6.9	8.1	6.9	8.2	8.3	6.9	7.0	8.4
26-Oct-05	19	15:30	3	8.6	8.8	8.0	7.7	7.6	7.4	8.2	8.4	6.8	6.3	7.8	7.2	7.2	7.5	6.8
26-Oct-05	19	15:30	4	8.0	7.6	8.0	7.6	6.7	7.5	7.1	7.7	7.1	6.1	7.0	6.9	7.3	7.3	6.8
27-Oct-05	20	8:00	1	8.3	8.1	7.6	7.3	8.1	7.0	7.4	7.9	6.6	6.3	7.6	7.1	7.4	7.1	7.7
27-Oct-05	20	8:00	4	8.0	7.8	7.7	7.9	6.9	7.1	7.0	7.4	6.9	5.6	7.6	6.9	7.6	7.8	8.0
27-Oct-05	20	15:00	2	8.3	8.4	7.7	7.6	7.8	7.6	7.0	7.8	6.8	6.2	7.9	7.3	7.6	7.4	8.3
27-Oct-05	20	15:00	4	8.2	8.0	8.0	8.2	7.0	7.4	7.4	7.8	7.0	6.0	7.4	7.0	7.8	7.5	8.1
28-Oct-05	21	8:00	4	8.2	8.6	7.9	8.1	7.9	7.8	7.7	8.2	8.0	7.2	7.9	7.4	7.2	7.9	7.0
28-Oct-05	21	8:00	6	8.8	6.8	7.8	6.2	7.9	7.6	5.6	8.1	7.4	7.9	7.8	7.6	7.4	6.9	6.9
28-Oct-05	21	14:30	4	9.3	8.3	8.4	7.7	7.1	8.0	8.1	7.3	8.4	7.1	7.9	8.0	7.8	7.8	6.3
28-Oct-05	21	14:30	8	8.9	9.1	8.3	7.7	7.1	7.7	7.2	8.3	6.6	8.2	8.4	8.1	7.3	7.8	7.2
29-Oct-05	22	8:30	4	8.9	8.1	8.4	8.3	7.4	7.2	7.1	7.4	7.9	7.4	7.1	6.8	7.3	7.5	7.6
29-Oct-05	22	8:30	5	8.6	6.7	8.0	7.8	7.2	5.7	7.5	8.1	7.5	7.9	7.4	7.2	6.4	6.6	7.1
29-Oct-05	22	17:00	2	8.7	7.2	7.5	7.3	6.4	7.3	6.8	7.0	7.4	7.4	7.9	7.1	7.1	8.0	8.5
29-Oct-05	22	17:00	4	8.1	7.6	7.9	8.0	6.8	7.4	8.3	7.3	7.6	6.9	7.4	7.4	7.3	8.3	8.2
30-Oct-05	23	7:00	4	8.0	7.6	8.2	7.3	7.3	7.9	7.4	8.1	7.7	7.3	8.1	7.0	7.0	8.0	7.2
30-Oct-05	23	7:00	7	8.5	6.5	7.9	7.9	7.3	7.2	7.0	7.7	7.8	7.6	8.0	7.8	8.2	5.6	6.9
30-Oct-05	23	18:00	3	8.3	8.6	7.4	8.3	7.2	7.9	6.9	7.9	6.6	9.0	8.5	7.0	8.0	7.7	8.2
30-Oct-05	23	18:00	4	8.3	7.2	7.7	7.9	6.6	8.2	7.3	8.2	8.4	7.7	8.6	7.6	7.3	8.0	8.5
31-Oct-05	24	6:00	1	8.7	8.2	7.2	7.1	7.7	7.5	6.7	7.5	6.6	8.6	7.4	8.1	7.8	8.3	8.2
31-Oct-05	24	6:00	4	8.2	7.5	7.4	7.2	6.8	7.7	6.9	6.7	7.0	7.8	7.6	7.3	7.6	8.3	8.0
31-Oct-05	24	15:30	4	8.6	6.9	8.3	8.1	7.6	7.3	7.9	7.0	6.7	6.4	7.2	7.1	7.1	7.8	6.8
31-Oct-05	24	15:30	6	8.5	8.7	8.1	8.2	7.8	4.9	7.0	7.0	6.4	6.8	6.7	7.3	6.6	5.5	6.9
1-Nov-05	25	8:30	4	7.9	7.2	7.1	7.4	7.4	7.2	6.9	7.2	7.0	6.4	8.5	7.3	6.9	8.3	7.3
1-Nov-05	25	8:30	6	8.0	6.6	7.5	7.4	6.5	6.2	6.4	7.9	6.1	6.8	7.2	7.5	6.8	6.2	6.9
1-Nov-05	25	16:20	4	7.9	6.0	7.6	7.1	6.8	6.9	7.5	7.5	7.9	7.7	6.8	6.9	7.0	7.1	7.8
1-Nov-05	25	16:20	8	8.0	8.3	7.6	7.5	7.3	7.6	7.7	8.1	6.7	8.1	7.3	6.7	6.5	6.5	7.1
2-Nov-05	26	8:15	4	8.0	4.3	8.1	8.2	6.9	7.1	7.5	8.1	7.6	6.3	7.7	8.8	8.9	8.5	8.5
2-Nov-05	26	8:15	5	7.9	6.7	8.0	7.6	4.3	7.4	7.3	7.3	7.1	7.1	8.1	7.7	7.6	7.5	8.6
2-Nov-05	26	15:00	2	7.8	7.7	7.8	6.8	7.3	7.3	5.5	6.8	7.3	8.0	6.1	7.2	7.7	7.5	5.0
2-Nov-05	26	15:00	4	7.5	4.2	7.4	7.2	7.3	7.3	7.5	6.9	7.4	6.0	7.2	7.4	7.1	7.7	6.0
3-Nov-05	27	8:15	4	7.4	6.1	7.3	7.2	6.1	6.7	7.5	7.2	7.0	7.1	6.9	7.6	7.6	8.4	8.0
3-Nov-05	27	8:15	7	7.6	5.9	7.5	7.2	6.6	6.8	6.9	6.7	6.5	7.4	6.7	7.2	7.3	5.6	7.7
3-Nov-05	27	15:00	3	8.1	7.6	7.1	7.0	6.6	7.1	5.2	7.1	5.9	7.1	6.0	7.3	6.9	7.4	6.7

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
3-Nov-05	27	15:00	4	7.9	4.9	7.2	7.5	6.1	7.0	5.8	6.6	7.3	6.3	5.7	6.8	6.7	7.9	6.9
4-Nov-05	28	7:10	1	6.6	7.1	6.5	7.8	6.8	7.2	7.6	7.1	6.6	8.1	7.1	7.1	7.0	7.3	7.6
4-Nov-05	28	7:10	2	7.8	6.4	6.7	7.5	6.4	6.5	7.8	6.8	7.0	7.0	7.0	7.5	7.6	7.5	7.3
4-Nov-05	28	7:10	3	7.7	7.1	7.9	7.8	7.2	7.1	7.5	7.0	7.4	6.8	7.2	7.8	7.8	7.7	7.4
4-Nov-05	28	7:10	4	7.4	5.3	7.4	7.1	5.6	7.4	8.0	7.5	7.8	7.1	6.9	7.7	7.2	7.0	7.7
4-Nov-05	28	7:10	5	7.5	6.6	7.1	7.8	5.1	6.7	7.1	7.5	7.6	7.3	7.0	7.7	7.2	6.0	7.5
4-Nov-05	28	7:10	6	7.4	6.8	7.2	7.0	7.2	6.0	6.8	7.0	7.1	7.4	7.4	7.8	6.9	6.3	7.2
4-Nov-05	28	7:10	7	7.5	5.6	7.6	7.5	5.8	7.6	7.5	7.4	7.8	7.7	7.9	7.8	7.2	7.2	7.3
4-Nov-05	28	7:10	8	7.3	6.0	7.4	6.8	6.1	7.1	7.8	7.7	6.5	7.7	7.5	7.6	7.3	7.0	7.1
			Average	**7.6**	**7.0**	**7.4**	**7.2**	**6.6**	**7.1**	**6.6**	**7.2**	**6.6**	**6.9**	**7.2**	**7.0**	**6.9**	**7.2**	**7.2**
			Minimum	6.3	3.4	5.0	2.5	4.1	3.2	3.4	4.4	3.4	2.7	2.8	4.2	3.1	2.4	4.2
			Maximum	9.3	9.1	8.6	8.8	8.6	8.4	8.4	8.6	8.4	9.0	8.8	8.9	8.9	53.9	9.0

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
pH

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	8.10	7.44	7.90	7.10	7.51	7.00	7.84	7.66	6.92	7.68	7.54	7.36	7.26	7.80	7.18
7-Oct-05	0	7:00	4	8.13	7.69	7.74	7.13	7.43	7.63	6.93	7.33	7.22	7.45	7.66	7.21	6.92	7.14	7.17
7-Oct-05	0	7:00	5	8.15	7.55	7.27	6.87	7.70	7.72	7.83	7.36	7.17	7.34	7.45	7.26	7.31	7.00	7.49
7-Oct-05	0	7:00	8	8.15	7.53	7.47	7.71	7.79	7.04	7.56	7.35	7.35	7.43	7.91	7.46	7.05	7.18	7.24
10-Oct-05	3	9:00	4	8.67	7.60	8.00	8.01	7.96	7.87	8.01	8.04	7.48	7.84	7.84	7.87	7.74	7.60	7.89
10-Oct-05	3	9:00	7	8.62	7.57	8.01	8.00	8.02	7.90	7.85	8.03	7.88	7.88	7.94	7.80	7.73	7.80	7.57
13-Oct-05	6	8:40	4	8.12	7.74	8.01	8.04	7.94	7.84	7.76	7.71	7.99	8.05	7.90	7.77	7.77	7.90	7.78
13-Oct-05	6	8:40	5	8.13	8.01	8.01	7.35	7.40	7.93	7.70	7.79	7.95	7.99	8.01	7.38	7.89	7.47	7.81
15-Oct-05	8	8:15	4	8.18	7.69	8.06	8.11	8.10	7.99	7.95	8.03	7.52	8.05	7.64	7.80	7.55	7.95	7.69
15-Oct-05	8	8:15	6	8.20	7.80	7.56	7.51	8.11	7.96	7.43	8.10	7.75	8.08	7.94	8.01	7.69	7.84	8.05
17-Oct-05	10	8:00	4	8.48	7.56	8.05	8.02	7.96	7.82	7.85	8.05	7.41	8.04	7.68	7.79	7.84	7.89	7.90
17-Oct-05	10	8:00	5	8.10	8.02	8.05	7.80	7.72	7.91	7.90	8.02	7.88	7.98	7.81	7.66	7.47	7.65	7.49
20-Oct-05	13	8:15	4	8.16	7.89	8.02	8.04	7.92	7.94	7.86	7.88	7.38	7.91	7.88	7.78	7.93	8.04	7.81
20-Oct-05	13	8:15	6	8.16	7.60	8.03	7.80	7.97	7.62	7.89	8.06	8.00	7.86	7.16	7.91	7.97	7.79	7.96
22-Oct-05	15	9:00	4	8.20	8.19	8.10	7.92	7.89	7.80	7.76	8.05	7.84	7.45	7.83	7.82	8.05	8.12	7.74
22-Oct-05	15	9:00	7	8.20	7.85	8.10	7.69	7.86	7.86	7.59	8.08	7.80	8.03	7.91	7.79	8.04	7.95	7.95
24-Oct-05	17	8:00	4	8.18	8.34	8.05	7.98	7.86	7.90	7.75	7.95	8.00	7.52	7.74	7.80	7.98	8.05	7.80
24-Oct-05	17	8:00	6	8.30	7.84	8.04	7.88	7.88	7.33	7.57	8.05	7.54	7.96	7.81	7.95	7.79	7.83	7.78
27-Oct-05	20	8:00	1	8.00	7.99	7.90	7.69	7.82	7.76	7.70	7.69	7.75	7.94	7.65	7.75	7.98	7.96	7.88
27-Oct-05	20	8:00	4	8.01	8.18	7.87	7.75	7.84	7.81	7.80	7.79	7.71	7.58	7.75	7.80	7.58	8.02	7.90
29-Oct-05	22	8:30	4	8.40	8.00	8.05	7.92	7.89	7.68	7.90	7.96	7.89	7.90	7.64	7.77	7.90	7.97	7.84
29-Oct-05	22	8:30	5	8.36	7.69	8.04	7.73	7.77	7.23	7.95	8.02	7.68	8.04	7.77	7.95	7.47	7.61	7.21
31-Oct-05	24	8:00	1	8.58	8.44	8.13	8.00	7.95	7.74	7.95	8.07	7.76	8.17	8.01	7.82	8.01	8.07	8.01
31-Oct-05	24	8:00	4	8.49	8.13	8.15	8.02	7.68	7.81	8.02	8.07	7.91	8.07	7.92	7.79	7.88	8.16	8.00
4-Nov-05	28	7:10	1	8.29	7.90	8.05	8.00	8.02	7.75	7.85	8.09	7.70	8.11	7.88	7.91	8.04	8.18	7.20
4-Nov-05	28	7:10	4	8.23	7.38	8.10	8.06	7.79	7.76	8.05	8.09	7.95	7.94	7.71	7.98	8.04	8.21	7.84
4-Nov-05	28	7:10	5	8.20	7.63	8.11	8.01	7.45	7.58	8.09	8.12	7.75	8.08	7.75	8.03	7.86	7.87	7.95
4-Nov-05	28	7:10	8	8.09	7.61	8.13	8.01	7.79	7.65	8.03	8.12	7.52	8.10	7.78	8.04	7.84	7.91	7.78
			Average	**8.25**	**7.82**	**7.96**	**7.79**	**7.82**	**7.71**	**7.80**	**7.91**	**7.67**	**7.87**	**7.77**	**7.76**	**7.74**	**7.82**	**7.71**
			Minimum	8.00	7.38	7.27	6.87	7.40	7.00	6.93	7.33	6.92	7.34	7.16	7.21	6.92	7.00	7.17
			Maximum	8.67	8.44	8.15	8.11	8.11	7.99	8.09	8.12	8.00	8.17	8.01	8.04	8.05	8.21	8.05

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	125	133	123	137	130	120	125	128	123	126	127	126	122	122	120
7-Oct-05	0	7:00	8	123	134	133	123	124	115	127	124	123	124	125	125	121	120	120
13-Oct-05	6	8:40	4	137	157	132	142	132	134	146	142	138	139	140	142	135	141	137
13-Oct-05	6	8:40	5	139	155	140	146	133	133	150	147	137	139	139	144	139	145	139
20-Oct-05	13	8:15	4	132	153	133	133	136	129	137	135	133	133	138	137	136	137	129
20-Oct-05	13	8:15	6	132	159	133	134	137	129	140	137	136	134	136	139	136	130	129
27-Oct-05	20	8:00	1	135	159	134	128	137	125	138	138	129	134	134	136	134	135	129
27-Oct-05	20	8:00	4	134	151	136	127	137	124	138	138	130	134	134	135	133	135	130
4-Nov-05	28	7:10	1	133	149	130	133	135	124	140	138	129	133	131	138	132	136	130
4-Nov-05	28	7:10	8	138	148	130	133	137	124	135	137	126	133	131	135	132	135	130
			Average	**133**	**150**	**132**	**134**	**134**	**126**	**138**	**136**	**130**	**133**	**133**	**136**	**132**	**134**	**129**
			Minimum	123	133	123	123	124	115	125	124	123	124	125	125	121	120	120
			Maximum	139	159	140	146	137	134	150	147	138	139	140	144	139	145	139

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Ammonia (ppm)

Date	Day	Time	Rep	Silica Sand	orm. Sedime	N. Bearskir	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	0.066	0.067	0.194	0.075	0.481	<0.063	0.321	0.269	<0.063	0.304	0.123	0.090	0.145	<0.063	<0.063
7-Oct-05	0	7:00	8	<0.063	0.069	0.396	0.547	0.505	<0.063	0.323	0.454	<0.063	0.458	0.089	<0.063	0.131	0.130	<0.063
4-Nov-05	28	7:10	1	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
4-Nov-05	28	7:10	8	<0.063	0.065	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
			Average	**<0.063**	**<0.063**	**0.163**	**0.165**	**0.263**	**<0.063**	**0.177**	**0.218**	**<0.063**	**0.207**	**0.069**	**<0.063**	**0.085**	**<0.063**	**<0.063**
			Minimum	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	0.066	0.069	0.396	0.547	0.505	<0.063	0.323	0.454	<0.063	0.458	0.123	0.090	0.145	0.130	<0.063

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
DOC (ppm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	1	2.1	4.3	2.0	3.2	3.2	13.3	4.1	2.6	14.3	4.2	6.7	3.6	5.0	8.7	9.2
7-Oct-05	0	7:00	8	1.9	3.8	2.4	14.8	3.6	10.4	3.9	2.3	9.5	2.3	5.0	3.4	7.1	6.0	7.9
4-Nov-05	28	7:10	1	1.9	2.3	1.9	1.9	1.7	2.0	1.6	1.8	1.9	2.0	1.7	1.8	1.7	2.0	2.4
4-Nov-05	28	7:10	8	1.8	2.1	1.8	1.6	1.5	2.2	1.6	1.7	2.2		2.4	1.8	2.6	2.2	2.1
			Average	**1.9**	**3.1**	**2.0**	**5.4**	**2.5**	**7.0**	**2.8**	**2.1**	**7.0**	**2.8**	**4.0**	**2.7**	**4.1**	**4.7**	**5.4**
			Minimum	1.8	2.1	1.8	1.6	1.5	2.0	1.6	1.7	1.9	2.0	1.7	1.8	1.7	2.0	2.1
			Maximum	2.1	4.3	2.4	14.8	3.6	13.3	4.1	2.6	14.3	4.2	6.7	3.6	7.1	8.7	9.2

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	3	47.2	40.4	48.0	46.8	53.6	51.6	51.2	49.6		46.4	61.2	47.2			
7-Oct-05	0	7:00	7	47.2	42.0	52.8	59.6	50.0	52.0	50.8	55.2	59.6	48.8	47.6	53.6	50.4		
4-Nov-05	28	7:10	3	42.8	46.0	41.6	42.0	43.2	40.0	44.0	47.6	42.0	41.2	44.4	46.8	46.4	45.2	42.4
4-Nov-05	28	7:10	7	44.0	50.4	42.8	43.2	44.4	40.4	44.0	45.6	38.8	43.6	40.4	52.0	45.2	46.0	41.6
			Average	**45.3**	**44.7**	**46.3**	**47.9**	**47.8**	**46.0**	**47.5**	**49.5**	**46.8**	**45.0**	**48.4**	**49.9**	**47.3**	**45.6**	**42.0**
			Minimum	42.8	40.4	41.6	42.0	43.2	40.0	44.0	45.6	38.8	41.2	40.4	46.8	45.2	45.2	41.6
			Maximum	47.2	50.4	52.8	59.6	53.6	52.0	51.2	55.2	59.6	48.8	61.2	53.6	50.4	46.0	42.4

Missing data due to samples being too cloudy to be able to determine endpoint.

Appendix Table 9. Water Chemistry Parameters for *H. azteca* 28-d Test Exposed to Sediments from Ashland Harbor, 7 October 2005 to 4 November 2005.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
7-Oct-05	0	7:00	2	52.4	44.4	47.6	59.6	59.2	48.8	56.4	48.0	49.2	48.8	60.8	60.4	63.6	53.2	59.6
7-Oct-05	0	7:00	6	51.6	40.0	44.0	52.8	50.8	47.2	54.8	59.6	55.2	56.4	49.2	54.8	51.2	51.6	48.8
4-Nov-05	28	7:10	2	48.4	58.0	47.2	48.0	46.4	44.0	50.4	51.2	46.0	46.8	44.8	48.4	48.8	51.6	47.6
4-Nov-05	28	7:10	6	48.4	56.8	44.8	48.4	51.6	46.0	51.6	50.8	46.8	49.6	47.6	52.0	50.8	53.2	48.4
			Average	**50.2**	**49.8**	**45.9**	**52.2**	**52.0**	**46.5**	**53.3**	**52.4**	**49.3**	**50.4**	**50.6**	**53.9**	**53.6**	**52.4**	**51.1**
			Minimum	48.4	40.0	44.0	48.0	46.4	44.0	50.4	48.0	46.0	46.8	44.8	48.4	48.8	51.6	47.6
			Maximum	52.4	58.0	47.6	59.6	59.2	48.8	56.4	59.6	55.2	56.4	60.8	60.4	63.6	53.2	59.6

APPENDIX 10

Survival and Growth of *H. azteca* following 10-d Exposure to Ashland Harbor Sediment and a Dilution Series Under laboratory Lighting
1 January 2006 to 13 January 2006

Appendix Table 10. Survival and Growth of *H. azteca* following 10-d of Exposure to Ashland Harbor Sediment and a Dilution Series Under Laboratory Light,

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected % Mortality	Total Dry wt (mg)	Individual Dry wt (mg)	Average Dry wt (mg)	Standard Deviation
A	Silica Sand	1	10	100.0			1.2	0.12		
A	Silica Sand	2	10	100.0			1.3	0.13		
A	Silica Sand	3	10	100.0			1.4	0.14		
A	Silica Sand	4	10	100.0			1.2	0.12		
A	Silica Sand	5	10	100.0			1.5	0.15		
A	Silica Sand	6	10	100.0			1.8	0.18		
A	Silica Sand	7	10	100.0			1.5	0.15		
A	Silica Sand	8	10	100.0	0.0		1.7	0.17	0.15	0.02
B	W. Bearskin	1	10	100.0			0.9	0.09		
B	W. Bearskin	2	10	100.0			1.3	0.13		
B	W. Bearskin	3	10	100.0			1.1	0.11		
B	W. Bearskin	4	10	100.0			1.0	0.10		
B	W. Bearskin	5	10	100.0			1.1	0.11		
B	W. Bearskin	6	10	100.0			1.3	0.13		
B	W. Bearskin	7	10	100.0			1.2	0.12		
B	W. Bearskin	8	8	80.0	7.1		1.0	0.13	0.11	0.01
C	Dilution Sedimen	1	10	100.0			1.1	0.11		
C	Dilution Sedimen	2	12	120.0			1.2	0.10		
C	Dilution Sedimen	3	9	90.0			1.1	0.12		
C	Dilution Sedimen	4	10	100.0			0.9	0.09		
C	Dilution Sedimen	5	10	100.0			1.0	0.10		
C	Dilution Sedimen	6	10	100.0			1.3	0.13		
C	Dilution Sedimen	7	10	100.0			1.4	0.14		
C	Dilution Sedimen	8	10	100.0	8.3		1.1	0.11	0.11	0.02
D	SQT9	1	10	100.0			1.9	0.19		
D	SQT9	2	10	100.0			1.8	0.18		
D	SQT9	3	10	100.0			1.7	0.17		
D	SQT9	4	10	100.0			1.9	0.19		
D	SQT9	5	10	100.0			1.6	0.16		
D	SQT9	6	9	90.0			2.1	0.23		
D	SQT9	7	10	100.0			1.8	0.18		
D	SQT9	8	9	90.0	4.6		1.4	0.16	0.18	0.02
E	SQT11	1	10	100.0			1.1	0.11		
E	SQT11	2	10	100.0			1.3	0.13		
E	SQT11	3	10	100.0			1.3	0.13		
E	SQT11	4	9	90.0			1.3	0.14		
E	SQT11	5	8	80.0			1.0	0.13		
E	SQT11	6	10	100.0			1.2	0.12		
E	SQT11	7	9	90.0			1.2	0.13		
E	SQT11	8	9	90.0	7.4		1.1	0.12	0.13	0.01
F	12.5% SQT1	1	10	100.0		100.0	1.3	0.13		
F	12.5% SQT1	2	10	100.0		100.0	1.6	0.16		
F	12.5% SQT1	3	9	90.0		99.9	1.1	0.12		
F	12.5% SQT1	4	10	100.0		100.0	1.3	0.13		
F	12.5% SQT1	5	9	90.0		99.9	1.3	0.14		
F	12.5% SQT1	6	10	100.0		100.0	0.9	0.09		
F	12.5% SQT1	7	10	100.0		100.0	1.0	0.10		
F	12.5% SQT1	8	10	100.0	4.6	100.0	1.1	0.11	0.12	0.02
G	25% SQT1	1	10	100.0		100.0	0.9	0.09		
G	25% SQT1	2	8	80.0		99.8	0.9	0.11		
G	25% SQT1	3	10	100.0		100.0	1.0	0.10		
G	25% SQT1	4	10	100.0		100.0	1.0	0.10		
G	25% SQT1	5	8	80.0		99.8	0.8	0.10		
G	25% SQT1	6	10	100.0		100.0	1.0	0.10		
G	25% SQT1	7	0	0.0		99.0				
G	25% SQT1	8	10	100.0	34.5	100.0	1.1	0.11	0.10	0.01
H	50% SQT1	1	1	10.0		99.1	0.1	0.10		
H	50% SQT1	2	2	20.0		99.2	0.1	0.05		
H	50% SQT1	3	1	10.0		99.1	0.2	0.20		
H	50% SQT1	4	3	30.0		99.3	0.4	0.13		

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected % Mortality	Total Dry wt (mg)	Individual Dry wt (mg)	Average Dry wt (mg)	Standard Deviation
H	50% SQT1	5	1	10.0		99.1	0.2	0.20		
H	50% SQT1	6	3	30.0		99.3	0.4	0.13		
H	50% SQT1	7	1	10.0		99.1	0.0	0.00		
H	50% SQT1	8	0	0.0	10.7	99.0			0.12	0.07
I	100% SQT1	1	0	0.0		99.0				
I	100% SQT1	2	0	0.0		99.0				
I	100% SQT1	3	0	0.0		99.0				
I	100% SQT1	4	0	0.0		99.0				
I	100% SQT1	5	0	0.0		99.0				
I	100% SQT1	6	0	0.0		99.0				
I	100% SQT1	7	0	0.0		99.0				
I	100% SQT1	8	0	0.0	0.0	99.0				
J	SQT4	1	10	100.0		100.0	1.8	0.18		
J	SQT4	2	10	100.0		100.0	1.8	0.18		
J	SQT4	3	9	90.0		99.9	1.7	0.19		
J	SQT4	4	9	90.0		99.9	1.8	0.20		
J	SQT4	5	10	100.0		100.0	1.6	0.16		
J	SQT4	6	9	90.0		99.9	1.8	0.20		
J	SQT4	7	9	90.0		99.9	1.5	0.17		
J	SQT4	8	9	90.0	5.2	99.9	1.5	0.17	0.18	0.02
K	SQT2	1	10	100.0		100.0	1.0	0.10		
K	SQT2	2	9	90.0		99.9	1.4	0.16		
K	SQT2	3	9	90.0		99.9	1.4	0.16		
K	SQT2	4	10	100.0		100.0	1.1	0.11		
K	SQT2	5	9	90.0		99.9	1.4	0.16		
K	SQT2	6	10	100.0		100.0	1.2	0.12		
K	SQT2	7	9	90.0		99.9	1.1	0.12		
K	SQT2	8	8	80.0	7.1	99.8	1.2	0.15	0.13	0.02
L	SQT5	1	10	100.0		100.0	1.6	0.16		
L	SQT5	2	10	100.0		100.0	2.0	0.20		
L	SQT5	3	9	90.0		99.9	1.4	0.16		
L	SQT5	4	10	100.0		100.0	2.0	0.20		
L	SQT5	5	10	100.0		100.0	1.7	0.17		
L	SQT5	6	7	70.0		99.7	0.8	0.11		
L	SQT5	7	9	90.0		99.9	1.8	0.20		
L	SQT5	8	9	90.0	10.4	99.9	1.9	0.21	0.18	0.03
M	SQT8	1	9	90.0		99.9	1.9	0.21		
M	SQT8	2	8	80.0		99.8	1.4	0.18		
M	SQT8	3	8	80.0		99.8	1.6	0.20		
M	SQT8	4	4	40.0		99.4	0.8	0.20		
M	SQT8	5	10	100.0		100.0	2.4	0.24		
M	SQT8	6	10	100.0		100.0	1.5	0.15		
M	SQT8	7	1	10.0		99.1	0.1	0.10		
M	SQT8	8	9	90.0	32.0	99.9	1.9	0.21	0.19	0.04

APPENDIX 11

Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 1 January 2006 to 13 January 2006

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
Temperature (° C)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	22.8	23.2	23.2	22.5	22.7	23.3	22.6	22.7	23.2	22.8	23.0	22.7	23.0
3-Jan-06	0	7:00	2	23.0	23.2	23.4	22.7	22.8	23.4	22.5	22.8	23.4	23.0	23.1	22.7	22.9
3-Jan-06	0	7:00	3	22.9	23.2	23.3	22.8	22.8	23.4	22.9	22.7	23.2	22.8	23.1	22.7	23.2
3-Jan-06	0	7:00	4	22.9	23.4	23.4	22.8	23.0	23.4	22.9	22.8	23.2	23.0	23.1	22.7	23.0
3-Jan-06	0	7:00	5	22.9	23.4	23.3	22.8	22.7	23.3	22.7	22.8	23.3	23.3	23.2	22.7	23.0
3-Jan-06	0	7:00	6	22.8	23.4	23.2	22.8	22.9	23.3	22.8	22.8	23.2	23.0	23.2	22.7	23.1
3-Jan-06	0	7:00	7	22.9	23.4	23.2	22.9	22.6	23.2	22.7	22.7	23.4	23.1	23.2	22.7	22.9
3-Jan-06	0	7:00	8	22.8	23.3	23.2	22.8	22.9	23.2	22.8	22.8	23.3	22.9	23.0	22.7	22.9
4-Jan-06	1	8:45	4	23.0	23.5	23.5	23.0	23.2	23.4	23.2	23.1	23.5	23.5	23.8	23.0	23.2
4-Jan-06	1	8:45	6	23.1	23.8	23.5	23.0	23.2	23.4	23.1	23.2	23.6	23.3	23.6	23.0	23.3
4-Jan-06	1	14:30	4	23.0	23.2	23.0	22.8	22.7	23.1	22.7	22.8	23.2	23.0	22.9	22.6	22.9
4-Jan-06	1	14:30	8	22.7	23.2	23.2	22.9	22.6	23.2	22.8	22.8	23.3	23.2	23.0	22.8	23.1
5-Jan-06	2	8:50	4	23.0	23.2	23.1	22.6	22.7	23.2	22.7	22.9	23.0	23.0	23.1	22.4	23.0
5-Jan-06	2	8:50	5	22.8	23.2	23.1	22.6	22.7	23.3	22.7	22.7	23.1	23.1	23.0	22.5	23.0
5-Jan-06	2	15:00	2	22.5	23.1	23.0	22.3	22.4	22.9	22.5	22.6	23.0	22.9	22.9	22.1	22.7
5-Jan-06	2	15:00	4	22.6	23.0	23.1	22.3	22.6	22.9	22.7	22.6	23.1	22.8	23.0	22.2	22.9
6-Jan-06	3	9:00	4	22.6	23.1	23.2	22.5	22.4	23.1	22.3	22.4	23.1	22.7	22.9	22.1	22.5
6-Jan-06	3	9:00	7	22.6	23.2	23.2	22.5	22.4	22.9	22.3	22.5	23.1	22.8	22.5	22.1	22.6
6-Jan-06	3	14:45	3	22.3	22.9	22.8	22.1	22.1	23.0	21.9	22.0	22.9	22.7	22.7	22.0	22.7
6-Jan-06	3	14:45	4	22.3	23.0	22.8	22.0	22.1	23.1	22.2	22.1	23.0	22.8	22.8	22.0	22.8
7-Jan-06	4	8:00	1	23.7	23.7	23.7	23.7	23.8	23.7	23.3	23.7	23.7	23.6	23.6	23.4	23.7
7-Jan-06	4	8:00	4	23.8	23.8	23.8	23.7	23.8	23.8	23.6	23.8	23.2	23.6	23.6	23.5	23.7
7-Jan-06	4	15:15	3	23.2	23.8	23.3	23.1	23.2	23.7	23.1	23.2	23.5	23.8	23.7	23.2	23.8
7-Jan-06	4	15:15	4	23.3	23.8	23.4	23.2	23.2	23.8	23.2	23.3	23.7	23.8	23.8	23.2	23.7
8-Jan-06	5	8:30	4	23.1	23.6	23.6	23.1	23.2	23.6	23.1	23.1	23.6	23.5	23.4	23.0	23.5
8-Jan-06	5	8:30	6	23.0	23.7	23.6	23.1	23.2	23.7	23.2	23.2	23.6	23.5	23.5	23.0	23.6
8-Jan-06	5	14:30	4	22.9	23.9	23.7	22.5	23.0	23.9	22.9	22.9	23.8	23.7	23.8	22.9	23.6
8-Jan-06	5	14:30	8	23.0	23.7	23.7	23.0	22.9	23.9	22.9	22.9	23.9	23.8	23.8	22.8	23.6
9-Jan-06	6	8:15	4	22.8	22.9	23.7	23.0	23.1	23.7	22.9	22.9	23.8	23.8	23.8	22.9	23.4
9-Jan-06	6	8:15	5	22.8	23.8	23.7	23.0	23.1	23.8	23.0	23.3	24.0	23.6	24.0	22.9	23.6
9-Jan-06	6	13:00	2	23.3	24.1	23.9	23.3	23.2	23.9	23.2	23.2	24.1	23.9	23.7	23.1	23.7
9-Jan-06	6	13:00	4	23.4	24.1	24.0	23.3	23.1	23.8	23.2	23.2	24.1	23.8	23.7	23.0	23.7
10-Jan-06	7	8:50	4	23.4	23.9	23.9	23.3	23.3	23.9	23.4	23.2	24.0	23.8	24.0	23.1	23.8
10-Jan-06	7	8:50	7	23.2	24.2	23.9	23.1	23.2	23.8	23.4	23.2	24.0	24.1	24.0	23.3	23.8
10-Jan-06	7	15:00	3	23.5	24.0	23.8	23.5	23.3	23.8	23.4	23.4	24.0	23.7	23.6	23.1	23.6
10-Jan-06	7	15:00	4	23.6	24.0	23.7	23.5	23.4	23.8	23.5	23.5	24.0	23.7	23.7	23.1	23.5
11-Jan-06	8	8:30	4	23.4	23.8	23.7	23.2	23.3	24.2	23.2	23.3	24.2	23.9	24.0	23.3	23.9
11-Jan-06	8	8:30	6	23.4	24.1	23.6	23.2	23.4	24.2	23.4	23.4	24.2	24.2	24.0	23.0	24.1
11-Jan-06	8	15:00	4	23.3	24.0	23.9	23.1	23.3	23.7	23.2	23.2	24.0	24.0	23.5	23.1	24.0
11-Jan-06	8	15:00	8	23.4	24.0	24.0	23.2	23.3	23.9	23.3	23.2	24.1	24.1	23.9	23.4	23.9
12-Jan-06	9	8:00	4	23.3	24.1	24.1	23.4	23.4	24.1	23.3	23.4	24.2	24.0	24.0	23.3	24.2
12-Jan-06	9	8:00	6	23.3	24.3	24.1	23.4	23.5	24.2	23.3	23.5	24.3	24.1	24.1	23.4	24.1
12-Jan-06	9	14:00	4	23.3	23.7	24.0	23.3	23.6	23.9	23.4	23.3	24.2	24.0	24.1	23.3	24.0
12-Jan-06	9	14:00	8	23.1	23.9	23.9	23.5	23.6	24.1	23.5	23.5	24.3	24.0	24.1	23.4	24.0

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
13-Jan-06	10	7:05	1	23.2	24.0	23.9	23.0	23.4	23.9	23.2	23.3	23.9	23.7	23.8	231.0	23.7
13-Jan-06	10	7:05	2	23.4	24.0	24.0	23.4	23.5	24.0	23.3	23.3	24.0	23.8	23.8	23.1	23.9
13-Jan-06	10	7:05	3	23.2	24.1	23.9	23.3	23.1	24.1	23.3	23.3	24.0	23.9	23.7	23.3	23.9
13-Jan-06	10	7:05	4	23.3	24.2	24.0	23.3	23.5	24.1	23.3	23.3	24.0	24.0	23.8	23.2	24.0
13-Jan-06	10	7:05	5	23.3	24.1	24.0	23.2	23.2	24.0	23.3	23.1	24.0	24.0	23.7	23.1	23.9
13-Jan-06	10	7:05	6	23.3	24.2	23.9	23.3	23.4	24.0	23.3	23.3	24.0	24.1	23.7	23.1	23.6
13-Jan-06	10	7:05	7	23.3	24.2	23.9	23.3	23.3	24.1	23.4	23.3	24.0	23.8	23.8	23.2	23.7
13-Jan-06	10	7:05	8	23.4	24.2	23.8	23.4	23.3	24.0	23.3	23.4	24.0	23.9	23.8	23.2	23.8
			Average	**23.1**	**23.7**	**23.6**	**23.0**	**23.1**	**23.6**	**23.0**	**23.1**	**23.7**	**23.5**	**23.5**	**26.9**	**23.5**
			Minimum	22.3	22.9	22.8	22.0	22.1	22.9	21.9	22.0	22.9	22.7	22.5	22.0	22.5
			Maximum	23.8	24.3	24.1	23.7	23.8	24.2	23.6	23.8	24.3	24.2	24.1	231.0	24.2

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	7.1	6.1	5.8	5.2	4.0	6.0	5.4	6.6	4.6	3.7	4.0	6.2	2.5
3-Jan-06	0	7:00	2	7.0	6.3	5.9	5.2	5.6	6.0	5.0	7.3	6.5	4.1	3.8	6.9	3.7
3-Jan-06	0	7:00	3	6.9	6.8	5.0	4.6	6.8	5.4	5.1	5.3	4.8	3.9	4.1	6.8	4.8
3-Jan-06	0	7:00	4	7.0	6.9	5.1	3.9	7.5	6.6	5.9	7.1	6.5	3.1	4.1	6.3	3.5
3-Jan-06	0	7:00	5	6.9	6.7	5.1	4.9	4.8	6.4	5.0	4.3	7.3	3.8	4.1	5.4	5.8
3-Jan-06	0	7:00	6	7.0	6.2	6.0	4.7	5.1	7.0	4.4	6.9	4.2	3.7	6.5	5.6	6.8
3-Jan-06	0	7:00	7	6.9	5.9	6.2	4.9	4.4	5.7	6.4	7.3	4.3	4.2	3.5	5.6	3.4
3-Jan-06	0	7:00	8	7.3	6.3	4.6	6.0	7.2	6.0	5.1	6.9	6.7	4.6	5.1	5.3	4.8
4-Jan-06	1	8:45	4	7.4	6.0	5.6	5.0	6.3	5.4	6.4	6.9	5.8	6.3	7.0	7.0	5.6
4-Jan-06	1	8:45	6	6.5	6.7	6.6	6.0	5.1	6.0	6.3	5.9	5.0	4.2	6.8	6.7	4.4
4-Jan-06	1	14:30	4	7.0	7.2	6.9	5.2	7.7	6.5	7.7	6.9	7.0	7.4	7.0	6.9	3.5
4-Jan-06	1	14:30	8	7.0	6.8	6.8	6.6	7.8	6.6	7.4	7.4	6.3	6.4	5.8	6.2	3.3
5-Jan-06	2	8:50	4	7.0	8.3	8.0	6.6	7.5	6.0	7.5	7.1	7.1	7.0	7.2	7.6	5.4
5-Jan-06	2	8:50	5	7.2	8.2	7.3	7.5	5.8	6.8	7.5	7.1	6.8	7.4	7.2	7.5	6.9
5-Jan-06	2	15:00	2	7.5	8.2	8.3	7.7	4.7	6.2	7.6	7.5	7.5	7.0	7.5	5.8	4.8
5-Jan-06	2	15:00	4	7.4	8.1	7.9	7.2	7.2	6.8	7.1	7.1	7.6	7.1	7.6	6.8	6.8
6-Jan-06	3	9:00	4	7.0	6.9	7.4	6.4	7.8	5.9	7.5	7.2	7.0	7.3	6.9	6.9	7.0
6-Jan-06	3	9:00	7	7.3	6.9	7.5	7.0	5.2	7.9	7.1	7.0	6.9	7.4	6.5	7.0	3.5
6-Jan-06	3	14:45	3	7.0	6.7	7.3	6.5	7.2	6.9	8.1	8.2	8.2	7.0	7.7	8.2	7.6
6-Jan-06	3	14:45	4	6.9	7.1	7.6	6.6	7.4	7.1	8.3	7.4	8.0	7.1	7.7	7.8	7.1
7-Jan-06	4	8:00	1	7.3	7.6	7.6	4.6	7.3	6.8	8.4	7.2	7.7	6.4	7.5	6.9	4.8
7-Jan-06	4	8:00	4	7.3	7.7	7.0	5.6	6.8	6.6	8.4	6.9	6.7	7.4	6.9	6.6	6.5
7-Jan-06	4	15:15	3	6.7	6.7	6.7	6.5	7.0	6.4	7.5	7.2	7.3	7.6	7.6	7.4	5.2
7-Jan-06	4	15:15	4	6.8	6.9	6.8	6.2	7.1	6.7	6.8	7.1	6.7	7.4	7.6	7.3	5.6
8-Jan-06	5	8:30	4	6.8	6.9	6.5	6.5	6.7	6.3	6.6	7.4	7.1	6.2	7.3	6.7	7.3
8-Jan-06	5	8:30	6	6.8	6.7	6.8	6.5	6.5	6.9	6.7	7.1	6.6	6.3	6.8	6.6	6.9
8-Jan-06	5	14:30	4	6.7	7.7	7.6	6.6	7.6	6.9	6.9	7.5	6.6	6.6	7.5	6.6	7.3
8-Jan-06	5	14:30	8	6.7	7.1	6.6	6.8	7.0	7.6	6.9	6.9	7.4	6.7	6.6	6.4	7.2
9-Jan-06	6	8:15	4	7.7	7.8	6.5	6.9	6.9	6.3	7.4	7.3	6.0	6.0	6.4	7.1	7.6
9-Jan-06	6	8:15	5	7.6	7.8	7.0	7.0	7.4	7.4	5.9	7.7	6.5	7.1	5.8	7.2	7.5
9-Jan-06	6	13:00	2	6.8	7.4	6.6	6.7	7.6	6.4	6.4	6.9	7.1	6.1	7.3	6.9	6.8
9-Jan-06	6	13:00	4	7.1	7.7	6.7	6.6	7.6	7.3	7.0	6.8	7.4	7.2	8.1	7.0	7.1
10-Jan-06	7	8:50	4	7.4	8.3	7.4	7.0	7.3	5.9	6.6	7.1	7.1	5.9	6.7	7.5	6.7
10-Jan-06	7	8:50	7	7.5	8.2	7.0	7.3	7.0	7.0	6.7	7.0	7.8	6.8	7.0	7.6	6.8
10-Jan-06	7	15:00	3	7.0	6.9	7.4	7.2	6.7	7.1	6.5	6.8	6.4	5.9	5.2	6.6	7.2
10-Jan-06	7	15:00	4	7.2	7.1	7.4	6.9	6.5	6.4	6.9	6.7	6.3	6.3	5.2	6.5	7.2
11-Jan-06	8	8:30	4	7.0	7.9	6.8	7.5	7.5	6.0	7.8	7.6	6.3	7.1	7.3	7.1	8.1
11-Jan-06	8	8:30	6	6.8	6.7	6.8	6.3	7.0	5.9	7.5	7.1	6.1	7.2	7.4	7.2	6.5
11-Jan-06	8	15:00	4	6.8	7.2	7.8	7.8	7.5	7.3	7.4	7.5	8.0	6.3	7.3	6.8	6.9
11-Jan-06	8	15:00	8	7.0	6.9	7.8	7.7	7.7	7.3	7.5	7.6	8.0	6.1	6.8	7.0	7.1
12-Jan-06	9	8:00	4	6.9	7.0	6.5	6.2	7.0	6.1	6.4	6.8	7.0	6.4	7.1	6.7	6.5
12-Jan-06	9	8:00	6	7.2	6.6	6.4	6.0	7.1	6.2	5.7	6.1	7.1	7.1	7.0	6.7	7.1
12-Jan-06	9	14:00	4	6.6	7.3	6.4	7.1	6.3	6.6	7.7	7.1	7.2	7.3	7.1	7.3	6.8
12-Jan-06	9	14:00	8	6.7	7.2	6.3	6.0	6.7	6.8	7.5	6.9	7.0	7.3	6.4	6.7	6.7

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
13-Jan-06	10	7:05	1	6.7	7.5	7.0	7.1	7.0	5.7	7.1	6.6	6.2	6.0	6.8	7.3	7.4
13-Jan-06	10	7:05	2	6.6	7.3	6.2	7.3	7.4	4.9	5.6	6.2	5.3	5.8	6.6	7.1	7.4
13-Jan-06	10	7:05	3	6.9	6.7	6.8	6.7	7.5	6.3	6.1	6.5	6.2	6.5	6.6	6.6	7.3
13-Jan-06	10	7:05	4	7.0	6.6	6.6	6.9	7.6	5.4	5.9	6.7	6.1	6.9	6.9	6.7	7.5
13-Jan-06	10	7:05	5	5.7	6.9	6.5	6.4	7.0	6.1	6.2	6.5	6.3	6.6	7.0	6.8	7.5
13-Jan-06	10	7:05	6	5.5	6.9	6.0	5.9	7.4	6.1	6.2	6.7	6.4	6.4	6.1	6.8	7.1
13-Jan-06	10	7:05	7	6.4	6.6	6.4	7.1	6.9	6.2	6.4	6.7	6.4	6.8	6.2	6.9	6.2
13-Jan-06	10	7:05	8	5.5	6.6	6.4	6.5	7.3	6.3	6.3	6.4	6.4	6.1	6.6	7.3	7.0
			Average	**6.9**	**7.1**	**6.7**	**6.4**	**6.8**	**6.4**	**6.7**	**6.9**	**6.6**	**6.2**	**6.5**	**6.8**	**6.2**
			Minimum	5.5	5.9	4.6	3.9	4.0	4.9	4.4	4.3	4.2	3.1	3.5	5.3	2.5
			Maximum	7.7	8.3	8.3	7.8	7.8	7.9	8.4	8.2	8.2	7.6	8.1	8.2	8.1

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
pH

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	7.80	7.56	7.46	7.22	7.74	7.62	7.87	7.96	7.53	7.89	7.77	7.54	6.90
3-Jan-06	0	7:00	4	8.13	7.89	7.88	7.23	7.73	7.80	7.70	7.97	7.59	7.10	7.17	7.55	7.09
3-Jan-06	0	7:00	5	8.17	8.00	7.28	7.22	7.10	7.87	7.73	7.79	7.78	7.20	7.14	7.35	7.55
3-Jan-06	0	7:00	8	8.18	7.76	7.17	7.01	7.70	7.64	7.47	7.95	7.85	7.21	7.29	7.59	7.13
13-Jan-06	10	7:05	1	7.95	8.18	8.01	7.87	8.01	7.59	8.01	8.06	7.92	7.80	7.92	7.92	7.93
13-Jan-06	10	7:05	4	7.96	8.17	8.06	7.90	8.05	7.59	7.63	7.94	7.93	8.03	7.79	7.84	8.00
13-Jan-06	10	7:05	5	7.76	8.22	8.00	7.83	7.74	7.79	7.87	8.00	8.01	8.06	7.96	7.96	8.02
13-Jan-06	10	7:05	8	7.79	8.23	7.81	7.96	7.94	7.91	7.85	8.03	8.01	7.89	7.86	7.98	7.98
			Average	**7.97**	**8.00**	**7.71**	**7.53**	**7.75**	**7.73**	**7.77**	**7.96**	**7.83**	**7.65**	**7.61**	**7.72**	**7.58**
			Minimum	7.76	7.56	7.17	7.01	7.10	7.59	7.47	7.79	7.53	7.10	7.14	7.35	6.90
			Maximum	8.18	8.23	8.06	7.96	8.05	7.91	8.01	8.06	8.01	8.06	7.96	7.98	8.02

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	146	143	156	155	129	155	154	143	148	150	142	146	144
3-Jan-06	0	7:00	8	147	143	164	145	133	151	142	142	144	149	145	144	142
13-Jan-06	10	7:05	1	134	131	138	133	131	141	138	135	139	141	136	136	137
13-Jan-06	10	7:05	8	135	130	139	133	130	136	138	134	136	139	136	133	135
			Average	**141**	**137**	**149**	**141**	**131**	**145**	**143**	**139**	**141**	**145**	**140**	**140**	**139**
			Minimum	134	130	138	133	129	136	138	134	136	139	136	133	135
			Maximum	147	143	164	155	133	155	154	143	148	150	145	146	144

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
nmonia (ppm)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	<0.063	0.279	0.265	0.604	<0.063	0.219	0.176	0.131	0.168	<0.063	<0.063	<0.063	<0.063
3-Jan-06	0	7:00	8	<0.063	0.196	0.480	0.264	<0.063	0.258	0.250	0.128	0.089	<0.063	<0.063	<0.063	<0.063
13-Jan-06	10	7:05	1	0.162	<0.063	0.173	0.242	0.140	0.394	0.170	0.149	0.217	0.101	0.160	0.160	0.144
13-Jan-06	10	7:05	8	0.263	<0.063	0.195	0.224	0.126	0.241	0.192	0.150	0.195	0.083	0.159	0.160	0.150
			Average	**0.122**	**0.135**	**0.278**	**0.334**	**0.082**	**0.278**	**0.197**	**0.140**	**0.167**	**0.062**	**0.100**	**0.100**	**0.089**
			Minimum	<0.063	<0.063	0.173	0.224	<0.063	0.219	0.170	0.128	0.089	<0.063	<0.063	<0.063	<0.063
			Maximum	0.263	0.279	0.480	0.604	0.140	0.394	0.250	0.150	0.217	0.101	0.160	0.160	0.150

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
DOC (ppm)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	1	2.9	2.7	3.5	5	44	3.9	3.6	3.7	5.7	9	12.9	9	5.3
3-Jan-06	0	7:00	8	2.3	2.8	3.6	5.1	32	3.6	3.3	3.8		14.5	18.5	6.7	3.5
13-Jan-06	10	7:05	1	2.2	2.5	3.8	2	2.2	1.8	1.6	1.7	2.6	2.1	2.6	3.4	2.7
13-Jan-06	10	7:05	8	1.9	2.5	2.9	1.8	2.7	2.4	2.1	3.9	2.1	1.8	2.5	1.8	2
			Average	**2.3**	**2.6**	**3.5**	**3.5**	**20.2**	**2.9**	**2.7**	**3.3**	**3.5**	**6.9**	**9.1**	**5.2**	**3.4**
			Minimum	1.9	2.5	2.9	1.8	2.2	1.8	1.6	1.7	2.1	1.8	2.5	1.8	2.0
			Maximum	2.9	2.8	3.8	5.1	44.0	3.9	3.6	3.9	5.7	14.5	18.5	9.0	5.3

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	3	44.4	45.2	53.2	54.0	56.0	52.4	54.8	52.4	52.0		68.0	57.2	
3-Jan-06	0	7:00	7	55.2	56.8	49.2	54.0		53.6	50.0	54.0	56.4	64.4		60.4	
13-Jan-06	10	7:05	3	44.0	43.6	48.8	48.4	47.2	48.0	50.4	48.8	48.0	53.2	50.0	47.6	47.6
13-Jan-06	10	7:05	7	51.6	44.8	48.0	48.4	36.8	49.2	49.2	46.4	50.4	51.6	50.8	49.2	49.6
			Average	**48.8**	**47.6**	**49.8**	**51.2**	**46.7**	**50.8**	**51.1**	**50.4**	**51.7**	**56.4**	**56.3**	**53.6**	**48.6**
			Minimum	44.0	43.6	48.0	48.4	36.8	48.0	49.2	46.4	48.0	51.6	50.0	47.6	47.6
			Maximum	55.2	56.8	53.2	54.0	56.0	53.6	54.8	54.0	56.4	64.4	68.0	60.4	49.6

Appendix Table 11. Water Chemistry Parameters for *H. azteca* Exposed to Sediments and a Dilution Series Under Laboratory Light, 3 January 2006 to 13 January 2006
Alkalinity (mg/L as CaCOe)

Date	Day	Time	Rep	Sand	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% STQ1	50% SQT1	100% SQT1	SQT4	SQT2	SQT5	SQT8
3-Jan-06	0	7:00	2	50.4	51.6	48.8	59.6	50.0	51.6	52.4	52.0	57.6	66.4	59.6	56.8	59.2
3-Jan-06	0	7:00	6	47.6	52.8	50.4	57.6	51.6	50.0	49.6	53.6	57.2	67.2	62.4	58.4	54.8
13-Jan-06	10	7:05	2	54.0	50.4	51.2	54.8	52.0	52.8	52.8	51.6	55.6	58.0	56.8	54.4	54.4
13-Jan-06	10	7:05	6	53.6	50.8	50.4	53.2	44.4	54.0	52.8	53.2	56.8	57.2	57.2	56.0	56.4
			Average	**51.4**	**51.4**	**50.2**	**56.3**	**49.5**	**52.1**	**51.9**	**52.6**	**56.8**	**62.2**	**59.0**	**56.4**	**56.2**
			Minimum	47.6	50.4	48.8	53.2	44.4	50.0	49.6	51.6	55.6	57.2	56.8	54.4	54.4
			Maximum	54.0	52.8	51.2	59.6	52.0	54.0	52.8	53.6	57.6	67.2	62.4	58.4	59.2

APPENDIX 12

Survival and Growth of *H. azteca* following 10-d Exposure to Ashland Harbor Sediment and Dilution Series Under UV Light, 1 January 2006 to 13 January 2006

Appendix Table 12. Survival and Growth of *H. azteca* following 10-d exposure to Ashland Harbor Sediment and Dilution Series Under UV light, 3 January 2006 to 13 January 2

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected % Mortality	Total Dry wt (mg)	Individual Dry wt (mg)	Average Dry wt (mg)	Standard Deviation
A	Silica Sand	1	10	100			1.2	0.12		
A	Silica Sand	2	9	90			1.2	0.13		
A	Silica Sand	3	11	110			1.1	0.10		
A	Silica Sand	4	10	100			1.2	0.12		
A	Silica Sand	5	10	100			1.1	0.11		
A	Silica Sand	6	10	100			1.5	0.15		
A	Silica Sand	7	8	80			1.1	0.14		
A	Silica Sand	8	11	110	9.9		1.3	0.12	0.12	0.02
B	Silica Sand w/ leafs	1	10	100			1.9	0.19		
B	Silica Sand w/ leafs	2	9	90			1.5	0.17		
B	Silica Sand w/ leafs	3	9	90			1.5	0.17		
B	Silica Sand w/ leafs	4	10	100			1.6	0.16		
B	Silica Sand w/ leafs	5	9	90			1	0.11		
B	Silica Sand w/ leafs	6	10	100			1.4	0.14		
B	Silica Sand w/ leafs	7	10	100			2.2	0.22		
B	Silica Sand w/ leafs	8	12	120	9.9		2	0.17	0.17	0.03
C	W. Bearskin	1	9	90			0.8	0.09		
C	W. Bearskin	2	10	100			1.2	0.12		
C	W. Bearskin	3	8	80			1	0.13		
C	W. Bearskin	4	9	90			0.9	0.10		
C	W. Bearskin	5	10	100			1.2	0.12		
C	W. Bearskin	6	9	90			0.9	0.10		
C	W. Bearskin	7	9	90			1	0.11		
C	W. Bearskin	8	9	90	6.4		1	0.11	0.11	0.01
D	Dilution sediment	1	9	90			1	0.11		
D	Dilution sediment	2	10	100			1.4	0.14		
D	Dilution sediment	3	10	100			1	0.10		
D	Dilution sediment	4	10	100			1.1	0.11		
D	Dilution sediment	5	10	100			1.2	0.12		
D	Dilution sediment	6	10	100			1	0.10		
D	Dilution sediment	7	10	100			1	0.10		
D	Dilution sediment	8	9	90	4.6		1.1	0.12	0.11	0.01
F	SQT9	1	9	90			1.7	0.19		
F	SQT9	2	10	100			1.5	0.15		
F	SQT9	3	9	90			1.6	0.18		
F	SQT9	4	10	100			1.4	0.14		
F	SQT9	5	10	100			1.6	0.16		
F	SQT9	6	10	100			1.1	0.11		
F	SQT9	7	7	70			1.5	0.21		
F	SQT9	8	8	80	11.3		1	0.13	0.16	0.03
G	SQT11	1	8	80			1	0.13		
G	SQT11	2	8	80			0.9	0.11		
G	SQT11	3	7	70			0.7	0.10		
G	SQT11	4	10	100			1.3	0.13		
G	SQT11	5	9	90			1	0.11		
G	SQT11	6	7	70			1	0.14		
G	SQT11	7	6	60			0.9	0.15		
G	SQT11	8	8	80	12.5		1	0.13	0.12	0.02
H	12.5%	1	8	80		99.8	0.8	0.10		
H	12.5%	2	9	90		99.9	0.8	0.09		
H	12.5%	3	3	30		99.3	0.6	0.20		
H	12.5%	4	9	90		99.9	0.9	0.10		
H	12.5%	5	10	100		100.0	1.3	0.13		
H	12.5%	6	8	80		99.8	0.9	0.11		
H	12.5%	7	8	80		99.8	0.8	0.10		
H	12.5%	8	8	80	21.0	99.8	0.8	0.10	0.12	0.04
I	12.5% w/ Leafs	1	10	100		100.0	1.6	0.16		
I	12.5% w/ Leafs	2	10	100		100.0	1.2	0.12		
I	12.5% w/ Leafs	3	9	90		99.9	1.6	0.18		
I	12.5% w/ Leafs	4	8	80		99.8	1.2	0.15		
I	12.5% w/ Leafs	5	10	100		100.0	1.4	0.14		
I	12.5% w/ Leafs	6	10	100		100.0	1.6	0.16		
I	12.5% w/ Leafs	7	10	100		100.0	2	0.20		
I	12.5% w/ Leafs	8	9	90	7.6	99.9	1.3	0.14	0.16	0.02

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected % Mortality	Total Dry wt (mg)	Individual Dry wt (mg)	Average Dry wt (mg)	Standard Deviation
J	25%	1	0	0		99.0				
J	25%	2	0	0		99.0				
J	25%	3	4	40		99.4	0.4	0.10		
J	25%	4	0	0		99.0				
J	25%	5	2	20		99.2	0.3	0.15		
J	25%	6	0	0		99.0				
J	25%	7	2	20		99.2	0.2	0.10		
J	25%	8	1	10	14.6	99.1	0.1	0.10	0.11	0.03
K	25% w/ Leafs	1	7	70		99.7	1.1	0.16		
K	25% w/ Leafs	2	4	40		99.4	0.3	0.08		
K	25% w/ Leafs	3	5	50		99.5	0.8	0.16		
K	25% w/ Leafs	4	7	70		99.7	0.7	0.10		
K	25% w/ Leafs	5	6	60		99.6	0.6	0.10		
K	25% w/ Leafs	6	4	40		99.4	0.4	0.10		
K	25% w/ Leafs	7	8	80		99.8	1.1	0.14		
K	25% w/ Leafs	8	3	30	17.7	99.3	0.3	0.10	0.12	0.03
L	50%	1	0	0		99.0				
L	50%	2	0	0		99.0				
L	50%	3	0	0		99.0				
L	50%	4	0	0		99.0				
L	50%	5	0	0		99.0				
L	50%	6	0	0		99.0				
L	50%	7	0	0		99.0				
L	50%	8	0	0	0.0	99.0				
M	50% w/ Leafs	1	0	0		99.0				
M	50% w/ Leafs	2	0	0		99.0				
M	50% w/ Leafs	3	0	0		99.0				
M	50% w/ Leafs	4	0	0		99.0				
M	50% w/ Leafs	5	0	0		99.0				
M	50% w/ Leafs	6	0	0		99.0				
M	50% w/ Leafs	7	0	0		99.0				
M	50% w/ Leafs	8	0	0	0.0	99.0				
N	100%	1	0	0		99.0				
N	100%	2	0	0		99.0				
N	100%	3	0	0		99.0				
N	100%	4	0	0		99.0				
N	100%	5	0	0		99.0				
N	100%	6	0	0		99.0				
N	100%	7	0	0		99.0				
N	100%	8	0	0	0.0	99.0				
O	100% w/ Leafs	1	0	0		99.0				
O	100% w/ Leafs	2	0	0		99.0				
O	100% w/ Leafs	3	0	0		99.0				
O	100% w/ Leafs	4	0	0		99.0				
O	100% w/ Leafs	5	0	0		99.0				
O	100% w/ Leafs	6	0	0		99.0				
O	100% w/ Leafs	7	0	0		99.0				
O	100% w/ Leafs	8	0	0	0.0	99.0				
P	SQT2	1	8	80		99.8	1.3	0.16		
P	SQT2	2	10	100		100.0	1.2	0.12		
P	SQT2	3	10	100		100.0	1.1	0.11		
P	SQT2	4	8	80		99.8	0.7	0.09		
P	SQT2	5	10	100		100.0	1	0.10		
P	SQT2	6	9	90		99.9	1.2	0.13		
P	SQT2	7	9	90		99.9	1.1	0.12		
P	SQT2	8	9	90	8.3	99.9	0.9	0.10	0.12	0.02
Q	SQT4	1	9	90		99.9	1	0.11		
Q	SQT4	2	8	80		99.8	0.9	0.11		
Q	SQT4	3	7	70		99.7	0.8	0.11		
Q	SQT4	4	5	50		99.5	0.6	0.12		
Q	SQT4	5	7	70		99.7	0.6	0.09		
Q	SQT4	6	6	60		99.6	0.6	0.10		
Q	SQT4	7	7	70		99.7	1	0.14		
Q	SQT4	8	8	80	12.5	99.8	1	0.13	0.11	0.02

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected % Mortality	Total Dry wt (mg)	Individual Dry wt (mg)	Average Dry wt (mg)	Standard Deviation
R	SQT5	1	3	30		99.3	0.3	0.10		
R	SQT5	2	6	60		99.6	0.7	0.12		
R	SQT5	3	5	50		99.5	0.4	0.08		
R	SQT5	4	5	50		99.5	0.8	0.16		
R	SQT5	5	0	0		99.0				
R	SQT5	6	6	60		99.6	0.8	0.13		
R	SQT5	7	4	40		99.4	0.5	0.13		
R	SQT5	8	3	30	20.0	99.3	0.4	0.13	0.12	0.03
S	SQT8	1	10	100		100.0	1.7	0.17		
S	SQT8	2	9	90		99.9	1.5	0.17		
S	SQT8	3	9	90		99.9	1.2	0.13		
S	SQT8	4	9	90		99.9	1.3	0.14		
S	SQT8	5	8	80		99.8	1.1	0.14		
S	SQT8	6	10	100		100.0	2	0.20		
S	SQT8	7	9	90		99.9	1.6	0.18		
S	SQT8	8	5	50	16.0	99.5	0.6	0.12	0.16	0.03

APPENDIX 13

Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV Light, 1 January 2006 to 13 January 2006

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006
Temeprature (° C)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	25% SQT1 w/	50% SQT1 w/	100% SQT1 w/	SQT1 w/	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:30	1	22.5	22.6	22.2	22.7	22.3	22.3	22.0	22.7	22.7	22.8	22.6	22.7	22.6	22.2	22.2	22.4	22.7	22.2
3-Jan-06	0	7:30	2	22.7	22.6	22.3	22.8	22.3	22.4	22.0	22.7	22.8	22.7	22.7	22.7	22.4	22.4	22.4	22.5	22.7	22.3
3-Jan-06	0	7:30	3	22.7	22.6	22.3	22.8	22.5	22.5	21.9	22.8	22.7	22.7	22.7	22.7	22.7	22.3	22.4	22.6	22.8	22.3
3-Jan-06	0	7:30	4	22.7	22.7	22.3	22.9	22.4	22.7	21.9	22.9	22.7	22.8	22.7	22.7	22.5	22.3	22.7	22.7	22.7	22.4
3-Jan-06	0	7:30	5	22.7	22.6	22.3	22.8	22.6	22.5	21.9	22.7	22.6	22.7	22.7	22.7	22.4	22.5	22.7	22.6	22.8	22.7
3-Jan-06	0	7:30	6	22.7	22.6	22.4	22.7	22.6	22.7	22.1	22.8	22.8	22.8	22.6	22.8	22.5	22.4	22.5	22.7	22.8	22.6
3-Jan-06	0	7:30	7	22.7	22.6	22.4	22.7	22.5	22.5	22.1	22.7	22.7	22.8	22.7	22.7	22.4	22.7	22.6	22.6	22.9	22.6
3-Jan-06	0	7:30	8	22.7	22.4	22.3	22.8	22.7	22.7	22.1	22.9	22.8	22.7	22.6	22.6	22.6	22.6	22.4	22.6	22.7	22.7
4-Jan-06	1	9:00	4	22.8	23.0	22.3	23.2	22.8	22.9	23.0	23.2	23.3	23.2	23.0	23.1	22.9	22.9	23.0	23.2	23.0	22.9
4-Jan-06	1	9:00	6	22.9	23.0	22.4	23.2	23.0	23.0	23.0	23.3	23.2	23.2	23.0	23.1	23.0	23.0	23.0	23.1	23.0	23.0
4-Jan-06	1	14:45	4	23.0	22.9	22.5	22.8	22.5	22.8	21.5	22.8	23.0	22.8	22.9	22.9	22.7	22.8	22.5	22.7	22.7	22.5
4-Jan-06	1	14:45	8	23.0	23.0	22.6	23.0	22.8	22.9	21.9	23.0	23.0	23.0	23.0	23.0	22.8	23.0	22.6	21.8	22.8	22.7
5-Jan-06	2	9:00	4	22.9	22.9	22.7	22.5	22.5	22.8	22.2	23.0	22.9	23.0	22.9	22.8	22.7	22.5	22.8	22.9	22.7	22.4
5-Jan-06	2	9:00	5	22.9	22.9	22.5	22.9	22.9	22.8	22.4	23.0	23.0	23.0	22.9	22.9	22.7	22.7	22.8	22.9	22.9	22.6
5-Jan-06	2	15:00	2	22.6	22.5	22.2	23.0	22.4	22.6	22.0	22.9	22.8	22.7	22.7	22.8	22.6	22.2	22.6	22.9	22.5	22.4
5-Jan-06	2	15:00	4	22.7	22.5	22.2	22.8	22.7	22.7	21.7	23.0	22.9	22.7	22.8	22.9	22.6	22.4	22.8	22.9	22.5	22.4
6-Jan-06	3	10:00	4	21.9	22.2	21.8	22.2	21.8	22.0	21.2	22.1	22.2	22.1	21.8	22.0	21.9	21.5	21.8	21.9	21.5	21.8
6-Jan-06	3	10:00	7	22.0	22.3	21.9	22.2	21.9	22.1	21.6	22.1	22.1	22.2	21.8	22.1	21.9	21.7	21.9	22.0	21.5	21.8
6-Jan-06	3	15:00	3	22.5	22.7	22.1	22.6	22.2	22.3	22.1	22.9	22.7	22.9	22.7	22.7	22.7	22.6	22.6	22.6	22.5	22.7
6-Jan-06	3	15:00	4	22.5	22.7	22.2	22.6	22.6	22.4	22.2	22.9	22.8	23.0	22.7	22.9	22.7	22.8	22.7	22.8	22.6	22.7
7-Jan-06	4	8:30	1	23.1	23.1	22.7	23.1	22.9	22.7	22.5	22.9	232.0	23.2	22.9	22.9	22.9	22.8	22.9	23.0	22.8	23.0
7-Jan-06	4	8:30	4	23.1	23.1	22.7	23.2	22.9	22.6	22.4	23.1	23.2	23.2	22.9	23.0	22.8	22.9	22.9	22.7	22.8	22.9
7-Jan-06	4	15:30	3	23.0	23.0	22.7	23.1	22.7	22.9	22.9	23.0	23.2	23.3	22.9	22.9	23.1	22.7	23.0	23.1	23.1	23.0
7-Jan-06	4	15:30	4	23.0	23.1	22.7	23.1	23.0	22.9	23.0	23.2	23.3	23.3	22.9	23.1	23.0	22.8	23.1	23.2	23.2	23.0
8-Jan-06	5	8:45	4	23.0	23.0	22.7	23.0	22.9	22.9	22.5	22.8	23.0	23.1	22.7	23.0	23.0	22.8	23.0	22.6	22.8	23.0
8-Jan-06	5	8:45	6	23.1	23.1	22.8	23.1	23.0	23.0	22.6	22.8	23.1	23.1	22.6	23.0	23.0	22.9	23.0	22.7	22.9	23.1
8-Jan-06	5	14:30	4	22.8	23.1	22.6	23.1	22.9	23.0	22.2	23.1	23.2	23.1	22.8	22.9	22.8	22.6	23.1	23.1	23.0	22.8
8-Jan-06	5	14:30	8	23.0	23.1	22.8	23.2	23.0	23.0	22.6	23.1	23.2	23.1	22.7	23.0	22.9	22.9	23.1	23.0	22.9	23.0
9-Jan-06	6	8:30	4	22.8	22.8	22.8	23.0	22.8	23.0	22.8	22.6	23.3	23.3	22.9	22.8	23.0	23.2	22.9	23.0	23.0	23.0
9-Jan-06	6	8:30	5	22.9	22.6	22.6	23.0	22.8	23.0	22.8	23.1	23.3	23.3	23.0	23.0	23.0	23.2	22.9	23.0	22.9	23.0
9-Jan-06	6	15:00	2	22.8	22.9	22.4	23.2	22.9	22.9	22.6	23.1	23.0	23.0	22.7	23.0	23.0	22.6	22.8	23.0	23.1	231.0
9-Jan-06	6	15:00	4	22.9	23.0	22.5	23.2	22.8	23.0	22.5	23.1	23.2	23.2	22.9	23.1	23.0	22.8	22.9	23.0	23.1	22.9
10-Jan-06	7	9:00	4	22.9	23.0	22.5	23.0	22.2	23.1	22.2	22.6	23.2	23.5	233.0	23.2	23.1	23.2	23.1	23.0	22.9	22.8
10-Jan-06	7	9:00	7	23.0	23.2	22.7	23.1	22.7	23.3	22.3	22.7	23.4	23.3	23.0	23.3	23.1	23.3	23.3	23.0	22.9	23.0
10-Jan-06	7	15:30	3	23.1	23.2	22.7	23.2	22.9	23.1	22.6	23.2	23.3	23.4	23.1	23.0	23.0	22.9	22.9	23.1	23.0	22.9
10-Jan-06	7	15:30	4	23.1	23.1	22.7	23.3	23.1	23.2	22.7	23.2	23.3	23.4	23.1	23.1	23.1	22.9	22.9	23.1	23.0	23.0
11-Jan-06	8	8:30	4	23.3	23.5	23.0	23.3	23.2	23.1	23.0	23.6	23.8	23.7	23.4	23.6	23.3	23.4	23.3	23.4	23.2	23.2
11-Jan-06	8	8:30	6	23.2	23.6	23.1	23.3	23.3	23.3	23.2	23.7	23.5	23.7	23.1	23.6	23.3	23.5	23.1	23.5	23.2	23.4
11-Jan-06	8	15:00	4	23.2	23.4	22.8	23.5	23.4	23.3	23.2	23.4	23.6	23.7	23.3	23.4	23.2	23.1	23.3	23.4	23.3	23.2
11-Jan-06	8	15:00	8	23.3	23.5	23.0	23.6	23.4	23.3	23.4	23.5	23.7	23.7	23.4	23.4	23.0	23.3	23.5	23.5	23.4	23.3
12-Jan-06	9	8:30	4	23.3	23.4	22.9	23.6	23.4	23.4	22.6	23.4	23.6	23.6	23.4	23.5	23.2	23.3	23.4	23.4	23.4	23.5
12-Jan-06	9	8:30	6	23.5	23.4	22.9	23.7	23.4	23.4	22.9	23.4	23.6	23.6	23.4	23.5	23.2	23.3	23.5	23.5	23.4	23.6
12-Jan-06	9	14:00	4	23.8	23.6	23.3	23.6	23.2	23.6	23.3	23.9	23.9	23.8	24.0	23.2	23.4	23.6	23.6	23.7	23.5	23.5
12-Jan-06	9	14:00	8	23.8	23.8	23.1	23.9	23.6	23.6	23.5	23.6	23.8	23.8	23.9	23.6	23.5	23.9	23.6	23.6	23.5	23.7
13-Jan-06	10	7:50	1	23.1	23.2	22.7	23.4	23.1	23.1	22.8	23.4	23.4	23.5	23.1	23.3	23.2	23.2	23.0	23.4	23.2	23.1
13-Jan-06	10	7:50	2	23.1	23.2	22.8	23.4	23.2	23.1	22.9	23.4	23.4	23.5	23.1	23.3	23.2	23.2	23.1	23.4	23.2	23.2
13-Jan-06	10	7:50	3	23.2	23.3	22.7	23.4	23.1	23.2	22.5	23.5	23.5	23.6	23.1	23.2	23.3	23.3	23.2	23.3	23.3	23.2
13-Jan-06	10	7:50	4	23.2	23.3	22.8	23.4	23.2	23.1	22.4	23.4	23.6	23.5	23.2	23.3	23.2	23.2	23.3	23.4	23.2	23.2
13-Jan-06	10	7:50	5	23.3	23.3	22.8	23.3	23.3	23.2	22.7	23.4	23.4	23.6	23.2	23.3	23.2	23.2	23.2	23.4	23.2	23.2
13-Jan-06	10	7:50	6	23.3	23.3	22.8	23.4	23.2	23.2	22.8	23.4	23.5	23.5	23.2	23.3	23.2	23.2	23.2	23.3	23.2	23.3
13-Jan-06	10	7:50	7	23.3	23.1	22.8	23.3	23.2	23.1	22.9	23.4	23.7	23.6	23.2	23.3	23.2	23.2	23.5	23.3	23.3	23.2
13-Jan-06	10	7:50	8	23.3	23.2	22.8	23.4	23.2	23.3	23.0	23.4	23.5	23.5	23.3	23.3	23.2	23.2	23.2	23.3	23.1	23.2
			Average	**23.0**	**23.0**	**22.6**	**23.1**	**22.8**	**22.9**	**22.5**	**23.1**	**27.2**	**23.2**	**27.0**	**23.0**	**22.9**	**22.9**	**22.9**	**23.0**	**22.9**	**26.9**
			Minimum	21.9	22.2	21.8	22.2	21.8	22.0	21.2	22.1	22.1	22.1	21.8	22.0	21.9	21.5	21.8	21.8	21.5	21.8
			Maximum	23.8	23.8	23.3	23.9	23.6	23.6	23.5	23.9	232.0	23.8	233.0	23.6	23.5	23.9	23.6	23.7	23.5	231.0

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:30	1	7.3	7.3	7.2	5.9	3.2	4.2	7.2	6.0	5.4	5.7	5.8	7.1	4.5	5.3	4.5	6.7	6.2	5.4
3-Jan-06	0	7:30	2	6.6	7.5	7.4	5.7	3.2	4.7	6.7	6.4	5.9	6.1	5.1	7.4	5.2	4.8	5.3	7.1	4.3	5.9
3-Jan-06	0	7:30	3	7.1	7.5	6.9	5.9	4.4	4.5	6.1	6.6	4.6	6.7	5.5	6.8	5.6	4.3	6.0	6.7	6.4	5.4
3-Jan-06	0	7:30	4	7.3	7.5	6.8	6.0	4.0	5.2	6.0	5.5	6.1	5.8	4.9	7.0	5.0	4.6	7.1	7.0	4.5	5.0
3-Jan-06	0	7:30	5	7.3	7.0	6.4	5.5	6.2	3.9	6.6	6.2	6.5	6.8	6.0	6.3	5.2	5.6	6.5	5.2	5.4	2.9
3-Jan-06	0	7:30	6	7.4	7.1	6.4	6.7	4.3	4.3	6.4	6.8	5.4	6.4	4.6	6.1	5.1	5.0	4.0	5.4	5.1	6.0
3-Jan-06	0	7:30	7	7.4	6.7	6.7	5.8	3.4	6.7	6.4	6.4	5.1	5.8	4.7	4.7	5.9	6.7	6.3	6.0	6.3	4.4
3-Jan-06	0	7:30	8	6.6	6.9	6.6	6.1	6.7	7.3	6.5	6.9	5.8	6.4	6.4	5.1	6.6	5.0	5.3	5.2	6.8	6.1
4-Jan-06	1	9:00	4	7.7	6.7	6.2	6.1	6.3	6.2	6.3	6.4	6.9	6.6	7.1	6.4	7.0	6.7	7.4	8.4	8.0	5.8
4-Jan-06	1	9:00	8	7.3	6.5	6.4	6.3	6.5	3.8	6.5	6.3	6.7	6.4	6.6	6.3	5.8	7.1	7.5	7.3	4.1	6.3
4-Jan-06	1	14:45	4	6.9	7.1	7.3	6.4	7.9	6.8	6.8	8.5	7.3	6.9	7.6	5.7	7.8	6.0	9.1	8.8	7.4	5.4
4-Jan-06	1	14:45	8	7.0	7.0	7.4	7.5	8.3	6.8	6.9	6.6	7.8	6.5	7.6	6.5	7.8	5.2	8.5	8.4	7.9	7.0
5-Jan-06	2	9:00	4	8.2	7.2	6.7	7.0	8.4	5.2	7.7	7.9	7.7	8.0	8.9	7.0	7.0	8.1	8.9	8.3	7.1	8.8
5-Jan-06	2	9:00	5	7.4	7.3	6.9	7.7	8.1	7.1	7.8	7.8	7.8	7.6	8.4	6.2	5.2	8.1	7.7	7.0	7.7	6.7
5-Jan-06	2	15:00	2	9.3	8.8	7.2	7.0	8.6	6.5	7.6	6.5	7.5	8.1	8.2	7.3	6.7	6.4	8.9	7.6	5.8	9.1
5-Jan-06	2	15:00	4	9.3	8.7	7.5	6.9	8.3	7.0	7.9	8.9	7.7	8.1	7.6	7.2	6.8	6.7	7.4	7.5	5.8	8.8
6-Jan-06	3	10:00	4	8.3	8.0	7.3	8.1	9.1	7.6	7.8	7.9	7.9	8.2	8.2	7.3	8.0	8.0	9.0	8.6	7.0	6.5
6-Jan-06	3	10:00	7	7.0	6.9	7.6	8.4	7.7	7.7	8.1	7.5	7.8	8.1	7.6	6.9	7.3	7.6	8.6	7.9	7.9	6.3
6-Jan-06	3	15:00	3	7.8	7.1	7.0	6.8	8.7	7.6	7.3	6.6	6.4	6.7	7.9	6.5	6.8	5.4	7.0	6.8	8.2	6.7
6-Jan-06	3	15:00	4	8.4	7.0	6.9	6.7	8.6	7.5	7.3	6.1	7.1	6.9	7.9	6.9	7.2	6.2	7.3	7.0	7.9	6.8
7-Jan-06	4	8:30	1	7.0	7.0	7.2	7.1	6.4	6.1	8.0	7.0	6.6	6.5	7.4	5.9	7.5	6.5	9.1	8.4	7.4	8.9
7-Jan-06	4	8:30	4	7.1	7.1	7.0	6.7	7.8	6.4	8.1	5.5	6.9	6.9	7.0	6.5	7.4	7.4	8.8	6.0	7.1	9.2
7-Jan-06	4	15:30	3	7.5	7.0	6.9	7.1	7.8	5.9	6.8	6.5	7.4	7.3	6.6	6.7	7.5	7.4	6.5	7.7	7.5	7.4
7-Jan-06	4	15:30	4	7.7	6.9	6.9	6.4	7.9	5.9	6.6	5.8	7.2	7.0	6.7	7.1	7.4	6.3	7.1	7.8	6.8	7.3
8-Jan-06	5	8:45	4	6.8	7.0	6.3	7.9	6.9	7.9	6.6	4.6	7.1	6.8	6.8	6.0	6.6	6.7	6.2	6.6	7.7	6.0
8-Jan-06	5	8:45	6	6.9	6.9	7.0	7.8	8.0	6.4	7.7	6.8	7.1	5.6	7.4	5.9	4.7	6.9	6.4	7.6	5.9	6.4
8-Jan-06	5	14:30	4	7.3	6.9	6.6	6.4	7.4	6.9	7.7	5.4	7.2	6.6	6.5	6.5	6.5	6.7	7.2	7.4	6.7	7.0
8-Jan-06	5	14:30	8	6.7	6.5	7.4	6.9	8.7	6.7	6.6	6.6	7.1	6.2	6.5	6.6	6.9	7.4	6.5	7.0	7.1	6.7
9-Jan-06	6	8:30	4	7.9	7.6	7.3	6.2	8.7	7.6	7.3	7.2	7.0	7.0	6.7	8.3	8.1	6.9	7.2	7.8	6.6	8.0
9-Jan-06	6	8:30	5	7.8	6.3	8.3	7.0	8.5	8.2	7.1	6.9	6.0	6.5	5.9	7.2	6.1	7.9	6.7	8.0	7.2	8.5
9-Jan-06	6	15:00	2	6.8	7.2	7.9	6.6	8.6	6.3	6.8	5.0	7.5	6.3	6.8	6.1	7.2	6.6	7.4	7.1	6.6	8.0
9-Jan-06	6	15:00	4	7.3	7.3	6.9	6.1	8.3	6.2	6.7	5.7	6.9	6.6	6.6	6.4	7.3	7.2	7.9	6.8	6.0	7.4
10-Jan-06	7	9:00	4	8.7	7.8	6.4	7.9	8.3	8.7	7.0	6.8	6.7	7.8	7.1	8.6	7.9	7.7	8.2	8.7	6.7	8.1
10-Jan-06	7	9:00	7	8.3	6.4	7.8	8.0	8.9	8.3	6.7	7.0	7.8	7.5	7.9	6.9	7.3	7.6	7.7	7.1	7.1	8.2
10-Jan-06	7	15:30	3	6.7	7.0	6.9	6.4	6.4	6.5	7.2	5.5	5.8	5.2	6.2	6.3	7.3	5.7	6.1	6.3	5.2	6.2
10-Jan-06	7	15:30	4	6.8	6.7	7.0	6.1	6.5	6.4	5.7	5.3	5.7	5.9	5.9	6.3	6.9	6.3	6.9	5.9	5.2	6.2
11-Jan-06	8	8:30	4	8.0	6.8	6.5	6.1	7.8	8.0	5.7	5.5	5.0	6.3	6.3	5.5	7.6	6.2	7.7	7.9	8.2	7.5
11-Jan-06	8	8:30	8	7.9	5.7	5.4	7.0	7.1	7.8	6.0	4.4	6.7	4.7	6.4	6.1	7.0	6.4	7.8	7.1	4.8	7.0
11-Jan-06	8	15:00	4	7.3	6.7	6.2	6.4	6.9	7.3	6.6	5.8	7.1	6.5	6.4	5.7	7.2	7.5	7.8	7.9	7.1	8.4
11-Jan-06	8	15:00	8	6.9	7.0	7.3	6.6	7.0	7.4	6.5	6.3	7.1	6.6	6.4	6.0	7.3	7.4	7.9	7.9	7.3	7.9
12-Jan-06	9	8:30	4	6.6	6.6	5.8	5.9	6.5	6.3	6.3	5.4	6.0	5.9	5.7	4.5	6.5	5.5	6.2	6.2	5.4	6.3
12-Jan-06	9	8:30	8	6.6	6.6	5.8	6.7	5.9	6.0	6.0	4.9	5.9	4.7	6.0	5.5	6.1	6.0	6.0	6.0	3.7	6.1
12-Jan-06	9	14:00	4	6.2	6.5	6.1	6.0	6.1	7.2	7.2	7.4	6.2	6.6	6.1	7.1	7.1	6.7	7.4	7.4	6.6	6.8
12-Jan-06	9	14:00	8	6.6	6.6	6.4	7.2	7.6	7.7	7.7	6.5	6.3	5.6	5.6	6.6	6.6	6.8	7.5	7.5	5.5	6.1
13-Jan-06	10	7:50	1	6.6	6.6	6.5	6.5	6.2	6.0	6.0	6.6	6.9	5.4	6.1	6.2	6.4	4.6	7.0	7.0	6.5	6.2
13-Jan-06	10	7:50	2	6.3	6.5	6.0	6.3	7.0	5.9	5.9	6.2	6.9	5.4	6.2	6.7	6.4	5.2	6.5	6.5	6.2	6.5
13-Jan-06	10	7:50	3	6.4	6.6	6.5	6.1	7.0	6.2	6.2	6.0	6.4	6.5	6.0	6.5	7.0	5.5	6.8	6.8	6.1	6.4
13-Jan-06	10	7:50	4	6.8	6.6	6.0	6.0	6.1	6.4	6.4	6.2	6.9	6.0	6.0	6.6	6.7	6.4	7.0	7.0	6.3	6.2
13-Jan-06	10	7:50	5	6.6	5.7	6.6	6.3	6.5	6.1	6.1	5.6	7.2	4.4	5.5	4.9	5.5	5.6	6.6	6.6	4.5	6.0
13-Jan-06	10	7:50	6	7.0	6.4	6.1	6.3	6.6	6.8	6.8	5.6	6.4	4.9	6.4	6.6	6.0	5.9	6.8	6.8	4.3	6.3
13-Jan-06	10	7:50	7	6.8	6.6	6.3	6.3	7.2	6.0	6.0	4.7	6.5	5.5	6.2	5.8	6.1	6.0	6.4	6.4	5.9	5.8
13-Jan-06	10	7:50	8	6.8	7.1	5.9	6.3	6.5	6.5	6.5	6.4	5.7	5.8	5.8	6.2	5.8	6.4	6.4	6.4	4.9	6.2
			Average	**7.3**	**7.0**	**6.8**	**6.7**	**6.9**	**6.5**	**6.8**	**6.3**	**6.7**	**6.4**	**6.6**	**6.4**	**6.6**	**6.4**	**7.1**	**7.1**	**6.3**	**6.7**
			Minimum	6.2	5.7	5.4	5.5	3.2	3.8	5.7	4.4	4.6	4.4	4.6	4.5	4.5	4.3	4.0	5.2	3.7	2.9
			Maximum	9.3	8.8	8.3	8.4	9.1	8.7	8.1	8.6	7.9	8.2	8.9	8.6	8.1	8.1	9.1	8.8	8.2	9.2

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006.

pH

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:00	1	8.11	7.99	7.95	7.42	7.22	6.85	7.56	7.78	7.54	7.37	7.68	7.43	7.85	6.97	7.63	6.80	7.79	7.27
3-Jan-06	0	7:00	4	8.14	8.07	7.92	7.43	7.17	7.09	7.49	7.89	7.61	7.43	7.93	7.45	7.44	7.38	7.79	6.84	7.88	7.13
3-Jan-06	0	7:00	5	8.16	8.13	7.82	7.54	7.89	6.72	7.71	7.69	7.75	7.77	7.41	7.52	7.27	7.88	7.78	7.08	7.70	7.02
3-Jan-06	0	7:00	8	8.15	8.14	7.90	7.66	7.77	7.84	7.90	7.89	7.51	7.66	7.80	7.50	7.76	7.89	7.58	7.47	7.81	7.70
13-Jan-06	10	7:05	1	8.12	8.15	7.79	7.98	8.04	7.55	7.68	8.00	7.62	7.50	7.58	7.56	7.98	7.54	7.72	8.00	7.71	7.93
13-Jan-06	10	7:05	4	8.10	8.17	7.53	7.75	7.71	7.56	7.63	7.82	7.70	7.63	7.57	7.64	7.90	7.71	8.01	8.01	7.82	7.72
13-Jan-06	10	7:05	5	8.17	7.82	7.74	7.92	8.07	7.55	7.45	7.50	7.79	7.38	7.53	7.48	7.54	7.65	7.84	7.71	7.45	7.93
13-Jan-06	10	7:05	8	8.17	8.19	7.78	8.02	7.98	7.90	7.70	7.93	7.58	7.91	7.56	7.71	7.77	7.74	7.77	7.83	7.46	7.75
			Average	**8.14**	**8.08**	**7.80**	**7.72**	**7.73**	**7.38**	**7.64**	**7.81**	**7.64**	**7.58**	**7.61**	**7.54**	**7.69**	**7.60**	**7.77**	**7.47**	**7.70**	**7.56**
			Minimum	8.10	7.82	7.53	7.42	7.17	6.72	7.45	7.50	7.51	7.37	7.41	7.43	7.27	6.97	7.58	6.80	7.45	7.02
			Maximum	8.17	8.19	7.95	8.02	8.07	7.90	7.90	8.00	7.79	7.91	7.93	7.71	7.98	7.89	8.01	8.01	7.88	7.93

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:00	1	149	147	144	159	163	136	155	148	143	151	150	150	146	151	148	151	148	153
3-Jan-06	0	7:00	8	146	146	142	151	160	137	151	147	151	145	146	148	145	149	147	155	148	150
13-Jan-06	10	7:05	1	136	133	132	135	136	130	137	137	139	142	140	141	133	136	138	134	133	133
13-Jan-06	10	7:05	8	135	132	130	135	135	130	137	137	141	140	135	138	132	133	138	135	137	132
			Average	**142**	**139**	**137**	**145**	**146**	**133**	**145**	**142**	**144**	**144**	**143**	**144**	**139**	**142**	**143**	**144**	**141**	**142**
			Minimum	135	132	130	135	135	130	137	137	139	140	135	138	132	133	138	134	133	132
			Maximum	*149*	*147*	*144*	*159*	*163*	*137*	*155*	*148*	*151*	*151*	*150*	*150*	*146*	*151*	*148*	*155*	*148*	*153*

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006.
Ammonia (ppm)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT6
3-Jan-06	0	7:00	1	<0.063	<0.063	0.143	0.327	0.816	<0.063	0.178	0.155	0.225	0.261	0.185	0.162	0.095	0.317	<0.063	<0.063	<0.063	<0.063
3-Jan-06	0	7:00	8	<0.063	<0.063	0.148	0.151	0.290	<0.063	0.127	0.116	0.217	0.136	0.133	0.224	0.065	0.205	<0.063	<0.063	<0.063	<0.063
13-Jan-06	10	7:05	1	0.248	0.106	0.107	0.277	0.292	0.148	0.252	0.267	0.312	0.442	0.439	0.361	0.161	0.353	0.100	0.127	0.139	0.130
13-Jan-06	*10*	*7:05*	*8*	*0.250*	*0.102*	*0.104*	*0.263*	*0.258*	*0.148*	*0.272*	*0.251*	*0.399*	*0.422*	*0.252*	*0.305*	*0.177*	*0.207*	*0.117*	*0.140*	*0.173*	*0.130*
			Average	**0.140**	**0.058**	**0.126**	**0.255**	**0.414**	**0.090**	**0.207**	**0.197**	**0.288**	**0.315**	**0.252**	**0.263**	**0.125**	**0.271**	**0.070**	**0.083**	**0.094**	**0.081**
			Minimum	<0.063	<0.063	0.104	0.151	0.258	<0.063	0.127	0.116	0.217	0.136	0.133	0.162	0.065	0.205	<0.063	<0.063	<0.063	<0.063
			Maximum	0.250	0.106	0.148	0.327	0.816	0.148	0.272	0.267	0.399	0.442	0.439	0.361	0.177	0.353	0.117	0.140	0.173	0.130

Appendix Table 13 Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006.
DOC (ppm)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
13-Jan-06	10	7:05	1	1.7	1.3		1.3	2.1		1.5	1.8	2.4	1.1	4.3	1.7	2.0	2.6	1.9	1.5	2.2	2.3
13-Jan-06	10	7:05	8	2.0		1.2	1.7	1.7	2.1	1.3	1.6	1.8	1.0	1.8	1.8	1.7	1.6	1.9	1.8	4.3	1.8
			Average	**1.9**	**1.3**	**1.2**	**1.5**	**1.9**	**2.1**	**1.4**	**1.7**	**2.1**	**1.1**	**3.1**	**1.8**	**1.9**	**2.1**	**1.9**	**1.7**	**3.3**	**2.1**
			Minimum	1.7	1.3	1.2	1.3	1.7	2.1	1.3	1.6	1.8	1.0	1.8	1.7	1.7	1.6	1.9	1.5	2.2	1.8
			Maximum	2.0	1.3	1.2	1.7	2.1	2.1	1.5	1.8	2.4	1.1	4.3	1.8	2.0	2.6	1.9	1.8	4.3	2.3

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light, 3 January 2006 to 13 January 2006
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:00	3	47.6	47.2	43.2	55.6	64.0		47.2	51.2	55.6	68.0	55.6	56.8	52.0	52.8	63.6	56.0	54.0	62.0
3-Jan-06	0	7:00	7	48.0	46.0	44.4	55.2	74.0	73.6	53.2	64.0	55.6	75.2	68.0	67.2	52.8	49.2	55.2	64.8	56.4	62.0
13-Jan-06	10	7:05	3	50.8	49.6	48.8	48.8	49.6	52.0	53.6	56.0	51.6	49.6	49.2	43.2	49.2	52.4	50.4	56.0	50.4	48.4
13-Jan-06	10	7:05	7	50.0	49.6	46.0	52.8	48.4	48.4	49.6	52.4	52.4	53.6	50.8	52.4	50.4	52.8	52.4	56.4	51.2	47.6
			Average	**49.1**	**48.1**	**45.6**	**53.1**	**59.0**	**58.0**	**50.9**	**55.9**	**56.3**	**61.6**	**55.9**	**54.9**	**51.1**	**51.8**	**55.4**	**58.3**	**53.0**	**55.0**
			Minimum	47.6	46.0	43.2	48.8	48.4	48.4	47.2	51.2	51.6	49.6	49.2	43.2	49.2	49.2	50.4	56.0	50.4	47.6
			Maximum	50.8	49.6	48.8	55.6	74.0	73.6	53.6	64.0	55.6	75.2	68.0	67.2	52.8	52.8	63.6	64.8	56.4	62.0

Appendix Table 13. Water Chemistry Parameters for *H. azteca* Exposed to Ashland Harbor Sediments and a Dilution Series Under UV light. 3 January 2006 to 13 January 2006
Alakinty (mg/L as CaCo3)

Date	Day	Time	Rep	Silica Sand	Silica Sand w/ leafs	W. Bearskin	Dilution Sediment	SQT9	SQT11	12.5% SQT1	12.5% SQT1 w/ leafs	25% SQT1	25% SQT1 w/ leafs	50% SQT1	50% SQT1 w/ leafs	100% SQT 1	100% SQT1 w/ leafs	SQT2	SQT4	SQT5	SQT8
3-Jan-06	0	7:00	2	50.4	51.6	48.8	48.4	72		51.2	52.8	54	52.4	50	52.4	59.6	57.6	60.8	55.6	60.8	60.4
3-Jan-06	0	7:00	6	50.4	48.8	47.6	5.08	63.2	50.4	51.6	54.4	50.8	50.4	54.4	52	57.6	55.2	62.8	63.6	62.8	60.4
13-Jan-06	10	7:05	2	56	54.8	52.4	54	55.2	54.4	53.6	56.8	56.4	57.2	59.6	58	56	58.8	58.4	56.8	60	56.6
13-Jan-06	10	7:05	6	57.2	56	53.2	53.6	57.6	55.6	56.8	57.2	59.6	58.8	56.4	58.4	58	54.8	57.2	60	56.4	57.6
			Average	**53.5**	**52.8**	**50.5**	**40.3**	**62.0**	**53.5**	**53.3**	**55.3**	**55.2**	**54.7**	**55.1**	**55.2**	**57.6**	**56.6**	**59.8**	**59.0**	**60.0**	**58.8**
			Minimum	50.4	48.8	47.6	5.1	55.2	50.4	51.2	52.8	50.8	50.4	50.0	52.0	56.0	54.8	57.2	55.6	56.4	56.8
			Maximum	57.2	56.0	53.2	54.0	72.0	55.6	56.8	57.2	59.6	58.8	59.6	58.4	59.6	58.8	62.8	63.6	62.8	60.4

APPENDIX 14

Survival and Growth of *Pimephales promelas* Following 7-d of Exposure to Ashland Harbor Sediments, July 8-18, 2005

Appendix Table 14. Survival and Growth of *Pimephales promelas* Following 7-d of Exposure to Ashland Harbor Sediments, July 8-15, 2005.

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected Mortallity (%)	Number Weighed	Total Dry Wt. (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
A	Silica Sand	1	10	100.0			10	5.7	0.57		
A	Silica Sand	2	10	100.0			10	6.1	0.61		
A	Silica Sand	3	8	80.0			8	5.2	0.65		
A	Silica Sand	4	10	100.0			10	7.8	0.78		
A	Silica Sand	5	10	100.0			9	8.4	0.93		
A	Silica Sand	6	9	90.0			9	5.5	0.61		
A	Silica Sand	7	10	100.0			10	7.2	0.72		
A	Silica Sand	8	9	90.0	7.6		9	7.6	0.84	0.71	0.13
B	Form. Sediment	1	9	90.0			9	5.6	0.62		
B	Form. Sediment	2	8	80.0			8	5.2	0.65		
B	Form. Sediment	3	9	90.0			9	5.9	0.66		
B	Form. Sediment	4	10	100.0			10	5.3	0.53		
B	Form. Sediment	5	9	90.0			9	4.7	0.52		
B	Form. Sediment	6	9	90.0			9	5.5	0.61		
B	Form. Sediment	7	10	100.0			10	4.7	0.47		
B	Form. Sediment	8	9	90.0	6.4		9	5.5	0.61	0.58	0.07
C	W. Bearskin	1	8	80.0			8	3.6	0.45		
C	W. Bearskin	2	9	90.0			8	3.8	0.48		
C	W. Bearskin	3	8	80.0			8	4.9	0.61		
C	W. Bearskin	4	7	70.0			7	10	1.43		
C	W. Bearskin	5	10	100.0			10	6.1	0.61		
C	W. Bearskin	6	9	90.0			9	5.2	0.58		
C	W. Bearskin	7	10	100.0			10	6.3	0.63		
C	W. Bearskin	8	5	50.0	16.7		5	3	0.60	0.67	0.31
D	SQT9	1	6	60.0			6	5.3	0.88		
D	SQT9	2	7	70.0			7	6.2	0.89		
D	SQT9	3	9	90.0			9	4.1	0.46		
D	SQT9	4	10	100.0			10	6.1	0.61		
D	SQT9	5	1	10.0			1	0.4	0.40		
D	SQT9	6	7	70.0			7	5.1	0.73		
D	SQT9	7	8	80.0			10	5.5	0.55		
D	SQT9	8	8	80.0	27.3		8	6.6	0.83	0.67	0.19
E	SQT10	1	9	90.0			9	7	0.78		
E	SQT10	2	10	100.0			10	6.2	0.62		
E	SQT10	3	9	90.0			9	9.6	1.07		
E	SQT10	4	10	100.0			10	7.4	0.74		
E	SQT10	5	10	100.0			10	5.7	0.57		
E	SQT10	6	10	100.0			10	8.9	0.89		
E	SQT10	7	10	100.0			10	6.6	0.66		
E	SQT10	8	9	90.0	5.2		9	6.4	0.71	0.75	0.16
F	SQT11	1	9	90.0			9	6.3	0.70		
F	SQT11	2	8	80.0			8	5.4	0.68		
F	SQT11	3	10	100.0			10	6.6	0.66		
F	SQT11	4	10	100.0			10	5.9	0.59		
F	SQT11	5	9	90.0			9	5.2	0.58		
F	SQT11	6	9	90.0			9	5.4	0.60		
F	SQT11	7	9	90.0			9	4.7	0.52		
F	SQT11	8	8	80.0	7.6		9	5.2	0.58	0.61	0.06

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected Mortality (%)	Number Weighed	Total Dry Wt. (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
G	SQT12	1	10	100.0			10	6.9	0.69		
G	SQT12	2	9	90.0			9	4.9	0.54		
G	SQT12	3	10	100.0			9	5.9	0.66		
G	SQT12	4	9	90.0			9	5.6	0.62		
G	SQT12	5	9	90.0			9	6	0.67		
G	SQT12	6	9	90.0			9	5.7	0.63		
G	SQT12	7	10	100.0			10	5.4	0.54		
G	SQT12	8	9	90.0	5.2		9	6	0.67	0.63	0.06
H	SQT6	1	10	100.0		100.1	10	3.4	0.34		
H	SQT6	2	9	90.0		99.9	9	4.8	0.53		
H	SQT6	3	10	100.0		100.1	10	6.8	0.68		
H	SQT6	4	9	90.0		99.9	9	6.7	0.74		
H	SQT6	5	8	80.0		99.8	8	5	0.63		
H	SQT6	6	9	90.0		99.9	9	5.4	0.60		
H	SQT6	7	10	100.0		100.1	10	4.3	0.43		
H	SQT6	8	10	100.0	7.4	100.1	10	5.9	0.59	0.57	0.13
I	SQT2	1	9	90.0		99.9	9	6.5	0.72		
I	SQT2	2	8	80.0		99.8	8	5.5	0.69		
I	SQT2	3	7	70.0		99.7	7	5.2	0.74		
I	SQT2	4	9	90.0		99.9	9	5.1	0.57		
I	SQT2	5	10	100.0		100.1	10	8.2	0.82		
I	SQT2	6	9	90.0		99.9	9	6.3	0.70		
I	SQT2	7	10	100.0		100.1	10	5.3	0.53		
I	SQT2	8	10	100.0	10.7	100.1	10	6.3	0.63	0.67	0.10
J	SQT7	1	10	100.0		100.1	10	5.3	0.53		
J	SQT7	2	9	90.0		99.9	9	4.5	0.50		
J	SQT7	3	8	80.0		99.8	8	3.5	0.44		
J	SQT7	4	9	90.0		99.9	9	5.1	0.57		
J	SQT7	5	10	100.0		100.1	10	5.5	0.55		
J	SQT7	6	9	90.0		99.9	9	6.8	0.76		
J	SQT7	7	8	80.0		99.8	8	4.2	0.53		
J	SQT7	8	9	90.0	7.6	99.9	9	3.9	0.43	0.54	0.10
K	SQT4	1	8	80.0		99.8	8	4.7	0.59		
K	SQT4	2	9	90.0		99.9	9	4.5	0.50		
K	SQT4	3	9	90.0		99.9	9	4.4	0.49		
K	SQT4	4	10	100.0		100.1	10	5.9	0.59		
K	SQT4	5	8	80.0		99.8	8	4.5	0.56		
K	SQT4	6	10	100.0		100.1	10	4.4	0.44		
K	SQT4	7	10	100.0		100.1	10	5.9	0.59		
K	SQT4	8	9	90.0	8.3	99.9	9	5.2	0.58	0.54	0.06
L	SQT3	1	6	60.0		99.6	6	3.3	0.55		
L	SQT3	2	8	80.0		99.8	8	7	0.88		
L	SQT3	3	7	70.0		99.7	7	3	0.43		
L	SQT3	4	9	90.0		99.9	9	5.8	0.64		
L	SQT3	5	10	100.0		100.1	10	5.6	0.56		
L	SQT3	6	10	100.0		100.1	10	6.3	0.63		
L	SQT3	7	9	90.0		99.9	9	4.8	0.53		
L	SQT3	8	7	70.0	14.9	99.7	7	6	0.86	0.63	0.16
M	SQT5	1	9	90.0		99.9	8	5.4	0.68		
M	SQT5	2	10	100.0		100.1	10	7	0.70		
M	SQT5	3	10	100.0		100.1	10	7.1	0.71		
M	SQT5	4	8	80.0		99.8	8	5.4	0.68		
M	SQT5	5	8	80.0		99.8	8	7	0.88		
M	SQT5	6	10	100.0		100.1	9	5.2	0.58		
M	SQT5	7	10	100.0		100.1	10	6.5	0.65		
M	SQT5	8	10	100.0	9.2	100.1	10	8.1	0.81	0.71	0.09

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Standard Deviation	Corrected Mortallity (%)	Number Weighed	Total Dry Wt. (mg)	Individual Dry Wt. (mg)	Average Dry Wt (mg)	Standard Deviation
N	SQT1	1	7	70.0		99.7	7	3.4	0.49		
N	SQT1	2	9	90.0		99.9	9	5.1	0.57		
N	SQT1	3	8	80.0		99.8	8	3.8	0.48		
N	SQT1	4	7	70.0		99.7	7	3.2	0.46		
N	SQT1	5	5	50.0		99.5	5	2.4	0.48		
N	SQT1	6	8	80.0		99.8	8	3.1	0.39		
N	SQT1	7	8	80.0		99.8	8	4.2	0.53		
N	SQT1	8	9	90.0	13.0	99.9	9	3.6	0.40	0.47	0.06
O	SQT8	1	9	90.0		99.9	9	7.3	0.81		
O	SQT8	2	10	100.0		100.1	10	6.2	0.62		
O	SQT8	3	8	80.0		99.8	7	4.4	0.63		
O	SQT8	4	9	90.0		99.9	9	6.5	0.72		
O	SQT8	5	10	100.0		100.1	10	6.7	0.67		
O	SQT8	6	9	90.0		99.9	9	6.6	0.73		
O	SQT8	7	10	100.0		100.1	10	6.4	0.64		
O	SQT8	8	10	100.0	7.4	100.1	10	6	0.60	0.68	0.07

APPENDIX 15

Water Chemistry Parameters for 7-d *Pimephales promelas*
Exposed to Ashland Harbor Sediments,
July 8-18, 2005

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Temperature (° C)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	22.3	23.0	22.8	22.8	22.8	22.2	22.6	22.3	22.7	22.5	22.4	22.3	22.7	23.0	22.2
8-Jul-05	0	7:30	2	22.3	22.9	22.8	22.7	22.9	22.2	22.7	22.3	22.6	22.6	22.4	22.4	22.8	22.9	22.3
8-Jul-05	0	7:30	3	22.4	22.9	22.9	22.8	22.9	22.2	22.3	22.2	22.7	22.6	22.5	22.4	22.7	22.9	22.4
8-Jul-05	0	7:30	4	22.3	22.8	22.9	22.8	22.9	22.2	22.7	22.2	22.9	22.6	22.6	22.4	22.8	22.9	22.4
8-Jul-05	0	7:30	5	22.5	22.8	22.9	22.9	23.0	22.2	22.7	22.3	22.8	22.5	22.8	22.4	22.8	22.8	22.6
8-Jul-05	0	7:30	6	22.5	22.8	22.9	22.8	22.9	22.2	22.7	22.3	22.8	22.6	22.8	22.4	22.9	22.9	22.5
8-Jul-05	0	7:30	7	22.4	22.7	22.8	22.9	22.9	22.3	22.6	22.3	22.7	22.5	22.7	22.5	23.0	22.8	22.5
8-Jul-05	0	7:30	8	22.5	22.8	22.8	22.8	22.9	22.1	22.7	22.4	22.7	22.4	22.7	22.5	23.0	22.9	22.5
8-Jul-05	0	16:30	1	22.1	23.0	22.8	22.9	23.0	22.4	23.0	22.7	23.0	22.8	23.0	22.7	23.2	23.2	22.8
8-Jul-05	0	16:30	4	22.3	23.1	22.8	22.9	23.0	22.3	22.9	22.7	23.1	22.8	23.0	22.7	23.2	23.2	22.8
9-Jul-05	1	9:00	4	23.1	22.9	23.4	23.0	23.1	23.3	23.2	23.2	23.2	23.2	23.2	23.0	23.1	23.2	23.3
9-Jul-05	1	9:00	6	23.1	22.9	23.4	23.1	23.2	23.3	23.2	23.3	23.3	23.2	23.2	23.2	23.1	23.2	23.3
9-Jul-05	1	18:00	4	23.5	23.4	23.6	23.5	23.6	23.8	23.7	23.7	23.6	23.7	23.5	23.8	23.7	23.7	23.8
9-Jul-05	1	18:00	8	23.5	23.4	23.6	23.5	23.6	23.8	23.8	23.8	23.6	23.7	23.8	23.8	23.7	23.7	23.8
10-Jul-05	2	8:45	4	23.4	23.2	23.4	23.4	23.4	23.6	23.3	23.6	23.4	23.5	23.4	23.5	23.4	23.4	23.5
10-Jul-05	2	8:45	5	23.5	23.3	23.5	23.5	23.5	23.5	23.5	23.6	23.4	23.6	23.4	23.5	23.4	23.5	23.5
10-Jul-05	2	19:00	2	23.8	23.5	23.7	23.8	23.8	24.0	23.9	24.0	23.8	24.0	23.8	24.0	23.9	24.0	24.0
10-Jul-05	2	19:00	4	23.8	23.6	23.8	23.7	23.8	24.1	24.0	24.0	23.9	24.0	24.0	24.1	23.9	24.0	24.0
11-Jul-05	3	7:00	4	23.4	23.1	23.5	23.4	23.5	23.6	23.4	23.6	23.2	23.4	23.5	23.4	23.3	23.4	23.4
11-Jul-05	3	7:00	7	23.3	23.1	23.4	23.1	23.4	23.6	23.5	23.5	23.3	23.3	23.4	23.3	23.3	23.3	23.6
11-Jul-05	3	15:30	3	23.8	23.7	23.9	23.9	24.0	24.0	24.0	23.9	23.9	24.1	23.9	24.0	23.9	24.0	24.0
11-Jul-05	3	15:30	4	23.9	23.7	24.0	24.0	23.9	24.0	24.0	24.0	24.0	24.1	23.9	24.1	23.9	24.0	24.1
12-Jul-05	4	7:00	1	23.4	23.4	23.4	23.6	23.5	23.2	23.5	23.3	23.4	23.5	23.4	23.4	23.5	23.6	23.5
12-Jul-05	4	7:00	4	23.6	23.3	23.1	23.5	23.4	23.3	23.4	23.3	23.6	23.3	23.3	23.6	23.6	23.7	23.6
12-Jul-05	4	15:00	3	24.2	24.1	24.1	24.3	24.2	24.1	23.6	24.1	24.1	24.3	24.2	24.3	24.1	24.2	24.2
12-Jul-05	4	15:00	4	24.4	24.2	24.1	24.3	24.2	24.1	24.2	24.1	24.2	24.3	24.2	24.4	24.2	24.2	24.2
13-Jul-05	5	8:45	4	24.3	24.3	24.3	24.6	24.4	24.3	24.5	24.4	24.4	24.5	24.3	24.4	24.4	24.4	24.4
13-Jul-05	5	8:45	6	24.4	24.4	24.6	24.6	24.5	24.4	24.5	24.5	24.4	24.5	24.3	24.4	24.3	24.3	24.5
13-Jul-05	5	15:00	4	23.6	23.5	23.7	23.9	23.7	23.7	23.7	23.7	23.7	23.8	23.8	24.1	23.8	23.7	23.9
13-Jul-05	5	15:00	8	23.6	23.5	23.8	23.9	23.7	23.7	23.7	23.8	23.7	23.8	23.8	24.0	23.7	23.7	23.9
14-Jul-05	6	8:30	4	23.4	23.3	23.6	23.6	23.4	23.4	23.5	23.4	23.4	23.5	23.5	23.6	23.5	23.4	23.5
14-Jul-05	6	8:30	5	23.4	23.4	23.6	23.6	23.4	23.4	23.5	23.5	23.5	23.6	23.5	23.7	23.4	23.3	23.6
14-Jul-05	6	15:00	2	23.5	23.5	23.6	23.6	23.6	23.6	23.8	23.6	23.7	23.6	23.6	23.8	23.6	23.5	23.7
14-Jul-05	6	15:00	4	23.5	23.5	23.7	23.8	23.6	23.7	23.8	23.6	23.6	23.6	23.6	23.8	23.6	23.5	23.7
15-Jul-05	7	7:00	1	21.7	22.0	22.0	22.1	22.2	21.6	22.1	21.8	22.1	22.1	22.0	22.2	22.1	22.0	21.7
15-Jul-05	7	7:00	2	21.7	22.0	22.0	22.1	22.2	21.7	22.1	21.8	22.1	22.1	22.0	22.2	22.2	22.0	21.8
15-Jul-05	7	7:00	3	21.8	22.0	22.1	22.2	22.2	21.7	22.2	21.9	22.1	22.1	22.1	22.2	22.0	22.0	21.8
15-Jul-05	7	7:00	4	21.8	22.0	22.1	22.2	22.2	21.8	22.2	21.9	22.1	22.1	22.1	22.2	22.1	22.0	21.9
15-Jul-05	7	7:00	5	21.8	22.0	22.1	22.2	22.2	21.7	22.2	21.9	22.1	22.1	22.5	22.2	22.1	22.0	21.9
15-Jul-05	7	7:00	6	21.8	22.0	22.1	22.2	22.3	21.8	22.2	21.9	22.1	22.1	22.1	22.1	22.1	21.9	21.9
15-Jul-05	7	7:00	7	21.8	22.0	22.1	22.2	22.2	21.8	22.2	21.9	22.1	22.1	22.1	22.1	22.1	21.9	21.8
15-Jul-05	7	7:00	8	21.8	22.0	22.1	22.2	22.2	21.8	22.2	21.9	22.1	22.1	22.1	22.1	22.1	21.9	21.9
			Average	**23.0**	**23.1**	**23.2**	**23.2**	**23.2**	**23.0**	**23.2**	**23.1**	**23.2**	**23.2**	**23.2**	**23.2**	**23.2**	**23.2**	**23.1**
			Minimum	21.7	22.0	22.0	22.1	22.2	21.6	22.1	21.8	22.1	22.1	22.0	22.1	22.0	21.9	21.7
			Maximum	24.4	24.4	24.6	24.6	24.5	24.4	24.5	24.5	24.4	24.5	24.3	24.4	24.4	24.4	24.5

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	7.6	6.5	6.4	4.6	4.3	6.3	6.2	6.5	7.4	6.7	6.8	7.1	5.9	5.8	6.4
8-Jul-05	0	7:30	2	7.9	6.1	6.9	6.4	4.6	6.0	5.7	6.3	5.9	6.2	6.9	7.8	6.7	5.9	6.4
8-Jul-05	0	7:30	3	7.8	6.8	5.6	5.3	2.9	6.3	7.5	7.0	7.3	7.5	6.6	7.4	7.3	7.2	6.4
8-Jul-05	0	7:30	4	7.9	6.7	6.5	7.4	4.3	5.8	5.8	6.9	7.8	7.2	7.0	7.8	7.1	7.5	6.5
8-Jul-05	0	7:30	5	7.2	5.9	6.0	5.8	6.6	5.6	6.3	7.6	6.6	7.0	7.9	7.2	6.2	6.5	6.6
8-Jul-05	0	7:30	6	7.3	6.2	5.5	4.3	2.6	5.5	5.7	7.7	6.8	7.2	6.7	7.8	6.2	5.9	7.2
8-Jul-05	0	7:30	7	7.0	6.0	5.9	7.4	5.6	5.3	6.4	6.5	5.1	5.8	7.4	6.9	7.8	6.3	6.6
8-Jul-05	0	7:30	8	7.0	6.1	5.9	3.7	5.5	6.0	7.7	7.4	6.8	6.8	7.7	7.8	8.0	7.5	7.3
8-Jul-05	0	16:30	1	7.5	7.1	6.0	5.4	4.1	5.4	6.9	5.7	6.9	6.2	6.5	6.3	5.0	6.8	5.6
8-Jul-05	0	16:30	4	7.2	6.5	6.4	5.6	5.9	5.4	6.3	5.7	7.3	6.4	6.6	6.6	5.8	7.0	6.1
9-Jul-05	1	9:00	4	6.4	6.3	6.4	6.1	5.9	4.9	4.5	5.6	6.4	5.6	6.6	6.7	4.8	6.3	3.1
9-Jul-05	1	9:00	6	6.2	4.0	4.2	6.2	5.9	4.9	4.2	6.0	4.5	4.4	6.7	5.9	6.9	6.4	3.4
9-Jul-05	1	18:00	4	6.5	6.1	7.0	6.2	6.5	5.7	5.9	6.0	5.1	6.1	6.2	6.0	6.1	6.5	3.5
9-Jul-05	1	18:00	8	6.2	5.2	6.6	5.7	5.8	6.5	6.0	6.2	6.2	6.0	6.6	6.3	6.6	5.1	5.9
10-Jul-05	2	8:45	4	6.5	6.8	6.6	6.4	6.0	3.6	5.9	6.3	6.6	6.3	6.2	5.2	4.0	6.3	3.7
10-Jul-05	2	8:45	5	5.9	4.0	5.8	6.2	5.4	3.7	6.3	6.4	5.9	5.2	6.3	4.2	5.6	6.3	2.5
10-Jul-05	2	19:00	2	6.9	5.8	6.9	6.1	6.1	4.1	4.5	6.5	6.1	6.4	6.6	6.4	5.4	6.5	4.0
10-Jul-05	2	19:00	4	6.8	6.6	6.8	6.3	5.9	4.0	6.3	6.7	6.6	6.5	6.4	6.1	4.0	6.5	4.8
11-Jul-05	3	7:00	4	6.6	6.7	6.7	5.0	5.6	5.0	5.9	6.0	6.1	6.4	6.3	5.0	4.6	6.1	5.0
11-Jul-05	3	7:00	7	6.6	4.1	6.3	4.8	6.5	4.7	6.1	6.3	6.4	6.1	6.5	5.8	6.1	6.0	4.7
11-Jul-05	3	15:30	3	6.4	6.6	6.6	6.5	5.3	5.7	6.6	6.5	6.1	6.4	6.8	6.4	4.4	6.4	4.3
11-Jul-05	3	15:30	4	6.4	6.6	6.5	4.1	5.4	4.2	6.0	6.1	6.4	6.1	6.6	6.1	4.1	6.6	6.4
12-Jul-05	4	7:00	1	6.4	5.8	5.6	5.5	4.5	6.8	6.5	6.1	6.4	6.6	5.7	6.4	6.1	6.1	5.4
12-Jul-05	4	7:00	4	6.5	6.1	5.4	5.9	4.9	6.4	6.6	6.4	6.2	7.0	6.7	6.6	4.9	6.5	6.2
12-Jul-05	4	15:00	3	6.2	6.4	6.3	5.9	3.4	6.2	6.4	6.5	6.5	6.3	5.3	6.1	3.6	6.2	5.1
12-Jul-05	4	15:00	4	6.4	5.5	6.2	5.6	3.2	6.1	6.2	6.4	6.1	6.3	5.6	5.7	4.8	6.1	6.0
13-Jul-05	5	8:45	4	5.8	5.9	6.7	5.8	5.2	6.8	6.4	6.4	6.1	6.2	5.5	5.9	4.9	5.4	5.6
13-Jul-05	5	8:45	6	4.1	5.1	4.5	3.4	3.6	4.6	4.1	5.2	5.6	4.5	6.3	6.6	6.3	6.2	4.8
13-Jul-05	5	15:00	4	6.3	6.4	6.5	4.2	5.8	6.4	6.6	6.3	5.9	6.3	6.0	4.9	5.2	6.4	5.5
13-Jul-05	5	15:00	8	5.1	5.8	6.3	5.1	5.3	6.4	6.4	6.4	5.3	6.2	6.4	6.2	6.3	6.3	5.7
14-Jul-05	6	8:30	4	6.7	6.1	6.0	5.5	4.7	6.3	6.3	6.1	5.9	5.4	5.9	4.1	5.1	5.8	6.0
14-Jul-05	6	8:30	5	5.5	5.4	4.0	5.6	5.8	5.6	3.3	5.3	5.4	5.1	6.0	4.1	5.7	6.2	5.3
14-Jul-05	6	15:00	2	7.2	6.1	6.5	4.6	5.4	6.2	4.4	6.5	5.6	6.0	6.4	6.3	4.6	5.6	6.2
14-Jul-05	6	15:00	4	6.8	6.3	6.3	4.1	4.6	5.2	5.6	6.3	5.9	6.1	6.3	6.2	5.0	5.7	6.3
15-Jul-05	7	7:00	1	7.0	7.0	6.8	5.3	5.0	6.2	6.5	6.5	6.5	6.4	6.7	5.6	3.8	6.3	4.3
15-Jul-05	7	7:00	2	7.2	6.8	6.6	4.0	5.9	6.3	4.3	6.6	6.6	5.8	6.0	5.6	3.7	6.3	5.4
15-Jul-05	7	7:00	3	7.2	6.7	6.6	5.9	6.0	5.6	6.4	6.5	6.4	6.7	6.7	6.3	5.5	6.1	3.9
15-Jul-05	7	7:00	4	7.6	7.0	6.5	3.8	6.4	5.6	6.5	6.7	6.1	6.0	6.5	6.2	5.1	6.0	5.9
15-Jul-05	7	7:00	5	6.4	6.6	6.6	4.4	6.5	6.4	4.6	5.8	6.2	5.1	6.1	5.5	5.4	6.4	5.1
15-Jul-05	7	7:00	6	7.0	5.4	6.0	5.1	5.6	4.3	4.8	5.9	5.5	4.5	6.3	6.0	6.1	6.7	5.6
15-Jul-05	7	7:00	7	6.8	6.5	6.5	6.0	6.1	6.7	6.0	6.4	6.5	5.7	6.5	6.2	6.1	5.8	6.0
15-Jul-05	7	7:00	8	6.6	6.9	6.6	6.1	5.1	7.0	6.9	6.4	5.8	6.0	6.7	6.4	6.8	6.6	4.7
			Average	**6.7**	**6.1**	**6.2**	**5.4**	**5.2**	**5.6**	**5.9**	**6.3**	**6.2**	**6.1**	**6.5**	**6.2**	**5.6**	**6.3**	**5.4**
			Minimum	4.1	4.0	4.0	3.4	2.6	3.6	3.3	5.2	4.5	4.4	5.3	4.1	3.6	5.1	2.5
			Maximum	7.9	7.1	7.0	7.4	6.6	7.0	7.7	7.7	7.8	7.5	7.9	7.8	8.0	7.5	7.3

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
pH

Date	Day	Time	Rep	Sand	ɔrm Sedime	N. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	8.11	6.66	7.12	7.02	7.71	7.31	7.32	7.45	7.92	7.61	7.47	7.39	7.64	7.90	7.34
8-Jul-05	0	7:30	4	8.12	7.19	7.19	7.65	7.43	7.28	7.38	7.44	7.91	7.67	7.49	7.57	7.61	7.87	7.36
8-Jul-05	0	7:30	5	8.12	6.58	7.54	7.82	7.86	7.22	7.39	7.74	7.87	7.66	7.61	7.49	7.63	7.83	7.33
8-Jul-05	0	7:30	8	8.12	6.68	7.58	6.97	7.67	7.31	7.37	7.95	7.93	7.61	7.56	7.53	7.64	7.81	7.38
11-Jul-05	3	7:00	4	8.09	8.00	8.00	7.56	7.72	7.41	7.72	7.73	7.94	7.80	8.06	7.76	7.48	7.92	7.25
11-Jul-05	3	7:00	7	8.10	7.91	8.03	7.05	8.01	7.27	7.90	7.93	7.75	7.60	7.96	7.62	7.81	7.87	7.44
15-Jul-05	7	7:00	1	8.70	8.14	8.06	7.60	7.66	7.70	7.96	7.92	7.88	7.87	7.84	7.85	7.53	8.03	7.56
15-Jul-05	7	7:00	4	8.38	8.06	8.06	7.41	7.70	7.58	8.01	8.10	7.73	7.74	7.87	7.82	7.55	7.82	7.79
15-Jul-05	7	7:00	5	7.91	7.98	8.09	7.46	8.05	7.79	7.60	7.78	7.73	7.59	7.85	7.76	7.61	8.01	7.62
15-Jul-05	7	7:00	8	7.95	8.21	8.10	7.70	7.75	8.04	8.10	7.88	7.71	7.83	8.02	7.84	7.90	8.02	7.61
			Average	**8.16**	**7.54**	**7.78**	**7.42**	**7.76**	**7.49**	**7.68**	**7.79**	**7.84**	**7.70**	**7.77**	**7.66**	**7.64**	**7.91**	**7.47**
			Minimum	7.91	6.58	7.12	6.97	7.43	7.22	7.32	7.44	7.71	7.59	7.47	7.39	7.48	7.81	7.25
			Maximum	8.70	8.21	8.10	7.82	8.05	8.04	8.10	8.10	7.94	7.87	8.06	7.85	7.90	8.03	7.79

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Sand	Form Sedimen	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	124	175	119	126	138	111	128	117	110	120	119	120	120	118	111
8-Jul-05	0	7:30	8	122	160	119	123	136	110	122	119	109	120	117	119	119	119	116
15-Jul-05	7	7:00	1	179	165	150	157	172	153	157	157	158	156	161	162	168	158	156
15-Jul-05	7	7:00	8	151	165	150	156	172	152	156	156	158	156	159	158	159	156	157
			Average	**144**	**166**	**134**	**140**	**154**	**131**	**141**	**137**	**134**	**138**	**139**	**140**	**141**	**138**	**135**
			Minimum	122	160	119	123	136	110	122	117	109	120	117	119	119	118	111
			Maximum	179	175	150	157	172	153	157	157	158	156	161	162	168	158	157

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Ammonia (ppm)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	<0.063	<0.063	0.169	0.116	0.929	<0.063	0.619	0.181	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
8-Jul-05	0	7:30	8	<0.063	<0.063	0.114	0.116	0.898	<0.063	0.137	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
15-Jul-05	7	7:00	1	0.081	0.066	0.26	0.312	2.245	0.299	0.544	0.159	0.406	0.33	0.348	0.209	0.487	0.282	0.213
15-Jul-05	7	7:00	8	0.09	<0.063	0.277	0.294	2.379	0.321	0.528	0.157	0.413	0.42	0.157	0.217	0.321	0.258	0.234
			Average	**<0.063**	**<0.063**	**0.205**	**0.210**	**1.613**	**0.171**	**0.457**	**0.132**	**0.221**	**0.204**	**0.142**	**0.120**	**0.218**	**0.151**	**0.128**
			Minimum	<0.063	<0.063	0.114	0.116	0.898	<0.063	0.137	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	0.09	0.066	0.277	0.312	2.379	0.321	0.619	0.181	0.413	0.42	0.348	0.217	0.487	0.282	0.234

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
DOC (ppm)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	1	2.4	*	4.3	*	4.6	24.9	4.6	4.4	21.3	6.2	15.3	8.1	6.2	9.6	14.4
8-Jul-05	0	7:30	8	2.8	7.1	3	4.9	3.8	22.6	3.6	3.6	29.4	5.7	11	8.1	6.3	5.2	20.3
15-Jul-05	7	7:00	1	6.6	2.6	2.6	2.6	2.9	3.2	2.3	2.3	3.5	6	3.2	2.5	3.5	3	3.3
15-Jul-05	7	7:00	8	2.4	2.8	2.6	2.6	2.9	3.2	2.1	2.1	3	2.6	2.6	2.6	3.1	16.3	3.5
			Average	**3.6**	**4.2**	**3.1**	**3.4**	**3.6**	**13.5**	**3.2**	**3.1**	**14.3**	**5.1**	**8.0**	**5.3**	**4.8**	**8.5**	**10.4**
			Minimum	2.4	2.6	2.6	2.6	2.9	3.2	2.1	2.1	3	2.6	2.6	2.5	3.1	3	3.3
			Maximum	6.6	7.1	4.3	4.9	4.6	24.9	4.6	4.4	29.4	6.2	15.3	8.1	6.3	16.3	20.3

* Sample lost, laboratory accident

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	3	48.8	47.2	48.8	54	57.6	51.6	48	50.8	54.8	47.2	62.8	51.6	53.2	47.2	57.6
8-Jul-05	0	7:30	7	48.8	38.8	48.4	48	55.2	54.8	53.6	49.6	62	56	53.6	52	48.8	51.2	50.4
15-Jul-05	7	7:00	3	46.8	54.8	49.6	53.2	56.4	51.6	51.2	52.4	51.6	51.6	53.2	53.2	57.6	51.2	54
15-Jul-05	7	7:00	7	52.8	58	50	53.2	55.6	49.2	52.4	52	53.2	52.8	52.8	55.2	52.8	508	51.2
			Average	**49.3**	**49.7**	**49.2**	**52.1**	**56.2**	**51.8**	**51.3**	**51.2**	**55.4**	**51.9**	**55.6**	**53.0**	**53.1**	**164.4**	**53.3**
			Minimum	46.8	38.8	48.4	48	55.2	49.2	48	49.6	51.6	47.2	52.8	51.6	48.8	47.2	50.4
			Maximum	52.8	58	50	54	57.6	54.8	53.6	52.4	62	56	62.8	55.2	57.6	508	57.6

Appendix Table 15. Water Chemistry Parameters for 7-d *Pimephales promelas* Exposed to Ahsland Harbor Sediments, July 8-15, 2005.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
8-Jul-05	0	7:30	2	50.8	47.2	49.2	51.6	59.2	48.8	55.6	51.2	50.4	48.8	47.2	50	52.4	50	52.4
8-Jul-05	0	7:30	6	49.2	44.4	50.4	56.4	65.6	47.6	55.6	48.4	48	48.8	53.2	49.2	52.4	48.4	49.2
15-Jul-05	7	7:00	2	53.2	55.6	50.4	56.8	60.8	52	57.2	54	55.6	54	55.6	55.2	58	55.2	54.4
15-Jul-05	7	7:00	6	54	55.6	48.4	54.4	61.6	52.8	57.2	52.4	55.6	54.4	56.8	55.6	54.8	53.2	54
			Average	**51.8**	**50.7**	**49.6**	**54.8**	**61.8**	**50.3**	**56.4**	**51.5**	**52.4**	**51.5**	**53.2**	**52.5**	**54.4**	**51.7**	**52.5**
			Minimum	49.2	44.4	48.4	51.6	59.2	47.6	55.6	48.4	48	48.8	47.2	49.2	52.4	48.4	49.2
			Maximum	54	55.6	50.4	56.8	65.6	52.8	57.2	54	55.6	54.4	56.8	55.6	58	55.2	54.4

APPENDIX 16

Survival and Growth of *Pimephales promelas* following 7-d Exposure to Ashland Harbor Sediment and UV Light, 27 January 2006 to 3 February 2006

Appendix Table 16. Survival and Growth of *Pimephales promelas* following 7-d Exposure to Ashland Harbor Sediment and UV Light, 27 January 2006 to

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Corrected Mortality (%)	Standard Deviation	Total Dry Wt (mg)	Individual Dry Wt (mg)	Average Dry Wt (mg)	Standard Deviation
A	Silica Sand	1	8	80.0			3.4	0.43		
A	Silica Sand	2	10	100.0			5.1	0.51		
A	Silica Sand	3	8	80.0			4.2	0.53		
A	Silica Sand	4	9	90.0			4.3	0.48		
A	Silica Sand	5	7	70.0			4.2	0.60		
A	Silica Sand	6	6	60.0			4.2	0.70		
A	Silica Sand	7	9	90.0			4.1	0.46		
A	Silica Sand	8	8	80.0		1.2	5.0	0.63	0.54	0.09
B	Form. Sediment	1	7	70.0			3.7	0.53		
B	Form. Sediment	2	7	70.0			4.0	0.57		
B	Form. Sediment	3	7	70.0			4.2	0.60		
B	Form. Sediment	4	4	40.0			2.0	0.50		
B	Form. Sediment	5	9	90.0			5.0	0.56		
B	Form. Sediment	6	10	100.0			6.6	0.66		
B	Form. Sediment	7	9	90.0			4.3	0.48		
B	Form. Sediment	8	6	60.0		1.9	3.9	0.65	0.57	0.07
C	W. Bearskin	1	9	90.0			4.3	0.48		
C	W. Bearskin	2	9	90.0			4.9	0.54		
C	W. Bearskin	3	9	90.0			5.3	0.59		
C	W. Bearskin	4	7	70.0			6.1	0.87		
C	W. Bearskin	5	9	90.0			5.7	0.63		
C	W. Bearskin	6	10	100.0			3.7	0.37		
C	W. Bearskin	7	9	90.0			4.3	0.48		
C	W. Bearskin	8	8	80.0		0.9	5.9	0.74	0.59	0.16
D	SQT9	1	8	80.0			6.8	0.85		
D	SQT9	2	9	90.0			6.7	0.74		
D	SQT9	3	10	100.0			5.2	0.52		
D	SQT9	4	8	80.0			5.2	0.65		
D	SQT9	5	5	50.0			3.4	0.68		
D	SQT9	6	10	100.0			6.2	0.62		
D	SQT9	7	7	70.0			4.8	0.69		
D	SQT9	8	9	90.0		1.7	5.3	0.59	0.67	0.10
E	SQT13	1	6	60.0			4.4	0.73		
E	SQT13	2	8	80.0			5.2	0.65		
E	SQT13	3	9	90.0			4.3	0.48		
E	SQT13	4	7	70.0			2.5	0.36		
E	SQT13	5	10	100.0			4.1	0.41		
E	SQT13	6	8	80.0			5.3	0.66		
E	SQT13	7	7	70.0			2.5	0.36		
E	SQT13	8	8	80.0		1.2	5.3	0.66	0.54	0.15
F	SQT11	1	7	70.0			4.8	0.69		
F	SQT11	2	7	70.0			4.4	0.63		
F	SQT11	3	8	80.0			6.5	0.81		
F	SQT11	4	6	60.0			4.4	0.73		
F	SQT11	5	8	80.0			4.3	0.54		
F	SQT11	6	8	80.0			4.4	0.55		
F	SQT11	7	7	70.0			3.0	0.43		
F	SQT11	8	8	80.0		0.7	6.2	0.78	0.64	0.13
G	SQT14	1	8	80.0			5.7	0.71		
G	SQT14	2	6	60.0			3.9	0.65		
G	SQT14	3	11	110.0			6.7	0.61		
G	SQT14	4	7	70.0			5.0	0.71		
G	SQT14	5	9	90.0			5.7	0.63		
G	SQT14	6	6	60.0			4.1	0.68		
G	SQT14	7	7	70.0			5.0	0.71		
G	SQT14	8	11	110.0		2.0	7.3	0.66	0.67	0.04
H	SQT6	1	8	80.0	100.0		4.0	0.50		
H	SQT6	2	8	80.0	100.0		4.5	0.56		
H	SQT6	3	10	100.0	100.2		7.1	0.71		
H	SQT6	4	8	80.0	100.0		5.1	0.64		

Treatment	Test Sediment	Rep	Number of Survivors (10)	Average Survival (%)	Corrected Mortality (%)	Standard Deviation	Total Dry Wt (mg)	Individual Dry Wt (mg)	Average Dry Wt (mg)	Standard Deviation
H	SQT6	5	5	50.0	99.6		3.4	0.68		
H	SQT6	6	6	60.0	99.7		4.6	0.77		
H	SQT6	7	10	100.0	100.2		5.6	0.56		
H	SQT6	8	7	70.0	99.9	1.8	4.0	0.57	0.62	0.09
I	SQT2	1	8	80.0	100.0		4.8	0.60		
I	SQT2	2	6	60.0	99.7		3.7	0.62		
I	SQT2	3	9	90.0	100.1		5.6	0.62		
I	SQT2	4	5	50.0	99.6		2.4	0.48		
I	SQT2	5	9	90.0	100.1		5.6	0.62		
I	SQT2	6	9	90.0	100.1		4.0	0.44		
I	SQT2	7	5	50.0	99.6		2.9	0.58		
I	SQT2	8	9	90.0	100.1	1.9	4.5	0.50	0.56	0.07
J	SQT7	1	3	30.0	99.4		1.7	0.57		
J	SQT7	2	7	70.0	99.9		3.7	0.53		
J	SQT7	3	5	50.0	99.6		2.3	0.46		
J	SQT7	4	0	0.0	99.0					
J	SQT7	5	4	40.0	99.5		2.9	0.73		
J	SQT7	6	5	50.0	99.6		2.8	0.56		
J	SQT7	7	2	20.0	99.2		2.0	1.00		
J	SQT7	8	5	50.0	99.6	2.2	2.8	0.56	0.63	0.18
K	SQT4	1	5	50.0	99.6		2.3	0.46		
K	SQT4	2	7	70.0	99.9		3.7	0.53		
K	SQT4	3	6	60.0	99.7		3.7	0.62		
K	SQT4	4	4	40.0	99.5		2.8	0.70		
K	SQT4	5	8	80.0	100.0		3.8	0.48		
K	SQT4	6	6	60.0	99.7		3.0	0.50		
K	SQT4	7	8	80.0	100.0		3.1	0.39		
K	SQT4	8	5	50.0	99.6	1.5	1.8	0.36	0.50	0.11
L	SQT3	1	10	100.0	100.2		3.2	0.32		
L	SQT3	2	6	60.0	99.7		3.1	0.52		
L	SQT3	3	6	60.0	99.7		1.7	0.28		
L	SQT3	4	10	100.0	100.2		5.6	0.56		
L	SQT3	5	2	20.0	99.2		0.9	0.45		
L	SQT3	6	8	80.0	100.0		4.4	0.55		
L	SQT3	7	4	40.0	99.5		1.6	0.40		
L	SQT3	8	9	90.0	100.1	2.9	5.0	0.56	0.45	0.11
M	SQT5	1	4	40.0	99.5		2.4	0.60		
M	SQT5	2	6	60.0	99.7		2.9	0.48		
M	SQT5	3	5	50.0	99.6		3.9	0.78		
M	SQT5	4	7	70.0	99.9		3.9	0.56		
M	SQT5	5	5	50.0	99.6		3.0	0.60		
M	SQT5	6	6	60.0	99.7		3.0	0.50		
M	SQT5	7	6	60.0	99.7		3.6	0.60		
M	SQT5	8	9	90.0	100.1	1.5	4.6	0.51	0.58	0.09
N	SQT 1	1	0	0.0	99.0					
N	SQT 1	2	0	0.0	99.0					
N	SQT 1	3	0	0.0	99.0					
N	SQT 1	4	0	0.0	99.0					
N	SQT 1	5	0	0.0	99.0					
N	SQT 1	6	0	0.0	99.0					
N	SQT 1	7	0	0.0	99.0					
N	SQT 1	8	0	0.0	99.0	0.0				
O	SQT8	1	8	80.0	100.0		5.0	0.63		
O	SQT8	2	6	60.0	99.7		4.3	0.72		
O	SQT8	3	8	80.0	100.0		3.9	0.49		
O	SQT8	4	6	60.0	99.7		3.5	0.58		
O	SQT8	5	7	70.0	99.9		4.7	0.67		
O	SQT8	6	5	50.0	99.6		3.3	0.66		
O	SQT8	7	9	90.0	100.1		5.8	0.64		
O	SQT8	8	8	80.0	100.0	1.4	4.2	0.53	0.61	0.08

APPENDIX 17

Water Chemistry of *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 3 February 2006

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Temperature (° C)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	23.2	23.0	23.3	23.2	23.3	23.3	23.0	23.2	23.1	23.2	23.1	23.3	23.2	23.2	23.1
27-Jan-06	0	7:00	2	23.4	23.1	23.4	23.5	23.3	23.4	23.1	23.3	23.1	23.2	23.4	23.3	23.1	23.2	23.2
27-Jan-06	0	7:00	3	23.4	23.0	23.4	23.3	23.3	23.3	23.1	23.3	23.1	23.3	23.1	23.2	23.1	23.3	23.3
27-Jan-06	0	7:00	4	23.4	23.0	23.4	23.4	23.3	23.4	23.0	23.4	23.1	23.2	23.1	23.2	23.2	23.3	23.3
27-Jan-06	0	7:00	5	23.3	22.8	23.4	23.2	23.3	23.4	23.3	23.2	23.3	23.4	23.1	23.2	23.1	23.1	23.3
27-Jan-06	0	7:00	6	23.3	23.0	23.3	23.3	23.3	23.4	23.3	23.3	23.3	23.3	23.2	23.0	23.3	23.2	23.3
27-Jan-06	0	7:00	7	23.7	22.7	23.4	23.2	23.2	23.4	23.3	23.2	23.4	23.3	23.2	23.3	23.2	23.3	23.3
27-Jan-06	0	7:00	8	23.3	22.8	23.3	23.4	23.2	23.3	23.3	23.2	23.3	23.3	23.2	23.2	23.2	23.3	23.4
28-Jan-06	1	8:15	4	23.3	23.1	23.5	23.3	22.3	23.5	23.1	23.3	23.4	23.3	23.0	23.0	23.0	23.3	23.4
28-Jan-06	1	8:15	6	23.3	23.0	23.6	23.3	22.3	23.5	23.1	23.7	23.4	23.5	23.3	23.2	23.2	23.4	23.5
28-Jan-06	1	15:45	4	23.5	22.9	23.3	23.5	23.2	23.4	23.5	23.4	23.2	23.4	23.1	23.1	23.1	23.4	23.4
28-Jan-06	1	15:45	8	23.5	23.0	23.6	23.5	23.0	23.5	23.5	23.5	23.5	23.4	23.2	23.2	23.3	23.4	23.4
29-Jan-06	2	8:45	4	23.3	23.3	23.5	23.2	23.1	23.1	23.3	23.2	23.0	23.4	23.0	23.2	23.1	23.3	23.3
29-Jan-06	2	8:45	5	23.4	23.3	23.6	23.3	23.2	23.2	23.3	23.4	23.4	23.6	23.0	23.4	23.0	23.5	23.1
29-Jan-06	2	17:45	2	23.3	23.3	23.4	23.2	23.1	22.9	22.8	23.0	23.2	23.1	23.1	23.2	23.3	23.3	23.3
29-Jan-06	2	17:45	4	23.2	23.3	23.4	23.3	23.2	22.9	23.0	23.2	23.3	23.3	23.1	23.2	23.4	23.3	23.4
30-Jan-06	3	9:00	4	23.1	23.5	23.2	23.3	23.0	23.4	23.1	23.3	23.5	23.3	23.4	23.2	23.4	23.3	23.4
30-Jan-06	3	9:00	7	23.0	23.5	23.2	23.4	23.1	23.4	23.1	23.3	23.6	23.4	23.3	23.2	23.4	23.4	23.2
30-Jan-06	3	15:10	3	23.6	23.8	23.7	23.6	23.8	23.6	23.0	23.7	24.0	23.7	23.5	23.6	23.5	23.6	23.6
30-Jan-06	3	15:10	4	23.7	23.8	23.8	23.8	23.8	23.8	23.7	23.7	24.0	23.8	23.5	23.7	23.6	23.6	23.6
31-Jan-06	4	8:30	1	23.2	23.4	23.1	23.2	23.0	23.0	23.2	23.3	23.4	23.3	23.0	23.2	22.8	23.4	23.4
31-Jan-06	4	8:30	4	23.3	23.2	23.1	23.3	23.1	23.2	23.3	23.4	23.0	23.3	23.0	23.3	23.2	23.5	23.4
31-Jan-06	4	15:30	3	23.2	23.2	23.0	23.6	23.8	23.2	23.3	23.3	23.2	23.3	23.3	23.5	22.5	23.1	23.5
31-Jan-06	4	15:30	4	23.3	23.2	23.3	23.7	23.5	23.2	23.5	23.3	23.5	23.3	23.3	23.6	22.5	23.3	23.5
1-Feb-06	5	8:30	4	23.2	23.4	23.5	22.9	23.6	23.2	23.3	23.3	23.2	23.4	23.0	23.3	22.8	22.9	23.4
1-Feb-06	5	8:30	6	23.3	23.2	23.4	23.1	23.5	23.2	23.4	23.2	23.4	23.5	23.1	23.3	23.3	23.4	23.4
1-Feb-06	5	15:00	4	23.2	23.7	23.6	23.7	23.3	23.3	23.5	23.5	23.1	23.4	23.2	23.6	23.0	23.4	23.5
1-Feb-06	5	15:00	8	23.2	23.5	23.6	23.6	23.5	23.5	23.4	23.2	23.6	23.5	23.2	23.6	23.2	23.3	23.0
2-Feb-06	6	8:20	4	23.0	23.7	23.5	23.7	22.6	23.2	23.4	23.7	23.5	23.5	23.3	23.4	23.4	23.5	23.5
2-Feb-06	6	8:20	5	23.1	23.6	23.6	23.7	23.7	23.4	23.5	23.7	23.5	23.8	23.3	23.6	23.5	23.5	23.5
2-Feb-06	6	8:20	2	23.0	23.7	23.1	22.9	23.6	23.0	23.3	23.3	23.5	23.1	23.2	23.2	23.2	23.4	23.6
2-Feb-06	6	8:20	4	23.1	23.3	23.3	23.1	23.4	23.2	23.3	23.3	23.6	23.3	23.3	23.3	23.2	23.5	23.5
3-Feb-06	7	7:00	1	21.5	23.4	23.2	23.3	23.5	23.4	23.2	23.3	23.3	23.3	23.0	23.3	23.0	23.1	23.3
3-Feb-06	7	7:00	2	23.2	23.5	23.4	23.4	23.5	23.4	23.2	23.3	23.3	23.3	23.0	23.4	23.1	23.3	23.2
3-Feb-06	7	7:00	3	23.1	23.4	23.4	23.4	23.6	23.4	23.4	23.4	23.4	23.3	23.1	23.5	23.2	23.3	23.2
3-Feb-06	7	7:00	4	23.2	23.5	23.4	23.4	23.6	23.4	23.4	23.5	23.4	23.3	23.1	23.4	23.2	23.4	23.3
3-Feb-06	7	7:00	5	23.1	23.4	23.4	23.5	23.5	23.3	23.4	23.5	23.5	23.5	23.2	23.3	23.3	23.2	23.2
3-Feb-06	7	7:00	6	23.1	23.5	23.3	23.5	23.5	23.4	23.4	23.5	23.4	23.4	23.0	23.4	23.2	23.4	23.2
3-Feb-06	7	7:00	7	23.1	23.4	23.3	23.4	23.5	23.3	23.3	23.5	23.5	23.4	23.1	23.4	23.1	23.2	23.2
3-Feb-06	7	7:00	8	23.1	23.4	23.4	23.4	23.4	23.4	23.4	23.5	23.6	23.4	23.0	23.4	23.2	23.3	23.3
			Average	**23.2**	**23.3**	**23.4**	**23.4**	**23.3**	**23.3**	**23.3**	**23.4**	**23.4**	**23.4**	**23.2**	**23.3**	**23.2**	**23.3**	**23.3**
			Minimum	21.5	22.7	23.0	22.9	22.3	22.9	22.8	23.0	23.0	23.1	23.0	23.0	22.5	22.9	23.0
			Maximum	23.7	23.8	23.8	23.8	23.8	23.8	23.7	23.7	24.0	23.8	23.5	23.7	23.6	23.6	23.6

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	7.5	7.1	6.9	3.5	3.9	7.9	4.4	7.3	3.0	8.0	6.1	7.9	7.6	5.9	7.5
27-Jan-06	0	7:00	2	7.7	7.3	6.2	5.6	3.3	7.8	5.2	8.2	3.2	7.6	6.1	8.3	7.6	6.2	6.0
27-Jan-06	0	7:00	3	7.9	7.2	6.8	4.8	4.8	7.0	4.9	6.5	4.4	8.1	6.1	7.2	7.7	6.1	8.0
27-Jan-06	0	7:00	4	7.8	7.7	6.5	4.8	3.6	6.3	6.8	7.2	3.2	7.4	6.5	6.0	7.5	5.4	7.3
27-Jan-06	0	7:00	5	8.2	7.3	7.1	4.4	3.9	5.8	7.7	7.0	4.1	7.5	6.9	8.1	8.2	6.8	3.7
27-Jan-06	0	7:00	6	7.5	8.3	7.1	4.4	5.2	5.4	5.6	7.4	4.7	7.0	8.3	5.2	5.7	7.7	5.4
27-Jan-06	0	7:00	7	7.6	7.3	6.8	4.5	4.3	6.0	7.3	7.8	7.7	8.0	8.2	7.7	6.5	7.7	6.5
27-Jan-06	0	7:00	8	7.5	7.6	7.2	6.4	4.2	6.6	7.1	7.8	6.2	7.2	8.2	7.7	5.3	7.2	7.5
28-Jan-06	1	8:15	4	7.5	6.7	8.4	8.9	8.2	6.4	8.6	6.8	6.6	7.3	6.7	8.2	8.9	8.0	8.5
28-Jan-06	1	8:15	6	7.5	7.2	7.0	8.2	4.8	6.6	6.9	7.8	6.5	7.4	7.3	8.0	8.5	8.3	8.4
28-Jan-06	1	15:45	4	8.2	5.6	6.4	6.9	7.9	5.6	7.9	7.6	8.8	5.9	7.5	9.1	8.0	7.5	8.2
28-Jan-06	1	15:45	8	8.3	4.6	7.8	6.8	5.6	4.9	6.7	8.1	7.4	7.2	7.8	8.1	8.1	8.0	8.3
29-Jan-06	2	8:45	4	7.3	4.2	5.8	8.2	8.0	4.7	7.1	8.7	8.4	7.0	5.2	6.5	8.9	7.2	8.5
29-Jan-06	2	8:45	5	7.9	6.7	6.5	6.5	6.9	4.5	6.0	5.9	8.2	8.3	5.7	7.4	8.8	7.8	7.2
29-Jan-06	2	17:45	2	6.2	6.6	5.0	7.7	7.8	8.5	7.5	8.9	9.0	7.9	7.6	7.9	5.0	5.7	7.2
29-Jan-06	2	17:45	4	5.7	6.7	5.0	7.8	7.6	6.7	6.8	7.8	8.3	7.4	7.0	7.8	4.5	5.6	7.2
30-Jan-06	3	9:00	4	7.3	5.2	5.0	7.0	6.7	6.4	8.0	7.3	6.4	7.7	7.0	6.8	5.9	7.3	6.8
30-Jan-06	3	9:00	7	7.3	4.9	4.7	6.7	4.2	4.1	7.2	5.1	7.3	7.7	8.0	4.4	7.5	8.1	7.0
30-Jan-06	3	15:10	3	4.6	7.3	4.9	5.9	8.1	5.3	4.4	5.3	7.0	6.5	7.6	5.8	7.1	7.9	7.8
30-Jan-06	3	15:10	4	6.7	7.3	5.1	7.8	7.6	4.9	7.3	5.0	7.1	8.0	7.6	6.4	7.0	7.9	8.1
31-Jan-06	4	8:30	1	4.1	4.2	7.1	5.2	4.2	5.8	2.9	7.7	5.0	6.1	5.6	6.2	7.8	5.4	6.7
31-Jan-06	4	8:30	4	6.0	4.3	5.8	6.1	5.6	7.0	5.0	7.0	6.1	7.1	4.0	6.6	7.0	6.6	7.0
31-Jan-06	4	15:30	3	3.6	7.2	8.2	6.1	6.8	6.9	5.0	6.3	6.1	6.8	6.7	6.5	7.8	7.3	6.9
31-Jan-06	4	15:30	4	6.9	7.1	6.7	6.5	7.3	6.8	6.4	6.3	6.6	6.2	5.8	6.6	6.8	6.4	6.8
1-Feb-06	5	8:30	4	5.8	6.7	4.8	5.8	6.2	6.8	5.4	5.7	5.9	4.5	4.4	5.0	6.4	6.0	6.2
1-Feb-06	5	8:30	6	6.1	5.9	5.2	6.3	6.4	7.4	3.4	4.1	4.7	6.3	5.2	6.1	6.4	6.6	6.5
1-Feb-06	5	15:00	4	6.6	6.2	5.0	5.5	6.8	6.7	6.8	5.6	7.5	6.1	6.7	6.1	7.4	6.9	7.4
1-Feb-06	5	15:00	8	6.5	3.8	4.8	5.2	7.1	7.3	2.5	7.3	7.8	7.5	5.6	6.7	7.7	8.1	7.3
2-Feb-06	6	8:20	4	5.1	5.5	4.8	6.1	6.8	6.2	5.4	6.3	6.0	4.3	4.7	5.7	7.4	7.0	7.2
2-Feb-06	6	8:20	5	5.3	3.6	5.5	6.0	6.7	5.6	4.3	5.7	3.7	6.2	3.7	6.6	7.2	7.0	6.5
2-Feb-06	6	8:20	2	6.0	5.5	6.2	5.2	5.9	6.9	6.0	6.4	6.3	6.1	4.6	6.0	6.3	5.7	4.6
2-Feb-06	6	8:20	4	5.8	5.1	4.9	6.0	6.3	6.0	5.9	6.4	6.0	5.3	5.9	6.0	6.9	6.0	4.1
3-Feb-06	7	7:00	1	3.5	3.5	6.4	5.7	6.4	6.3	4.6	4.7	4.7	6.4	6.9	7.6	5.8	6.7	7.2
3-Feb-06	7	7:00	2	4.0	3.8	6.0	5.7	6.2	6.8	4.5	4.8	6.3	6.5	5.9	5.9	5.6	6.0	6.8
3-Feb-06	7	7:00	3	3.8	4.5	4.8	5.4	6.4	6.3	5.6	4.3	6.0	6.6	4.7	6.3	6.0	6.4	6.1
3-Feb-06	7	7:00	4	4.4	4.8	3.6	5.6	6.2	6.4	6.3	4.8	6.2	6.5	4.9	6.3	6.1	6.7	5.8
3-Feb-06	7	7:00	5	4.5	3.8	4.5	6.0	5.7	4.5	6.8	5.6	4.9	6.6	6.1	6.4	6.5	6.6	6.2
3-Feb-06	7	7:00	6	4.2	4.2	5.5	6.3	5.9	6.1	4.7	6.1	5.6	6.2	4.8	6.6	6.3	6.7	6.2
3-Feb-06	7	7:00	7	4.1	3.9	5.2	6.0	5.7	5.3	4.5	6.4	6.3	6.4	5.1	6.5	6.6	6.7	6.3
3-Feb-06	7	7:00	8	4.2	3.9	5.7	5.8	6.0	5.3	4.0	5.9	6.1	6.3	5.0	6.4	6.1	7.0	6.3
			Average	**6.2**	**5.8**	**5.9**	**6.1**	**6.0**	**6.2**	**5.8**	**6.5**	**6.1**	**6.8**	**6.2**	**6.8**	**7.0**	**6.9**	**6.8**
			Minimum	3.5	3.5	3.6	3.5	3.3	4.1	2.5	4.1	3.0	4.3	3.7	4.4	4.5	5.4	3.7
			Maximum	8.3	8.3	8.4	8.9	8.2	8.5	8.6	8.9	9.0	8.3	8.3	9.1	8.9	8.3	8.5

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
pH

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	8.04	7.48	7.65	7.09	7.39	8.01	7.63	7.91	7.11	7.80	7.48	8.09	7.99	7.78	7.97
27-Jan-06	0	7:00	4	8.20	7.47	7.57	7.13	7.37	7.66	7.96	8.05	7.12	7.56	7.89	7.94	8.06	7.87	7.99
27-Jan-06	0	7:00	5	8.24	7.56	7.83	7.23	7.44	7.12	8.03	7.57	7.96	7.97	8.03	8.09	8.09	7.74	7.88
27-Jan-06	0	7:00	8	8.26	7.46	7.73	7.53	7.45	7.72	8.06	7.88	7.99	7.47	8.08	8.05	8.03	7.66	8.02
30-Jan-06	3	9:00	4	8.21	7.57	7.47	7.75	7.86	7.41	8.01	7.92	7.00	7.42	7.97	7.91	8.00	7.89	7.77
30-Jan-06	3	9:00	7	8.07	7.62	7.49	7.62	7.52	7.52	8.16	8.00	7.46	7.49	8.00	8.00	8.00	7.46	7.81
2-Feb-06	7	7:00	1	7.55	7.52	8.11	7.78	8.15	7.95	7.77	7.56	7.56	7.91	8.08	8.13	7.95	7.85	8.01
2-Feb-06	7	7:00	4	8.15	7.69	7.79	7.85	8.11	7.78	8.05	7.60	7.96	7.82	7.54	7.90	7.96	7.91	7.97
2-Feb-06	7	7:00	5	8.16	7.53	7.48	8.12	7.80	7.48	8.12	7.71	7.58	8.17	7.97	7.99	8.18	7.95	7.86
2-Feb-06	7	7:00	8	7.76	7.59	7.97	7.93	7.92	7.65	7.69	7.80	7.96	8.13	7.51	8.11	8.14	7.97	8.01
			Average	**8.06**	**7.55**	**7.71**	**7.60**	**7.70**	**7.63**	**7.95**	**7.80**	**7.57**	**7.77**	**7.86**	**8.02**	**8.04**	**7.81**	**7.93**
			Minimum	7.55	7.46	7.47	7.09	7.37	7.12	7.63	7.56	7.00	7.42	7.48	7.90	7.95	7.46	7.77
			Maximum	8.26	7.69	8.11	8.12	8.15	8.01	8.16	8.05	7.99	8.17	8.08	8.13	8.18	7.97	8.02

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	170	149	136	151	161	132	175	142	139	151	138	143	136	138	129
27-Jan-06	0	7:00	8	141	156	137	141	160	131	155	143	139	149	137	142	133	137	129
3-Feb-06	7	7:00	1	172	183	148	157	171	148	178	155	160	153	146	157	153	140	150
3-Feb-06	7	7:00	8	163	185	147	155	170	147	187	147	158	153	153	156	153	149	147
			Average	**161**	**168**	**142**	**151**	**166**	**139**	**173**	**147**	**149**	**151**	**143**	**150**	**144**	**141**	**139**
			Minimum	141	149	136	141	160	131	155	142	139	149	137	142	133	137	129
			Maximum	172	185	148	157	171	148	187	155	160	153	153	157	153	149	150

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Ammonia (ppm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	<0.063	<0.063	0.165	1.185	3.534	<0.063	1.711	0.121	<0.063	0.113	<0.063	<0.063	<0.063	0.089	<0.063
27-Jan-06	0	7:00	8	<0.063	<0.063	0.188	0.37	3.102	<0.063	1.015	0.132	<0.063	0.156	<0.063	<0.063	<0.063	<0.063	<0.063
3-Feb-06	7	7:00	1	2.406	1.015	0.637	1.235	2.251	0.707	3.026	0.794	0.821	0.814	0.296	0.934	0.863	0.743	0.532
3-Feb-06	7	7:00	8	1.688	1.122	0.608	1.204	2.446	0.701	3.443	0.515	0.715	0.778	0.476	0.93	0.885	0.695	0.534
			Average	**1.040**	**0.549**	**0.400**	**0.999**	**2.833**	**0.368**	**2.299**	**0.391**	**0.400**	**0.465**	**0.208**	**0.482**	**0.453**	**0.390**	**0.283**
			Minimum	<0.063	<0.063	0.165	0.370	2.251	<0.063	1.015	0.121	<0.063	0.113	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	2.406	1.122	0.637	1.235	3.534	0.707	3.443	0.794	0.821	0.814	0.476	0.934	0.885	0.743	0.534

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
DOC (ppm)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	1	2.9	5.0	3.4	4.0	8.3	4.4	4.7	2.6	10.0	3.6	3.4	3.9	4.3	4.4	5.1
27-Jan-06	0	7:00	8	3.1	4.2	3.8	4.2	6.1	5.0	2.8	2.6	5.8	3.6	3.3	3.8	7.6	4.1	6.8
3-Feb-06	7	7:00	1	4.5	2.8	2.3	2.9	2.7	4.0	4.2	2.5	5.4	2.8	2.1	2.8	2.6	2.7	3.0
3-Feb-06	7	7:00	8	3.7	2.9	3.0	4.0	2.8	3.7	4.2	2.2	4.1	2.4	3.3	2.8	2.7	2.6	2.6
			Average	**3.6**	**3.7**	**3.1**	**3.8**	**5.0**	**4.3**	**4.0**	**2.5**	**6.3**	**3.1**	**3.0**	**3.3**	**4.3**	**3.5**	**4.4**
			Minimum	2.9	2.8	2.3	2.9	2.7	3.7	2.8	2.2	4.1	2.4	2.1	2.8	2.6	2.6	2.6
			Maximum	4.5	5.0	3.8	4.2	8.3	5.0	4.7	2.6	10.0	3.6	3.4	3.9	7.6	4.4	6.8

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	3	46.0	51.6	50.0	63.6	63.6	88.8	62.0	51.6		54.4	56.8	60.8	74.0	54.8	67.2
27-Jan-06	0	7:00	7	58.4	51.6	56.4	70.8	60.4	72.8	56.4	55.6	53.6	54.0	54.8	60.4	58.4	49.6	64.0
3-Feb-06	7	7:00	3	46.4	62.8	54.8	49.6	53.2	52.0	57.6	52.4	50.0	51.6	50.8	60.4	48.8	48.4	49.6
3-Feb-06	7	7:00	7	51.2	60.8	47.2	50.0	56.8	52.0	58.8	57.2	54.4	50.8	48.8	52.0	56.0	50.0	48.4
			Average	**50.5**	**56.7**	**52.1**	**58.5**	**58.5**	**66.4**	**58.7**	**54.2**	**52.7**	**52.7**	**52.8**	**58.4**	**59.3**	**50.7**	**57.3**
			Minimum	46.0	51.6	47.2	49.6	53.2	52.0	56.4	51.6	50.0	50.8	48.8	52.0	48.8	48.4	48.4
			Maximum	58.4	62.8	56.4	70.8	63.6	88.8	62.0	57.2	54.4	54.4	56.8	60.8	74.0	54.8	67.2

Appendix Table 17. Water Chemistry Parameters fo *Pimephales promelas* Exposed to Ashland Harbor Sediments and UV Light, 27 January 2006 to 2 February 2006.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Silica Sand	Form. Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
27-Jan-06	0	7:00	2	59.2	52.4	56.8	62.0	79.6	53.6	66.4	57.6	71.6	55.2	58.8	60.4	55.2	48.0	52.8
27-Jan-06	0	7:00	6	54.4	54.8	55.6	69.6	70.0	52.4	64.8	56.4	61.2	46.4	53.6	67.2	53.2	51.6	55.2
3-Feb-06	7	7:00	2	63.2	68.0	54.8	60.8	67.2	57.6	73.2	60.4	62.0	58.4	60.0	61.2	58.0	56.4	57.2
3-Feb-06	7	7:00	6	63.6	65.2	47.2	59.6	67.2	58.4	71.6	72.0	64.4	60.0	60.4	59.6	58.8	58.4	59.2
			Average	**60.1**	**60.1**	**53.6**	**63.0**	**71.0**	**55.5**	**69.0**	**61.6**	**64.8**	**55.0**	**58.2**	**62.1**	**56.3**	**53.6**	**56.1**
			Minimum	54.4	52.4	47.2	59.6	67.2	52.4	64.8	56.4	61.2	46.4	53.6	59.6	53.2	48.0	52.8
			Maximum	63.6	68.0	56.8	69.6	79.6	58.4	73.2	72.0	71.6	60.0	60.4	67.2	58.8	58.4	59.2

APPENDIX 18

Survival and Growth of *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006

Appendix Table 18. Survival and Growth of *C. dilutus* exposed to Ashland Harbor Sediment, 10 February 2006 to 3 March 2006.

Treatment	Test Sediment	Rep	Number of Survivors (12)	Average Survival (%)	Standard Deviation	Number Weighed	Total Dry (oven)Wt (mg)	Ash Wt (mg)	Ash-Free(AF) Dry Wt (mg)	Individual AF Dry Wt (mg)	Average AF Dry Wt (mg)	Standard Deviation
A	Silica Sand	1	14			14	12.8	1.5	11.3	0.81		
A	Silica Sand	2	10			9	9.6	1	8.6	0.96		
A	Silica Sand	3	12			12	9.4	0.9	8.5	0.71		
A	Silica Sand	4	12			12	11.4	1.1	10.3	0.86		
A	Silica Sand	5	13			13	13	1.8	11.2	0.86		
A	Silica Sand	6	9			9	11.4	1.3	10.1	1.12		
A	Silica Sand	7	12			12	11.5	1.1	10.4	0.87		
A	Silica Sand	8	14	100%	18	14	10.3	1	9.3	0.66	0.86	0.14
B	Form. Sediment	1	3			3	8.2	1.7	6.5	2.17		
B	Form. Sediment	2	0			0						
B	Form. Sediment	3	2			2	6	1.1	4.9	2.45		
B	Form. Sediment	4	5			5	3.5	0.5	3	0.60		
B	Form. Sediment	5	3			1	2	0.2	1.8	1.80		
B	Form. Sediment	6	6			6	1.7	0.3	1.4	0.23		
B	Form. Sediment	7	5			4	8.9	2.1	6.8	1.70		
B	Form. Sediment	8	5	30%	20	5	10.3	2.5	7.8	1.56	1.50	0.81
C	W. Bearskin	1	11			11	17.5	3	14.5	1.32		
C	W. Bearskin	2	10			10	16.9	4.1	12.8	1.28		
C	W. Bearskin	3	12			12	18.8	4.3	14.5	1.21		
C	W. Bearskin	4	12			12	19.8	4.7	15.1	1.26		
C	W. Bearskin	5	11			9	12.7	2.3	10.4	1.16		
C	W. Bearskin	6	12			12	18.9	3.6	15.3	1.28		
C	W. Bearskin	7	12			11	16.7	3.6	13.1	1.19		
C	W. Bearskin	8	13	97%	9	12	16.8	3.4	13.4	1.12	1.23	0.07
D	SQT9	1	4			1	1.6	0.1	1.5	1.50		
D	SQT9	2	1			1	4.4	0.1	4.3	4.30		
D	SQT9	3	0			0						
D	SQT9	4	8			4	7.8	1	6.8	1.70		
D	SQT9	5	0			0						
D	SQT9	6	1			0						
D	SQT9	7	0			0						
D	SQT9	8	2	17%	28	0					2.50	1.56
E	SQT13	1	7			7	18.3	3	15.3	2.19		
E	SQT13	2	5			1	2.8	0.3	2.5	2.50		
E	SQT13	3	0			0						
E	SQT13	4	5			3	10.4	0.9	9.5	3.17		
E	SQT13	5	4			0						
E	SQT13	6	0			0						
E	SQT13	7	0			0						
E	SQT13	8	1	23%	28	1	2.2	0.3	1.9	1.90	2.44	0.54
F	SQT11	1	2			1	1.6	0.1	1.5	1.50		
F	SQT11	2	0			0						
F	SQT11	3	1			0						
F	SQT11	4	0			0						
F	SQT11	5	0			0						
F	SQT11	6	0			0						
F	SQT11	7	0			0						
F	SQT11	8	0	3%	7	0					1.50	
G	SQT14	1	1			1	4.2	0.4	3.8	3.80		
G	SQT14	2	3			1	4.4	1.2	3.2	3.20		
G	SQT14	3	6			2	5.5	0.5	5	2.50		
G	SQT14	4	2			0						
G	SQT14	5	9			8	14.8	2.2	12.6	1.58		
G	SQT14	6	1			1	2.7	0.5	2.2	2.20		
G	SQT14	7	6			1	2.4	0.2	2.2	2.20		
G	SQT14	8	1	30%	30	0					2.58	0.80
H	SQT6	1	12			12	24.2	8.9	15.3	1.28		
H	SQT6	2	11			9	15.3	3.9	11.4	1.27		
H	SQT6	3	14			12	17.4	5.2	12.2	1.02		
H	SQT6	4	11			8	14.4	3	11.4	1.43		
H	SQT6	5	12			10	16.8	4.6	12.2	1.22		
H	SQT6	6	13			13	18.9	4.1	14.8	1.14		
H	SQT6	7	9			9	16.2	4.3	11.9	1.32		
H	SQT6	8	10	96%	16	10	16.3	4.7	11.6	1.16	1.23	0.12

Treatment	Test Sediment	Rep	Number of Survivors (12)	Average Survival (%)	Standard Deviation	Number Weighed	Total Dry (oven)Wt (mg)	Ash Wt (mg)	Ash-Free(AF) Dry Wt (mg)	Individual AF Dry Wt (mg)	Average AF Dry Wt (mg)	Standard Deviation
I	SQT2	1	0			0						
I	SQT2	2	0			0						
I	SQT2	3	0			0						
I	SQT2	4	0			0						
I	SQT2	5	0			0						
I	SQT2	6	0			0						
I	SQT2	7	0			0						
I	SQT2	8	0	0%	0	0						
J	SQT7	1	0			0						
J	SQT7	2	0			0						
J	SQT7	3	1			0						
J	SQT7	4	0			0						
J	SQT7	5	3			1	3.2	0.3	2.9	2.90		
J	SQT7	6	0			0						
J	SQT7	7	0			0						
J	SQT7	8	0	4%	11	0					2.90	
K	SQT4	1	2			2	5.9	0.5	5.4	2.70		
K	SQT4	2	0			0						
K	SQT4	3	2			2	5.8	0.6	5.2	2.60		
K	SQT4	4	2			1	2.3	0.1	2.2	2.20		
K	SQT4	5	0			0						
K	SQT4	6	1			0						
K	SQT4	7	0			0						
K	SQT4	8	0	7%	10	0					2.50	0.26
L	SQT3	1	2			1	4.1	0.1	4	4.00		
L	SQT3	2	3			3	8.9	0.9	8			
L	SQT3	3	2			1	4.7	0.4	4.3	4.30		
L	SQT3	4	1			1	3.1	0.3	2.8	2.80		
L	SQT3	5	3			1	3.3	0.2	3.1			
L	SQT3	6	1			0						
L	SQT3	7	0			0						
L	SQT3	8	0	13%	12	0					3.70	0.79
M	SQT5	1	2			0						
M	SQT5	2	0			0						
M	SQT5	3	0			0						
M	SQT5	4	0			0						
M	SQT5	5	1			0						
M	SQT5	6	3			0						
M	SQT5	7	0			0						
M	SQT5	8	0	6%	12	0						
N	SQT 1	1	0			0						
N	SQT 1	2	1			0						
N	SQT 1	3	0			0						
N	SQT 1	4	0			0						
N	SQT 1	5	0			0						
N	SQT 1	6	0			0						
N	SQT 1	7	0			0						
N	SQT 1	8	0	1%	4	0						
O	SQT8	1	0			0						
O	SQT8	2	0			0						
O	SQT8	3	0			0						
O	SQT8	4	1			0						
O	SQT8	5	0			0						
O	SQT8	6	0			0						
O	SQT8	7	0			0						
O	SQT8	8	0	1%	4	0						

APPENDIX 19

Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments,
10 February 2006 to 3 March 2006

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Temperature (° C)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	1	22.9	23.7	23.3	22.8	23.0	23.2	22.9	23.0	23.1	23.2	23.4	22.8	22.8	23.1	22.9
10-Feb-06	0	7:00	2	23.0	23.5	23.4	23.3	23.1	23.4	22.9	23.0	23.4	23.2	23.3	23.0	22.8	23.2	22.9
10-Feb-06	0	7:00	3	23.1	23.6	23.4	23.0	23.1	23.1	23.1	23.0	23.4	23.1	23.3	22.9	22.9	23.2	22.9
10-Feb-06	0	7:00	4	23.0	23.6	23.4	23.1	23.2	23.1	22.9	22.9	23.4	23.2	23.2	22.9	22.8	23.2	22.9
10-Feb-06	0	7:00	5	23.0	23.6	23.4	22.9	22.9	23.2	22.9	22.9	23.5	23.3	23.2	22.9	22.8	23.1	23.0
10-Feb-06	0	7:00	6	23.0	23.7	23.4	23.0	23.0	23.6	22.9	22.9	23.3	23.4	23.2	22.9	22.9	23.3	22.9
10-Feb-06	0	7:00	7	23.0	23.6	23.4	23.0	23.0	23.0	22.9	22.9	23.4	23.2	23.2	22.8	22.9	23.2	22.8
10-Feb-06	0	7:00	8	23.0	23.6	23.3	23.0	23.0	23.2	23.0	22.9	23.3	23.4	23.2	22.8	23.0	23.2	22.9
11-Feb-06	1	9:15	4	23.1	23.7	23.5	22.9	23.2	23.5	23.0	23.0	23.6	23.4	23.4	23.1	23.0	23.7	23.0
11-Feb-06	1	9:15	6	23.0	23.8	23.6	23.1	23.2	23.6	23.0	23.1	23.5	23.5	23.6	23.1	23.0	23.4	23.2
11-Feb-06	1	18:00	4	23.1	23.7	23.6	23.4	23.4	23.3	23.3	23.0	23.6	23.5	23.4	23.1	23.1	23.8	23.4
11-Feb-06	1	18:00	8	23.1	23.7	23.6	23.3	23.3	23.6	23.3	23.1	23.7	23.6	23.4	23.3	23.3	23.7	23.3
12-Feb-06	2	9:15	4	23.1	23.5	23.6	23.0	23.0	23.7	23.3	23.2	23.6	23.5	23.4	23.1	23.0	23.9	23.0
12-Feb-06	2	9:15	5	23.1	23.7	23.6	23.6	23.1	23.8	23.1	23.1	23.7	23.5	23.6	23.1	23.0	23.7	23.0
12-Feb-06	2	18:10	2	23.1	23.7	23.7	23.2	23.2	23.4	23.0	23.2	24.0	23.8	23.6	23.1	23.1	23.9	23.3
12-Feb-06	2	18:10	4	23.2	23.8	23.7	23.3	23.3	23.6	23.3	23.2	23.8	23.6	23.5	23.2	23.2	24.0	23.2
13-Feb-06	3	9:00	4	23.1	23.7	23.5	22.9	23.0	23.2	23.2	22.8	23.5	23.4	23.2	22.9	22.9	23.6	23.0
13-Feb-06	3	9:00	7	23.0	23.7	23.4	23.0	23.0	23.5	23.1	22.9	23.6	23.3	23.4	23.0	23.0	23.5	23.0
13-Feb-06	3	15:45	3	23.2	23.8	23.4	23.3	23.2	23.6	23.1	23.0	23.5	23.5	23.3	23.1	23.1	23.4	23.1
13-Feb-06	3	15:45	4	23.3	23.9	23.4	23.3	23.3	23.6	23.2	23.0	23.6	23.5	23.3	23.1	23.1	23.6	23.1
14-Feb-06	4	9:30	1	23.0	23.7	23.5	23.1	23.0	23.5	23.0	22.9	23.3	23.4	23.4	22.8	22.9	23.3	23.1
14-Feb-06	4	9:30	4	23.0	23.8	23.3	23.0	23.0	23.3	23.0	22.9	23.5	23.3	23.4	22.9	22.9	23.5	23.2
14-Feb-06	4	16:00	3	22.4	23.2	22.9	22.6	22.4	23.0	22.4	22.4	23.0	22.9	22.7	22.7	22.6	23.0	22.8
14-Feb-06	4	16:00	4	22.5	23.1	22.8	22.6	22.4	23.1	22.5	22.4	23.0	22.9	22.9	22.5	22.6	23.2	22.8
15-Feb-06	5	9:20	4	23.2	23.6	23.4	23.4	23.3	23.5	23.5	23.2	23.0	23.2	23.3	23.4	23.0	23.5	23.0
15-Feb-06	5	9:20	6	23.2	23.6	23.5	23.4	23.3	23.3	23.4	23.3	23.3	23.3	23.3	23.4	23.1	23.3	23.1
15-Feb-06	5	15:30	4	22.5	22.9	22.7	22.7	22.5	22.2	22.7	22.5	22.8	22.8	22.9	22.5	22.9	23.0	23.4
15-Feb-06	5	15:30	8	22.5	22.9	23.8	22.9	22.7	22.4	22.7	22.7	23.0	23.0	23.0	22.8	22.9	23.0	23.4
16-Feb-06	6	8:00	4	23.6	23.4	23.3	23.5	23.3	23.5	23.5	23.0	23.3	23.3	23.3	23.0	23.1	23.6	23.1
16-Feb-06	6	8:00	5	23.3	23.4	23.2	23.4	23.3	23.4	23.3	23.2	23.2	23.4	23.3	23.1	23.2	23.6	23.2
16-Feb-06	6	15:40	2	23.0	23.0	22.7	23.1	22.9	22.9	23.0	22.8	22.8	23.0	23.2	22.8	23.0	23.1	22.5
16-Feb-06	6	15:40	4	23.0	23.1	22.8	23.1	22.9	22.9	23.0	22.8	22.9	23.0	23.1	22.8	23.0	23.2	22.5
17-Feb-06	7	6:30	4	23.2	23.4	22.8	23.2	23.2	23.0	23.2	22.8	23.0	22.8	22.8	22.8	23.0	23.2	22.8
17-Feb-06	7	6:30	7	23.2	23.4	23.0	23.3	23.2	23.0	23.2	23.0	23.1	22.9	23.0	23.0	23.0	23.3	22.8
17-Feb-06	7	15:20	3	22.6	23.0	22.4	22.7	22.6	22.9	22.7	22.5	22.9	22.4	22.7	22.7	22.6	22.9	22.1
17-Feb-06	7	15:20	4	22.7	23.1	22.5	22.7	22.7	22.8	22.7	22.3	23.1	22.8	22.8	22.6	22.7	23.1	22.2
18-Feb-06	8	7:00	4	22.6	23.1	22.6	22.8	22.6	22.6	22.8	22.2	22.5	22.5	22.6	22.4	22.5	22.5	22.2
18-Feb-06	8	7:00	6	22.6	23.0	22.6	22.9	22.5	22.8	22.5	22.2	22.5	22.5	22.6	22.3	22.5	22.6	22.2
18-Feb-06	8	18:00	4	23.1	23.3	23.0	23.0	22.9	22.6	23.0	22.8	22.9	23.0	23.0	22.9	23.0	23.1	22.7
18-Feb-06	8	18:00	8	23.1	23.3	22.9	23.2	22.9	22.9	23.2	22.9	22.9	23.0	23.0	23.0	23.0	23.1	22.6
19-Feb-06	9	8:30	4	23.2	23.2	22.8	23.2	23.2	22.6	23.1	22.9	23.1	23.0	22.9	22.7	23.1	23.1	22.7
19-Feb-06	9	8:30	7	23.1	23.3	23.0	23.3	23.1	22.8	23.3	23.0	23.1	23.1	23.0	22.9	23.3	22.8	22.9
19-Feb-06	9	16:40	1	23.3	23.6	23.3	23.5	23.5	23.2	23.4	23.4	23.4	23.5	23.3	23.3	23.5	23.5	23.0
19-Feb-06	9	16:40	4	23.4	23.7	23.4	23.6	23.5	23.3	23.5	23.4	23.5	23.5	23.4	23.2	23.4	23.6	23.1
20-Feb-06	10	8:40	4	23.3	23.7	23.4	23.6	23.5	23.5	23.4	23.3	23.3	23.5	23.4	23.3	23.3	23.5	23.1
20-Feb-06	10	8:40	5	23.4	23.6	23.3	23.6	23.5	23.4	23.5	23.5	23.4	23.5	23.4	23.3	23.4	23.3	23.1
20-Feb-06	10	15:30	2	23.5	23.5	23.4	23.5	23.4	23.5	23.5	23.5	23.5	23.5	23.5	23.2	23.4	23.5	23.5
20-Feb-06	10	15:30	4	23.5	23.6	23.4	23.6	23.4	23.3	23.4	23.3	23.6	23.4	23.5	23.2	23.4	23.7	23.5
21-Feb-06	11	8:30	4	23.5	23.6	23.4	23.4	23.3	23.4	23.2	23.3	23.3	23.3	23.4	23.2	23.2	23.4	23.3
21-Feb-06	11	8:30	7	23.5	23.6	23.3	23.5	23.2	23.3	23.3	23.1	23.4	23.2	23.3	23.2	23.0	23.4	23.3
21-Feb-06	11	15:00	3	22.8	22.9	22.9	23.0	22.9	22.8	22.8	22.7	23.0	22.7	22.7	22.7	22.8	22.7	22.7
21-Feb-06	11	15:00	4	22.8	22.9	22.9	22.9	22.8	22.8	22.9	22.8	23.1	22.8	22.8	22.7	22.8	22.9	22.7

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
22-Feb-06	12	9:10	1	23.5	23.8	23.6	23.4	23.3	23.5	23.3	23.2	23.5	23.5	23.5	23.3	23.1	23.6	23.2
22-Feb-06	12	9:10	4	23.5	23.8	23.6	23.3	23.2	23.4	23.3	23.3	23.6	23.4	23.4	23.3	23.0	23.6	23.2
22-Feb-06	12	15:30	4	23.4	23.8	23.6	23.5	23.4	23.6	23.4	23.2	23.6	23.6	23.5	23.3	23.3	23.6	23.4
22-Feb-06	12	15:30	5	23.5	23.9	23.6	23.6	23.5	23.7	23.4	23.3	23.7	23.6	23.5	23.3	23.5	23.5	23.6
23-Feb-06	13	9:00	4	23.0	23.3	23.2	23.1	23.2	23.0	23.2	23.0	23.2	23.6	23.1	23.1	23.0	23.3	23.1
23-Feb-06	13	9:00	6	23.1	23.6	23.2	23.3	23.2	23.4	23.1	23.0	23.4	23.1	23.0	23.0	23.2	23.3	23.1
23-Feb-06	13	14:30	4	22.9	23.1	22.9	23.0	23.0	22.9	23.0	22.9	23.0	22.8	23.1	22.9	22.9	23.3	22.8
23-Feb-06	13	14:30	8	23.1	23.1	23.0	23.2	23.0	22.9	23.0	22.9	23.0	23.0	23.1	23.1	23.1	23.3	23.0
24-Feb-06	14	8:00	4	23.0	23.3	23.3	23.3	23.0	23.0	23.3	23.3	23.0	23.0	23.3	23.3	23.0	23.3	23.1
24-Feb-06	14	8:00	5	23.1	23.2	23.3	23.2	23.0	23.0	23.2	23.2	23.0	23.2	23.3	23.2	23.0	23.3	23.2
24-Feb-06	14	15:30	2	23.0	23.3	22.8	23.1	22.8	23.0	23.2	23.2	23.1	23.2	23.0	22.9	23.0	23.2	22.7
24-Feb-06	14	15:30	4	23.0	23.1	22.8	23.0	23.1	23.0	23.3	23.2	23.1	23.0	23.1	23.0	22.9	23.3	22.7
25-Feb-06	15	8:50	4	23.5	23.7	23.4	23.7	23.6	23.5	23.8	23.5	23.4	23.2	23.2	23.3	23.3	23.4	23.3
25-Feb-06	15	8:50	7	23.7	23.7	23.4	23.8	23.6	23.4	23.7	23.5	23.2	23.2	23.4	23.4	23.5	23.3	23.3
25-Feb-06	15	15:15	3	23.9	23.5	23.3	23.8	23.7	23.3	23.7	23.6	23.3	23.2	23.2	23.5	23.7	23.4	23.1
25-Feb-06	15	15:15	4	23.9	23.6	23.4	23.9	23.8	23.4	23.8	23.6	23.5	23.4	23.2	23.5	23.8	23.6	23.2
26-Feb-06	16	9:00	1	23.5	23.4	23.2	23.6	23.4	23.0	23.5	23.2	23.1	22.9	23.2	23.2	23.1	23.2	22.9
26-Feb-06	16	9:00	4	23.4	23.4	23.1	23.6	23.4	23.0	23.5	23.2	23.2	23.0	23.0	23.1	23.2	23.3	22.9
26-Feb-06	16	16:00	4	23.6	23.5	23.0	23.4	23.4	23.4	23.4	23.2	23.3	22.8	22.7	23.0	23.1	23.3	23.0
26-Feb-06	16	16:00	8	23.5	23.5	23.0	23.5	23.2	22.9	23.5	23.2	23.3	23.0	22.8	23.2	23.3	23.2	23.1
27-Feb-06	17	10:00	4	23.7	23.6	23.4	23.6	23.6	23.1	23.5	23.3	23.3	23.0	23.2	23.4	23.5	23.4	23.2
27-Feb-06	17	10:00	6	23.7	23.6	23.4	23.6	23.6	23.5	23.5	23.4	23.3	23.3	23.3	23.5	23.6	23.4	23.1
27-Feb-06	17	15:30	4	23.2	23.1	23.0	23.2	23.1	22.7	23.0	22.9	23.1	23.0	22.8	22.8	23.0	23.2	22.9
27-Feb-06	17	15:30	8	23.2	23.1	22.9	23.3	23.1	23.0	23.0	22.9	22.9	23.1	22.7	23.0	23.1	23.1	23.0
28-Feb-06	18	9:00	4	23.6	23.5	23.2	23.6	23.6	23.3	24.6	23.6	23.3	23.3	23.3	23.2	23.4	23.3	23.1
28-Feb-06	18	9:00	5	24.6	23.6	23.4	23.6	23.6	23.4	23.5	24.4	23.6	23.5	23.2	23.2	23.4	23.2	23.2
28-Feb-06	18	15:00	2	23.2	22.9	22.7	23.3	23.1	22.7	23.4	22.8	23.0	22.8	22.9	23.2	22.9	23.0	22.9
28-Feb-06	18	15:00	4	23.2	22.9	22.7	23.3	23.2	22.8	23.4	22.9	23.0	22.7	22.8	23.2	22.9	23.0	22.9
1-Mar-06	19	9:10	4	23.7	23.5	23.3	23.7	23.4	23.0	23.6	23.4	23.4	23.2	23.1	23.2	23.4	23.3	23.4
1-Mar-06	19	9:10	7	23.7	23.4	23.3	23.7	23.7	23.3	23.6	23.4	23.3	23.1	23.1	23.3	23.5	23.1	23.3
1-Mar-06	19	18:00	3	23.0	22.9	22.7	23.1	23.1	22.6	23.0	23.0	22.8	22.5	22.8	23.0	22.8	22.7	22.7
1-Mar-06	19	18:00	4	23.0	23.0	22.6	23.1	23.1	22.7	23.1	23.0	23.0	22.6	22.7	22.8	22.8	22.8	22.8
2-Mar-06	20	5:45	1	23.5	23.2	23.0	23.1	23.2	23.0	23.3	23.1	23.0	22.6	22.8	22.7	23.0	22.7	23.0
2-Mar-06	20	5:45	2	23.2	23.2	23.0	23.4	23.5	23.0	23.6	23.1	23.1	22.7	22.7	22.9	23.0	22.8	23.0
2-Mar-06	20	5:45	3	23.3	23.1	23.1	23.3	23.0	23.0	23.4	23.2	22.9	22.7	22.9	22.9	22.8	22.8	23.0
2-Mar-06	20	5:45	4	23.3	23.2	23.0	23.3	23.2	23.0	23.4	23.0	23.0	22.8	23.0	23.1	22.9	23.1	23.1
2-Mar-06	20	5:45	5	23.2	23.2	23.0	23.5	23.1	23.3	23.3	23.2	23.0	22.5	22.8	23.0	23.0	22.8	23.0
2-Mar-06	20	5:45	6	23.3	23.2	22.8	23.6	23.2	22.9	23.2	23.1	23.1	22.9	22.8	23.0	23.0	22.9	23.0
2-Mar-06	20	5:45	7	23.2	23.2	22.8	23.2	23.0	22.8	23.2	23.1	23.1	22.8	22.8	23.1	23.0	22.9	23.0
2-Mar-06	20	5:45	8	23.3	23.1	23.0	23.1	23.1	22.9	23.2	23.0	22.9	22.9	23.8	23.1	23.1	23.0	23.1
			Average	**23.2**	**23.4**	**23.2**	**23.3**	**23.2**	**23.2**	**23.2**	**23.1**	**23.2**	**23.1**	**23.1**	**23.0**	**23.1**	**23.3**	**23.0**
			Minimum	22.4	22.9	22.4	22.6	22.4	22.2	22.4	22.2	22.5	22.4	22.6	22.3	22.5	22.5	22.1
			Maximum	24.6	23.9	23.8	23.9	23.8	23.8	24.6	24.4	24.0	23.8	23.8	23.5	23.8	24.0	23.6

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	1	5.9	6.5	6.4	4.8	7.3	4.8	6.1	7.6	6.2	7.9	6.2	6.4	6.1	7.6	7.8
10-Feb-06	0	7:00	2	6.1	6.6	7.0	3.6	5.9	4.2	6.3	7.7	7.0	7.9	5.1	7.0	6.1	7.5	5.4
10-Feb-06	0	7:00	3	6.3	6.8	6.6	3.6	4.8	4.8	7.0	7.6	6.8	7.4	7.1	6.0	7.9	7.6	6.0
10-Feb-06	0	7:00	4	6.5	7.0	6.9	4.3	8.0	4.8	5.9	7.7	7.0	6.2	6.2	6.1	6.4	7.3	5.5
10-Feb-06	0	7:00	5	6.6	7.1	7.2	4.2	3.9	3.1	6.2	7.5	5.5	7.1	6.1	6.2	7.0	7.2	7.2
10-Feb-06	0	7:00	6	6.7	7.1	7.4	3.9	6.5	4.2	5.6	7.7	5.0	8.3	6.0	5.1	5.7	7.1	5.8
10-Feb-06	0	7:00	7	6.9	7.2	7.5	5.2	5.6	4.7	5.6	7.8	5.1	8.5	5.1	6.5	6.8	7.1	6.3
10-Feb-06	0	7:00	8	7.1	7.8	6.8	4.5	5.5	3.4	7.1	7.9	4.4	8.4	6.2	5.4	7.4	8.3	6.4
11-Feb-06	1	9:15	4	4.0	4.6	4.8	5.0	5.1	5.2	5.7	5.5	6.4	6.2	6.5	6.0	5.7	6.2	7.4
11-Feb-06	1	9:15	6	4.6	4.3	4.8	4.7	5.0	3.7	5.4	5.8	6.1	6.0	5.7	6.2	5.5	6.2	6.8
11-Feb-06	1	18:00	4	5.0	5.4	5.8	6.5	6.0	5.1	6.2	6.2	7.0	7.2	5.3	7.2	5.7	7.2	6.9
11-Feb-06	1	18:00	8	5.0	5.4	4.6	4.9	5.6	3.7	6.1	6.3	6.6	6.0	6.2	6.3	6.9	7.3	6.4
12-Feb-06	2	9:15	4	3.0	3.8	3.5	4.5	4.7	4.4	4.6	4.4	5.1	5.3	5.3	5.0	5.2	5.2	5.4
12-Feb-06	2	9:15	5	3.1	3.6	3.7	4.3	4.5	4.9	4.7	4.4	5.0	5.0	5.3	4.7	5.2	5.2	5.7
12-Feb-06	2	18:10	2	2.5	3.0	3.5	3.9	2.5	4.3	4.6	4.1	4.5	4.5	4.0	4.5	4.8	4.9	4.0
12-Feb-06	2	18:10	4	2.6	2.8	2.9	3.9	3.5	3.3	4.0	4.1	4.5	4.6	3.9	4.4	4.5	5.3	3.9
13-Feb-06	3	9:00	4	4.5	4.3	5.0	5.0	3.8	4.2	5.1	5.1	5.2	5.0	5.0	5.1	5.1	5.2	4.7
13-Feb-06	3	9:00	7	4.3	4.4	4.5	4.6	2.4	5.0	5.2	4.6	4.7	4.6	4.3	5.0	4.9	5.4	4.4
13-Feb-06	3	15:45	3	7.0	6.9	6.1	6.8	5.0	6.9	6.7	7.0	6.9	7.2	5.5	7.3	6.8	8.2	6.4
13-Feb-06	3	15:45	4	7.0	6.1	5.6	6.9	5.9	4.4	6.7	7.0	7.3	7.3	7.3	7.2	6.9	8.5	6.5
14-Feb-06	4	9:30	1	7.8	6.0	6.4	6.3	2.3	4.2	5.0	5.6	6.5	6.4	6.1	6.2	6.1	7.8	5.1
14-Feb-06	4	9:30	4	6.0	6.1	6.2	6.6	3.5	6.0	5.2	5.6	6.2	5.8	5.7	6.5	5.6	7.9	5.7
14-Feb-06	4	16:00	3	6.4	4.6	4.4	6.6	2.9	6.0	5.5	6.1	6.3	4.0	3.6	7.2	3.8	6.6	5.8
14-Feb-06	4	16:00	4	6.3	3.7	4.4	6.4	2.8	5.8	6.5	5.1	6.9	4.8	3.4	6.6	3.8	7.3	6.9
15-Feb-06	5	9:20	4	7.8	6.6	7.3	6.6	6.7	5.6	7.6	6.2	7.6	7.6	7.9	8.1	5.2	8.0	6.9
15-Feb-06	5	9:20	6	6.4	5.9	7.4	6.6	5.9	7.3	4.9	4.8	8.1	7.8	7.8	7.9	7.4	7.7	7.1
15-Feb-06	5	15:30	4	5.8	6.4	6.4	6.9	4.0	4.8	7.1	6.1	7.9	7.0	6.8	8.8	4.9	7.8	7.1
15-Feb-06	5	15:30	8	6.6	6.3	6.6	6.9	6.3	3.8	6.2	5.1	7.1	7.4	6.3	7.6	6.0	7.3	6.5
16-Feb-06	6	8:00	4	6.6	6.7	6.6	6.6	4.9	6.5	6.5	6.1	6.8	6.6	6.7	7.3	3.6	7.3	6.4
16-Feb-06	6	8:00	5	5.9	6.3	6.8	6.9	4.4	6.2	5.4	7.0	6.4	5.7	6.9	7.9	4.0	7.6	7.0
16-Feb-06	6	15:40	2	6.9	6.6	6.1	8.1	6.3	7.2	6.3	5.5	4.4	8.0	8.5	6.6	3.1	7.2	6.0
16-Feb-06	6	15:40	4	6.4	6.7	6.9	7.9	6.9	7.3	6.8	5.4	4.7	8.0	8.1	7.3	4.6	7.5	6.3
17-Feb-06	7	6:30	4	7.6	6.1	7.5	7.3	5.0	5.0	8.3	7.2	7.7	8.0	8.2	8.4	7.8	8.5	6.6
17-Feb-06	7	6:30	7	6.0	6.7	7.7	7.8	2.9	6.6	7.0	7.1	8.5	6.4	5.7	8.1	7.3	6.7	6.9
17-Feb-06	7	15:20	3	6.5	5.0	6.8	7.6	5.9	5.6	4.7	6.4	6.2	8.1	6.4	7.1	6.3	7.5	6.5
17-Feb-06	7	15:20	4	6.0	3.8	6.3	4.7	4.9	5.0	5.3	4.4	7.1	8.1	6.7	6.9	3.5	6.8	6.0
18-Feb-06	8	7:00	4	6.8	6.9	6.2	6.8	6.0	6.1	7.4	5.8	7.5	5.9	7.1	7.0	4.2	7.6	6.8
18-Feb-06	8	7:00	6	5.3	6.4	6.1	7.1	5.4	7.4	5.4	5.2	6.6	5.3	7.3	6.9	6.9	7.6	6.3
18-Feb-06	8	18:00	4	5.9	5.6	6.6	7.4	6.7	4.0	6.4	6.5	8.4	6.3	6.3	6.4	5.8	6.4	6.5
18-Feb-06	8	18:00	8	6.5	5.6	4.3	7.3	5.4	7.2	6.3	6.9	6.3	5.1	6.2	6.5	6.5	6.6	6.1
19-Feb-06	9	8:30	4	6.6	5.6	6.7	6.2	5.0	4.2	6.6	5.7	6.8	6.5	6.4	6.3	6.1	6.7	6.5
19-Feb-06	9	8:30	7	6.6	5.9	6.4	6.5	5.4	4.0	6.9	6.0	5.9	6.9	5.6	6.6	6.7	5.9	6.6
19-Feb-06	9	16:40	1	6.1	5.7	5.4	6.1	5.6	6.8	6.9	6.5	5.6	6.0	6.8	7.0	6.6	7.0	5.6
19-Feb-06	9	16:40	4	6.7	6.7	5.9	6.4	4.9	6.4	7.2	5.7	6.2	5.9	7.0	7.2	6.8	7.4	5.9
20-Feb-06	10	8:40	4	6.4	5.7	6.2	6.0	5.2	7.0	6.3	5.5	6.7	6.1	6.8	6.9	5.8	7.1	5.9
20-Feb-06	10	8:40	5	6.2	5.1	5.4	6.2	3.0	6.4	5.2	6.4	6.1	5.3	6.0	6.2	6.4	6.0	6.3
20-Feb-06	10	15:30	2	6.7	5.2	6.5	6.4	5.6	6.3	7.2	5.2	7.1	7.2	8.0	8.0	6.6	7.0	5.3
20-Feb-06	10	15:30	4	6.3	5.4	6.6	6.2	7.1	6.5	7.2	4.9	7.6	7.2	7.9	7.3	5.9	6.8	5.6
21-Feb-06	11	8:30	4	5.4	4.8	6.5	6.7	6.9	4.4	6.7	5.4	7.1	6.6	6.7	6.9	5.3	7.4	6.2
21-Feb-06	11	8:30	7	5.2	5.8	6.9	7.1	5.7	6.7	7.1	5.5	7.0	4.8	6.6	6.8	6.0	7.0	6.5
21-Feb-06	11	15:00	3	7.4	2.6	7.0	7.1	6.4	6.7	6.7	4.9	6.6	4.2	7.4	6.8	6.9	7.7	4.8
21-Feb-06	11	15:00	4	6.9	2.4	6.7	7.0	6.5	7.0	7.2	4.4	6.8	4.6	4.4	4.4	3.9	7.4	4.5

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
22-Feb-06	12	9:10	1	7.3	3.5	6.8	6.9	6.4	6.8	6.4	6.6	6.4	6.8	6.9	7.0	6.7	7.5	5.8
22-Feb-06	12	9:10	4	7.2	1.2	7.2	6.9	2.8	4.4	4.2	6.5	6.7	6.4	6.4	7.4	5.7	7.5	5.8
22-Feb-06	12	15:30	4	6.9	6.4	6.2	7.7	2.3	3.7	4.8	7.1	6.4	6.7	5.9	7.4	4.7	8.2	6.3
22-Feb-06	12	15:30	5	7.1	5.4	6.3	7.3	3.2	3.9	4.3	7.0	6.8	6.6	5.8	5.8	5.3	7.0	6.6
23-Feb-06	13	9:00	4	9.0	7.3	6.6	6.4	1.9	2.6	3.0	5.5	7.9	7.4	8.1	7.7	7.6	7.7	6.4
23-Feb-06	13	9:00	6	6.7	5.7	7.0	7.2	2.1	7.9	2.0	5.3	7.3	7.6	7.0	5.4	7.9	7.8	7.5
23-Feb-06	13	14:30	4	7.4	6.5	6.5	6.4	4.3	5.1	5.9	6.6	6.5	7.5	6.3	6.7	4.9	7.2	6.2
23-Feb-06	13	14:30	8	7.5	6.4	6.7	6.7	3.4	6.0	6.7	5.2	5.6	7.1	5.6	7.2	7.2	7.1	7.0
24-Feb-06	14	8:00	4	7.0	6.9	7.2	6.6	4.1	5.0	6.2	6.6	6.9	7.7	6.6	6.9	4.6	7.6	6.9
24-Feb-06	14	8:00	5	7.4	7.2	7.2	6.9	3.7	4.6	6.9	5.9	6.0	7.9	6.6	6.4	7.0	7.4	7.4
24-Feb-06	14	15:30	2	7.9	7.3	6.4	7.6	5.6	4.9	6.3	6.8	6.6	7.0	4.6	4.6	3.6	7.4	3.6
24-Feb-06	14	15:30	4	7.4	2.6	6.3	8.0	7.2	5.4	5.9	7.1	6.4	7.1	6.1	4.6	4.1	7.4	3.7
25-Feb-06	15	8:50	4	7.9	5.0	7.1	7.1	6.0	3.4	3.0	6.1	7.5	7.8	4.0	8.1	6.0	7.8	5.2
25-Feb-06	15	8:50	7	7.6	5.3	7.8	8.3	4.2	7.7	5.0	5.6	4.2	8.1	4.6	7.5	7.7	7.8	7.2
25-Feb-06	15	15:15	3	8.0	6.9	7.5	7.5	7.6	7.0	6.8	6.5	7.6	8.3	7.5	7.7	6.5	7.3	7.4
25-Feb-06	15	15:15	4	7.9	6.2	7.0	7.2	7.0	5.5	5.4	6.4	7.3	7.7	6.9	7.6	6.0	7.3	7.3
26-Feb-06	16	9:00	1	7.9	4.7	6.4	6.8	7.7	7.1	6.5	5.8	7.1	7.4	7.3	8.8	8.5	7.4	7.3
26-Feb-06	16	9:00	4	8.5	5.8	6.2	7.5	8.3	6.9	3.7	2.8	8.1	8.1	6.9	8.7	8.6	8.1	7.7
26-Feb-06	16	16:00	4	7.5	4.1	6.8	7.3	7.1	6.3	3.3	5.0	6.6	7.4	6.0	7.7	5.3	7.1	6.3
26-Feb-06	16	16:00	8	7.6	1.4	6.7	7.1	6.8	6.5	1.7	4.4	2.7	7.3	3.2	7.4	6.1	7.4	7.2
27-Feb-06	17	10:00	4	7.7	4.6	7.1	7.5	7.3	6.4	5.5	5.0	7.5	8.4	7.1	7.6	5.1	7.8	7.3
27-Feb-06	17	10:00	6	7.8	4.1	6.8	7.2	6.3	7.9	5.6	4.1	6.3	8.4	5.8	7.4	4.0	7.6	7.5
27-Feb-06	17	15:30	4	7.7	3.5	6.7	4.7	7.3	6.0	6.5	3.3	8.0	6.3	4.0	6.6	4.2	7.5	5.6
27-Feb-06	17	15:30	8	7.5	2.6	6.8	5.5	7.3	7.0	3.0	3.2	4.7	6.7	3.0	7.1	6.1	6.5	6.4
28-Feb-06	18	9:00	4	7.2	7.1	6.9	7.5	7.2	6.0	6.6	4.6	6.4	7.1	7.3	7.0	3.2	8.6	8.2
28-Feb-06	18	9:00	5	6.8	5.2	6.9	6.7	6.7	6.8	4.4	4.3	7.0	6.4	6.1	7.8	4.3	6.5	8.4
28-Feb-06	18	15:00	2	8.1	3.4	7.0	7.9	7.6	2.8	7.3	4.2	3.4	7.1	7.0	7.3	2.6	7.5	5.3
28-Feb-06	18	15:00	4	8.0	2.2	6.8	7.4	7.2	4.2	6.9	6.7	6.8	4.3	5.5	6.7	2.8	7.1	6.6
1-Mar-06	19	9:10	4	8.1	5.8	6.3	7.6	7.0	5.7	7.2	5.7	7.2	7.9	8.2	8.2	3.0	8.2	7.6
1-Mar-06	19	9:10	7	7.8	3.6	6.6	7.2	6.6	7.8	7.4	5.1	6.6	7.3	5.9	6.4	5.6	7.5	8.5
1-Mar-06	19	18:00	3	7.6	4.7	6.8	6.6	7.5	6.0	7.2	7.4	8.3	6.0	5.0	8.5	7.6	6.9	6.5
1-Mar-06	19	18:00	4	7.3	2.8	6.5	5.9	7.0	4.6	7.1	6.1	7.1	5.5	5.0	7.8	4.8	7.0	5.5
2-Mar-06	20	5:45	1	7.6	5.4	7.2	8.4	7.1	7.4	7.1	6.2	7.8	6.9	6.5	7.7	7.7	7.3	6.8
2-Mar-06	20	5:45	2	7.3	5.8	7.1	8.1	7.0	7.5	6.8	6.2	7.7	7.2	5.1	8.5	3.7	7.7	6.8
2-Mar-06	20	5:45	3	6.7	4.3	6.8	8.1	7.5	6.1	7.5	6.8	7.4	7.1	5.4	8.2	6.8	8.0	7.0
2-Mar-06	20	5:45	4	6.9	6.1	7.0	6.2	7.3	6.3	7.0	5.0	7.3	7.5	6.9	8.4	3.6	8.3	7.3
2-Mar-06	20	5:45	5	5.1	3.5	7.2	7.0	7.0	6.6	7.2	5.5	7.1	5.4	6.3	8.3	4.7	6.0	7.0
2-Mar-06	20	5:45	6	4.5	4.0	5.9	7.3	7.2	6.7	6.5	4.1	7.1	7.3	6.2	7.4	4.8	6.9	7.6
2-Mar-06	20	5:45	7	5.4	6.2	6.9	7.0	7.7	6.4	6.7	4.9	7.4	7.1	6.4	7.7	5.0	6.0	7.9
2-Mar-06	20	5:45	8	7.3	3.6	6.6	7.3	7.1	6.9	6.6	4.7	6.0	7.3	6.6	7.9	6.4	6.4	7.8
			Average	**6.6**	**5.3**	**6.4**	**6.5**	**5.6**	**5.6**	**6.0**	**5.8**	**6.5**	**6.7**	**6.1**	**6.9**	**5.7**	**7.2**	**6.4**
			Minimum	2.5	1.2	2.9	3.6	1.9	2.6	1.7	2.8	2.7	4.0	3.0	4.4	2.6	4.9	3.6
			Maximum	9.0	7.8	7.8	8.4	8.3	7.9	8.3	7.9	8.5	8.5	8.5	8.8	8.6	8.6	8.5

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
pH

Date	Day	Time	Rep	Sand	ɔrm Sedime	N. Bearskir	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	1	8.26	7.59	7.60	7.20	7.91	6.86	7.76	8.01	7.24	7.88	7.54	7.77	7.65	7.82	7.80
10-Feb-06	0	7:00	4	8.27	7.43	7.59	7.37	8.01	6.61	7.82	7.93	7.58	7.25	7.63	7.71	7.40	7.82	7.24
10-Feb-06	0	7:00	5	8.28	7.73	8.06	7.17	7.43	6.81	7.79	7.86	7.58	7.93	7.53	7.96	7.46	7.91	7.80
10-Feb-06	0	7:00	8	8.28	7.98	7.71	7.40	7.53	6.65	7.92	7.90	7.09	7.33	7.39	7.31	7.78	7.68	7.56
13-Feb-06	3	9:00	4	8.19	7.64	7.47	7.95	7.72	7.22	7.28	7.99	7.67	7.89	7.58	7.98	7.83	7.97	7.80
13-Feb-06	3	9:00	7	8.09	7.80	7.64	7.77	7.48	7.94	7.41	7.62	8.00	7.77	7.62	7.91	7.91	7.90	7.96
16-Feb-06	6	8:00	4	7.86	7.53	7.38	7.35	7.34	7.21	7.47	7.30	7.39	7.39	7.47	7.65	7.38	7.46	7.68
16-Feb-06	6	8:00	5	7.57	7.57	7.38	7.41	6.95	7.52	7.58	7.32	7.46	7.42	7.55	7.72	7.45	7.37	7.74
18-Feb-06	8	7:00	4	8.48	8.11	7.79	7.90	7.80	7.65	8.16	7.65	8.08	7.68	8.13	8.05	7.59	8.19	8.00
18-Feb-06	8	7:00	6	7.74	8.02	7.76	8.02	7.91	8.17	7.78	7.55	7.77	7.59	7.97	7.98	7.86	8.15	8.10
23-Feb-06	13	9:00	4	8.33	7.92	7.98	7.98	7.42	7.24	7.50	7.66	8.13	7.96	8.09	8.05	7.93	8.22	7.87
23-Feb-06	13	9:00	6	7.98	7.76	7.93	8.82	7.44	8.15	7.45	7.52	8.10	8.01	7.81	7.77	7.20	8.22	8.13
27-Feb-06	17	10:00	4	8.44	7.38	8.04	8.10	8.17	7.65	7.80	7.53	8.10	8.07	7.99	7.89	7.55	8.19	8.07
27-Feb-06	17	10:00	6	8.41	7.33	8.08	8.07	8.02	8.12	7.77	7.45	7.77	8.18	7.64	8.06	7.64	8.06	8.02
2-Mar-06	20	5:45	1	8.12	7.56	7.92	7.84	8.05	7.69	8.06	7.67	7.91	7.41	7.75	7.72	7.71	7.73	7.81
2-Mar-06	20	5:45	4	8.07	7.52	7.91	7.70	8.11	7.81	8.08	7.50	7.99	7.50	8.06	8.05	7.34	8.10	7.91
2-Mar-06	20	5:45	5	7.60	7.29	7.94	7.96	7.93	7.77	8.05	7.51	7.80	7.43	7.58	7.99	7.43	8.55	7.90
2-Mar-06	20	5:45	8	8.07	7.34	7.61	7.91	7.94	7.83	7.99	7.40	7.60	7.97	7.61	8.03	8.05	7.64	7.98
			Average	**8.11**	**7.64**	**7.77**	**7.77**	**7.73**	**7.49**	**7.76**	**7.63**	**7.74**	**7.70**	**7.72**	**7.87**	**7.62**	**7.94**	**7.85**
			Minimum	7.57	7.29	7.38	7.17	6.95	6.61	7.28	7.30	7.09	7.25	7.39	7.31	7.20	7.37	7.24
			Maximum	8.48	8.11	8.08	8.82	8.17	8.17	8.16	8.01	8.13	8.18	8.13	8.06	8.05	8.55	8.13

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	1	175	183	157	166	189	145	175	161	166	173	158	179	157	165	150
10-Feb-06	0	7:00	8	167	169	157	166	199	150	171	158	161	170	157	160	157	160	150
16-Feb-06	6	8:00	4	150	179	149	148	164	146	159	156	152	160	155	168	151	150	147
16-Feb-06	6	8:00	5	152	179	149	148	172	147	159	157	153	157	154	161	149	155	146
23-Feb-06	13	9:00	4	156	171	146	150	173	157	175	151	155	159	158	151	152	153	154
23-Feb-06	13	9:00	6	155	180	145	150	171	153	177	151	160	157	158	153	152	153	154
2-Mar-06	20	5:45	1	146	165	139	144	149	145	147	141	150	154	149	148	147	146	144
2-Mar-06	20	5:45	8	146	180	137	145	149	145	145	141	150	147	151	146	147	145	143
			Average	**156**	**176**	**147**	**152**	**171**	**148**	**163**	**152**	**156**	**160**	**155**	**158**	**152**	**153**	**148**
			Minimum	146	165	137	144	149	145	145	141	150	147	149	146	147	145	143
			Maximum	175	183	157	166	199	157	177	161	166	173	158	179	157	165	154

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Ammonia (ppm)_

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	1	<0.063	<0.063	0.280	1.488	2.612	<0.063	1.416	0.194	<0.063	0.080	<0.063	<0.063	<0.063	<0.063	<0.063
10-Feb-06	0	7:00	8	<0.063	<0.063	0.208	1.313	6.242	0.068	0.973	0.095	<0.063	0.097	<0.063	<0.063	<0.063	<0.063	<0.063
2-Mar-06	20	5:45	1	0.322	<0.063	0.093	<0.063	0.205	0.097	<0.063	0.078	<0.063	0.280	0.105	0.064	0.269	0.118	0.132
2-Mar-06	20	5:45	8	0.307	<0.063	0.087	<0.063	0.259	0.078	<0.063	0.136	0.140	0.075	0.122	<0.063	0.257	0.180	0.089
			Average	**0.173**	<0.063	**0.167**	**0.716**	**2.330**	**0.069**	**0.613**	**0.126**	**0.059**	**0.133**	**0.073**	**0.040**	**0.147**	**0.090**	**0.071**
			Minimum	<0.063	<0.063	0.087	<0.063	0.205	<0.063	<0.063	0.078	<0.063	0.075	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	0.307	<0.063	0.280	1.488	6.242	0.097	1.416	0.194	0.140	0.280	0.122	0.064	0.269	0.180	0.132

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Sand	Form Sediment	W. Bearskin	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	2	53.2	51.2	54.8	63.6	80.8		72.0	56.0	59.8	52.0	58.8	52.0	52.8	55.6	53.2
10-Feb-06	0	7:00	6	53.6	54.2	53.2	60.8	72.0		79.6	60.4	59.8	48.8	63.6	68.8	67.6	55.2	62.0
2-Mar-06	20	5:45	2	56.4	69.2	41.2	53.2	52.8	53.2	54.8	55.2	55.6	53.2	58.8	53.6	56.0	50.8	54.4
2-Mar-06	20	5:45	6	55.6	73.2	53.6	54.0	56.0	52.8	59.6	54.8	56.0	53.2	55.6	53.2	54.0	50.0	52.0
			Average	**54.7**	**62.0**	**50.7**	**57.9**	**65.4**	**53.0**	**66.5**	**56.6**	**57.8**	**51.8**	**59.2**	**56.9**	**57.6**	**52.9**	**55.4**
			Minimum	53.2	51.2	41.2	53.2	52.8	52.8	54.8	54.8	55.6	48.8	55.6	52.0	52.8	50.0	52.0
			Maximum	56.4	73.2	54.8	63.6	80.8	53.2	79.6	60.4	59.8	53.2	63.6	68.8	67.6	55.6	62.0

Appendix Table 19. Water Chemistry Parameters for *C. dilutus* Exposed to Ashland Harbor Sediments, 10 February 2006 to 3 March 2006.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Sand	ɔrm Sedime	N. Bearskir	SQT9	SQT13	SQT11	SQT14	SQT6	SQT2	SQT7	SQT4	SQT3	SQT5	SQT1	SQT8
10-Feb-06	0	7:00	3	36.4	49.2	52.8	71.6	60.4		58.0	53.6	57.2	60.8	78.8	58.0	54.8	56.4	59.6
10-Feb-06	0	7:00	7	50.4	53.2	54.4	55.2	66.4		66.8	58.0	64.4	52.4	58.8	61.2	54.0	57.6	
2-Mar-06	20	5:45	3	50.0	70.4	44.8	50.4	52.8	49.2	54.4	50.4	54.4	55.7	54.4	51.2	52.4	48.4	49.6
2-Mar-06	20	5:45	7	51.6	63.6	47.6	52.8	56.0	58.8	55.6	51.6	53.6	50.8	56.0	56.4	50.4	46.4	56.4
			Average	**47.1**	**59.1**	**49.9**	**57.5**	**58.9**	**54.0**	**58.7**	**53.4**	**57.4**	**54.9**	**62.0**	**56.7**	**52.9**	**52.2**	**55.2**
			Minimum	36.4	49.2	44.8	50.4	52.8	49.2	54.4	50.4	53.6	50.8	54.4	51.2	50.4	46.4	49.6
			Maximum	51.6	70.4	54.4	71.6	66.4	58.8	66.8	58.0	64.4	60.8	78.8	61.2	54.8	57.6	59.6

APPENDIX 20

Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005
Temperature (° C)

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	1	23.0	23.1	22.9	23.1	23.0	22.8	23.0	22.9	22.8	23.1	23.2	22.7
12-Aug-05	0	7:30	2	24.2	24.0	24.7	24.1	24.0	24.0	23.9	23.9	23.9	24.0	23.8	24.2
12-Aug-05	0	7:30	3	23.0	23.2	22.5	23.1	22.9	23.1	23.1	22.9	23.3	23.0	22.9	23.1
12-Aug-05	0	7:30	4	24.0	24.5	24.6	24.7	24.0	24.2	23.6	24.1	24.1	23.8	23.9	24.2
12-Aug-05	0	14:20	4	23.6	23.9	24.6	23.7	23.8	24.0	23.8	24.0	23.5	23.4	23.7	24.1
13-Aug-05	1	9:45	2	22.2	22.1	22.4	21.3	21.6	22.0	22.3	22.1	21.8	22.1	21.9	22.0
13-Aug-05	1	9:45	4	22.3	21.3	22.2	21.8	21.8	21.8	22.4	22.4	22.0	21.8	21.6	20.9
13-Aug-05	1	16:15	1	20.1	20.3	19.9	20.2	19.9	20.0	19.7	20.1	21.4	20.2	20.6	20.4
13-Aug-05	1	16:15	3	20.0	20.0	20.2	20.1	20.1	20.1	20.0	19.9	20.1	20.0	20.2	20.1
14-Aug-05	2	9:00	2	22.5	22.1	21.5	21.5	21.2	22.6	21.3	21.7	22.2	21.4	21.3	22.5
14-Aug-05	2	9:00	4	22.4	22.6	23.2	22.6	21.1	21.9	21.9	22.3	21.8	21.5	21.4	21.7
14-Aug-05	2	15:50	1	22.0	21.1	21.5	22.1	21.2	22.9	21.4	21.6	22.8	21.9	21.7	21.5
14-Aug-05	2	15:50	3	21.9	21.9	21.3	22.1	22.0	21.4	21.3	21.1	21.3	21.1	21.1	21.6
15-Aug-05	3	8:10	2	23.1	22.8	22.6	22.7	22.6	23.0	22.7	22.5	22.6	22.6	22.7	22.8
15-Aug-05	3	8:10	4	22.8	23.1	23.4	22.9	22.5	22.9	22.6	22.9	22.9	22.8	22.6	22.7
15-Aug-05	3	15:25	1	22.0	21.6	22.0	21.9	21.9	22.6	21.8	22.0	21.7	22.0	22.0	22.1
15-Aug-05	3	15:25	3	22.0	22.0	21.6	21.8	21.5	22.0	22.0	21.9	22.3	21.8	21.6	21.8
16-Aug-05	4	7:45	2	23.3	23.3	23.3	23.3	22.6	23.4	23.1	23.2	22.7	23.2	23.0	22.8
16-Aug-05	4	7:45	4	23.6	23.6	24.1	23.4	22.5	23.3	23.0	22.7	23.3	23.0	23.0	22.5
16-Aug-05	4	15:10	1	22.0	21.7	21.9	22.2	22.1	22.6	21.7	21.9	21.7	22.0	22.1	21.7
16-Aug-05	4	15:10	3	22.1	22.0	21.5	21.9	21.7	2.2	21.8	21.5	222.0	21.9	21.6	21.7
17-Aug-05	5	8:15	2	23.4	22.5	23.3	23.3	23.4	23.5	23.4	23.2	23.2	23.1	23.1	23.4
17-Aug-05	5	8:15	4	23.4	23.5	24.3	23.5	23.1	23.4	23.0	23.1	22.7	23.4	23.5	23.0
17-Aug-05	5	15:25	1	23.4	22.8	22.9	23.4	23.5	23.5	23.4	23.2	23.1	23.4	23.4	22.9
17-Aug-05	5	15:25	3	23.2	23.3	22.4	23.2	23.1	23.2	23.0	22.3	23.7	22.8	22.7	23.0
18-Aug-05	6	8:00	2	23.1	22.8	23.1	22.5	22.0	23.1	22.9	22.6	22.6	22.7	22.7	23.3
18-Aug-05	6	8:00	4	22.9	23.7	23.3	22.8	22.8	23.1	22.9	22.1	23.0	22.6	22.3	22.4
18-Aug-05	6	15:45	1	22.1	21.0	21.3	21.4	21.6	21.4	21.3	21.3	21.2	21.3	21.6	21.0
18-Aug-05	6	15:45	3	21.8	21.5	21.0	21.7	22.2	21.7	21.3	20.8	21.2	21.1	21.0	20.9
19-Aug-05	7	8:30	2	22.1	22.7	21.8	22.4	22.1	22.5	22.1	22.1	21.9	22.1	22.1	22.0
19-Aug-05	7	8:30	4	22.3	22.0	23.2	22.3	22.3	22.4	21.8	21.7	22.2	22.1	22.2	22.0
19-Aug-05	7	15:40	1	23.1	22.4	22.6	22.9	22.9	23.2	22.9	22.6	22.6	22.8	22.8	22.4
19-Aug-05	7	15:40	3	22.8	22.7	22.1	22.8	22.7	22.8	22.6	22.6	23.1	22.5	22.6	22.5
20-Aug-05	8	8:30	2	22.4	22.1	21.9	22.3	22.0	22.3	22.0	22.2	21.9	22.0	22.2	22.3
20-Aug-05	8	8:30	4	22.1	22.6	23.0	22.4	22.2	22.3	21.7	22.2	22.1	22.0	22.0	21.9
20-Aug-05	8	15:45	1	22.6	22.0	22.3	22.3	22.5	22.9	22.1	22.2	21.7	22.0	2.3	21.8
20-Aug-05	8	15:45	3	22.5	22.2	21.8	2.2	22.0	22.3	22.2	22.0	22.3	22.0	21.7	21.9
21-Aug-05	9	9:00	2	22.1	22.0	21.3	21.9	21.9	22.0	21.9	21.2	21.8	22.2	21.7	22.1
21-Aug-05	9	9:00	4	21.6	22.4	22.9	22.3	21.5	21.9	21.6	22.1	22.0	21.9	21.8	22.0
21-Aug-05	9	15:30	1	22.2	21.2	23.1	21.5	21.2	21.9	23.1	21.5	21.6	21.1	21.8	21.1
21-Aug-05	9	15:30	3	21.9	21.3	20.9	21.0	21.6	21.8	21.4	21.0	20.9	21.3	21.1	21.2
22-Aug-05	10	8:30	2	21.7	21.7	21.5	21.8	21.8	21.6	21.8	20.5	21.6	21.7	21.7	21.7
22-Aug-05	10	8:30	4	21.7	21.7	22.6	21.9	21.8	21.6	21.7	21.7	21.4	21.6	21.7	21.7
22-Aug-05	10	15:10	1	22.0	21.3	21.4	22.1	21.8	22.7	21.2	21.8	21.6	21.8	22.0	21.4
22-Aug-05	10	15:10	3	22.2	21.9	21.3	21.6	21.3	21.7	21.8	21.4	22.9	21.3	21.3	21.7

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
23-Aug-05	11	8:00	2	23.3	22.6	22.6	23.2	22.6	22.9	23.3	21.0	22.2	22.7	22.9	22.4
23-Aug-05	11	8:00	4	23.3	23.7	23.2	23.2	22.9	22.6	22.2	22.3	22.4	22.5	22.4	22.8
23-Aug-05	11	14:45	1	23.5	22.1	22.4	23.0	23.2	23.4	22.7	22.5	22.2	22.8	22.9	22.2
23-Aug-05	11	14:45	3	23.2	22.8	22.0	22.7	22.4	23.2	22.4	22.1	23.0	22.2	22.1	22.3
24-Aug-05	12	8:30	2	23.1	23.1	23.6	23.4	23.0	23.3	23.0	21.8	22.7	23.0	23.2	23.1
24-Aug-05	12	8:30	4	23.1	23.1	23.9	23.4	23.0	23.4	22.8	22.8	23.0	22.9	22.9	22.9
24-Aug-05	12	15:20	1	22.6	22.5	23.1	23.6	23.5	24.1	23.3	22.5	23.2	23.4	22.7	22.8
24-Aug-05	12	15:20	3	23.6	23.1	22.5	22.9	23.2	23.1	22.2	21.6	23.2	22.5	22.4	3.2
25-Aug-06	13	8:45	2	23.6	23.4	23.0	23.5	23.4	23.7	23.4	22.1	23.1	23.1	23.3	23.4
25-Aug-06	13	8:45	4	23.4	23.6	23.4	23.3	23.4	23.5	23.5	22.9	23.3	23.3	23.3	23.0
25-Aug-06	13	15:15	1	22.7	22.6	22.7	23.1	23.0	23.3	23.0	22.3	22.4	22.7	22.4	22.3
25-Aug-06	13	15:15	3	23.4	22.8	22.0	22.6	23.0	22.8	22.0	21.2	22.8	22.3	22.0	22.2
26-Aug-05	14	8:15	2	24.1	23.7	23.6	24.0	23.8	23.9	23.7	22.4	23.4	23.7	23.9	24.0
26-Aug-05	14	8:15	4	23.9	23.7	24.5	24.0	23.9	24.0	23.4	23.9	23.7	23.6	23.7	23.6
26-Aug-05	14	15:00	1	22.7	22.7	22.9	22.7	23.0	22.9	22.7	23.0	22.7	22.6	22.4	22.9
26-Aug-05	14	15:00	3	22.9	22.5	23.0	22.5	22.9	22.6	22.9	22.5	22.9	22.9	22.7	22.7
27-Aug-05	15	9:30	2	23.4	22.7	23.0	22.7	22.8	23.0	22.9	21.4	22.5	22.7	22.9	22.9
27-Aug-05	15	9:30	4	23.3	22.3	23.6	22.5	22.9	23.2	22.4	22.9	22.6	22.9	22.6	27.7
27-Aug-05	15	15:00	1	22.5	21.0	22.7	23.2	22.8	22.9	22.4	22.1	22.1	22.6	22.3	21.8
27-Aug-05	15	15:00	3	22.7	22.4	21.4	22.8	22.2	22.4	21.6	21.6	22.5	21.0	21.1	22.2
28-Aug-05	16	9:10	2	23.4	23.8	22.9	22.8	23.0	23.1	23.0	21.5	22.6	22.6	22.9	22.8
28-Aug-05	16	9:10	4	23.4	22.4	23.7	22.2	23.0	23.3	22.5	22.9	22.7	22.7	22.8	22.8
28-Aug-05	16	15:40	1	22.5	22.5	22.1	23.3	22.8	23.4	22.0	21.9	22.1	22.4	21.9	21.8
28-Aug-05	16	15:40	3	23.1	22.1	22.1	22.8	22.5	23.5	22.2	21.8	22.7	22.0	21.8	22.4
29-Aug-05	17	8:10	2	23.2	22.4	22.6	22.9	22.6	22.8	22.6	22.5	22.6	22.5	22.6	22.6
29-Aug-05	17	8:10	4	23.1	22.0	23.2	22.4	22.6	23.0	22.0	22.7	22.3	22.4	22.5	22.6
29-Aug-05	17	15:00	1	23.2	22.6	22.7	23.3	23.1	23.5	22.7	22.9	22.7	22.9	22.8	22.7
29-Aug-05	17	15:00	3	23.3	23.0	22.1	22.7	22.8	23.0	22.7	22.3	22.8	22.5	23.3	22.6
30-Aug-05	18	8:00	2	22.5	22.1	21.2	22.0	22.3	22.5	21.8	22.1	21.9	21.6	21.7	22.0
30-Aug-05	18	8:00	4	22.2	21.9	22.2	22.2	21.7	22.2	22.3	22.2	22.1	22.1	22.0	2.2
30-Aug-05	18	15:00	1	22.0	21.4	21.4	22.2	21.9	22.3	21.0	21.4	21.4	21.7	21.4	21.4
30-Aug-05	18	15:00	3	22.4	21.7	20.7	21.5	21.4	22.0	21.6	21.1	21.4	21.3	21.1	21.2
31-Aug-05	19	9:00	2	23.0	22.6	22.4	23.0	22.9	22.7	22.8	22.1	22.7	22.7	22.8	22.6
31-Aug-05	19	9:00	4	22.9	22.8	22.6	22.8	22.8	23.1	22.6	22.3	22.4	22.8	22.8	22.6
31-Aug-05	19	15:10	1	23.3	22.2	21.9	23.2	23.4	22.7	23.0	22.6	22.9	23.1	22.8	22.0
31-Aug-05	19	15:10	3	23.4	22.7	21.8	23.0	23.1	23.3	22.6	22.1	23.0	21.8	21.8	23.0
1-Sep-05	20	7:00	2	22.4	22.5	22.5	22.5	22.7	22.4	22.7	22.0	22.0	22.4	22.4	22.1
1-Sep-05	20	7:00	4	22.6	22.4	22.4	22.6	22.9	22.7	22.8	22.9	22.2	22.6	22.1	22.4
1-Sep-05	20	15:10	1	23.0	22.2	22.2	22.9	22.7	23.1	22.5	22.1	22.1	22.7	22.4	22.4
1-Sep-05	20	15:10	3	23.1	22.6	22.0	22.7	22.4	22.9	22.3	22.1	22.4	22.3	21.8	22.4
2-Sep-05	21	7:20	2	22.3	22.2	22.5	22.5	22.5	22.5	22.1	22.0	22.2	22.3	22.3	22.1
2-Sep-05	21	7:20	4	22.7	22.2	22.4	22.4	22.4	22.2	22.3	21.6	22.1	22.3	22.2	22.4
2-Sep-05	21	15:15	1	23.0	21.9	22.3	22.9	23.0	22.5	22.2	22.2	22.6	22.8	22.4	22.2
2-Sep-05	21	15:15	3	23.2	22.4	22.1	22.5	22.5	22.7	22.1	21.8	22.6	21.9	21.6	22.1
3-Sep-05	22	9:45	2	21.7	21.7	22.4	21.5	21.9	21.6	22.0	21.5	21.9	21.3	21.2	21.7
3-Sep-05	22	9:45	4	21.1	21.5	22.3	21.6	21.3	21.7	21.6	21.8	21.5	22.1	21.9	21.5
3-Sep-05	22	16:30	1	22.8	21.9	22.1	22.8	22.8	23.0	22.2	22.0	22.3	22.6	22.2	22.1
3-Sep-05	22	16:30	3	22.9	22.5	21.8	22.3	22.4	22.7	22.0	21.8	22.4	22.0	21.6	22.3

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
4-Sep-05	23	8:45	2	23.3	22.7	22.7	23.0	22.7	23.0	22.8	22.9	22.8	22.4	22.5	22.8
4-Sep-05	23	8:45	4	23.1	22.8	21.9	23.0	22.7	23.3	22.5	22.4	22.7	22.7	22.6	22.5
4-Sep-05	23	16:20	1	22.9	22.0	22.1	21.9	22.7	22.8	22.4	22.1	22.1	22.6	22.2	22.3
4-Sep-05	23	16:20	3	22.9	22.5	23.0	22.4	22.4	22.8	22.3	21.9	22.3	22.1	21.8	22.4
6-Sep-05	24	9:00	2	23.4	22.8	22.0	23.1	22.8	23.1	22.9	22.5	22.9	22.2	22.6	23.0
6-Sep-05	24	9:00	4	23.1	22.8	22.8	23.1	22.7	23.3	23.6	23.0	22.7	22.9	22.7	22.7
6-Sep-05	24	14:45	1	23.1	23.0	22.0	22.8	23.2	23.3	22.0	22.8	22.6	22.8	22.6	22.1
6-Sep-05	24	14:45	3	23.3	22.5	21.9	22.5	22.7	22.7	22.2	23.0	22.8	21.9	21.9	22.4
6-Sep-05	25	8:00	2	23.8	23.4	22.7	23.6	23.6	23.8	23.7	23.3	23.6	22.4	23.4	23.6
6-Sep-05	25	8:00	4	23.6	23.5	23.6	23.7	23.4	23.8	23.7	23.6	23.5	23.5	23.6	23.5
6-Sep-05	25	16:05	1	24.2	23.1	23.6	24.1	24.2	24.5	24.2	23.5	24.0	24.1	23.9	23.7
6-Sep-05	25	16:05	3	24.1	23.1	23.6	24.1	24.2	24.1	23.9	23.5	24.3	23.5	23.3	24.1
7-Sep-05	26	8:15	2	23.8	21.6	22.4	23.4	23.1	23.4	23.2	22.9	23.1	22.4	22.8	23.1
7-Sep-05	26	8:15	4	23.4	22.9	23.2	23.3	23.0	23.5	22.9	23.2	22.8	23.1	23.1	23.0
7-Sep-05	26	15:00	1	23.5	21.6	22.4	23.1	23.3	23.8	23.0	22.0	22.8	23.0	22.5	22.4
7-Sep-05	26	15:00	3	23.2	22.9	22.3	23.0	23.0	23.3	22.7	22.1	23.2	21.8	21.7	23.0
8-Sep-05	27	8:00	2	22.8	22.8	22.2	23.0	22.8	23.3	23.1	21.9	22.7	22.1	22.5	22.9
8-Sep-05	27	8:00	4	22.7	23.0	23.1	23.0	22.7	23.3	22.7	22.9	22.8	22.8	22.9	22.7
8-Sep-05	27	14:30	1	22.3	22.1	21.5	22.5	22.6	22.9	21.9	22.3	22.0	22.3	21.8	21.6
8-Sep-05	27	14:30	3	23.1	20.8	21.5	22.1	22.1	22.7	22.2	21.5	22.2	21.0	21.0	22.3
9-Sep-05	28	6:00	1	22.3	22.1	21.7	21.8	21.7	22.0	21.1	21.1	20.9	21.2	20.8	20.6
9-Sep-05	28	6:00	2	23.1	22.7	21.7	22.6	22.6	22.0	22.3	21.7	22.0	21.6	21.7	22.1
9-Sep-05	28	6:00	3	22.2	21.3	20.7	21.5	21.5	21.9	21.0	20.5	21.1	20.1	20.0	21.3
9-Sep-05	28	6:00	4	22.9	22.7	22.6	22.5	22.2	22.9	22.3	22.2	22.1	22.1	22.0	22.1
			Average	**22.8**	**22.4**	**22.4**	**22.5**	**22.5**	**22.6**	**22.4**	**22.2**	**24.2**	**22.3**	**22.1**	**22.1**
			Minimum	20.0	20.0	19.9	2.2	19.9	2.2	19.7	19.9	20.1	20.0	2.3	2.2
			Maximum	24.2	24.5	24.7	24.7	24.2	24.5	24.2	24.1	222.0	24.1	23.9	27.7

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
Dissolved Oxygen (mg/L)

Date	Day	Time	Rep	Form Sed	W. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	1	7.0	5.4	0.7	0.6	0.7	0.5	6.1	0.6	0.7	3.1	3.3	0.9
12-Aug-05	0	7:30	2	6.8	5.0	0.4	0.7	0.7	0.6	5.7	4.1	3.4	1.9	3.2	1.9
12-Aug-05	0	7:30	3	6.9	5.7	0.5	0.6	0.9	0.6	5.2	0.9	1.6	1.3	4.0	2.4
12-Aug-05	0	7:30	4	7.2	5.8	0.6	0.9	0.6	0.6	5.8	1.2	4.5	1.2	3.5	0.6
12-Aug-05	0	14:20	4	6.4	5.9	1.0	0.5	0.8	0.9	5.5	2.5	5.0	2.0	5.0	0.7
13-Aug-05	1	9:45	2	6.1	5.3	2.5	1.3	0.8	0.9	5.8	3.9	3.6	2.1	4.5	2.0
13-Aug-05	1	9:45	4	5.7	5.5	2.7	0.5	1.5	0.9	5.2	2.0	5.1	1.0	4.9	3.1
13-Aug-05	1	16:15	1	6.2	5.7	4.1	2.6	4.4	1.7	5.9	3.6	5.6	4.8	5.2	4.9
13-Aug-05	1	16:15	3	5.6	6.0	3.0	3.4	1.9	1.9	5.0	4.1	5.3	3.9	4.6	4.9
14-Aug-05	2	9:00	2	5.8	5.8	3.5	0.6	0.9	2.7	5.1	4.5	4.5	4.9	4.8	5.4
14-Aug-05	2	9:00	4	5.6	5.1	2.3	0.5	2.6	2.5	5.1	3.5	4.3	47.0	4.9	4.9
14-Aug-05	2	15:50	1	5.6	5.6	3.4	1.8	5.4	2.5	5.8	3.8	4.4	4.2	4.3	4.6
14-Aug-05	2	15:50	3	4.8	5.5	3.3	1.6	4.1	3.7	5.1	4.1	4.4	3.7	4.9	5.3
15-Aug-05	3	8:10	2	4.7	5.3	3.6	0.6	3.2	2.7	4.5	4.9	3.9	4.3	3.1	4.6
15-Aug-05	3	8:10	4	6.0	5.4	3.3	0.5	1.5	1.4	4.2	3.6	4.1	3.5	3.4	4.1
15-Aug-05	3	15:25	1	5.1	5.9	3.6	2.1	4.3	2.3	5.2	3.8	3.4	3.7	3.8	4.4
15-Aug-05	3	15:25	3	5.4	5.7	3.1	2.1	4.7	2.8	4.7	3.8	3.9	3.4	4.6	4.7
16-Aug-05	4	7:45	2	7.2	7.9	7.3	6.8	7.5	7.4	8.0	4.6	7.7	7.4	7.5	8.1
16-Aug-05	4	7:45	4	5.8	7.8	7.6	7.7	7.8	7.6	8.0	7.8	7.0	7.8	7.8	5.5
16-Aug-05	4	15:10	1	7.1	7.7	7.6	7.5	7.3	7.3	7.2	7.1	7.5	7.4	6.8	7.6
16-Aug-05	4	15:10	3	7.5	7.8	7.5	7.0	7.5	4.0	7.5	7.3	5.2	7.0	7.4	7.6
17-Aug-05	5	8:15	2	6.9	7.4	7.4	6.0	7.3	6.8	7.3	5.7	7.2	7.5	7.2	5.7
17-Aug-05	5	8:15	4	4.9	7.4	6.9	6.7	7.0	6.8	5.4	7.2	7.2	7.3	7.2	7.3
17-Aug-05	5	15:25	1	6.2	5.8	6.8	6.2	6.9	5.9	6.7	6.2	6.9	6.8	6.5	7.0
17-Aug-05	5	15:25	3	7.0	7.1	6.9	6.7	7.1	6.9	6.9	6.8	6.6	6.5	7.1	7.0
18-Aug-05	6	8:00	2	7.1	6.9	6.0	7.4	8.2	7.8	7.9	6.6	7.7	8.3	7.3	4.6
18-Aug-05	6	8:00	4	4.3	7.1	6.9	5.8	6.1	7.2	8.0	8.0	8.2	8.0	7.9	7.7
18-Aug-05	6	15:45	1	7.0	8.4	8.1	7.9	8.2	7.7	7.8	7.9	8.5	8.0	7.5	8.1
18-Aug-05	6	15:45	3	8.4	8.6	8.0	7.5	8.0	7.3	7.7	8.0	7.6	6.9	4.9	8.2
19-Aug-05	7	8:30	2	7.4	7.5	7.7	0.8	7.6	7.6	7.9	6.4	7.7	7.9	7.4	7.7
19-Aug-05	7	8:30	4	2.2	8.0	7.7	7.5	7.8	7.3	8.0	7.9	7.4	7.6	7.7	8.0
19-Aug-05	7	15:40	1	6.4	7.5	7.2	7.1	7.2	7.0	7.5	7.1	7.3	7.2	6.8	7.4
19-Aug-05	7	15:40	3	7.4	7.6	7.3	7.1	7.4	7.3	7.3	5.7	6.8	6.4	6.7	6.9
20-Aug-05	8	8:30	2	7.4	7.5	7.7	6.8	8.2	7.4	7.9	7.4	7.9	7.8	7.7	7.7
20-Aug-05	8	8:30	4	7.6	7.8	7.3	7.7	7.6	7.5	7.8	6.3	7.7	7.9	7.7	8.5
20-Aug-05	8	15:45	1	5.4	7.7	7.3	7.2	7.5	5.6	7.7	6.0	8.0	8.2	7.6	7.8
20-Aug-05	8	15:45	3	7.6	8.1	7.4	7.4	7.7	7.4	7.5	7.3	7.4	6.0	7.8	8.0
21-Aug-05	9	9:00	2	7.4	7.9	8.0	7.5	8.0	8.2	8.2	7.7	7.9	8.0	7.6	8.5
21-Aug-05	9	9:00	4	7.8	7.9	7.9	7.4	7.5	8.1	8.2	7.8	7.5	7.8	8.4	4.4
21-Aug-05	9	15:30	1	5.0	7.9	7.6	7.4	7.7	7.6	7.8	6.2	7.6	7.8	7.4	7.8
21-Aug-05	9	15:30	3	7.7	7.8	7.6	7.5	7.7	7.7	7.6	7.7	7.2	4.2	7.8	7.9

Date	Day	Time	Rep	Form Sed	W. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
22-Aug-05	10	8:30	2	7.4	8.1	8.1	7.5	8.0	8.0	7.6	7.5	7.5	7.8	7.6	8.2
22-Aug-05	10	8:30	4	7.8	8.2	7.5	7.6	7.5	7.8	5.8	8.0	7.8	7.8	7.9	6.1
22-Aug-05	10	15:10	1	5.6	8.0	7.7	8.0	7.7	8.3	7.7	7.5	8.1	7.7	7.3	8.4
22-Aug-05	10	15:10	3	7.3	7.7	7.7	8.0	8.1	7.8	8.4	7.5	6.2	7.7	7.7	7.7
23-Aug-05	11	8:00	2	7.3	8.2	7.8	8.0	8.7	8.3	8.5	8.3	7.6	8.5	7.5	8.4
23-Aug-05	11	8:00	4	6.6	8.4	7.9	7.7	8.0	8.6	8.1	8.3	8.0	8.5	8.1	8.7
23-Aug-05	11	14:45	1	4.7	7.5	8.0	7.1	7.3	8.4	7.6	7.6	8.4	7.7	7.8	7.3
23-Aug-05	11	14:45	3	6.6	6.4	7.5	7.5	7.5	7.8	7.8	7.8	7.0	7.6	6.1	7.7
24-Aug-05	12	8:30	2	7.2	7.6	7.5	7.7	8.0	8.6	8.0	7.7	7.6	7.5	7.7	7.8
24-Aug-05	12	8:30	4	1.5	7.8	7.7	7.3	8.1	7.8	8.3	7.8	7.6	7.9	7.9	7.7
24-Aug-05	12	15:20	1	7.1	7.7	7.5	2.9	7.3	7.0	7.3	7.3	7.3	7.4	7.4	7.6
24-Aug-05	12	15:20	3	6.7	7.6	7.7	7.8	7.4	7.6	7.6	7.5	7.3	7.4	7.6	7.1
25-Aug-06	13	8:45	2	7.2	7.0	7.5	7.3	7.1	7.8	7.3	7.3	7.3	7.5	7.3	7.6
25-Aug-06	13	8:45	4	5.4	7.4	7.4	7.3	7.0	7.6	7.9	7.9	7.1	7.9	7.1	7.6
25-Aug-06	13	15:15	1	7.1	7.4	7.7	7.6	7.9	7.5	8.2	7.3	8.5	7.7	8.2	8.4
25-Aug-06	13	15:15	3	6.4	8.3	7.8	8.1	7.6	8.1	8.3	7.5	8.1	7.5	8.5	8.4
26-Aug-05	14	8:15	2	6.9	7.1	7.2	7.0	7.5	7.6	7.6	7.6	7.3	7.2	6.9	6.9
26-Aug-05	14	8:15	4	7.0	7.3	7.1	6.9	7.4	7.4	7.7	7.2	7.5	7.4	7.4	7.4
26-Aug-05	14	15:00	1	7.3	7.0	7.0	7.0	6.8	7.5	7.4	7.5	6.8	8.4	6.8	8.0
26-Aug-05	14	15:00	3	7.6	6.9	6.7	7.4	7.6	8.3	7.0	6.9	7.4	8.0	7.4	6.7
27-Aug-05	15	9:30	2	6.9	7.2	7.4	7.1	7.4	8.1	7.7	7.7	7.1	7.3	7.0	5.7
27-Aug-05	15	9:30	4	7.1	7.5	6.9	7.2	7.3	7.4	8.0	7.6	7.0	7.2	7.9	7.3
27-Aug-05	15	15:00	1	6.9	7.9	8.0	7.7	8.9	6.5	7.9	7.1	7.8	7.5	7.4	8.1
27-Aug-05	15	15:00	3	7.4	7.8	7.9	8.0	7.7	7.4	8.0	7.5	7.4	7.5	7.9	7.8
28-Aug-05	16	9:10	2	7.0	7.3	7.4	7.0	7.4	7.4	7.8	7.8	7.7	7.6	8.0	6.2
28-Aug-05	16	9:10	4	7.0	7.5	7.1	7.0	7.5	7.4	7.8	7.3	7.2	7.9	8.0	7.8
28-Aug-05	16	15:40	1	7.5	7.9	7.8	7.5	7.7	7.4	7.5	6.7	8.3	7.5	7.6	7.8
28-Aug-05	16	15:40	3	7.5	7.5	7.8	7.7	7.4	7.6	7.6	7.6	7.9	7.3	7.8	7.4
29-Aug-05	17	8:10	2	7.1	7.7	8.2	8.0	8.2	8.1	8.2	8.1	7.1	8.3	8.1	7.8
29-Aug-05	17	8:10	4	7.3	7.8	7.9	7.8	7.8	8.0	8.1	8.2	7.9	8.3	8.2	8.1
29-Aug-05	17	15:00	1	6.8	7.7	7.8	7.0	8.0	8.2	7.8	6.9	8.0	8.3	8.2	7.7
29-Aug-05	17	15:00	3	7.0	8.0	8.0	7.6	8.2	8.0	7.8	7.5	7.9	7.7	7.8	7.5
30-Aug-05	18	8:00	2	7.3	7.5	7.5	7.5	7.6	7.7	7.8	6.7	7.5	8.0	8.0	5.5
30-Aug-05	18	8:00	4	1.4	7.6	7.4	7.1	7.7	7.8	7.6	7.7	7.3	8.1	8.0	7.9
30-Aug-05	18	15:00	1	6.8	7.7	7.8	7.7	8.2	8.1	8.0	7.2	7.9	8.2	8.2	7.8
30-Aug-05	18	15:00	3	6.9	7.5	8.0	8.1	8.1	8.1	8.0	7.7	7.9	7.9	8.0	7.8
31-Aug-05	19	9:00	2	6.9	7.3	7.6	6.7	7.5	8.1	8.1	7.8	6.9	7.4	7.6	7.5
31-Aug-05	19	9:00	4	7.2	7.1	7.1	7.3	7.5	7.3	8.2	7.2	7.6	7.6	7.9	8.0
31-Aug-05	19	15:10	1	6.0	7.6	7.8	7.4	7.4	8.0	7.8	7.3	8.0	7.9	7.2	7.9
31-Aug-05	19	15:10	3	6.6	7.8	7.9	8.0	7.5	7.3	7.4	7.3	7.8	7.6	7.5	8.1
1-Sep-05	20	7:00	2	7.3	7.4	5.5	6.7	8.0	7.1	8.0	7.0	7.7	7.6	7.8	7.2
1-Sep-05	20	7:00	4	6.9	7.0	7.3	6.9	7.6	7.6	7.7	7.0	7.9	7.2	7.9	7.6
1-Sep-05	20	15:10	1	5.9	6.9	8.1	7.1	8.0	8.1	7.6	6.5	7.8	8.2	7.5	8.1
1-Sep-05	20	15:10	3	6.7	7.8	7.7	7.6	7.7	7.6	7.8	7.3	8.0	7.4	7.8	8.0
2-Sep-05	21	7:20	2	7.2	7.6	4.8	6.6	7.4	7.2	7.6	7.3	7.0	7.5	7.4	7.6

Date	Day	Time	Rep	Form Sed	W. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
2-Sep-05	21	7:20	4	7.0	7.6	7.3	7.3	7.5	7.6	7.8	7.6	7.4	7.2	7.5	7.5
2-Sep-05	21	15:15	1	6.3	7.5	7.9	7.5	7.5	6.1	7.7	6.8	7.5	7.4	6.7	8.0
2-Sep-05	21	15:15	3	6.6	7.5	8.0	7.4	7.5	7.4	7.8	7.8	7.4	7.5	7.8	7.2
3-Sep-05	22	9:45	2	7.4	7.6	7.9	7.0	7.7	7.8	7.6	7.6	7.3	7.7	7.2	7.7
3-Sep-05	22	9:45	4	7.5	7.8	7.5	7.5	7.0	7.5	8.0	7.7	7.1	7.3	7.6	7.7
3-Sep-05	22	16:30	1	5.8	7.1	7.4	6.7	7.3	6.1	7.7	7.2	8.3	7.9	7.1	8.0
3-Sep-05	22	16:30	3	7.0	7.8	7.6	7.4	7.6	7.5	7.7	7.6	8.3	7.8	7.8	7.5
4-Sep-05	23	8:45	2	7.0	7.5	7.3	6.6	7.5	8.2	7.8	7.7	7.0	5.1	7.4	8.1
4-Sep-05	23	8:45	4	7.1	7.7	7.8	8.0	7.7	7.4	7.7	7.7	7.7	8.2	7.4	7.8
4-Sep-05	23	16:20	1	5.7	7.6	7.8	7.9	7.0	7.8	7.7	6.5	7.8	7.3	7.0	7.5
4-Sep-05	23	16:20	3	7.0	7.6	7.0	7.5	7.7	7.8	7.8	7.5	7.8	7.8	7.6	7.1
6-Sep-05	24	9:00	2	7.6	7.8	7.8	6.4	7.8	7.8	7.8	7.5	7.2	8.0	7.2	7.4
6-Sep-05	24	9:00	4	7.3	7.5	7.1	7.1	7.4	7.3	7.9	7.4	8.0	7.9	7.5	7.6
6-Sep-05	24	14:45	1	7.0	7.4	8.0	7.6	8.0	7.9	7.2	8.2	7.2	8.0	7.3	8.0
6-Sep-05	24	14:45	3	7.5	7.8	8.1	7.5	8.0	7.4	7.6	7.1	8.4	7.7	7.6	8.0
6-Sep-05	25	8:00	2	7.4	7.9	8.1	6.9	7.9	7.7	8.0	7.5	6.7	7.5	7.4	7.2
6-Sep-05	25	8:00	4	7.5	7.6	7.7	7.5	7.7	7.6	8.1	7.2	7.2	7.9	7.4	7.8
6-Sep-05	25	16:05	1	6.0	7.2	6.9	6.8	6.5	7.1	7.3	6.7	7.0	7.0	7.2	6.7
6-Sep-05	25	16:05	3	6.8	7.1	7.1	7.1	6.8	7.3	7.2	6.1	6.8	7.3	7.4	6.8
7-Sep-05	26	8:15	2	7.5	7.7	8.0	6.8	7.4	7.8	7.5	7.4	6.9	8.0	7.3	7.8
7-Sep-05	26	8:15	4	7.2	7.7	7.5	6.5	7.0	7.2	7.5	7.3	7.5	7.2	7.6	8.0
7-Sep-05	26	15:00	1	6.1	7.5	7.9	7.1	7.3	7.1	7.1	7.0	7.2	7.2	7.6	7.9
7-Sep-05	26	15:00	3	6.5	7.7	7.8	7.2	7.2	7.3	7.4	7.0	6.9	7.2	7.6	7.0
8-Sep-05	27	8:00	2	7.1	7.5	7.4	7.1	8.1	7.3	7.6	7.5	7.3	8.1	7.8	7.4
8-Sep-05	27	8:00	4	7.0	7.2	7.1	7.0	7.5	7.2	7.6	8.1	7.5	7.9	7.7	8.0
8-Sep-05	27	14:30	1	6.5	7.3	7.5	6.3	7.0	7.5	7.6	7.0	7.7	7.8	7.6	7.3
8-Sep-05	27	14:30	3	6.5	7.2	7.2	7.8	6.8	7.4	7.2	4.3	7.9	7.9	5.0	7.6
9-Sep-05	28	6:00	1	6.7	8.0	7.9	5.3	7.0	7.1	6.9	7.5	7.5	7.3	6.7	7.5
9-Sep-05	28	6:00	2	6.7	7.2	7.4	6.7	6.7	7.6	7.1	7.0	7.2	7.1	7.0	7.3
9-Sep-05	28	6:00	3	7.2	7.8	7.8	7.5	7.4	7.4	7.2	7.6	7.5	7.5	7.9	7.4
9-Sep-05	28	6:00	4	7.0	7.1	7.3	7.1	6.8	7.0	7.6	7.0	7.8	7.5	7.7	7.5
			Average	**6.6**	**7.3**	**6.8**	**6.3**	**6.8**	**6.7**	**7.3**	**6.7**	**7.0**	**7.3**	**7.0**	**6.9**
			Minimum	1.4	5.0	0.4	0.5	0.6	0.5	4.2	0.6	0.7	1.0	3.1	0.6
			Maximum	8.4	8.6	8.2	8.1	8.9	8.6	8.5	8.3	8.5	47.0	8.5	8.7

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
pH

Date	Day	Time	Rep	Form Sed	W. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	4	6.73	7.39	7.21	7.12	7.18	7.28	7.58	7.03	7.26	7.16	7.21	6.84
15-Aug-05	3	8:10	4	7.43	7.28	7.23	7.72	6.90	7.22	7.37	7.19	7.32	7.33	7.31	7.28
18-Aug-05	6	8:00	1	7.86	7.98	7.90	8.02	7.92	8.05	7.97	7.81	7.94	8.01	7.96	8.01
20-Aug-05	8	8:30	2	8.03	8.03	8.02	8.23	8.00	8.02	8.09	7.59	7.82	7.99	7.91	7.98
22-Aug-05	10	8:30	3	8.10	8.05	7.93	8.05	7.99	8.21	8.06	7.91	7.74	8.04	7.54	7.86
25-Aug-06	13	8:45	4	8.18	8.09	7.99	8.00	7.97	8.19	8.07	7.96	7.69	8.00	7.60	7.89
27-Aug-05	15	9:30	1	8.01	7.92	7.94	8.04	7.89	7.85	7.99	7.79	8.08	8.07	8.04	8.07
29-Aug-05	17	8:10	2	8.05	8.04	8.00	8.15	7.97	8.11	8.14	7.99	8.08	8.05	8.03	7.73
1-Sep-05	20	7:00	3	7.94	8.00	8.05	7.99	7.88	8.08	8.12	8.11	8.06	8.09	8.18	8.01
3-Sep-05	22	9:45	4	8.08	7.98	7.94	8.21	7.75	8.08	8.18	8.02	8.01	8.05	8.10	8.07
9-Sep-05	28	6:00	4	7.94	7.73	7.80	7.87	7.64	7.98	8.00	7.92	8.00	8.08	8.20	8.00
			Average	**7.9**	**7.9**	**7.8**	**7.9**	**7.7**	**7.9**	**8.0**	**7.8**	**7.8**	**7.9**	**7.8**	**7.8**
			Minimum	6.7	7.3	7.2	7.1	6.9	7.2	7.4	7.0	7.3	7.2	7.2	6.8
			Maximum	8.2	8.1	8.1	8.2	8.0	8.2	8.2	8.1	8.1	8.1	8.2	8.1

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
Conductivity (µmhos/cm)

Date	Day	Time	Rep	Form Sed	N. Bearskir	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	4	187	119	152	398	102	147	117	113	119	206	120	98
18-Aug-05	6	8:00	1	175	110	108	125	104	272	123	122	114	114	115	108
25-Aug-06	13	8:45	4	120	110	110	127	107	181	124	121	113	118	117	113
1-Sep-05	20	7:00	3	151	116	121	143	89	145	119	124	109	135	126	117
9-Sep-05	28	6:00	4	149	109	114	147	107	127	126	119	148	168	142	129
			Average	**156**	**113**	**121**	**188**	**102**	**174**	**122**	**120**	**121**	**148**	**124**	**113**
			Minimum	120	109	108	125	89	127	117	113	109	114	115	98
			Maximum	187	119	152	398	107	272	126	124	148	206	142	129

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
Ammonia (ppm)

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	1	0.157	0.588	0.297	8.561	<0.063	3.294	0.311	<0.063	<0.063	<0.063	<0.063	<0.063
9-Sep-05	28	6:00	1	<0.063	0.111	0.096	0.172	<0.063	<0.063	0.114	<0.063	0.078	0.072	<0.063	<0.063
			Average	0.094	0.350	0.197	4.367	<0.063	1.663	0.213	<0.063	0.055	0.052	<0.063	<0.063
			Minimum	<0.063	0.111	0.096	0.172	<0.063	<0.063	0.114	<0.063	<0.063	<0.063	<0.063	<0.063
			Maximum	0.157	0.588	0.297	8.561	<0.063	3.294	0.311	<0.063	0.078	0.072	<0.063	<0.063

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
Hardness (mg/L as CaCO3)

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	3	32.4	46.4	65.6	98.8		58.4	52.4					
9-Sep-05	28	6:00	3	71.6	42	45.2	54.8	36.4	55.6	46	48.8	48.4	56.4	53.6	45.6
			Average	52.0	44.2	55.4	76.8	36.4	57.0	49.2	48.8	48.4	56.4	53.6	45.6
			Minimum	32.4	42.0	45.2	54.8	36.4	55.6	46.0	48.8	48.4	56.4	53.6	45.6
			Maximum	71.6	46.4	65.6	98.8	36.4	58.4	52.4	48.8	48.4	56.4	53.6	45.6

Appendix Table 20. Water Chemistry Parameters for *Lumbriculus variegatus* Exposed to Ashland Harbor Sediments, 12 August 2005.
Alkalinity (mg/L as CaCO3)

Date	Day	Time	Rep	Form Sed	W. Bearskin	SQT9	SQT10	SQT11	SQT12	SQT6	SQT2	SQT4	SQT3	SQT5	SQT8
12-Aug-05	0	7:30	2	38.4	42	62	75.6		63.2	54	56.4	55.2	65.6	78.8	52.4
9-Sep-05	28	6:00	2	73.2	46	55.2	54	47.6	54.4	55.6	52.4	60.4	54.8	95.6	50
			Average	55.8	44.0	58.6	64.8	47.6	58.8	54.8	54.4	57.8	60.2	87.2	51.2
			Minimum	38.4	42.0	55.2	54.0	47.6	54.4	54.0	52.4	55.2	54.8	78.8	50.0
			Maximum	73.2	46.0	62.0	75.6	47.6	63.2	55.6	56.4	60.4	65.6	95.6	52.4

APPENDIX 21

Water Chemistry Parameters for Equilibrium Study

Appendix Table 21. Water Chemistry Parameters for Equilibrium Study
Temperature (° C)

Date	Day	Time	Rep	SQT7	SQT8
2-Aug-05	0	8:00	1	23.5	23.6
2-Aug-05	0	8:00	2	23.6	23.7
2-Aug-05	0	8:00	3	23.6	23.7
2-Aug-05	0	8:00	4	23.7	23.7
2-Aug-05	0	8:00	5	23.6	23.7
2-Aug-05	0	8:00	6	23.7	23.7
2-Aug-05	0	8:00	7	23.7	23.6
2-Aug-05	0	8:00	8	23.7	23.6
2-Aug-05	0	16:45	1	23.8	23.9
2-Aug-05	0	16:45	4	23.9	23.9
3-Aug-05	1	8:30	4	23.6	23.6
3-Aug-05	1	8:30	6	23.6	23.7
3-Aug-05	1	15:10	4	23.9	24.0
3-Aug-05	1	15:10	8	23.9	24.0
4-Aug-05	2	8:45	4	23.3	23.3
4-Aug-05	2	8:45	5	23.3	23.1
4-Aug-05	2	15:00	2	23.1	23.1
4-Aug-05	2	15:00	4	23.1	23.1
5-Aug-05	3	8:00	4	19.7	19.8
5-Aug-05	3	8:00	7	19.8	19.7
5-Aug-05	3	15:00	3	22.4	22.4
5-Aug-05	3	15:00	4	22.4	22.5
6-Aug-05	4	9:00	1	23.8	23.9
6-Aug-05	4	9:00	4	23.8	23.9
7-Aug-05	5	7:45	4	23.4	23.4
7-Aug-05	5	7:45	6	23.5	23.4
7-Aug-05	5	15:15	4	23.9	23.9
7-Aug-05	5	15:15	8	23.9	23.9
8-Aug-05	6	9:00	4	23.6	23.7
8-Aug-05	6	9:00	5	23.6	23.6
8-Aug-05	6	15:45	2	23.7	23.7
8-Aug-05	6	15:45	4	23.7	23.7
9-Aug-05	7	9:00	4	23.4	23.4
9-Aug-05	7	9:00	7	23.3	23.5
9-Aug-05	7	14:45	3	24.0	24.1
9-Aug-05	7	14:45	4	24.0	24.0
10-Aug-05	8	7:45	4	23.1	23.1
10-Aug-05	8	7:45	6	23.1	23.1
10-Aug-05	8	15:20	4	23.4	23.5
10-Aug-05	8	15:20	8	23.4	23.5
11-Aug-05	9	6:00	4	21.7	21.7
11-Aug-05	9	6:00	7	21.7	21.8
12-Aug-05	10	6:25	4	23.3	23.3
12-Aug-05	10	6:25	5	23.2	23.4
12-Aug-05	10	14:00	2	22.8	23.2
12-Aug-05	10	14:00	4	22.9	23.2
13-Aug-05	11	9:00	4	21.0	23.0
13-Aug-05	11	9:00	7	20.9	23.0

Date	Day	Time	Rep	SQT7	SQT8
13-Aug-05	11	9:00	3	21.8	21.8
13-Aug-05	11	9:00	4	21.6	22.1
14-Aug-05	12	8:45	1	20.2	20.5
14-Aug-05	12	8:45	4	20.4	20.2
14-Aug-05	12	15:30	4	21.2	21.3
14-Aug-05	12	15:30	5	21.2	21.3
15-Aug-05	13	7:30	4	21.0	22.4
15-Aug-05	13	7:30	6	22.4	22.5
15-Aug-05	13	15:15	4	22.4	23.2
15-Aug-05	13	15:15	8	22.8	22.1
16-Aug-05	14	8:30	4	22.5	22.7
16-Aug-05	14	8:30	5	22.6	22.6
16-Aug-05	14	15:00	2	23.1	23.4
16-Aug-05	14	15:00	4	23.1	23.4
17-Aug-05	15	8:10	4	23.1	23.2
17-Aug-05	15	8:10	7	23.0	23.2
17-Aug-05	15	15:10	3	23.3	23.5
17-Aug-05	15	15:10	4	23.3	23.5
18-Aug-05	16	7:00	1	23.1	23.2
18-Aug-05	16	7:00	4	23.0	23.3
18-Aug-05	16	15:45	4	22.3	22.6
18-Aug-05	16	15:45	5	22.0	22.5
19-Aug-05	17	8:00	4	22.6	22.7
19-Aug-05	17	8:00	6	22.6	22.8
19-Aug-05	17	15:30	4	23.2	23.3
19-Aug-05	17	15:30	8	23.2	23.4
20-Aug-06	18	8:30	4	22.2	23.2
20-Aug-06	18	8:30	5	22.4	23.1
20-Aug-06	18	16:05	2	22.7	22.8
20-Aug-06	18	16:05	4	22.6	22.8
21-Aug-05	19	8:45	4	22.1	22.2
21-Aug-05	19	8:45	7	22.2	22.3
21-Aug-05	19	15:25	3	22.6	22.6
21-Aug-05	19	15:25	4	22.6	22.6
22-Aug-05	20	8:10	1	22.0	22.2
22-Aug-05	20	8:10	4	21.9	22.0
22-Aug-05	20	15:00	2	23.1	23.3
22-Aug-05	20	15:00	4	23.1	23.3
23-Aug-05	21	7:30	4	23.0	22.9
23-Aug-05	21	7:30	6	22.9	23.2
23-Aug-05	21	14:45	4	23.3	23.4
23-Aug-05	21	14:45	8	23.3	23.4
24-Aug-05	22	8:30	4	23.1	23.3
24-Aug-05	22	8:30	5	23.1	23.2
24-Aug-05	22	15:15	2	22.9	22.0
24-Aug-05	22	15:15	4	22.9	23.1
25-Aug-05	23	8:15	4	22.8	22.9
25-Aug-05	23	8:15	7	22.6	23.1
			Average	22.8	23.0
			Minimum	19.7	19.7
			Maximum	24.0	24.1

Appendix Table 21. Water Chemistry Parameters for Equilibrium Study
Dissolved Oxygen (mg/L)

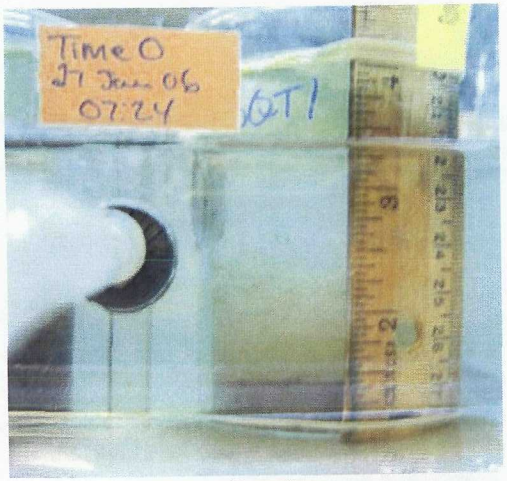
Date	Day	Time	Rep	SQT7	SQT8
2-Aug-05	0	8:00	1	5.0	4.1
2-Aug-05	0	8:00	2	5.0	5.1
2-Aug-05	0	8:00	3	6.7	5.0
2-Aug-05	0	8:00	4	5.4	4.7
2-Aug-05	0	8:00	5	4.5	5.1
2-Aug-05	0	8:00	6	4.1	5.4
2-Aug-05	0	8:00	7	5.4	6.2
2-Aug-05	0	8:00	8	6.5	6.3
2-Aug-05	0	16:45	1	5.9	4.2
2-Aug-05	0	16:45	4	4.7	3.7
3-Aug-05	1	8:30	4	4.5	4.3
3-Aug-05	1	8:30	6	4.2	4.6
3-Aug-05	1	15:10	4	4.5	5.1
3-Aug-05	1	15:10	8	6.3	4.2
4-Aug-05	2	8:45	4	4.3	4.8
4-Aug-05	2	8:45	5	4.3	3.7
4-Aug-05	2	15:00	2	6.2	4.9
4-Aug-05	2	15:00	4	5.3	6.7
5-Aug-05	3	8:00	4	5.1	6.7
5-Aug-05	3	8:00	7	6.5	5.4
5-Aug-05	3	15:00	3	6.8	5.1
5-Aug-05	3	15:00	4	5.6	6.9
6-Aug-05	4	9:00	1	6.4	4.5
6-Aug-05	4	9:00	4	6.0	6.4
7-Aug-05	5	7:45	4	6.2	6.0
7-Aug-05	5	7:45	6	3.4	5.6
7-Aug-05	5	15:15	4	5.2	5.0
7-Aug-05	5	15:15	8	5.5	5.9
8-Aug-05	6	9:00	4	5.3	5.6
8-Aug-05	6	9:00	5	4.5	4.3
8-Aug-05	6	15:45	2	6.4	5.8
8-Aug-05	6	15:45	4	6.1	6.5
9-Aug-05	7	9:00	4	6.9	7.1
9-Aug-05	7	9:00	7	6.8	7.1
9-Aug-05	7	14:45	3	6.7	5.3
9-Aug-05	7	14:45	4	5.9	6.7
10-Aug-05	8	7:45	4	6.5	6.6
10-Aug-05	8	7:45	6	6.1	6.0
10-Aug-05	8	15:20	4	6.8	5.5
10-Aug-05	8	15:20	8	6.1	6.8
11-Aug-05	9	6:00	4	6.6	6.7
11-Aug-05	9	6:00	7	6.9	6.1
12-Aug-05	10	6:25	4	6.4	6.8
12-Aug-05	10	6:25	5	3.7	6.0
12-Aug-05	10	14:00	2	6.9	6.1
12-Aug-05	10	14:00	4	6.8	6.3
13-Aug-05	11	9:00	4	7.4	5.9
13-Aug-05	11	9:00	7	5.6	6.2

Date	Day	Time	Rep	SQT7	SQT8
13-Aug-05	11	9:00	3	6.7	5.8
13-Aug-05	11	9:00	4	7.6	6.2
14-Aug-05	12	8:45	1	6.5	5.7
14-Aug-05	12	8:45	4	7.2	5.9
14-Aug-05	12	15:30	4	6.4	7.1
14-Aug-05	12	15:30	5	3.0	7.0
15-Aug-05	13	7:30	4	6.8	7.1
15-Aug-05	13	7:30	6	3.8	7.3
15-Aug-05	13	15:15	4	6.8	7.0
15-Aug-05	13	15:15	8	6.7	7.1
16-Aug-05	14	8:30	4	7.1	7.3
16-Aug-05	14	8:30	5	3.3	6.8
16-Aug-05	14	15:00	2	7.3	7.0
16-Aug-05	14	15:00	4	6.4	7.1
17-Aug-05	15	8:10	4	6.4	6.6
17-Aug-05	15	8:10	7	6.8	7.0
17-Aug-05	15	15:10	3	7.0	7.1
17-Aug-05	15	15:10	4	6.1	6.8
18-Aug-05	16	7:00	1	6.9	7.4
18-Aug-05	16	7:00	4	5.9	6.9
18-Aug-05	16	15:45	4	6.9	7.1
18-Aug-05	16	15:45	5	6.5	7.7
19-Aug-05	17	8:00	4	6.7	7.1
19-Aug-05	17	8:00	6	7.1	7.5
19-Aug-05	17	15:30	4	7.4	7.1
19-Aug-05	17	15:30	8	7.2	7.1
20-Aug-06	18	8:30	4	8.1	6.5
20-Aug-06	18	8:30	5	7.8	6.9
20-Aug-06	18	16:05	2	7.6	8.0
20-Aug-06	18	16:05	4	7.7	7.9
21-Aug-05	19	8:45	4	7.8	8.0
21-Aug-05	19	8:45	7	7.2	7.8
21-Aug-05	19	15:25	3	8.0	8.2
21-Aug-05	19	15:25	4	7.9	8.1
22-Aug-05	20	8:10	1	8.3	8.3
22-Aug-05	20	8:10	4	7.6	8.4
22-Aug-05	20	15:00	2	7.4	7.5
22-Aug-05	20	15:00	4	7.2	7.5
23-Aug-05	21	7:30	4	6.9	7.0
23-Aug-05	21	7:30	6	7.4	7.6
23-Aug-05	21	14:45	4	7.5	7.9
23-Aug-05	21	14:45	8	7.7	7.9
24-Aug-05	22	8:30	4	7.6	7.7
24-Aug-05	22	8:30	5	5.0	7.4
24-Aug-05	22	15:15	2	7.4	7.8
24-Aug-05	22	15:15	4	7.3	7.6
25-Aug-05	23	8:15	4	7.1	7.4
25-Aug-05	23	8:15	7	7.3	7.9
			Average	6.3	6.4
			Minimum	3.0	3.7
			Maximum	8.3	8.4

APPENDIX 22

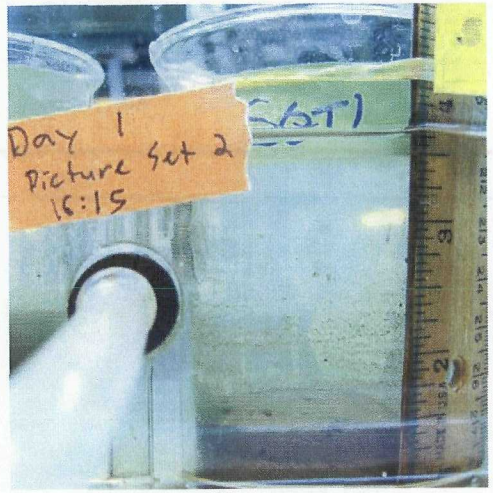
Suspended Sediment Photos

SQT1

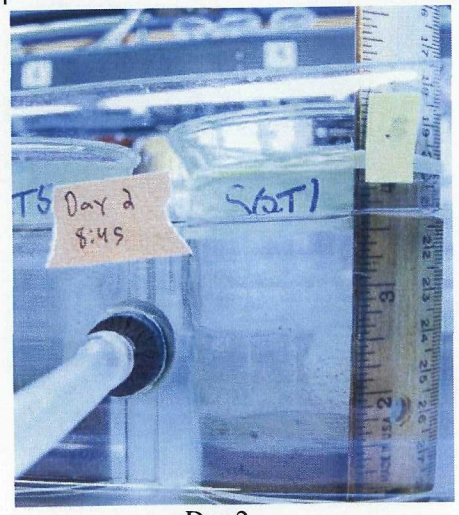


Day 0
27 Jan 06 at 7:24

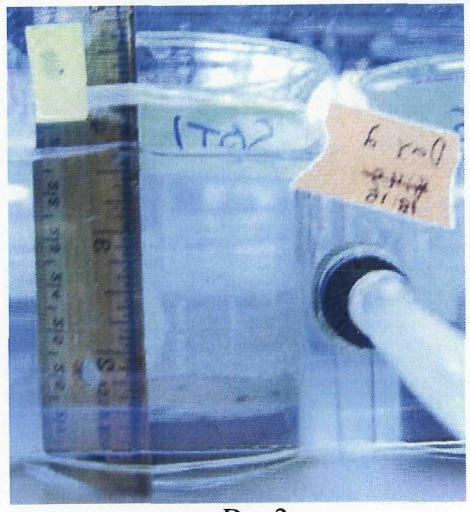
Day 1
28 Jan 06 at 9:15



Day 1
28 Jan 06 at 16:15

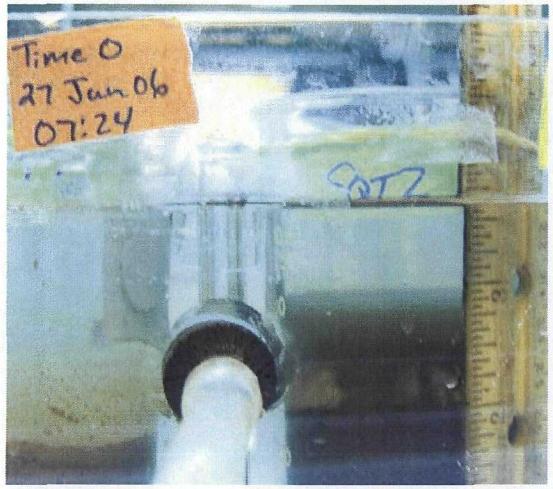


Day 2
29 Jan 06 at 8:45

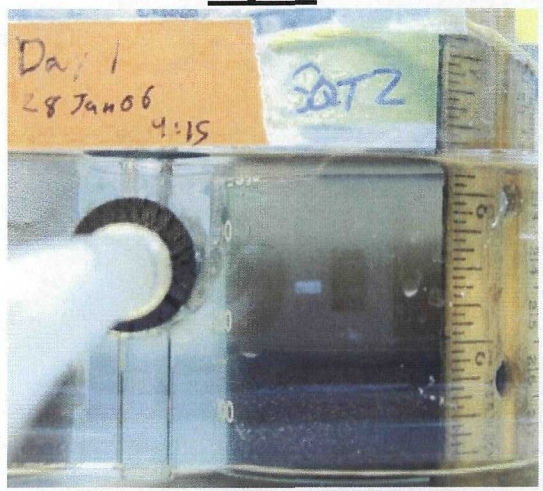


Day 2
29 Jan 06 at 18:15

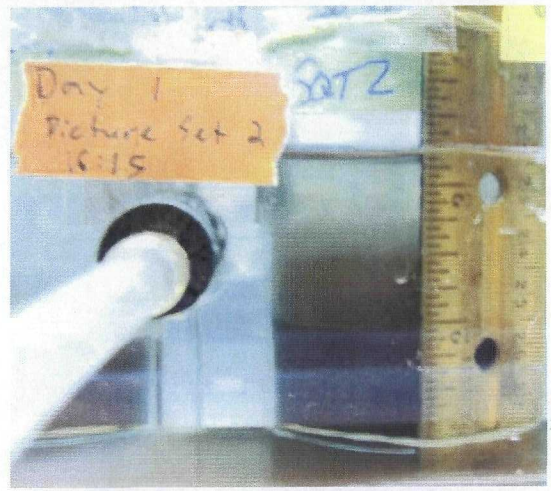
SQT2



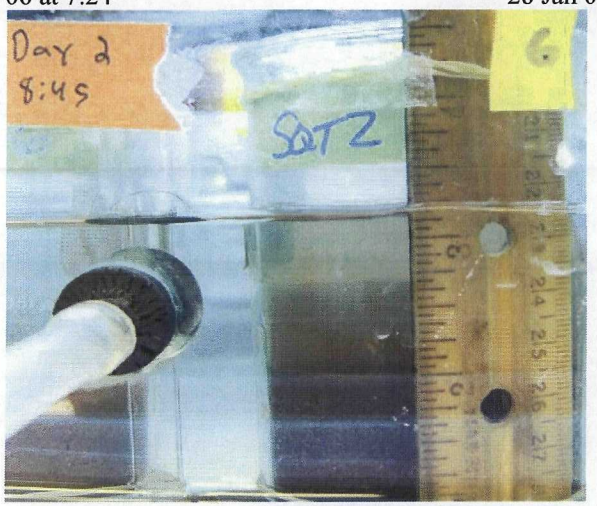
Day 0
27 Jan 06 at 7:24



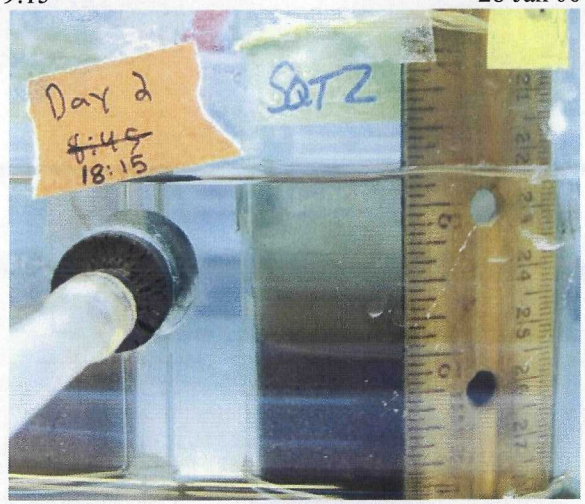
Day 1
28 Jan 06 at 9:15



Day 1
28 Jan 06 at 16:15

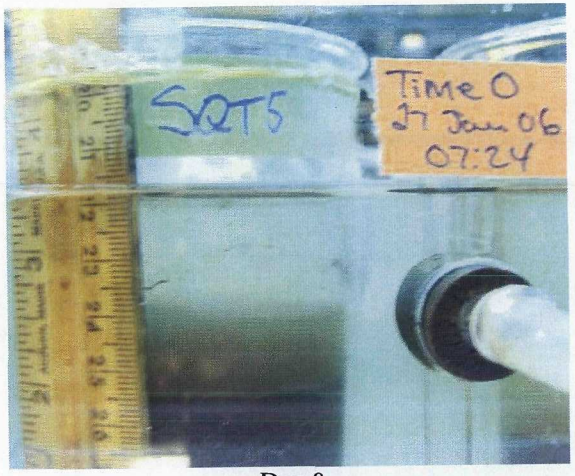


Day 2
29 Jan 06 at 8:45



Day 2
29 Jan 06 at 18:15

SQT5



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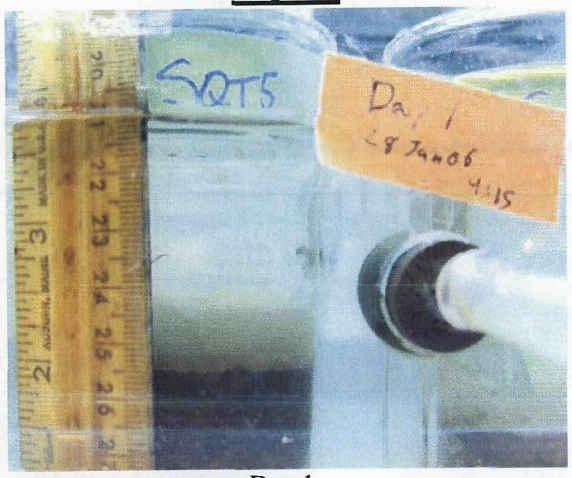
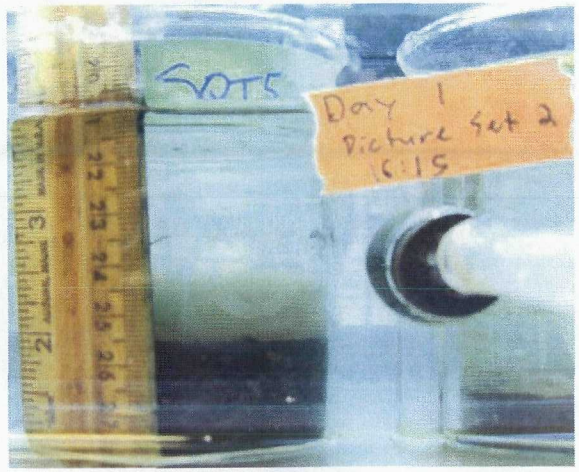
27 Jan 06 at 7:24

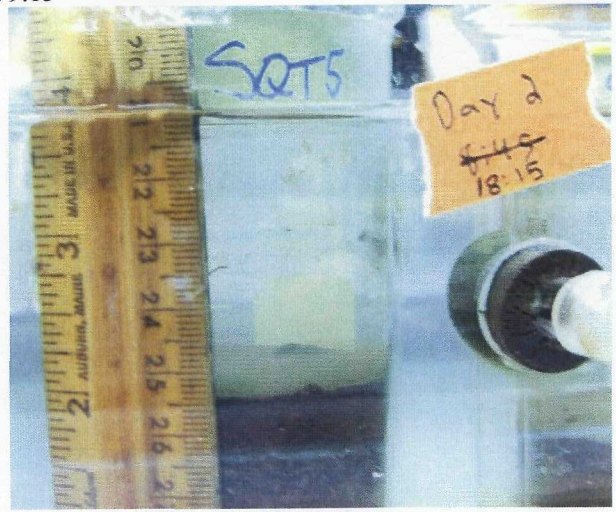


Day 1
28 Jan 06 at 9:15



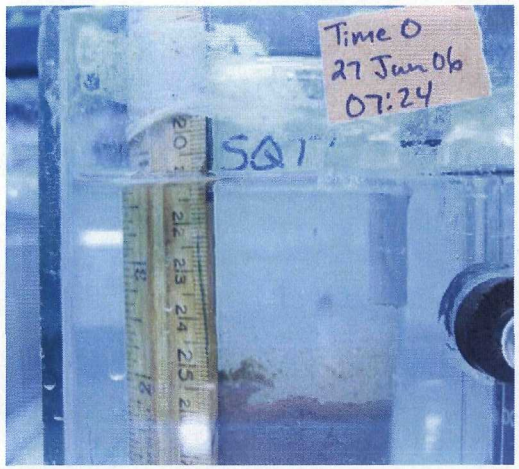
Day 1
28 Jan 06 at 16:15

Day 2
29 Jan 06 at 8:45

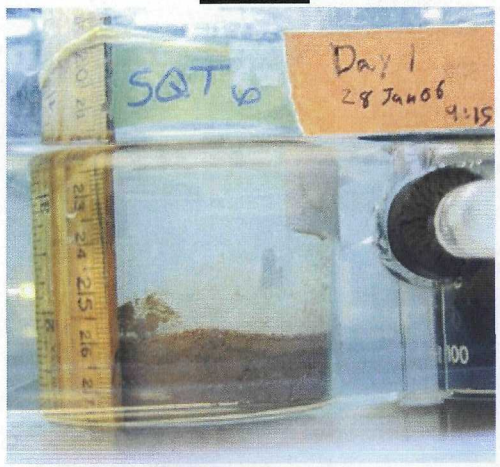


Day 2
29 Jan 06 at 18:15

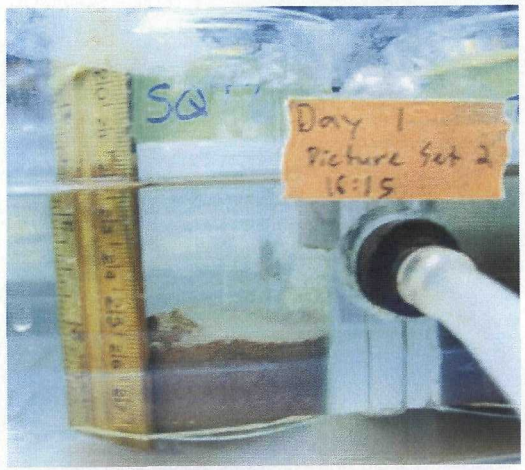
SQT6



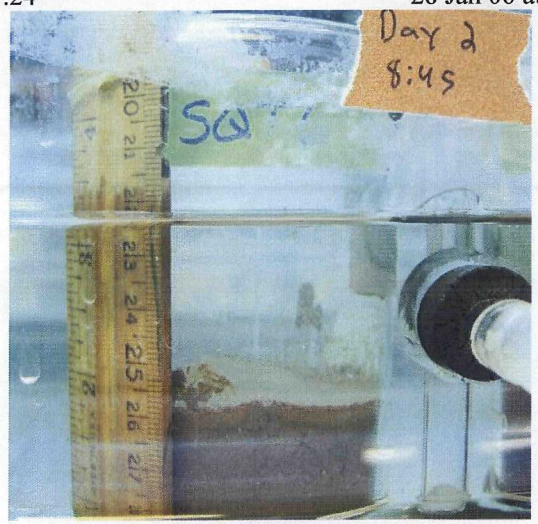
Day 0
27 Jan 06 at 7:24



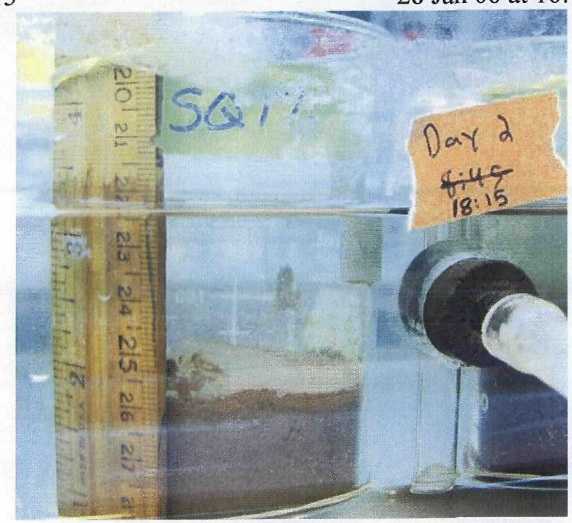
Day 1
28 Jan 06 at 9:15



Day 1
28 Jan 06 at 16:15



Day 2
29 Jan 06 at 8:45



Day 2
29 Jan 06 at 18:15

APPENDIX 23

Field UV Measurements

Samples collected 31 August 2005

UVA Sunny (microWatts/cm2)

Site SQT2 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	928	1219	1046	940	1033.3	134.7
2 cm	815	1117	997	888	954.3	131.8
mid	97.5	105.2	106.4	116	106.3	7.6
bottom	15.1	11.1	15.6	15.6	14.4	2.2

Site SQT2 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	2090	2530	2460	2740	2455.0	270.9
2 cm	2350	2130	2100	1967	2136.8	158.8
mid	216	175	193	153	184.3	26.8
bottom	31.1	31.8	31.8	30.8	31.4	0.5

Site SQT2 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	3890	3690	3900	3890	3842.5	101.8
2 cm	2888	3000	3010	2760	2914.5	116.9
mid	270	280	284	248	270.5	16.1
bottom	36	37.7	25.4	26.8	31.5	6.3

Site SQT2 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	2310	1577	2510	2320	2179.3	411.9
2 cm	2260	2220	2090	1697	2066.8	257.0
mid	102		117	170	129.7	35.7
bottom	0.101		21.8	27.2	16.4	14.3

Site SQT2 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	357	341	334	353	346.3	10.6
2 cm	269	274	277	252	268.0	11.2
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

UVB Sunny (microWatts/cm2)

Site SQT2 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	159.6	137.2	136.2	150.9	146.0	11.3
2 cm	120.8	116.1	125.7	112.3	118.7	5.8
mid	3.23	3.98	4.05	4.08	3.8	0.4
bottom	0.267	0.24	0.233	0.245	0.2	0.0

Site SQT2 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	237	219	226	196.3	219.6	17.2
2 cm	200	205	178.9	162.4	186.6	19.7
mid	6.65	7.04	5.5	4.79	6.0	1.0
bottom	0.662	0.453	0.484	0.473	0.5	0.1

Site SQT2 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	367	332	329	333	340.3	17.9
2 cm	284	288	280	247	274.8	18.8
mid	79.2	79.4	79.4	71.4	77.4	4.0
bottom	0.125	0.275	0.112	0.116	0.2	0.1

Site SQT2 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	233	256	251	217	239.3	17.8
2 cm	203	199.7	229	199.6	207.8	14.2
mid	4.94	4.61	5.51	4.28	4.8	0.5
bottom	0.05	0.05	0.09	0.14	0.1	0.0

Site SQT2 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	75.1	70.5	70.4	69.1	71.3	2.6
2 cm	61	59.4	59.9	54.5	58.7	2.9
mid	2.06	2.12	2.08	1.88	2.0	0.1
bottom	0.01	0.01	0.023	0.036	0.0	0.0

UVA Sunny (microWatts/cm2)

Site SQT1 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	1120	1188	1336	1303	1236.8	100.4
2 cm	969	1106	1287	1305	1166.8	159.6
mid	192	153.5	219	241	201.4	37.7
bottom	36	27.7	40.9	41.4	36.5	6.4

Site SQT1 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	1344	1543	1938	2400	1806.3	466.5
2 cm	1771	1426	1974	2120	1822.8	300.7
mid	332	392	383	381	372.0	27.1
bottom	72.2	70.8	66.3	56.1	66.4	7.3

Site SQT1 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	3650	3340	3280	3340	3402.5	167.4
2 cm	2870	2690	2960	2660	2795.0	143.9
mid	360	370	230	200	290.0	87.6
bottom	0	0	0	0	0.0	0.0

Site SQT1 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	2020	1883	1807	1801	1877.8	101.9
2 cm	1412	1497	1434	1334	1419.3	67.3
mid	241	205	216	195.4	214.4	19.7
bottom	30	25.8	14.19	30	25.0	7.5

Site SQT1 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	316	256	241	228	260.3	38.9
2 cm	220	203	173	196	198.0	19.5
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

UVB Sunny (microWatts/cm2)

Site SQT1 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	149.8	147.5	151	145.4	148.4	2.5
2 cm	144.5	142.1	131.3	136.3	138.6	5.9
mid	10.16	12.2	9.08	10.69	10.5	1.3
bottom	0.799	0.924	0.733	0.709	0.8	0.1

Site SQT1 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	223	230	233	201	221.8	14.5
2 cm	189.9	178.9	229	162.3	190.0	28.4
mid	7.26	6.55	12.3	9.18	8.8	2.6
bottom	0.56	0.595	0.551	0.601	0.6	0.0

Site SQT1 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	399	389	396	385	392.3	6.4
2 cm	385	335	354	335	352.3	23.6
mid	26.6	30.8	24.4	25	26.7	2.9
bottom	1.323	1.406	1.117	1.176	1.3	0.1

Site SQT1 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	190.8	198.1	199.7	191.4	195.0	4.6
2 cm	137.7	160.1	122.6	161.9	145.6	18.9
mid	8.07	6.99	7.56	7.29	7.5	0.5
bottom	0.279	0.267	0.271	0.248	0.3	0.0

Site SQT1 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	31.9	32	31.9	30.7	31.6	0.6
2 cm	27.9	27.8	25.4	26.1	26.8	1.2
mid	1.448	0.916	1.296	1.027	1.2	0.2
bottom	0	0	0	0	0.0	0.0

Samples Collected 3 August 05 by MT, HM

UVA Cloudy (microWatts/cm2)

Site SQT1 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	804	732	755	710	750.3	40.3
2 cm	378	354	488	502	430.5	75.3
mid	10.8	12.4	9.1	8.7	10.3	1.7
bottom	1	0.9	1.1	0.89	1.0	0.1

Site SQT1 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	1973	1991	1993	2130	2021.8	72.7
2 cm	1102	1369	1883	1507	1465.3	325.3
mid	6.96	6.5	6.5	5.5	6.4	0.6
bottom	2.6	2.2	2.6	2.5	2.5	0.2

Site SQT1 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	828	781	780	727	779 0	41.3
2 cm	455	624	642	500	555.3	91.9
mid	6.8	4.97	5.9	5.8	5.9	0.7
bottom	0.88	1	0.66	0.66	0.8	0.2

Site SQT1 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	2250	2150	2130	2230	2190.0	58.9
2 cm	1513	1865	1983	1491	1713.0	248.5
mid	23.3	32.6	26.6	22	26.1	4.7
bottom	3.1	3.1	2.7	2.7	2.9	0.2

Site SQT1 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	300	275	278	272	281.3	12 7
2 cm	214	147.6	236	232	207.4	41.0
mid	1.3	2.96	3.1	3	2.6	0.9
bottom	0.57	6.4	0.4	0.35	1.9	3.0

UVB Cloudy (microWatts/cm2)

Site SQT1 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	59.2	70.5	75.1	76.2	70.3	7.8
2 cm	24.7	38.1	57.4	76.2	49.1	22.5
mid	0.04	0.04	0.5	0.2	0.2	0.2
bottom	0.48	0.24	0.5	0.6	0.5	0.2

Site SQT1 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	199.3	224	216	231	217.6	13.6
2 cm	81	153.9	80.4	147.7	115.8	40.6
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

Site SQT1 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	90	81.7	82	81.1	83.7	4.2
2 cm	61.9	36.4	58.9	48.1	51.3	11 6
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

Site SQT1 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	298	283	277	251	277.3	19.6
2 cm	180.5	901	928	198	551.9	418.9
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

Site SQT1 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	41.7	37.3	37	34.2	37.6	3.1
2 cm	22.6	23.5	30.9	23.4	25.1	3.9
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

UVA Cloudy (microWatts/cm2)

Site SQT2 Time 08:00

Depth	Reading 1	Reading 2	Readlng 3	Reading 4	AVG	STD
0 cm	1144	1147	1172	1194	1164.3	23.5
2 cm	808	753	706	821	772.0	53.0
mid	3.45	3.67	3.5	3.78	3.6	0.2
bottom	0.2	0.18	0.2	0.265	0.2	0.0

Site SQT2 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm						
2 cm						
mid						
bottom						

Site SQT2 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	928	1075	1088	1044	1033.8	72.9
2 cm	621	729	827	717	723.5	84.2
mid	2.5	2.4	2.94	3	2.7	0.3
bottom	0.14	0.16	0.15	0.15	0.2	0.0

Site SQT2 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	1959	1944	1823	1444	1792.5	240.2
2 cm	933	1260	7850	1233	2819.0	3357.3
mid	8.7	5.8	5.7	5.7	6.5	1.5
bottom	0.13	0.19	0	0.1	0.1	0.1

Site SQT2 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	175.1	168.1	165.6	150.5	164.8	10.4
2 cm	11.5	12.6	125.6	75.8	56.4	55.1
mid	0 8	0.4	0.7	0 6	0.6	0.2
bottom	0	0.1	0	0	0.0	0.1

UVB Cloudy (microWatts/cm2)

Site SQT2 Time 08:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	153.4	163.7	158.3	170.5	161.5	7.3
2 cm	92.5	86.5	66.7	37.1	70.7	25.0
mid	0.06	0	0	0.27	0.1	0.1
bottom	0.2	0.6	0	0	0.2	0.3

Site SQT2 Time 10:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	242	241	240	239	240.5	1.3
2 cm	131.7	92.7	11.6	96.9	83.2	50.8
mid	0.15	0	0	0	0.0	0.1
bottom	0	0	0	0	0.0	0.0

Site SQT2 Time 14:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	74	82.4	83.8	87.9	82.0	5.8
2 cm	31.1	41.1	58.3	47.2	44.4	11.4
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

Site SQT2 Time 16:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	178	145.8	141.8	134	149.9	19.4
2 cm	16.9	71.9	84.5	62	58.8	29.4
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0.0

Site SQT2 Time 18:00

Depth	Reading 1	Reading 2	Reading 3	Reading 4	AVG	STD
0 cm	9 1	6.8	7	6 9	7.5	1.1
2 cm	3 9	3.4	4	4.3	3.9	0.4
mid	0	0	0	0	0.0	0.0
bottom	0	0	0	0	0.0	0 0

ATTACHMENT 3

BENTHIC MACROINVERTEBRATE COMMUNITY INVESTIGATION- ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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January 24, 2007

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The incorporation of benthic invertebrate community data into a Triad evaluation provides an *in situ* evaluation of toxicity. Benthic invertebrates are useful bioindicators because: 1) they are abundant across a broad array of sediment types, 2) they are relatively sedentary, completing most or all of their life cycle in the same microhabitat, 3) they respond to the cumulative effects of various stressors having differing magnitudes and periods of exposure, and 4) they integrate both the effects of stressors and the population compensatory mechanisms evolved over time to survive in a highly variable and potentially stressful environment.

2.1 FIELD SAMPLING METHODS

Benthic invertebrate community samples were collected during the period June 18 thru June 24, 2005 from eight Site Triad stations and four reference Triad stations. Two additional reference Triad stations were sampled on September 27, 2005. The sampling design for this benthic community investigation was provided in the approved RI/FS Work Plan (URS 2005). That Work Plan included a power analysis based upon the results of a benthic study conducted by SEH in 1998 (SEH 1998). The results of that power analysis was used as the basis for the study design developed to assess whether the benthic community at the Site was affected by contaminants in Site sediments. Benthic invertebrate community sampling and laboratory processing methodology were consistent with the approved Field Sampling Plan. Procedures are described in SOPs 240 and 360 in the FSP. Details of the benthic sampling procedures and stations sampled are reported in Attachment 1 to this Triad report. and summarized here.

After reconnaissance sampling was conducted to identify potential wood and sand substrate stations, four sand[1] and four wood mulch stations were sampled in the Site area and two sand and two wood mulch stations (later augmented by two more Reference Sand stations) were sampled in reference areas. At each Triad location, five replicate samples were collected for benthic invertebrate community analysis and five co-located replicates were collected for chemical analyses.

2.2 LABORATORY ANALYSIS

Benthic community samples were returned to the URS Milwaukee office, packaged for hazardous material shipment, and shipped to Aquatic Resources Center, in Nashville TN. All samples were received in satisfactory condition.

At Aquatic Resources Center each sample was logged into a laboratory tracking book. Analysis consisted of washing each sample in a US Series No. 60 (250 µm mesh) sieve to remove ethanol and excess detritus. The sample was then subsampled. It was placed onto a screen, which was placed into a larger tray, and enough water added to cover the contents. The contents were distributed evenly over the screen, which was lifted from the water so that the sample contents settled onto the screen. The screen was divided into 30 equal portions. According to laboratory protocol for subsampling, a total of 25 samples were subsampled using a 16 grid tray. One sample was split between two 30 grid trays (60 grids) and 15 grids were subsampled from each of these trays. The remaining 34 samples were subsampled using the 30 grid subsampling tray.

A scoop was used to remove the contents of the subsample. The contents of this subsample were examined using a dissecting microscope and all the organisms were removed. This procedure was repeated until a minimum of 100 organisms was removed, ensuring that each subsample was sorted in its entirety. The organisms removed were enumerated by major groupings (e.g., mayflies, caddisflies, worms) and placed into glass vials to which 70 percent ethanol had been

[1] It was later decided that Station SQT3 was more representative of a "wood mulch" station because of its high organic carbon levels. This will have no effect on the statistical analyses conducted however since stations were blocked in the ANCOVA irrespective of their substrate type. In addition ANOVAs testing the effects of carbon normalized PAHs used the actual organic carbon content irrespective if the station was initially classified as a wood or sand station. In the step-wise regression grain size and not whether the substrate was sand or wood was the independent variable.

added. Upon completion of this process, the vials were labeled (date, location, taxonomic group, number of organisms) and were ready for identification using a dissecting microscope. The chironomid (midgefly) larvae and oligochaetes (aquatic segmented worms) were mounted on microscope slides using CMCP mounting medium for identification using a compound microscope.

Identifications were performed using a dissecting scope for larger specimens. Mounted specimens were identified using a compound microscope. Identifications were recorded on laboratory bench sheets along with sample information (e.g., date, location, sample ID), sorter initials, date sorted, etc.

Quality control (QC) checks were performed on six samples for sorting efficiency. These samples were sorted by a biologist different than the original sorter. If more than 20 percent of the total number of organisms was missed all replicate samples sorted by that person would be re-examined. Results from the QC checks are presented in the table below, all samples passed the QC checks.

Sample ID	Rep	Original Count	Sorter Initials	QC Count	Percent Error
NSP-SE-SQT2-0605-BCA	B	111	TWA	2	1.8
NSP-SE-SQT4-0605-BCA	D	111	HTM	1	0.9
NSP-SE-SQT7-0605-BCA	B	157	GE	0	0.0
NSP-SE-SQT10-0605-BCA	B	102	TWA	1	1.0
NSP-SE-SQT12-0605-BCA	A	149	HTM	2	1.3
NSP-SE-SQT12-0605-BCA	B	104	TWA	0	0.0
NSP-SE-SQT13-0905-BCA	B	114	GE	12	9.5

Quality control (QC) checks were performed on six samples for verification of identifications. If there were disagreements between taxonomists they were resolved by re-examination of the specimens in question. There was 100 percent agreement for the six samples listed below.

NSP-SE-SQT2-0605-BCA-D

NSP-SE-SQT3-0605-BCA-D

NSP-SE-SQT4-0605-BCA-C

NSP-SE-SQT6-0605-BCA-A

NSP-SE-SQT9-0605-BCA-D

NSP-SE-SQT10-0605-BCA-B

The data were entered into an Excel spreadsheet as a matrix with sample number as column headings and taxa in the rows.

2.3 BENTHIC DATA ANALYSIS

The similarity of benthic communities between study and reference sampling locations was evaluated using comparisons of species abundances and community metrics and multivariate approaches, including hierarchical cluster analysis and discriminant analysis.

At Aquatic Resources the benthic community data were entered into a spreadsheet for analysis of biological condition based on several metrics. The metrics listed below follow Wisconsin Department of Natural Resources Macroinvertebrate Data Interpretation Guidance Manual (2003) and U.S. Environmental Protection Agency Lake and Reservoir Bioassessment and Biocriteria Technical Guidance Document (1998). It should be noted that many of these metrics, e.g. BI and relative tolerance, were developed to identify organic pollution with high oxygen demand, i.e. BOD and COD in streams so they may not be sensitive to stressors at the Site.

Abundance - The number of organisms (individuals) found at each site can indicate whether an area is supporting a large, and coupled with taxa richness, diverse community.

Taxa Richness -The number of distinct taxa reflects the health of the community through a measurement of the variety of taxa present. This measure generally increases with increasing water quality, habitat diversity and/or habitat suitability.

ETO(Ephemeroptera/Trichoptera/Odonata-mayflies/caddisflies/ dragonflies) Index - The ETO Index is the total number of distinct taxa within these three orders. This value summarizes taxa richness within the insect orders that are generally considered to be most sensitive to pollution. Some ETO taxa, however, are pollution tolerant (e.g., *Caenis*, some *Oecetis*).

ETO/(ETO+Chironomidae) Ratio - A measure of the abundance ratio of these two groupings indicates the balance of the benthic community. This ratio has similar considerations as the ETO Index, as not all ETO taxa are intolerant, and not all chironomid taxa are tolerant.

Percent Dominance by a Taxon - This measure is the percent occurrence of the most dominant taxon for each site. This measure is based on the assumption that dominance by a single taxon reflects an impaired community.

Percent Chironomidae (midgeflies) - The ratio of Chironomidae individuals to the total number of individuals in the sample can indicate enrichment or presence of heavy metals. Generally chironomid abundance increases with increasing organic enrichment or heavy metal concentrations.

Percent Oligochaeta (aquatic segmented worms) – An increase in organic enrichment of the sediment could result in an increase in this component of the benthic community.

Percent Non-insects – The ratio of non-insects to the total number of individuals is expected to decrease in response to an increased level of stress to the benthic community.

Crustacea + Mollusca taxa – This measure is the total number of distinct taxa within these two major taxonomic groups. The number of taxa within these two groups is expected to decrease under elevated levels of acid stress.

Percent Crustacea + Mollusca – This measure is the percent occurrence of these two major taxonomic groups in each sample. The percent occurrence of these two groups would decrease with increased levels of acid stress.

Shannon Diversity Index (H) – This measure of diversity accounts for both abundance and evenness of species present in a sample. Shannon's H is calculated as:

$$H = -? \quad p_i \ln p_i$$

where (p_i) is the relative proportion of species "i". Values for this index range between 1.5 and 3.5 with higher values representing higher diversity.

Shannon's Equitability – This measure is calculated by dividing Shannon's H by the natural log (ln) of the total number of taxa in the sample. The range of values for Shannon's E is between 0 and 1, with 1 being indicative of complete evenness or homogeneity (i.e. the same number of each species).

Biotic Index - The BI assigns tolerance values to individual taxa ranging from 0 to 10, with 0 being intolerant of pollution and 10 being very tolerant. The tolerance value assigned to the various taxa are taken from a variety of sources including Barbour et al. (1999), Bode *et al.* (2002), and Illinois EPA (1987) but are primarily related to tolerance of low oxygen conditions caused by high BOD or COD (organic pollution). The formula for calculating the BI is:

$$BI = ? \frac{(tv)_i n_i}{N}$$

where $(tv)_i$ is the tolerance value of the ith taxon,

n_i is the abundance of the ith taxon, and

N is the total number of individuals in the sample.

Functional Feeding Groups - The proportion of different feeding groups can indicate unbalanced or unstable communities, as well as provide some indication of types of pollution.

2.4 COMPARISON TO REGIONAL BENTHIC COMMUNITY DATA

These metrics were compared to the results of other Lake Superior benthic macroinvertebrate community studies to determine whether there are major differences in various benthic community attributes including:

- Total taxa richness;
- Total chironomid richness;
- Total density;
- Chironomid density;
- Oligochaete density; and
- Relative species abundance

2.5 STATISTICAL ANALYSIS

In analysis of the benthic community data we were interested in answering two questions:

1) Are there relationships between the various measures of benthic community structure, such as taxa richness or relative tolerance, and physicochemical attributes of the samples, such as concentration of PAHs or grain size characteristics of the substrate; and
2) Are there differences in biological attributes among the categories of the stations, such as Sand, Reference Sand, Wood and Reference Wood?

These two questions differ only in the type of data being analyzed. In general, we look for relationships between things that are measured or counted; the measured or counted quantity is the distance from zero, or absence of the thing measured or counted. Such data are called ratio data, because numbers take on meaning relative to each other: four species is twice as many as two species, 20 % is half of 40%, etc. We look for differences between things that can be categorized by some attribute that it either possesses or does not possess: a substrate is either sand or it is not sand; 'not sand' must therefore have some other attribute. Such data are called categorical data, because something is either in a category or it is not. If relationships or differences are found, then the physical or chemical variables can be said to be explanatory for the biological variables. In statistical parlance, the explanatory variable is said to be the independent variable; the variable explained is said to be the dependent variable.

To search for relationships and differences we start with null hypotheses. For ratio data the null hypothesis is that there is no relationship between two variables (a potential explanatory variable actually has no explanatory power); for categorical data the null hypothesis is that there is no difference in some measured variable among the various categories of the physical variable. If we can reject the null hypothesis, then we infer that an alternative hypothesis is likely to be true; there IS a relationship, there IS a difference. To reject a null hypothesis we use statistics to calculate the probability of acquiring our data if the null hypothesis is true. If the probability of our data is low (customarily equal to or less than 0.05, or one time in twenty) we reject the null hypothesis and infer that the alternative is true. The probability of getting our data if the null hypothesis is true is called its significance. We thus generally say that there is a 'significant' relationship or difference if the significance is <0.05.

There are many ways of estimating significance, but a standard method is the general linear model (GLM), a general method which allows use of ratio data, categorical data, or both at the same time. It also allows consideration of multiple independent variables, multiple dependent variables, or both, at the same time, allowing complex inferences. This method partitions variation in some variable of interest into that which can be explained by an explanatory variable, and that which cannot be explained, or the 'error.' The ratio of explained to unexplained variation is used to calculate the significance. Obviously, the greater this ratio, i.e. the more variation that can be explained compared to the variation that can't, the less likely the null hypothesis is to be true, and the more likely it is that an independent variable really has explanatory power. An advantage of the GLM is that there are ways to use information we are not really interested in, but that can explain some variation, to reduce the error. For example, if we are not really interested in looking for differences among the sampling stations, but we know that which station a sample came from explains some variation, that variation should therefore be removed from the error and put into the explained variation. This gives us a more accurate (and lower) estimate of the significance. Inclusion of an uninteresting independent variable in a GLM is called blocking, and inclusion of the uninteresting variable is said to increase the efficiency of the design. As it turns out (see below), there is great variation within the five replicate samples

taken from each station for most variables. This information is used in our analyses to make them more efficient.

Evaluation of the Effect of PAHs and Substrate Type on Benthic Community Characteristics

Statistical analysis of the Ashland benthic community data was performed using SYSTAT Version 10 (SPSS 2000). All but two of the methods used in this analysis, box and whisker plots and cluster analysis, are variations of the GLM. Least-squares regression (hereafter, regression) looks for relationships between one dependent and one or more independent variables. A variant of regression is step-wise regression, in which a dependent variable is examined for its relationship with a number of explanatory variables, and a subset of independent variables that have the greatest explanatory power is chosen. This process is known as model fitting. An advantage of regression is that the regression coefficients calculated tell us the nature of the relationship: positive coefficients tell us that as an independent variable increases, the dependent variable increases; negative coefficients tell us the opposite.

Analysis of variance (ANOVA) is mathematically identical to regression, but with the difference that the independent variables are categorical. ANOVA is used to ask if there are differences among the means of some dependent variable calculated for each of the various categories of the independent variable. When there are more than two categories of the explanatory variable, and ANOVA reports a significant difference somewhere among them, we actually don't know exactly where differences lie. There are many ways of identifying where differences lie between categories, but the conceptually simplest is to perform pair wise comparisons, calculating the probability that the means for the dependent variable as calculated for any two categories are equal. Methods for performing all pair wise comparisons that are known to perform well statistically include Tukey's HSD (honestly significant difference) and Bonferroni-adjusted tests (Sokal and Rohlf 1995).

Analysis of covariance (ANCOVA) is a combination of regression and ANOVA, with both ratio and categorical independent variables. In this analysis we use ANCOVA to look for relationships between biological and physical and chemical parameters, as in regression, while at the same time removing uninteresting variation within stations, a categorical variable (See discussion of blocking, above.)

Multivariate analysis of variance (MANOVA) is an extension of ANOVA to include several dependent variables of interest at the same time. For example, we might wish to characterize communities by their proportions of several functional groups (e.g., shredders, filter feeders, etc.) and ask if communities vary among station categories, i.e. Sand, Reference Sand, Wood and Reference Wood, with regard to all such groups, analyzed simultaneously, a more interesting approach than just looking at each functional group one at a time with ANOVA. A byproduct of MANOVA are discriminant functions (DFs). These combine the several dependent variables into a single score for each sample. There are as many DFs as there are dependent variables, but the method maximizes as much as possible the information in the first and second DFs. That is, the 1st DF includes the information that distinguishes the category that is most different from other categories, the 2nd DF then includes the information not used in the 1st DF to distinguish the next category of samples that is now the most different from the others. The usefulness of DFs is that they can reduce dimensionality of a dependent variable data set to a more tractable number. For example, information about six functional groups cannot be visualized at one time, but

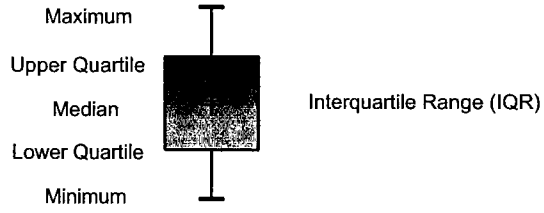
reduced to two DFs each sample can be represented on a bivariate graph, with each graph axis representing a combination, and information about, all six groups.

Cluster Analysis and Box Plots

One of the non-GLM methods used in this analysis is cluster analysis, as implemented in SYSTAT 10. This method searches for patterns in the data by calculating how similar stations are to each other, using, as in MANOVA, a number of variables simultaneously. The two most similar are then combined and similarities recalculated. This process is repeated until all stations but one have been combined. The clusters generated can then be graphed to see if pattern, based on other categories, can be ascertained. There are many ways of clustering; for this analysis we used euclidian distance[2] with average linkage (cf. Sneath and Sokal 1973). A number of cluster trees were developed using the following groups of community metrics:

1) All community variables;
2) Density and Numbers of Taxa, ETO Taxa, Ratio of ETO/ETO+Chironomidae, Crustacea+Mollusca Taxa;
3) Percent chironomids, oligochaetes, crustaceans, tolerant, facultative and intolerant;
4) All functional groups; and
5) Percent tolerant, facultative and intolerant;

Comparisons of benthic community metrics between study and reference area samples were also presented as box and whisker plots representing the maximum, minimum, upper and lower quartile, and median values for all replicates at a station as follows:



The median represents the 50th percentile of replicate sample data; upper and lower quartiles represent the 75th and 25th percentiles of the replicate data, respectively. The interquartile range (IQR) is the range of values between the upper and lower quartiles. The maximum value is the greatest value that falls between the upper quartile value and the upper inner fence, which is defined as the upper quartile value plus 1.5 times the IQR. The minimum value is defined as the lowest value that falls within the lower quartile value and the lower inner fence, defined as the lower quartile value minus 1.5 times the IQR. Values that fall outside of the inner fences are considered outliers. Values that fall between the inner fences and outer fences, defined as 3.0 times the IQR plus/minus the quartiles, are considered outside values and are represented as open circles. Values that fall outside the outer fences are considered far outside values and are represented by asterisks.

[2] This is a multivariate approach that compares the relatively similarity of stations based upon the values of all variables.

Data Transformation

GLM has several underlying assumptions about how data are distributed. It assumes that the errors are normally distributed, that the amounts of unexplained variation are equal among categories, and that each observation is independent. Often data violate these assumptions, and must be transformed to bring them more in line. There are certain types of data for which there are standard transforms, and the appropriate transform was used in the analysis of the Ashland benthic community data. Proportional data, i.e. percent filterers, gathers, parasites, predators, scrapers and shredders, were subject to the usual transform for proportional data, the arcsine of the square root of the observed proportion (Zar 1974). Counts (e.g., number of ETO taxa) were transformed as (observed count + 1)$^{1/2}$, the usual transform for counts (Zar 1974.)

Data for all variables, including PAH concentrations, carbon normalized PAH concentrations (NOC-PAHs), density data and benthic community metrics were graphed as box and whisker plots by station (Figure 1.1) and the boxplots were examined for evidence of outliers and lack of equality of variances. Density had many outliers, and this variable was therefore transformed to its natural logarithm. Shannon diversity appeared to lack homogenity of variances and was rank transformed (Yandell 1997). TPAH and NOC-PAH data were dominated by the large variation at Site Sand Station SQT1, and also had conspicuous outliers. The distribution of these PAH data had been previously tested using ProUCL (USEPA 2003) and found to be non parametric. These two variables were also rank-transformed. The transforms applied to each biological variable are specified in Table 1.1.

Power Analysis

Because of the high degree of variability observed in the data an *a priori* power analysis was conducted using SamplePower 2.0®, with 1, 55 degrees of freedom (df) (Rothstein et al. 2000). In addition, an *a posteriori* power analysis was performed on the result of the ANCOVAs (Cohen 1988). While *a posteriori* power analyses have limited usefulness, they can shed light on the frequency with which high variability makes detection of real effects difficult, using the actual partitioning of variability into that explained by PAH concentration (after removing among station variability) and unexplained variability.

3.1 BENTHIC COMMUNITY STRUCTURE

Approximately 133 taxa were identified from the benthic samples collected in this investigation (Table 1.2). Abundances of all taxa are tabulated in Appendix 1. Benthic community metrics calculated for each sample replicate are tabulated in Appendix 2. The abundance of the dominant taxonomic groups were plotted by sample replicate (Figure 1.2). These taxa included:

- The sabellid polychaete, *Manayunkia speciosa;*
- Total tubificid (an oligchaete) worms
- Total nematodes
- The amphipod, *Gammarus faciatus;*
- The isopod, *Caecidotea racovitzai;*
- Total chironomids (midgeflies);
- Total Ephemeroptera (mayflies);
- Total Trichoptera (caddisflies);
- Sphaerid clams (including *Pisidium* sp.); and
- The gastropod, *Amnicola limnosa.*

PAH levels (as total PAHs [TPAH] and as NOC-PAHs) in each of these replicate samples were plotted (Figure 1.3) to identify any obvious patterns that might be related to the abundances of dominant taxa.

3.2 STATISTICAL RESULTS

All SYSTAT output generated during this analysis is found in Appendices 3 and 4.

The box and whisker plots (Figure 1.1) revealed that there was substantial variation amongst replicate samples for most variables, including PAH levels, density and all benthic community metrics, at most of the stations. This variation within the same stations indicates substantial heterogeneity in the distribution of most biological characteristics within the relatively small areas defined by a single sampling station.

To test for possible effects of PAH concentration (both TPAH and NOC-PAH) on the biological variables, each biological measure was regressed by least squares on TPAH and NOC-PAH in an analysis of covariance (ANCOVA), with station as a categorical block covariate. Use of the blocking covariate removes variation due to the station factor from the error mean square and makes the analysis more efficient. There were significant relationships between TPAH and per cent dominance, per cent chironomidae, per cent non-insecta, Shannon diversity, and per cent gatherers (Table 1.3). However, only percent chironomidae and Shannon Diversity was negatively related to TPAH; the other three measures, i.e. percent dominance, percent non-insects and percent gatherers, were actually positively related to TPAH (Table 1.3), i.e. as TPAH levels increased these metrics increased. Number of ETO taxa and the ratio of ETO/ ETO + chironomid taxa were significantly and negatively related to NOC-PAH. As NOC-PAH increased, the abundance of ETO decreased and the abundance of chironomids increased. This led to a decrease in the ratio of ETO to chironomid taxa. This suggests there may be increasing stress with increased NOC-PAHs. However, there is no consistent pattern as Reference Sand stations SQT10 and SQT12 have the lowest abundance ratio of ETO/ETO+chironomids.

As PAH explained little variation in the biological metrics, each metric was analyzed for its relationship with the physical characteristics of each sample site. Physical factors included the

proportion of five different grain sizes of sediment from each sample(fines, fine sand, medium sand, coarse sand and gravel - the proportions summing to 1.0) and the type of substrate, categorized as Sand, Reference Sand, Wood, or Reference Wood). Each biological measure was used as a dependent variable in a step-wise regression on the six independent variables: fines, fine sand, medium sand, course sand, gravel, with substrate type as a categorical variable (Appendix 4). A full model was fitted, then through a number of iterations variables were allowed to leave and enter the model until a model was found that included all variables with a significance of 0.15 or less. (This was an initially back step process with automatic stepping forward or backward with probabilities of 0.15 or less entering or leaving the model). The results are provided in Table 1.4 and Appendix 4. The physical characteristics are significantly related to several of the measures of community structure. The most frequent predictors of the biotic measures were percent fines or percent fine sand, with negative relationships to several of these variables. A negative relationship means that the values of these biological metrics decrease as the proportion of fine-grained sediment increases. There was also a significant difference amongst the substrate categories for a number of the biological metrics.

To further examine the relationships with substrate, all biological variables were analyzed with a one-way analysis of variance (ANOVA), with station as a randomized block factor to make the ANOVA more efficient. If a significant difference among substrates was found by ANOVA, its nature was identified by pair-wise tests, Bonferroni-adjusted for multiple comparisons, comparing Site Sand with Reference Sand Stations and Site Wood with Reference Wood Stations. These results are summarized in Table 1.5 and Appendix 5. Only six substrate category effects were significant including:

1) Higher percent non insects, crustacea+mollusca, filter-feeders, and predators at Reference Wood than at Site Wood stations.
2) Lower percent parasites at Reference Wood than at Site Wood stations.
3) Lower per cent facultative species at Reference Sand than at Site Sand stations.

To search for other patterns that might explain community structure within the samples, MANOVA and discriminant function analysis was used with groupings of biological metrics as dependent variables, with substrate type as the independent variable and station as a blocking factor. Groupings were the set of functional roles (percent gatherers, predators, parasites, scrapers, shredders, filter feeders) and the set of tolerances (percent intolerant, facultative, and tolerant species). Groupings based on functional roles defined significant differences among substrate types by MANOVA (Appendix 6). The pattern for this group is illustrated in Figure 1.4. The first discriminant function, significant at $p<0.001$, separated Wood Stations from the other substrates. The 2nd function, also significant at $p<0.001$, separated Reference Wood from the Sand substrates. The 3rd function was not significant; as Figure 1.4 illustrates, Site Sand and Reference Sand were not discriminated by this 3rd function (Appendix 6). Thus, this aspect of community structure, as measured by presence of functional groups differed significantly between Wood, Reference Wood, and the Sand substrates.

The MANOVA results for groupings based upon tolerance, illustrated in Figure 1.5, indicated more overlap amongst groupings although there was some separation of Site Sand from Reference Sand and Site Wood from Reference Wood. The MANOVA results based upon selected taxa separates Site sand from Reference Sand but not Site Wood from Reference Wood (Figure 1.6 and Appendix 6).

Cluster Analysis

The results of the cluster analyses are presented in Figures 1.7a-1.7e and Appendix 7. Pattern among stations of the same substrate category was not apparent using any set or subset of variables, including the group of functional classifications that defined a difference between the communities of Wood and Reference Wood in MANOVA. This discrepancy attests to the power of MANOVA to detect differences even with the substantial variation among stations revealed by the cluster analysis. The major conclusion derived from the cluster analyses is the generality that there was great variability in community structure among stations, even those with grossly similar substrate characteristics, e.g., all the Reference Sand Stations and all the Reference Wood Stations.

Power Analysis

Because of the substantial variation among sampling locations, the variation due to sampling location, which included substrate effects, was ("partialed" out) in the ANCOVAs before looking for effects of PAH. Our null hypothesis was that including carbon normalized PAHs (NOCPAH) and total PAHs (TPAH) in the model produced no increase in R^2 (variation explained) after removing the variation explained by among station variability. Cohen (1988) posits increase in R^2 of 0.02, 0.13, and 0.26 as 'small', 'medium', and 'large' effect sizes, respectively. Using these effect sizes in Cohen's own program, SamplePower 2.0®, with 1, 55 degrees of freedom (df) our analysis reveals an a priori power to reject the null hypothesis when the alternative hypothesis of a 'medium' effect is true of 0.819. The power to detect a 'large' effect is 0.993 or almost certainty. So based upon these results if PAHs are having any effect on community structure, it is small. Power to detect a 'small' effect was 0.182,

To further evaluate the power of our analyses, we performed an a posteriori power analysis on the result of our ANCOVAS. As previously discussed, although *a posteriori* analyses have limited usefulness, they can shed light on the frequency with which high variability makes detection of real effects difficult, using the actual partitioning of variability into that explained by PAH concentration (after removing among station variability) and unexplained variability. Table 1.6 presents the result of that analysis: power to detect a 'small' effect after partialing out station variability varied from a low of 0.34 to as high as 0.94. Average power was 0.57, or better than one chance in two of rejecting a false null hypothesis. Power to detect a 'medium' effect was 1.0: certainty for all 22 biological metrics! Again this indicates that the power of these statistical analyses to detect a change due to PAH was substantial.

The third and last column in Table 1.6 presents the effect sizes for the effect of both NOCPAH and TPAH, respectively. Average increase in R^2 for including NOCPAH in the model was 0.005; that for including TPAH in the model was 0.0036. The actual effect sizes observed were in general much smaller than Cohen's standard for a 'small' effect. Again, if PAHs are affecting community structure, the effect is small. Since we had good power to detect a 'medium' effect, failure to reject the null hypothesis in most of the ANCOVAs was not due to low power.

Taxa richness was variable amongst stations with number of taxa at each station ranging from 8 to 30 (average = 20.9). Total number of unique taxa for all stations was 133. With the exception of two stations, Site Wood SQT2 and Site Wood SQT4, there wasn't substantial difference in the average number of taxa across all station replicates (Figure 1.1).

Dominant taxa were chironomids which made up an average 32.6% (maximum 84 to 91% in the five replicate samples from Sand Reference Station SQT12) of the abundance in each sample. In all, 58 taxa of chironomids were identified (Figure 1.1 and Appendix 2). The next most abundant taxa were a sabellid polychaete (*Manayunkia speciosa*), oligochaetes (primarily tubificids), nematodes, an isopod (*Caecidotea racovitzai*), amphipods (including *Gammarus fasciatus*), the unionid snail (*Amnicola limnosa*), sphaerid clams (including *Pisidium* spp.), mayflies, and caddisflies. Together these ten taxa made up approximately 94% of the total number of individuals (Appendix 1). Chironomids and tubificids alone made up approximately 50% total number of individuals. Aquatic insects made up 75% of the taxa; the majority of these were chironomid taxa.

These results are very similar to the results of other studies of benthic communities in this area of Lake Superior. Breneman, et al. (2000) found similar results in a recent study of the benthos in the St. Louis River estuary and adjacent nearshore waters although this area is subjected to more riverine influences than the Site or other areas within Chequamegon Bay. They found 80 taxa, largely on the basis of genus level identifications; 85% of the taxa identified were insects. As with the present study the majority of the taxa were chironomids (43 genera). They also found that Oligochaeta worms (Enchytraeidae, Naididae, and Tubificidae: Annelida) were the most abundant taxon.

Data from a lakewide study conducted in 1994, 2000 and 2003 by USEPA and NOAA were also reviewed for similarities (T. Corry, USEPA-Duluth, personal communication). This study had three stations in Chequamegon Bay although in deeper water than Site and reference stations used in this study. Dominant taxa collected in the three stations in Chequamegon Bay in the USEPA study were similar to those in this study with one exception. Dominant taxa were chironomids, tubificids, the sabellid worm, *Manayunkia speciosa*, and sphaerid clams (including *Pisidium* sp.). *Diporeia hoyi* was an abundant species in the USEPA study and absent from this study. This probably can be explained by the different depths sampled. Stations sampled in this investigation were closer to shore and in shallower water.

Very few patterns in the distribution of the taxa were discerned and only two appeared to be possibly related to the levels of PAHs (either TPAH or NOC-PAH) (Figure 1.2). The epibenthic isopod, *C. racovitzai*, was more abundant at Site Wood Stations, than at either Reference Wood, Reference Sand and Site Sand Stations. The unionid snail, *A. limnosa*, also an epibenthic species, was absent from any of the Site Wood Stations but was present at Reference Sand, Site Sand and Reference Wood Stations. Its exclusion from the Site Wood Stations may be due to a combination of PAH levels and/or wood mulch substrate. Other than that example there didn't seem to be a consistent pattern in the distribution of dominant taxa. *M. speciosa* was abundant at Reference Sand Stations SQT 13 and 14, but it was even more abundant at Site Sand Station SQT 7, a station where NOC-PAH ranged from 1014 to 62,900 µg/gOC (Figure 1.3). Likewise tubificids were abundant at Reference Sand Stations SQT10, SQT13 and SQT 14 but were also abundant at Site Sand Station SQT7. Mayflies (Ephemoptera) were abundant at Reference Sand Stations SQT13 and SQT14, but were also abundant at several Site Sand Stations (Figure 1.2).

The only other noteworthy result was the high density of chironomids at Reference Sand Station SQT12. Densities of chironomids at this station were 22,000 to 63,300/m2 and based upon this result the percentage of tolerant taxa at this station was the highest of any station (Figure 1.1 and Appendix 2).

As discussed previously, review of the box and whisker plots (Figure 1.1) indicated that there was substantial variation amongst replicate samples for most variables, including PAH levels, organism density and all benthic community metrics, at most of the stations. Examination of these plots did not indicate any obvious relationships with the levels of PAH (either as TPAH or NOC-PAH).

Statistical analysis confirmed this observation. The results of the ANCOVA (Table 1.3) indicated few significant relationships between the benthic community metrics and the level of PAHs, either as TPAH or NOC-PAH. In fact, with the exception of two metrics, the number of ETO taxa and the ratio of ETO/ ETO + chironomid abundance, all significant relationships indicated that as TPAH or NOC-PAH increased, the biological metric increased. These results suggest that the putatively most sensitive taxa, Ephemeroptera, Trichoptera, Odonata are negatively affected by increasing levels of NOC-PAHs. However the negative relationship of the ratio of ETO/ETO+chironomid abundance to NOC-PAH levels suggest that the number of chironomids are positively related to NOC-PAHs, i.e., the chironomid abundance increased as NOC-PAH levels increased.

Results of the cluster analysis (Figure 1.7a through 1.7e) indicated few stations of the same substrate category were highly similar. Site Sand Station SQT1 was very similar to Site Sand Station SQT7 when the proportion of tolerant, facultative and intolerant taxa was considered. These two stations are both sand substrate, are adjacent to one another, and have the highest levels of NOC-PAHs. However, when clusters were based upon other metrics SQT7 was very similar to some of the Reference Sand stations such as SQT 12 and SQT14 and quite different from SQT1. Three of the Site Wood Stations SQT4, SQT8 and SQT2 were similar based upon percent functional groups. Based upon other metrics, however, Site Wood stations were very Similar to Reference Wood stations.

The results of the MANOVA based upon some metrics, e.g., suggested there was some separation of Site Sand from Reference Sand stations and Site Wood from Reference Wood stations (Figure 1.4, 1.5 and 1.6), however these results were not consistent for all metrics and as discussed previously, the ANCOVA provided little evidence that this separation could be explained by the levels of PAH (either as TPAH or NOC-PAH).

Based upon *a priori* and *a posteriori* power analyses, this sampling design had adequate power detect a minimum of a medium effect due to the presence of PAHs or NOC-PAHs.

One may also argue that analyzing 22 different metrics of community structure constitutes a form of meta-analysis. Our repeated inability to detect an effect spread over a number of different measures of community structure further suggests the effect of PAHs on benthic community structure, if any, has to be small.

Clearly the nature of the substrate had a much greater influence on benthic community metrics than did the level of PAHs. Based upon the step-wise regression and the one-way ANOVA, grain size and substrate type were significant explanatory factors for the variation in the benthic

community (Tables 1.4 and 1.5). For most of the benthic community variables the finer grain sizes were associated with lower values.

There were also significant substrate category effects including the following:

1) Higher percent non insects, crustacea+mollusca, filter-feeders, and predators at Reference Wood than at Site Wood stations.
2) Lower percent parasites at Reference Wood than at Site Wood stations.
3) Lower per cent facultative species at Reference Sand than at Site Sand stations.

However, these six significant results don't support a conclusion that Site stations, whether sand or wood substrate, negatively influence benthic community metrics.

The overall results suggest that PAH levels (whether TPAH or NOC-PAH) are playing only a minor role in structuring communities, overshadowed by substrate effects (e.g., grain size and whether the substrate category was wood or sand). Perhaps this is not surprising as it was expected that a benthic community inhabiting an area with a wood mulch substrate would differ from that inhabiting a sand substrate. It has also been well-established in benthic ecology that grain size and substrate type is often a significant explanatory factor of differences in benthic community structure.

Breneman, D., C. Richards and S. Lozano. 2000. Environmental Influences on Benthic Community Structure in a Great Lakes Embayment. J Great Lakes Res. 26(3):287-304

Cohen Jacob. 1988. Statistical Power Analysis for the Behavioral Sciences, 2nd ed. Hillsdale, NJ, Lawrence Erlbaum Associates, Publishers.

Rothstein, Hannah., Jacob Cohen, David Schoenfeld and Jesse Berlin. 2000. SamplePower release 2.0. Chicago, SPSS Inc.

SEH. 1998. Ecological Risk Assessment. Ashland Lakefront Property.

Sneath, P.H. . and R.R. Sokal. 1973. Numerical Taxonomy. W. H. Freeman, NY.

Sokal, R.R. and F. J. Rohlf. 1995. Biometry, 3rd ed.. W. H. Freeman, NY.

SPSS. 2000. SYSTAT 10. SPSS, Inc. Chicago, IL.

URS. 2005. Remedial Investigation/Feasibility Study (RI/FS) Work Plan. Revision: 02.

Yandell, B. S. 1997. Practical Data Analysis for Designed Experiments. Chapman & Hall, NY.

Zar, J. H. 1974. Biostatistical Analysis. Prentice-Hall, Englewood Cliffs, NJ

TABLES

Table 1.1. Data Transformations. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

Variable	Transform
PAH and NOC-PAH Concentrations	Rank
Density (estimated abundance)	Logarithmic
Number of Taxa	Square Root
Number of ETO Taxa	Square Root
Number of ETO+Chironomidae Taxa	Square Root
Percent Dominance	ArcSine
Percent Chironomidae	ArcSine
Percent Oligochaeta	ArcSine
Percent Non-insects	ArcSine
Number of Crustacea+Mollusca Taxa	Square Root
Percent Crustacea+Mollusca	ArcSine
Shannon Diversity Index	Rank
Shannon Equitability	ArcSine
Biotic index (HBI)	None
Percent Intolerant (<3.51)	ArcSine
Percent Facultative (3.51-6.50)	ArcSine
Percent Tolerant (>6.50)	ArcSine
Percent Filterers	ArcSine
Percent Gatherers	ArcSine
Percent Parasites	ArcSine
Percent Predators	ArcSine
Percent Scrapers	ArcSine
Percent Shredders	ArcSine

Table 1.2. Phylogenetic List of Taxa Found in Benthic Invertebrate Samples, July and September 2005. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

- Nematoda
- Turbellaria
- Annelida
  - Polychaeta
    - Sabellidae
      - *Manayunkia speciosa*
  - Aphanoneura
    - Aeolosomatidae
      - *Aeolosoma*
  - Hirudinea
    - Erpobdellidae
  - Oligochaeta
    - Tubificida
      - Tubificidae
        - *Amphichaeta*
        - *Arcteonais lomondi*
        - *Aulodrilus americanus*
        - *Aulodrilus limnobius*
        - *Aulodrilus pigueti*
        - *Aulodrilus pluriseta*
        - *Limnodrilus hoffmeisteri*
        - *Limnodrilus udekemianus*
        - *Nais bretscheri*
        - *Nais simplex*
        - *Nais variabilis*
        - *Paranais*
        - *Piguetiella*
        - *Potamothrix moldaviensis*
        - *Potamothrix vejdovskyi*
        - *Pristina aequiseta*
        - *Pristina osborni*
        - *Slavina appendiculata*
        - *Specaria josinae*
        - *Spirosperma ferox*
        - *Stylaria lacustris*
        - *Vejdovskyella intermedia*
        - Tubificinae: bifid chaetae
        - Tubificinae: hair + pectinate chaetae
    - Enchytraeida
      - Enchytraeidae
    - Lumbricida
      - Lumbricidae
    - Lumbriculida
      - Lumbriculidae
- Arthropoda
  - Crustacea
    - Amphipoda
      - Gammaridae
    - Isopoda
      - Asellidae
        - *Caecidotea*
        - *Caecidotea racovitzai*
  - Arachnida
    - Acariformes
      - Amoenacaridae
        - *Amoenacarus*
      - Arrenuridae
        - *Arrenurus*
      - Pionidae
        - *Forelia*
        - *Piona*
      - Halacaridae
      - Lebertiidae
        - *Lebertia*
      - Limnesiidae
        - *Limnesia*
        - *Tyrrellia*
      - Mideopsidae
        - *Mideopsis*
  - Insecta
    - Ephemeroptera
      - Caenidae
        - *Caenis*
      - Ephemeridae
        - *Ephemera*
        - *Hexagenia*
    - Hemiptera
      - Corixidae
    - Trichoptera
      - Dipseudopsidae
        - *Phylocentropus*
      - Hydroptilidae
        - *Hydroptila*
      - Leptoceridae
        - *Mystacides sepulcharis*
        - *Oecetis*
      - Polycentropodidae
        - *Polycentropus*
    - Diptera
      - Ceratopogonidae
        - *Culicoides*
        - *Mallochohelea*
        - *Probezzia*
      - Empididae
        - *Hemerodromia*
      - Chironomidae

Gammarus *Gammarus fasciatus* Hyalellidae *Hyalella azteca*	*Ablabesmyia* *Ablabesmyia annulata* *Ablabesmyia mallochi* *Ablabesmyia simpsoni*
Chironomus *Cladotanytarsus* (early instar) *Cladotanytarsus* sp. grp. A *Cladotanytarsus mancus* grp. *Cladotanytarsus vanderwulpi* grp. *Corynoneura* *Cricotopus* *Cricotopus/Orthocladius* *Cryptochironomus* *Cryptotendipes* *Demicryptochironomus* *Endochironomus* *Epoicocladius* *Glyptotendipes* *Harnischia curtilamellata* *Heterotrissocladius marcidus* grp *Hydrobaenus* *Microtendipes pedellus* grp. *Microtendipes rydalensis* grp. *Monodiamesa* (cf. *bathyphila*) *Monodiamesa depectinata* *Nilothauma* *Pagastia* *Pagastiella* *Parachironomus arcuatus* grp. *Paracladius* *Paracladopelma* *Parakiefferiella* *Paralauterborniella nigrohalterale* *Paratanytarsus* *Paratendipes* *Phaenopsectra*	*Polypedilum flavum* *Polypedilum halterale* grp. *Polypedilum scalaenum* grp. *Potthastia longimana* *Procladius* *Psectrocladius* *Pseudochironomus* *Rheotanytarsus* *Stempellina* *Stempellinella* *Stictochironomus* *Synorthocladius* *Tanytarsus* *Thienemannniella* *Thienemannimyia* grp. *Tribelos jucundum* Mollusca Bivalvia Sphaeriidae *Musculium* *Pisidium* Unionidae Gastropoda Hydrobiidae *Amnicola limosa* Physidae *Physa* Planorbidae *Gyraulus* *Helisoma anceps* Valvatidae *Valvata tricarinata*

Table 1.3. Probabilities That There Is No Relationship between Biological Metrics and TPAH or NOCPAH, Derived from ANCOVA. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

BIOLOGICAL METRIC	Probability That a Null Hypothesis of No Relationship is True: with Total PAH	with NOC- PAH
Density (estimated abundance)	0.621	0.978
Number of Taxa	0.218	0.792
Number of ETO Taxa	0.257	**0.002****
Ratio of ETO/ETO+Chironomidae Taxa	0.194	**0.013***
Percent Dominance	**0.033***	0.089
Percent Chironomidae	**0.007****	0.288
Percent Oligochaeta	0.11	0.965
Percent Non-insects	**0.012***	0.654
Number of Crustacea+Mollusca Taxa	0.692	0.548
Percent Crustacea+Mollusca	0.443	0.136
Shannon Diversity Index	**0.023***	0.699
Shannon Equitability	0.206	0.335
Biotic index (HBI)	0.713	0.525
Percent Intolerant (<3.51)	0.929	0.868
Percent Facultative (3.51-6.50)	0.367	0.828
Percent Tolerant (>6.50)	0.34	0.744
Percent Filterers	0.259	0.859
Percent Gatherers	**0.038***	0.588
Percent Parasites	0.53	0.979
Percent Predators	0.069	0.785
Percent Scrapers	0.571	0.237
Percent Shredders	0.119	0.075

* indicates a significant relationship ($p<0.05$), ** a highly significant relationship ($p<0.01$).

Table 1.4. Results from Step-wise Regressions to Determine Relationships between Biological Measures and Sediment and Substrate Characteristics. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

	Substrate Effects					Effects of Sediment Grain Size				
						P(No relationship with dependent variable)				
BIOLOGICAL METRIC	P(No Substrate Effect)[1]	P(Sand=SandRef)	Direction of Difference	P(Wood=WoodRef)	Direction of Difference	Fines	Fine Sand	Medium Sand	Course Sand	Gravel
Density (estimated abundance)	**<0.001**	1		**0.03471**	Wood>Wref	**0.00038**		0.12105		
Number of Taxa						**0.03655**	**0.00185**		**0.00303**	
Number of ETO Taxa							0.09211	0.11422		
Percent ETO/(ETO+Chironomidae)							**0.00222**			
Percent Dominance						0.14604	0.07573			
Percent Chironomidae						0.08054	**0.00001**			
Percent Oligochaeta	**0.00877**	**0.0371**	Sand>SRef	0.50911						
Percent Non-insects						0.08014	**0.00001**			
Number of Crustacea+Mollusca Taxa	0.11575									
Percent Crustacea+Mollusca	**0.01553**	1		1		**0.00026**	**0.00011**		**0.0254**	
Shannon Diversity Index							0.0746			
Shannon Equitability	No model fitted except constant									
Biotic index (HBI)	0.13568						0.12883			**0.00696**
Percent Intolerant (<3.51)										
Percent Facultative (3.51-6.50)	**0.00394**	1		1		0.07123	**0.0242**			
Percent Tolerant (>6.50)	**0.00528**	0.9208		1		0.0568	**0.02462**			
Percent Filterers	**0.00425**	1		**0.00245**	Wood>Wref	**0.01332**		**0.02857**		
Percent Gatherers	**0.00591**	1		**0.01674**	Wood<Wref	**0.00049**	**0.02091**		0.0745	
Percent Parasites	**0.00369**	1		1		**0.00163**	**0.02977**		0.07473	
Percent Predators	0.07034							**0.00325**		
Percent Scrapers	**0.00007**	0.45907		**0.01584**	Wood>Wref		**0.00129**			
Percent Shredders	0.08254					0.09622	0.09419	0.09829	**0.03937**	0.10218

[1] A significant substrate effect can arise because of differences between sand and wood derived substrates.

Significant results are bolded.

Blank fields indicate a variable was not included in the model

Table 1.5. Results of ANOVA for Substrate Effects. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

BIOLOGICAL METRIC	Probability of No Substrate Effect	Probability of No Difference Between Sand and SandRef	Direction of Difference	Probability of No Difference Between Wood and WoodRef	Direction of Difference
Density (estimated abundance)	0.85223				
Number of Taxa	**0.00403****	0.10338		1.00	
Number of ETO Taxa	0.56861				
Number of ETO+Chironomidae Taxa	0.51826				
Percent Dominance	0.91471				
Percent Chironomidae	0.86312				
Percent Oligochaeta	**0.00039*****	0.49		1.00	
Percent Non-insects	**0.01321****	1.00		**0.03252***	WoodRef>Wood
Number of Crustacea+Mollusca Taxa	0.82564				
Percent Crustacea+Mollusca	**<0.001*****	0.1304		**<0.001*****	WoodRef>Wood
Shannon Diversity Index	0.70535				
Shannon Equitability	0.23043				
Biotic index (HBI)	0.05625				
Percent Intolerant (<3.51)	0.92591				
Percent Facultative (3.51-6.50)	**0.00609****	**0.00075*****	SandRef<Sand	0.73448	
Percent Tolerant (>6.50)	**0.00935****				
Percent Filterers	**0.00501****	1.00		**0.0149***	WoodRef>Wood
Percent Gatherers	0.75322				
Percent Parasites	**0.0003*****	1.00		**0.00902****	Wood>WoodRef
Percent Predators	**0.00476****	0.20635		**0.02322***	WoodRef>Wood
Percent Scrapers	**0.00053*****	0.73522		0.40136	
Percent Shredders	0.9438				

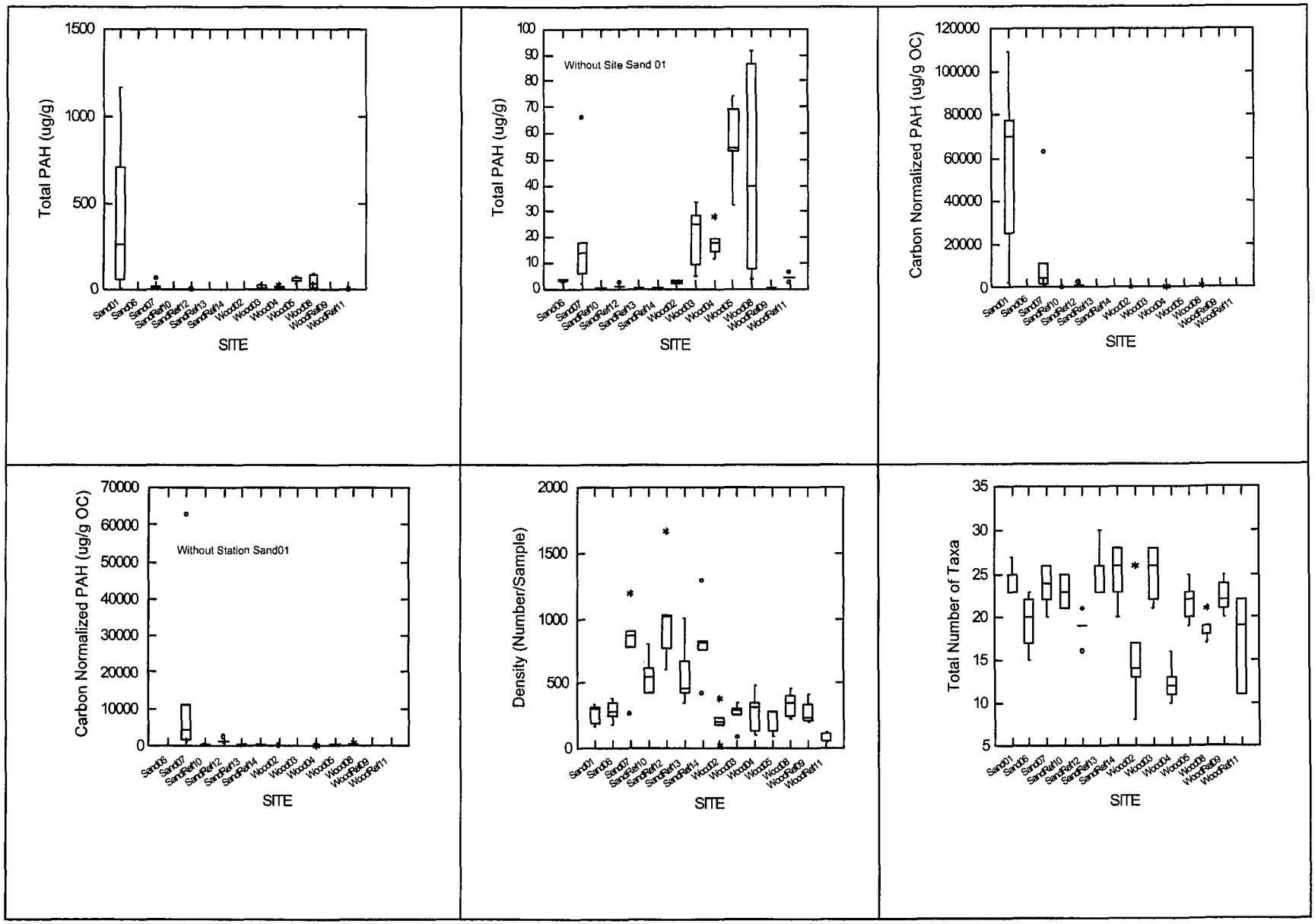
Significant results are bolded; * indicates significant ($p<0.05$), ** indicates highly significant $p<0.01$), *** indicates very highly significant $p<0.001$).

Table 1.6. *A Posteriori* Power Analysis of ANCOVA. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.

Biological Metric	Variance Explained by Sample Station	Variance Explained by Station and NOCPAH	Actual Effect Size	Power to Detect a Small Effect	Variance Explained by Station and TotalPAH	Actual Effect Size
Density (estimated abundance)	0.69446	0.71771	0.02325	0.58	0.70295	0.00849
Number of Taxa	0.63395	0.63396	0.00001	0.5	0.63395	0
Number of ETO Taxa	0.5699	0.57244	0.00254	0.44	0.57034	0.00044
Number of ETO+Chironomidae Taxa	0.53295	0.54034	0.00739	0.41	0.53295	0
Percent Dominance	0.56409	0.5642	0.00011	0.44	0.56953	0.00544
Percent Chironomidae	0.8484	0.85441	0.00601	0.87	0.84845	5E-05
Percent Oligochaeta	0.69626	0.70025	0.00399	0.58	0.69725	0.00099
Percent Non-insects	0.84205	0.84876	0.00671	0.87	0.84229	0.00024
Number of Crustacea+Mollusca Taxa	0.47486	0.47491	0.00005	0.37	0.4774	0.00254
Percent Crustacea+Mollusca	0.86975	0.86979	0.00004	0.94	0.87389	0.00414
Shannon Diversity Index	0.67942	0.68258	0.00316	0.59	0.6805	0.00108
Shannon Equitability	0.58817	0.59444	0.00627	0.45	0.58966	0.00149
Biotic index (HBI)	0.63016	0.63064	0.00048	0.5	0.63165	0.00149
Percent Intolerant (<3.51)	0.57394	0.57427	0.00033	0.44	0.57408	0.00014
Percent Facultative (3.51-6.50)	0.80509	0.80595	0.00086	0.78	0.80627	0.00118
Percent Tolerant (>6.50)	0.80769	0.80898	0.00129	0.78	0.8091	0.00141
Percent Filterers	0.63268	0.6343	0.00162	0.5	0.64102	0.00834
Percent Gatherers	0.64641	0.65763	0.01122	0.51	0.6499	0.00349
Percent Parasites	0.68239	0.68357	0.00118	0.56	0.70259	0.0202
Percent Predators	0.63023	0.65637	0.02614	0.5	0.64187	0.01164
Percent Scrapers	0.64705	0.65067	0.00362	0.51	0.65462	0.00757
Percent Shredders	0.41942	0.42382	0.00440	0.34	0.4196	0.00018
	Averages:		0.00503	0.57		0.003661

FIGURES

Figure 1.1 Box and Whisker Plots of PAH Levels and Benthic Community Metrics. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.



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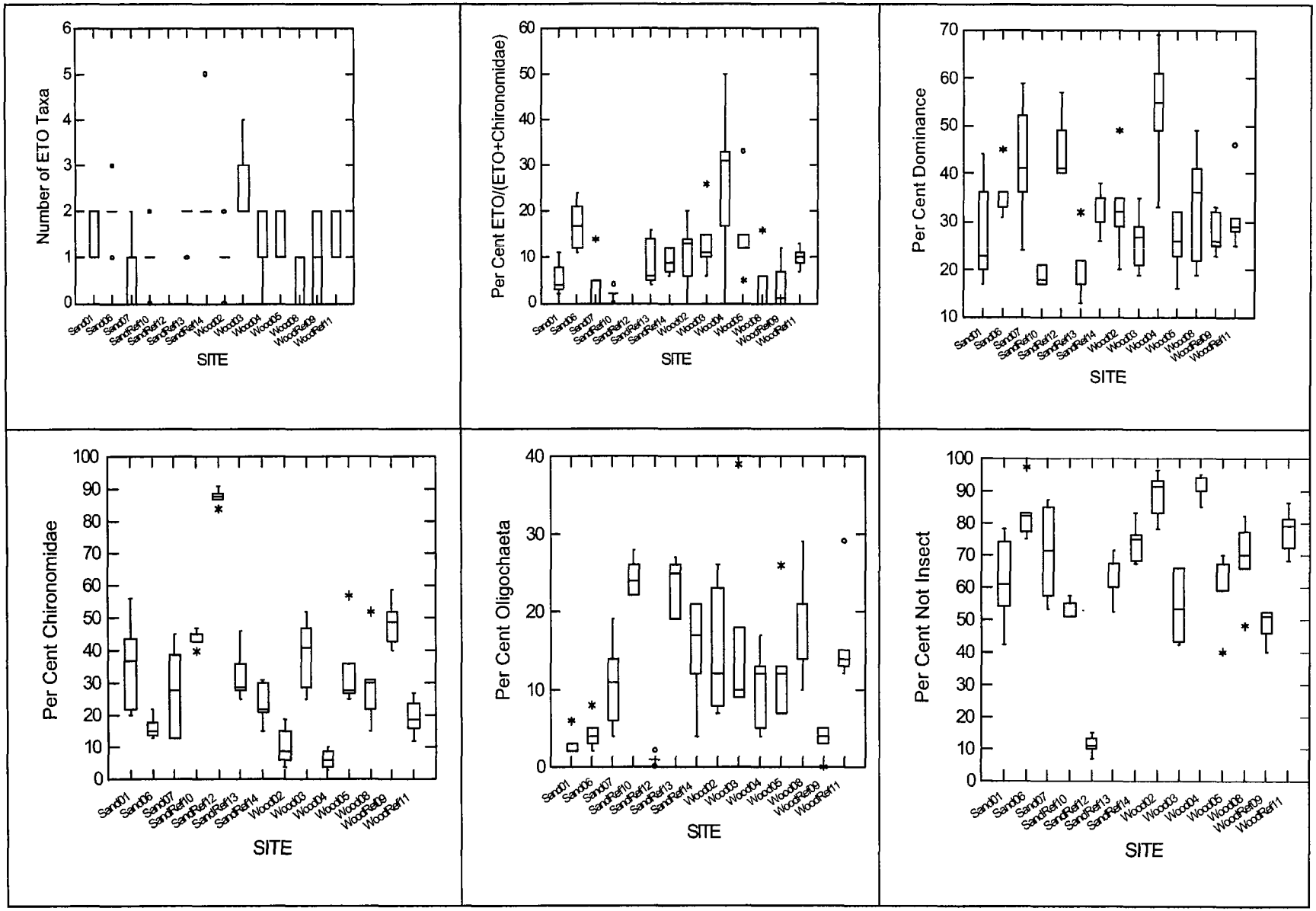

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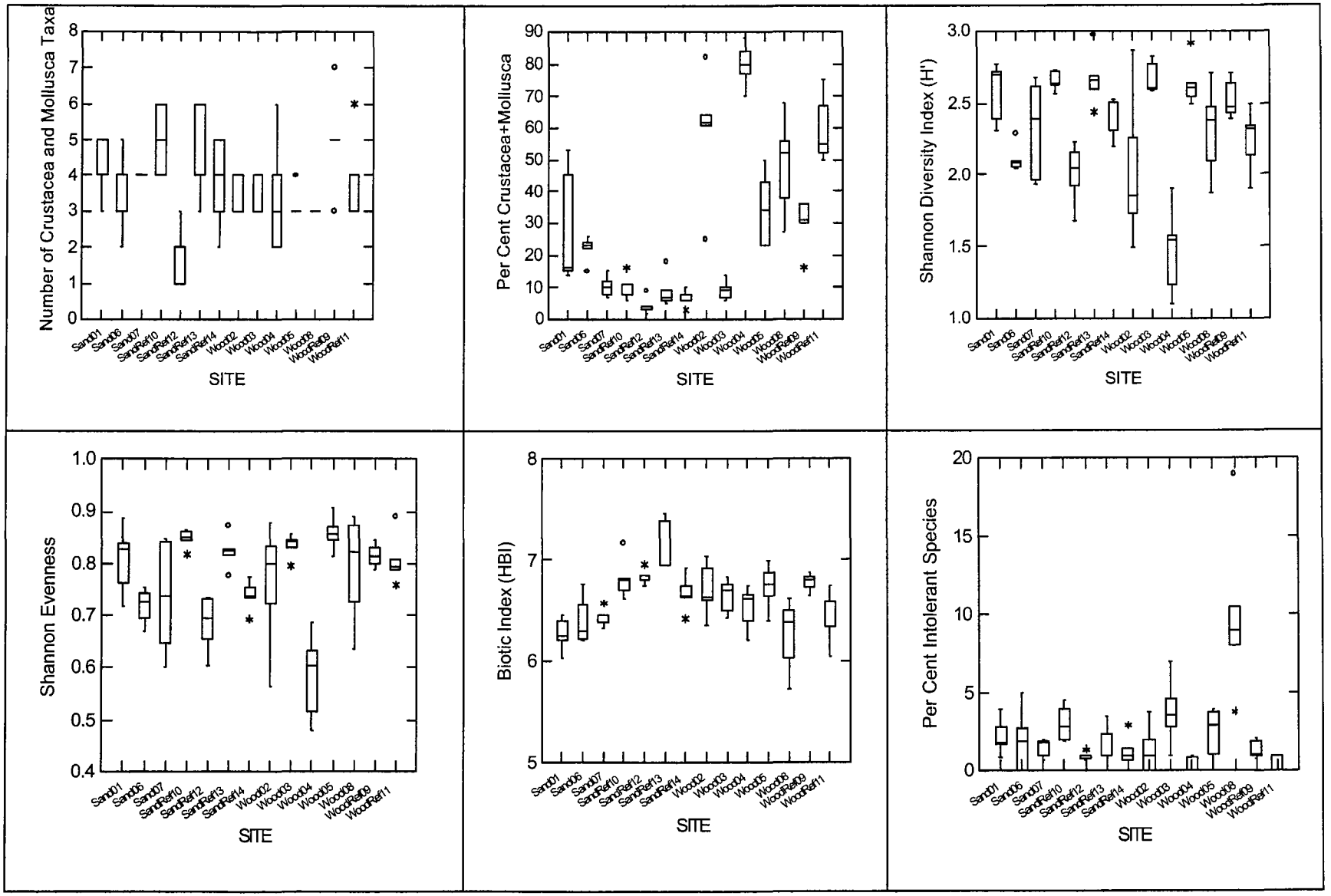

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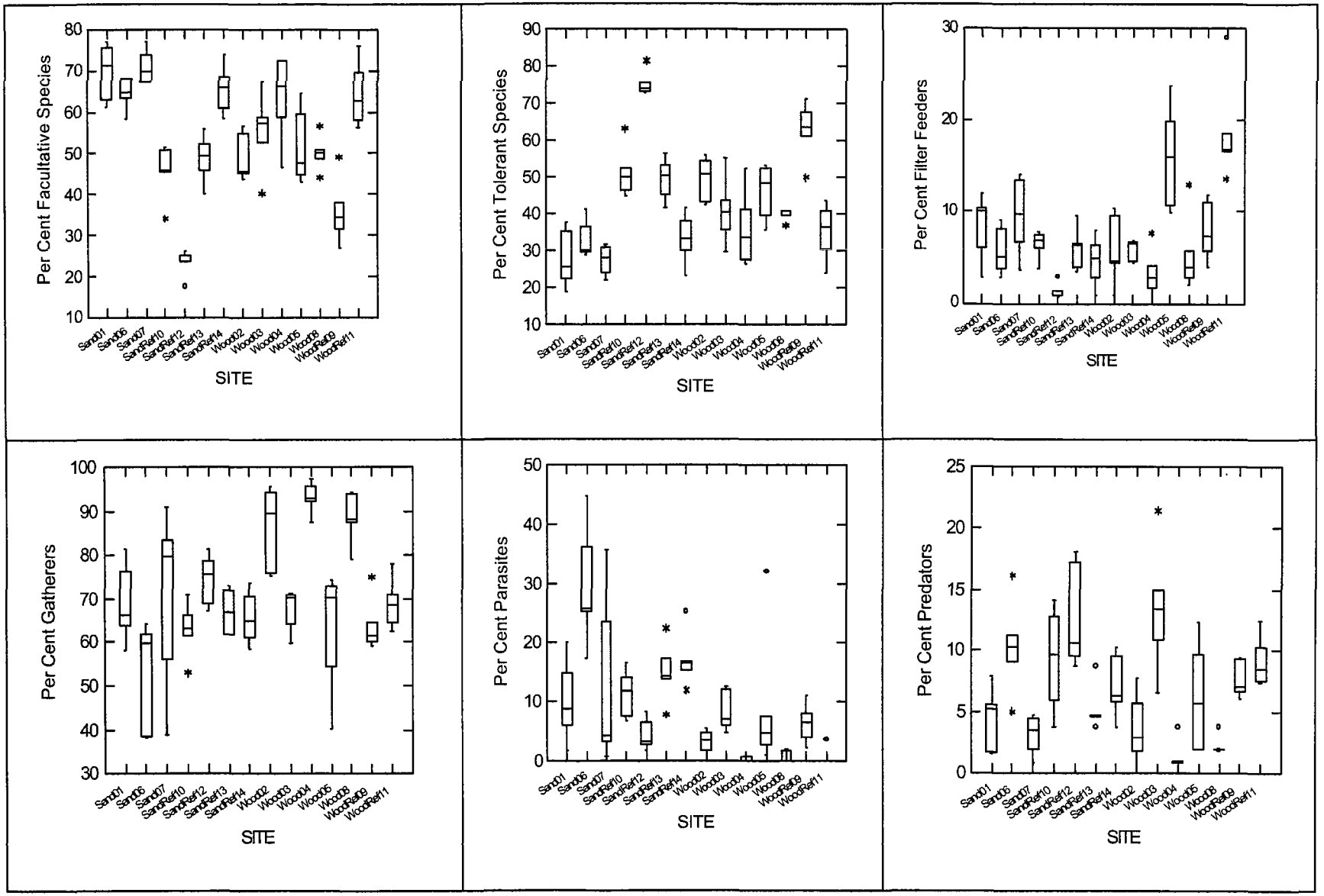

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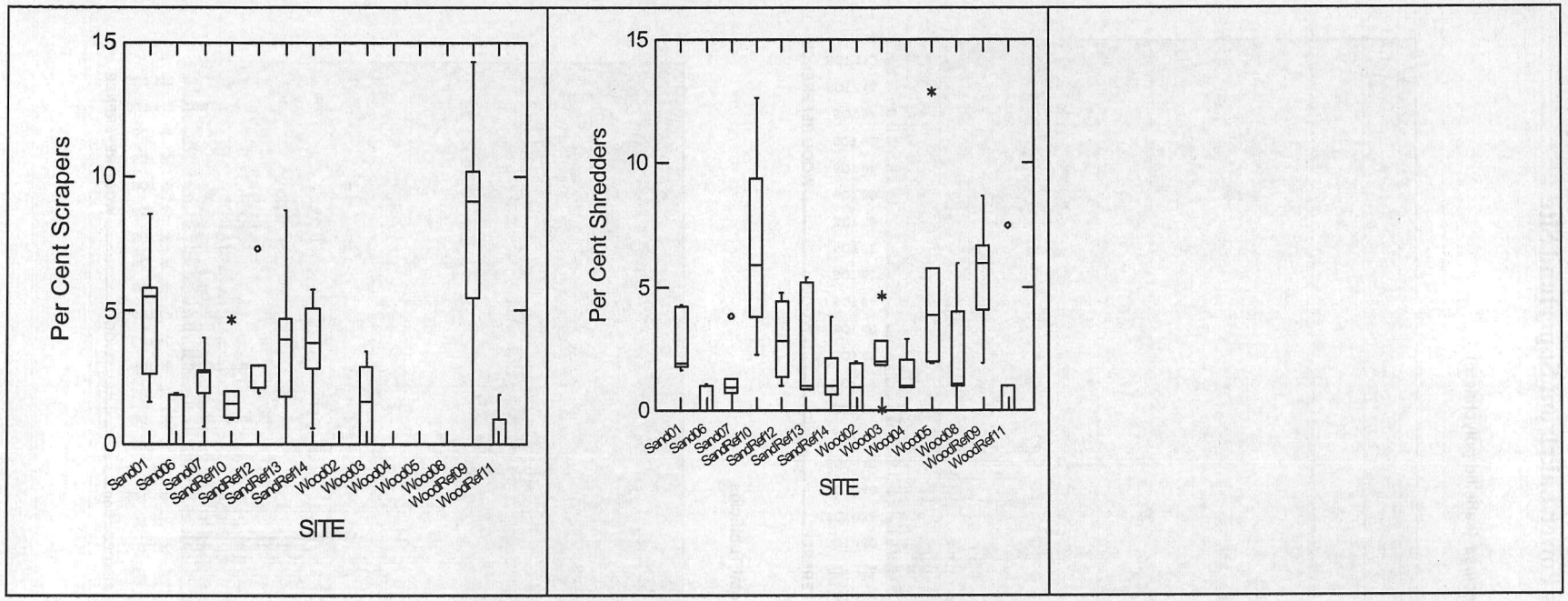
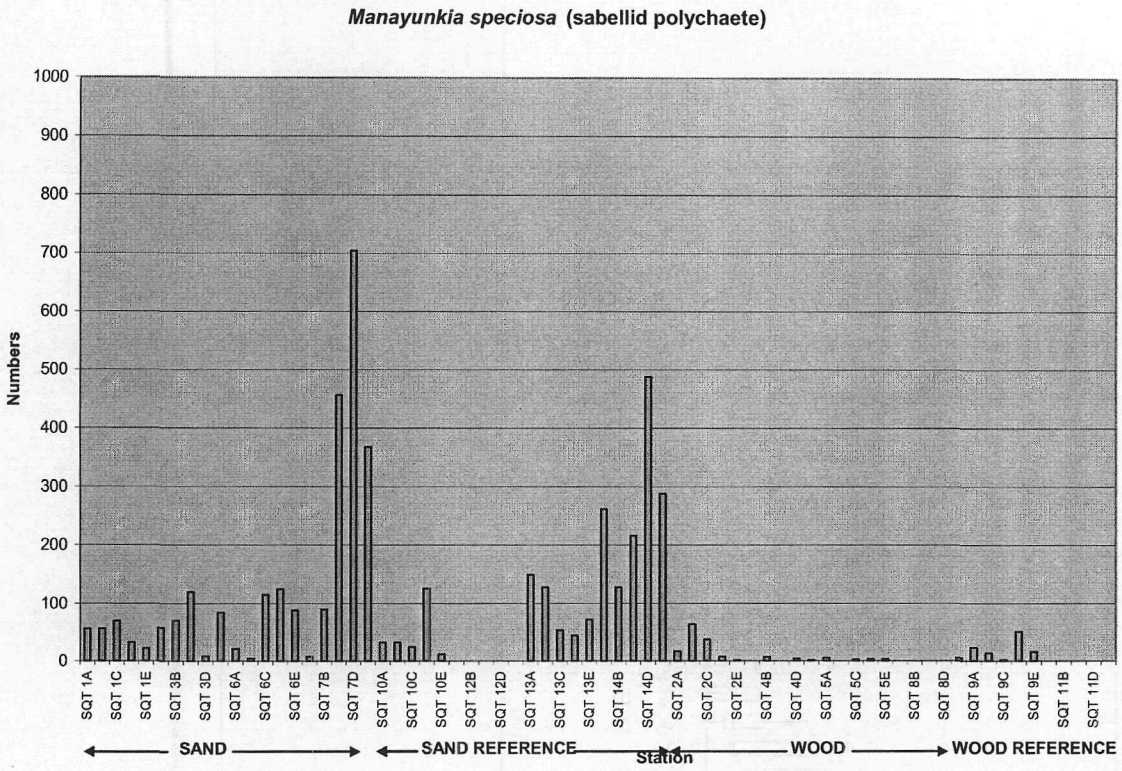
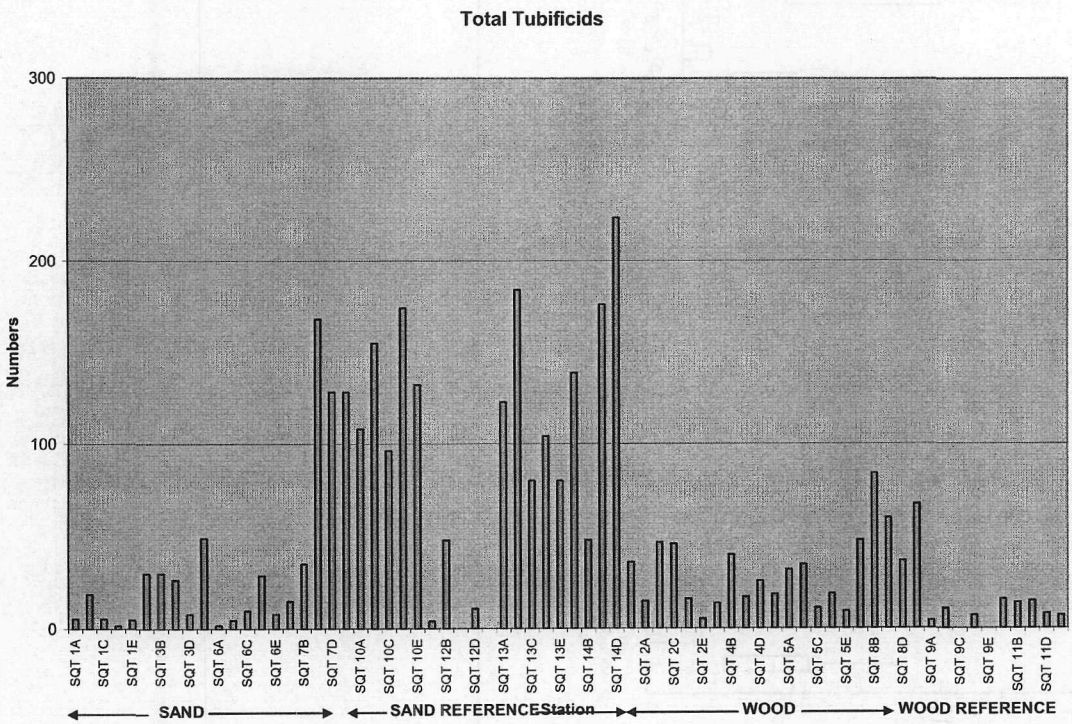


Figure 1.2. Abundance of Dominant Species. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site





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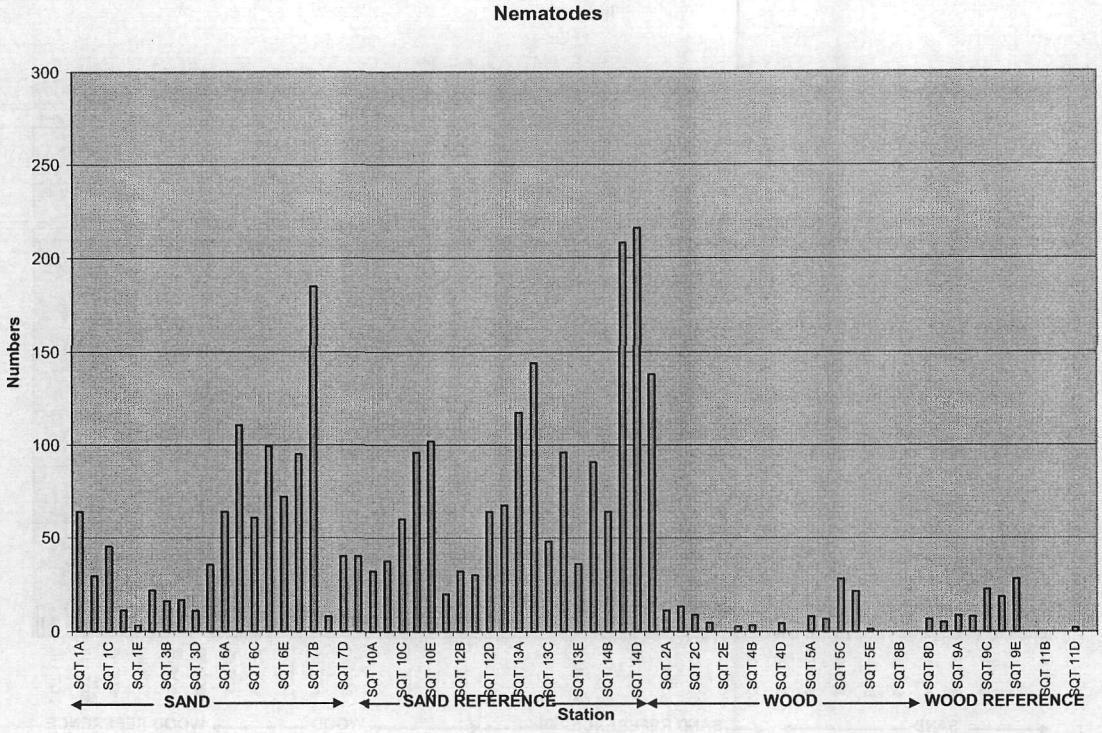

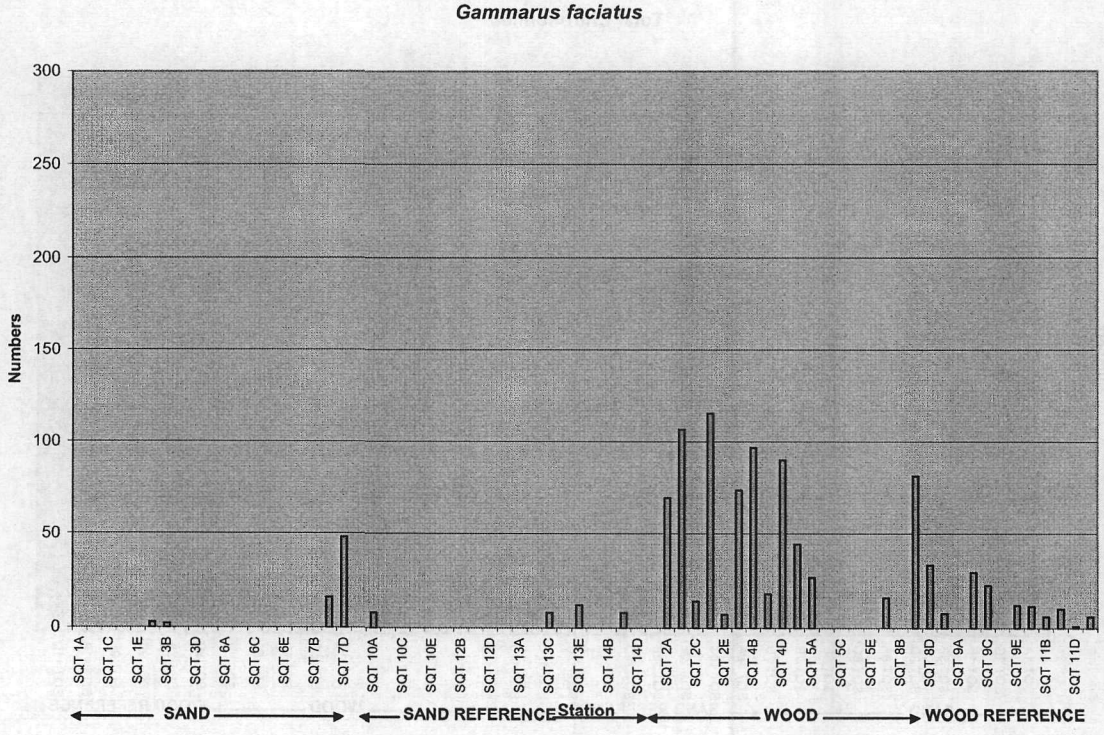

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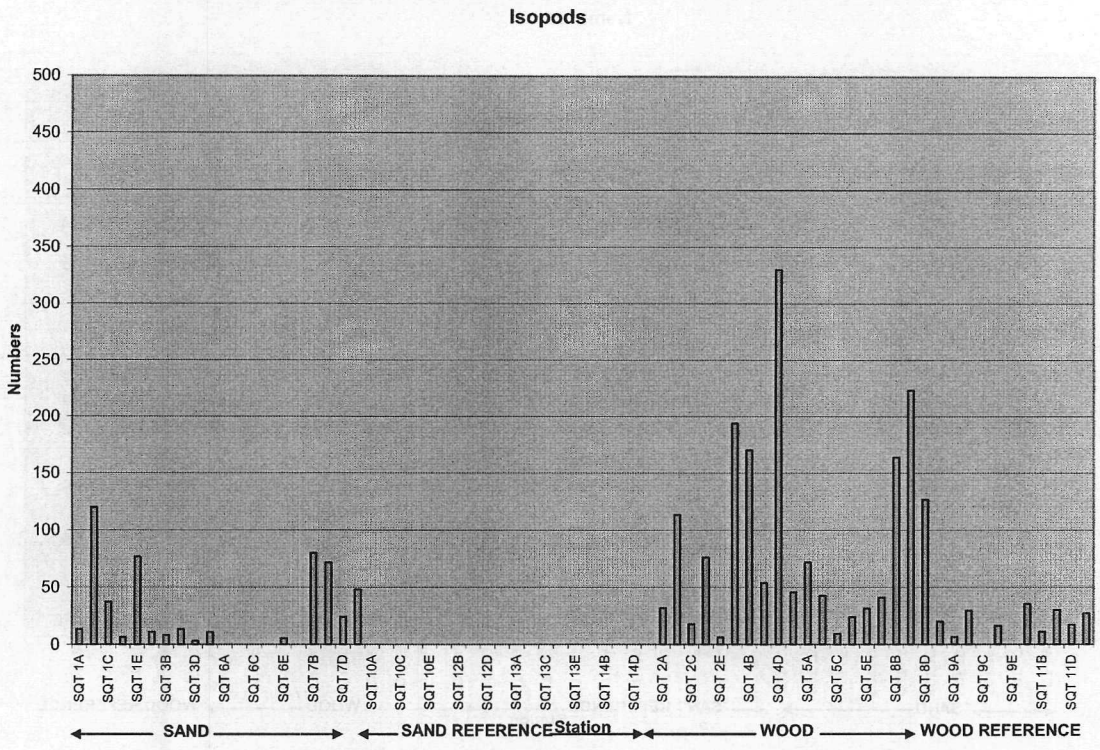

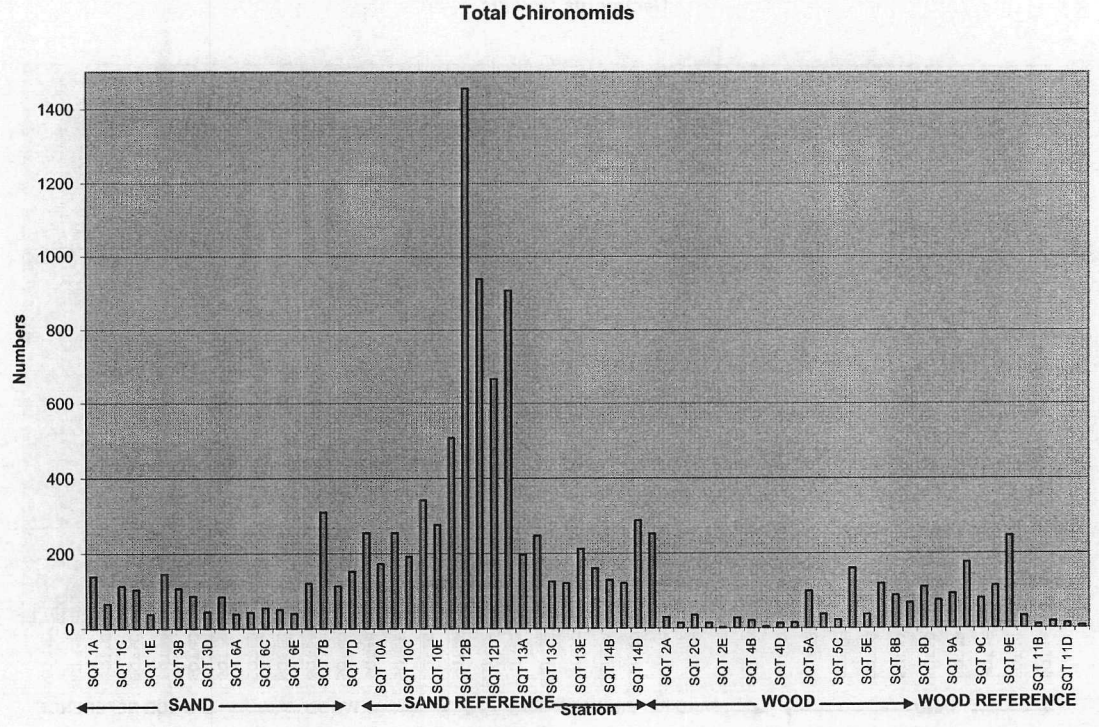

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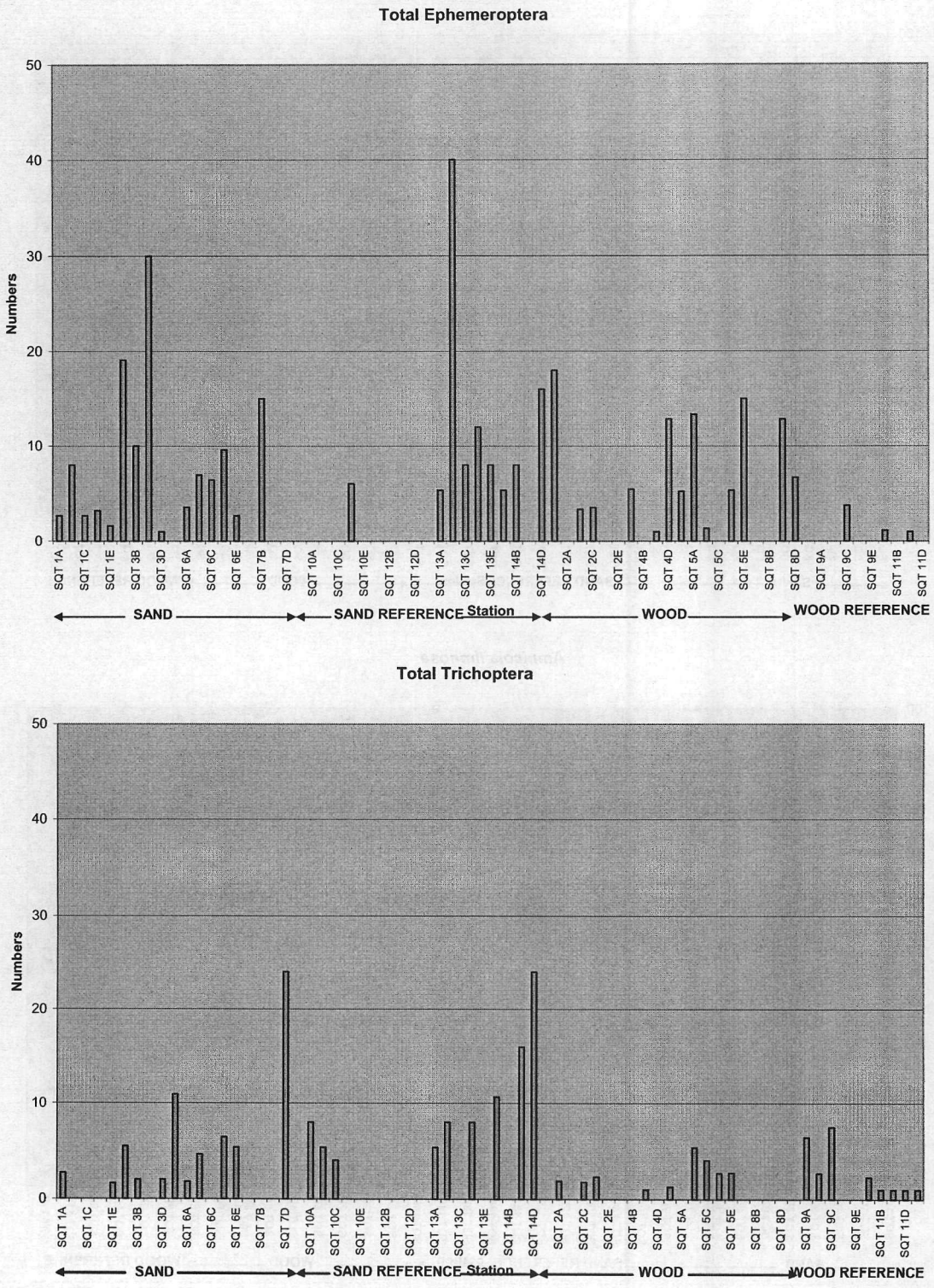
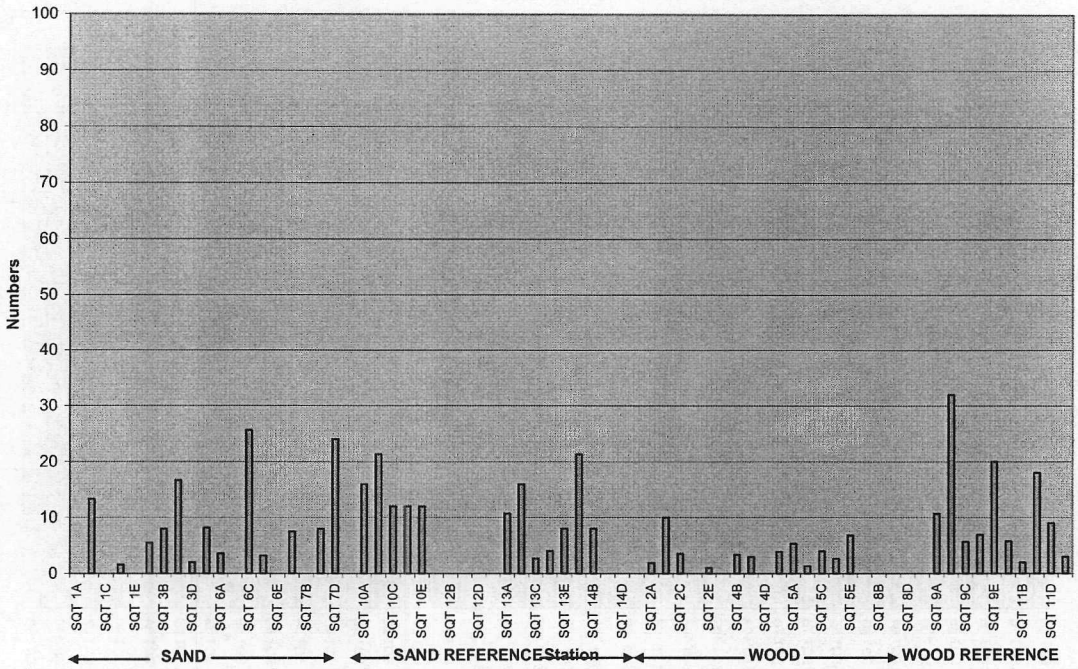


Figure 1.2. Abundance of Dominant Species. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site

Pisidium sp



Amnicola limnosa

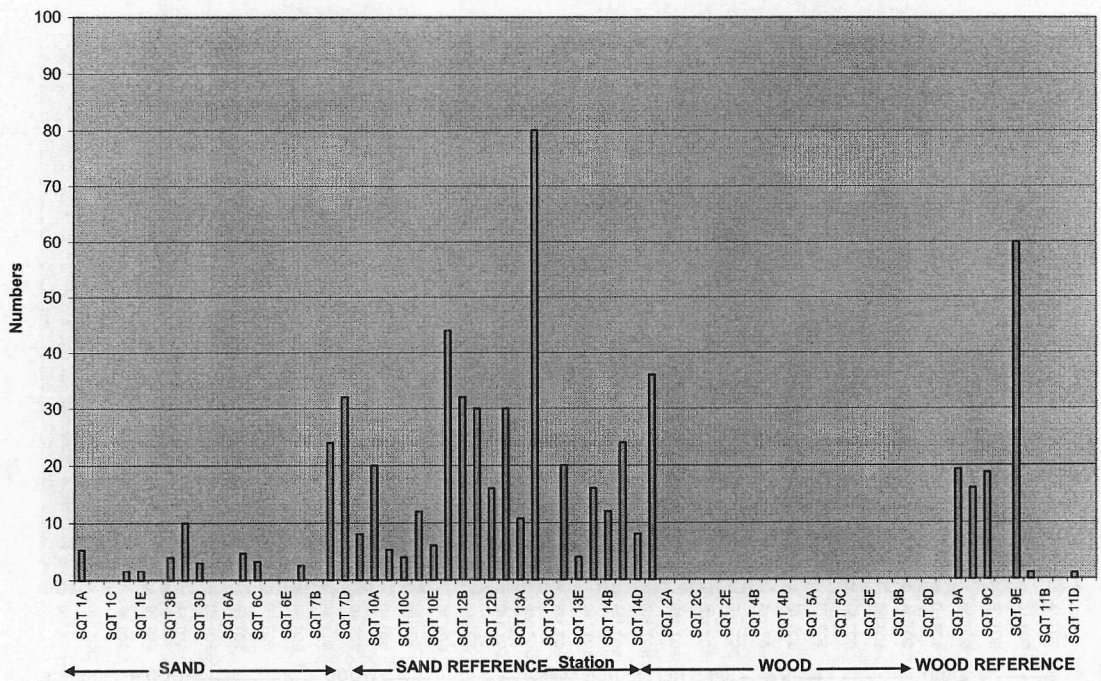
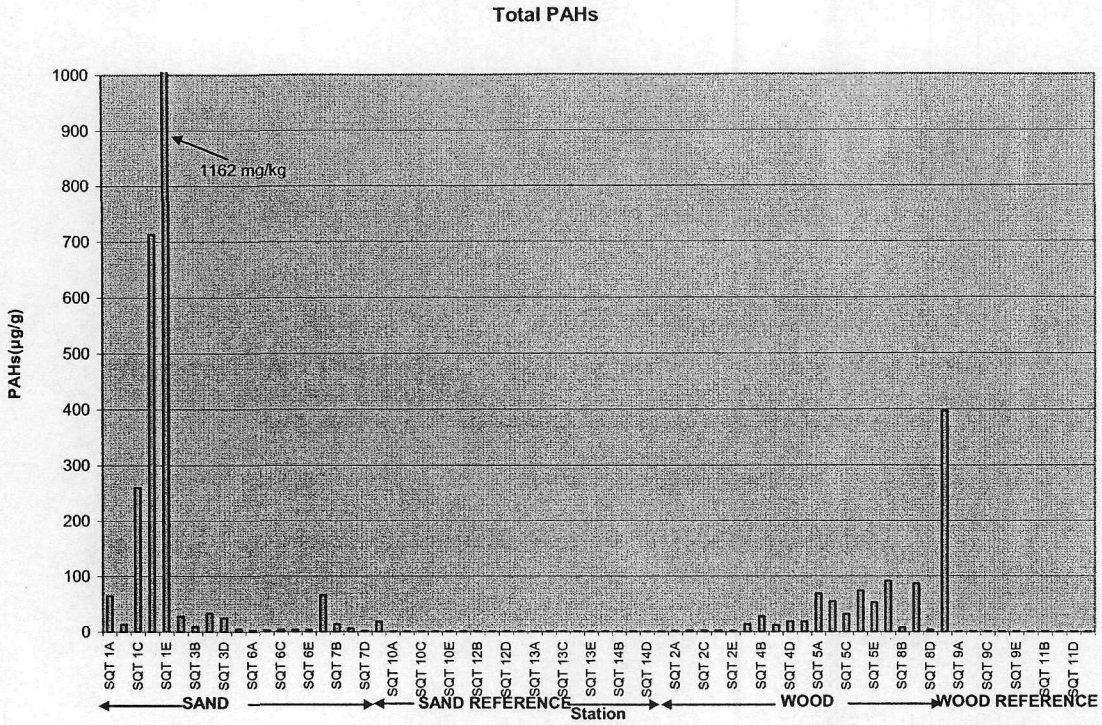


Figure 1.3. PAHs and NOC-PAHs by Station. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site



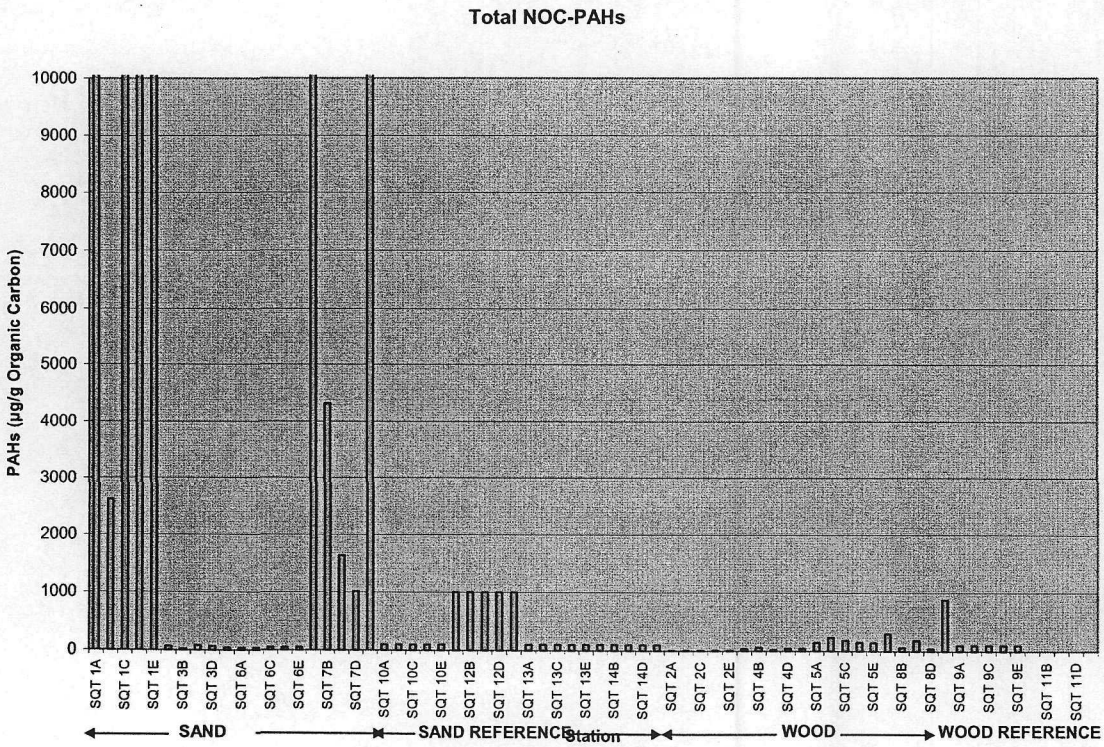
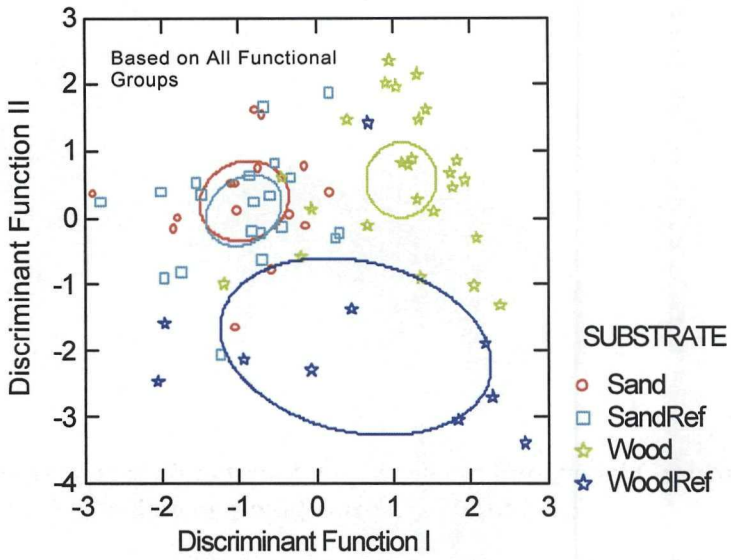
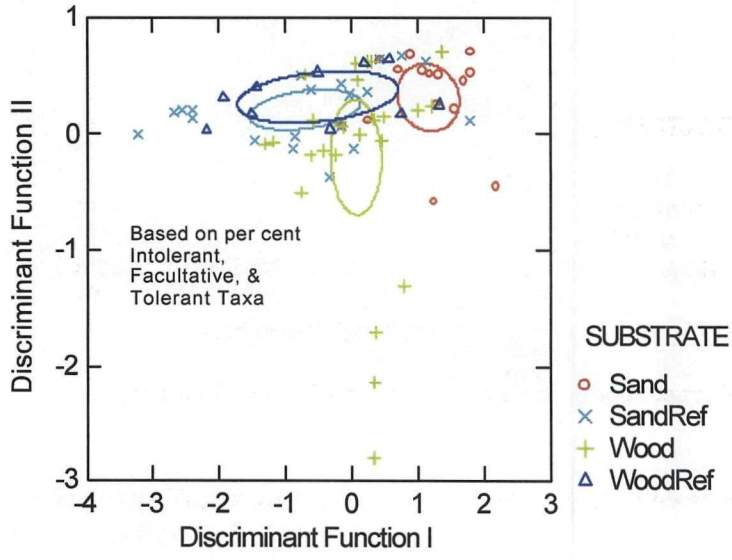


Figure 1.4. Results of Discriminant Function Analysis Using Functional Groups. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.



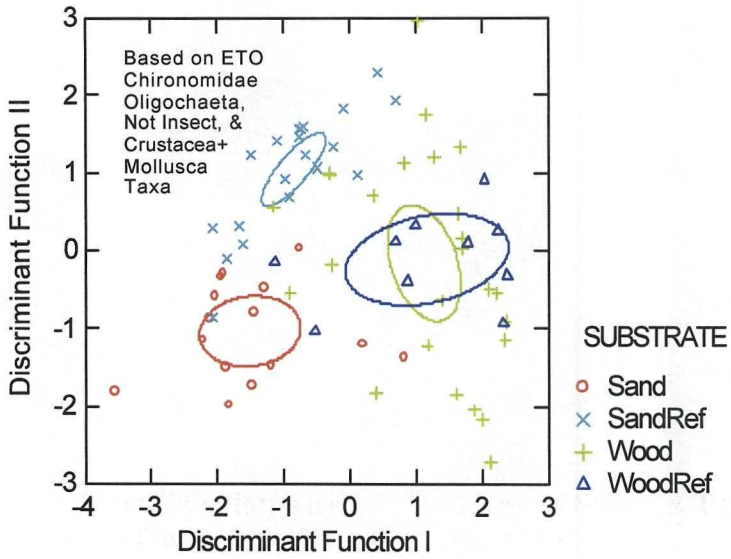
Ellipses are 95% confidence intervals around group centroids.

Figure 1.5. Results of Discriminant Function Analysis Using Relative Tolerance. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.



Ellipses are 95% confidence intervals around group centroids.

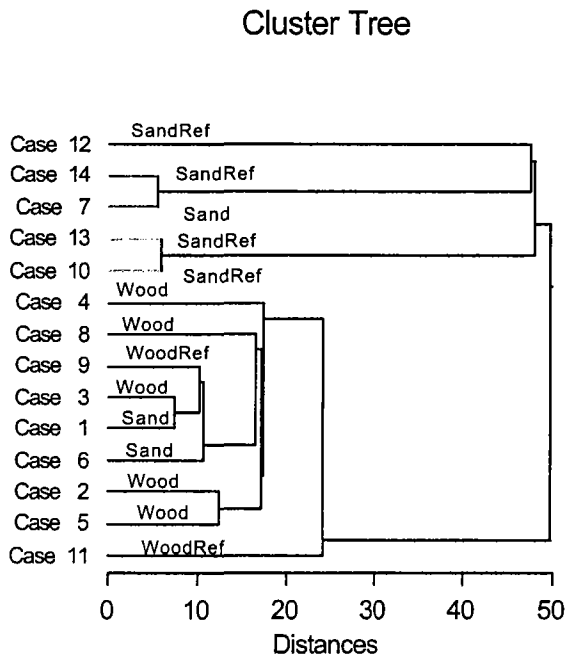
Figure 1.6. Results of Discriminant Function Analysis Based upon Selected Taxa. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.



Ellipses are 95% confidence intervals around group centroids.

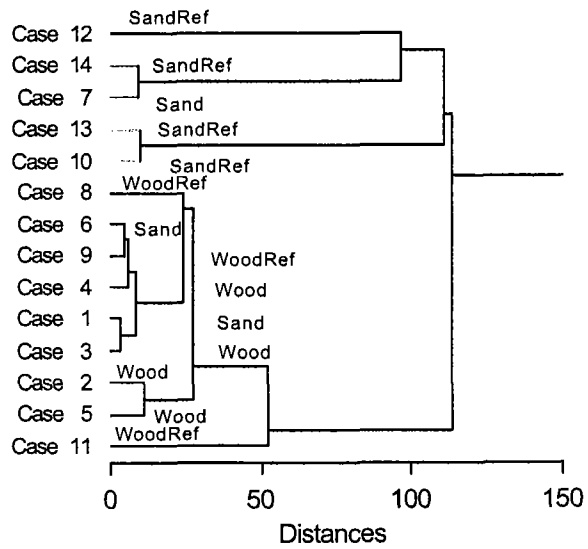
Figure 1.7 a-e. Cluster Trees for Various Combinations of Biological Metrics. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.*

Based Upon All Community Metrics



7a

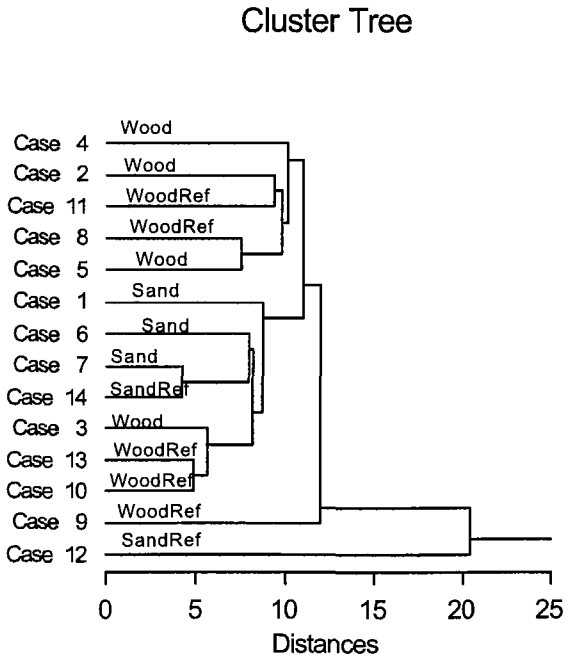
Based Upon Density and Numbers of Taxa, ETO Taxa, Ratio of ETO/ETO+Chironomidae, Crustacea+Mollusca Taxa



7b

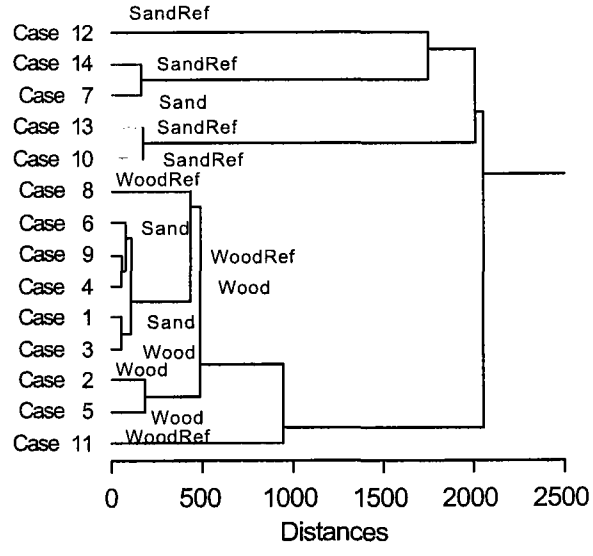
Figure 1.7 a-e. Cluster Trees for Various Combinations of Biological Metrics. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.*

Based Upon Percent Chironomids, Oligochaetes, Crustaceans + Molluscs, Tolerant, Facultative and Intolerant.



6a

Based Upon All Functional Groups

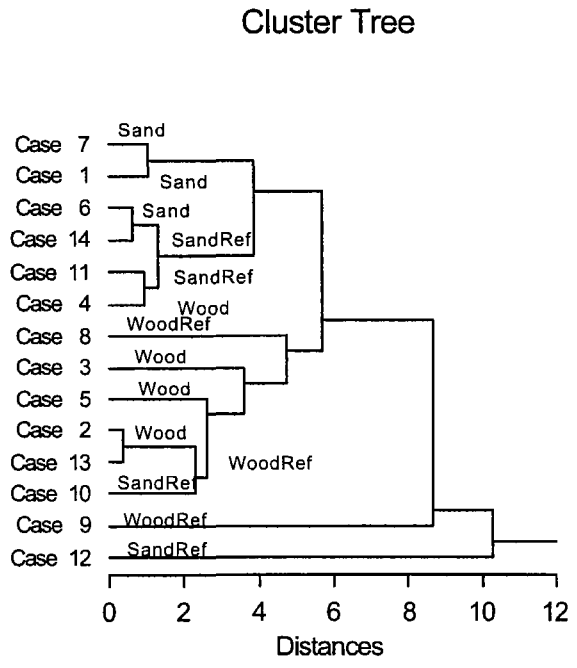


7c

7d

Figure 1.7 a-e. Cluster Trees for Various Combinations of Biological Metrics. Sediment Quality Triad Report. Ashland/Northern States Power Lakefront Superfund Site.*

Based upon Percent Tolerant, Facultative & Tolerant



7e

* = "Case" Number on Cluster Trees is the same as SQT Station Number.

APPENDICES

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 1A	SQT 1B	SQT 1C	SQT 1D	SQT 1E	SQT 2A	SQT 2B	SQT 2C	SQT 2D	SQT 2E	SQT 3A	SQT 3B	SQT 3C
Nematoda	64	29	45	11	3	11	13	9	5		22	16	17
Turbellaria													
Manayunkia speciosa	56	56	69	32	22	17	63	37	7	1	57	70	120
Aeolosoma													
Amphichaeta													
Arcteonais lomondi													
Aulodrilus americanus									2				7
Aulodrilus limnobius								2			3		3
Aulodrilus pigueti						2							
Aulodrilus pluriseta					2						3		
Limnodrilus hoffmeisteri					2								
Limnodrilus udekemianus													
Naidinae													
Nais bretscheri												2	
Nais simplex		3							2				
Nais variabilis		3											
Paranais													
Piguetiella													
Potamothrix moldaviensis			3				3	2			3		
Potomothrix vejdovskyi							3	4			3		
Pristina aequiseta													
Pristina osborni													
Slavina appendiculata		3											
Specaria josinae													
Spirosperma ferox		5				6	3	5	9	1		8	
Stylaria lacustris		3											
Vejdovskyella intermedia													
Tubificinae: bifid chaetae	5	3	3	2	2	6	37	25	2	4	19	20	13
Tubificinae: hair + pectinate chaetae						2		9					3
Enchytraeidae			5	2				2					3
Lumbricidae													
Lumbriculidae													
Erpobdellidae													
Gammarus	3	5	3		6								3
Gammarus fasciatus						69	107	14	115	7	3	2	
Hyalella azteca													
Caecidotea													
Caecidotea racovitzai	13	120	37	6	77	32	113	18	76	6	11	8	13
Acariformes		3											
Amoenacarus													
Arrenurus													
Forelia			8	3	3								10
Halacaridae								4					
Hygrobates													
Lebertia		3	3										3
Limnesia													
Mideopsis													
Piona			3	2	3								
Tyrrellia													
Caenis	3	8	3	3	2		3	4			14	6	23
Ephemera													
Hexagenia											5	4	7

TAXA	SQT 1A	SQT 1B	SQT 1C	SQT 1D	SQT 1E	SQT 2A	SQT 2B	SQT 2C	SQT 2D	SQT 2E	SQT 3A	SQT 3B	SQT 3C
Corixidae					2								
Dipseudopsidae													
Hydroptila	3				2								
Leptoceridae												2	
Mystacides sepulcharis													
Oecetis						2			2		3		
Phylocentropus								2			3		
Polycentropus													
Culicoides													
Mallochohelea	3		3								5		
Probezzia													
Hemerodromia													
Chironomidae			3		2	2					3	2	
Ablabesmyia													
Ablabesmyia annulata													
Ablabesmyia mallochi													
Ablabesmyia simpsoni													
Chironominae													
Chironomini													
Chironomus		3											3
Cladotanytarsus (early instar)			3	3									
Cladotanytarsus sp. grp. A	3	3						2	2			2	3
Cladotanytarsus mancus grp.	5		3								3	4	3
Cladotanytarsus vanderwulpi grp.	13		3	8	5			2			3		
Corynoneura													
Cricotopus					3								
Cricotopus/Orthocladius	5												
Cryptochironomus	3		8	5		4		7			3		
Cryptotendipes			3								25	12	3
Demicryptochironomus												2	
Endochironomus													
Epoicocladius											3		

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 1A	SQT 1B	SQT 1C	SQT 1D	SQT 1E	SQT 2A	SQT 2B	SQT 2C	SQT 2D	SQT 2E	SQT 3A	SQT 3B	SQT 3C
Glyptotendipes													
Harnischia curtilamellata												2	
Heterotrissocladius marcidus grp	5	13		2	3	6	3	2			3	12	3
Hydrobaenus	3												
Microtendipes pedellus grp.													
Microtendipes rydalensis grp.													
Monodiamesa (cf. *bathyphila*)													
Monodiamesa depectinata													
Nilothauma								2			3	2	
Orthocladiinae	3		3								3		
Pagastia													
Pagastiella	8		8								19	10	13
Parachironomus arcuatus grp.					2								
Paracladius	35			26				2			8		3
Paracladopelma	16	8	8	11	6	9					5	2	10
Parakiefferiella		11	29	6	3	2							
Paralauterborniella nigrohalterale												8	3
Paratanytarsus					3								
Paratendipes													
Phaenopsectra													
Polypedilum flavum													
Polypedilum halterale grp.				2								2	
Polypedilum scalaenum grp.	8	5	5	6		4	3	4			5	10	7
Potthastia longimana	3	3	3	3								2	
Procladius						6	7	4	5		55	28	33
Psectrocladius		3	3	2	3								
Pseudochironomus								4					
Rheotanytarsus													
Stempellina			3								3		
Stempellinella													
Stictochironomus	13	5	8	13	3			4	2	1			
Synorthocladius													
Tanypodinae													
Tanytarsini												2	
Tanytarsus	16	13	19	18	5			2			5	2	
Thienemannniella			3		2								
Thienemannimyia grp.													
Tribelos jucundum			3					4	5	1		4	
Musculium						15	7	7	2				
Pisidium		13		2		2	10	4		1	5	8	17
Sphaeriidae	16	8		3		4		4					7
Unionidae													
Amnicola limosa	5			2	2							4	10
Gyraulus													
Helisoma anceps													
Hydrobiidae													
Physa													
Planorbidae					2								
Valvata tricarinata	8	5	8	14	5								
Total number of individuals	**317**	**336**	**307**	**186**	**173**	**199**	**377**	**184**	**238**	**22**	**305**	**258**	**347**

TAXA	SQT 3D	SQT 3E	SQT 4A	SQT 4B	SQT 4C	SQT 4D	SQT 4E	SQT 5A	SQT 5B	SQT 5C	SQT 5D	SQT 5E	SQT 6A
Nematoda	11	35	3	3		4		8	7	28	21	1	64
Turbellaria													
Manayunkia speciosa	9	85		7		4	1	5		2	3	3	21
Aeolosoma									3				
Amphichaeta													
Arcteonais lomondi													
Aulodrilus americanus		5		3	1								
Aulodrilus limnobius					2								
Aulodrilus pigueti													
Aulodrilus pluriseta								3				1	
Limnodrilus hoffmeisteri				10	1	4							
Limnodrilus udekemianus													
Naidinae													
Nais bretscheri													
Nais simplex						4							
Nais variabilis													
Paranais													
Piguetiella													
Potamothrix moldaviensis	1	3										1	
Potomothrix vejdovskyi													
Pristina aequiseta													
Pristina osborni									4				
Slavina appendiculata													
Specaria josinae													
Spirosperma ferox		14	11	7	2	4	5	3					
Stylaria lacustris													
Vejdovskyella intermedia													
Tubificinae: bifid chaetae	7	27	3	20	10	13	13	27	20	10	16	7	2
Tubificinae: hair + pectinate chaetae					1				11	1	3		
Enchytraeidae													2
Lumbricidae		3											
Lumbriculidae													
Erpobdellidae													
Gammarus	1							3	1	3	27	22	28
Gammarus fasciatus			74	97	18	90	44	27					
Hyalella azteca													
Caecidotea													2
Caecidotea racovitzai	3	11	194	170	54	330	46	72	43	9	24	31	
Acariformes													
Amoenacarus													
Arrenurus													
Forelia									1		5		
Halacaridae													
Hygrobates													
Lebertia													
Limnesia													
Mideopsis													
Piona													
Tyrrellia													
Caenis			5		1	13	5	13	1		5	15	
Ephemera													
Hexagenia	1												4

TAXA	SQT 3D	SQT 3E	SQT 4A	SQT 4B	SQT 4C	SQT 4D	SQT 4E	SQT 5A	SQT 5B	SQT 5C	SQT 5D	SQT 5E	SQT 6A
Corixidae													
Dipseudopsidae									1	2	3		
Hydroptila													
Leptoceridae		3											
Mystacides sepulcharis													
Oecetis													
Phylocentropus	2	8			1		1		4	2		3	2
Polycentropus													
Culicoides													
Mallochohelea													
Probezzia													
Hemerodromia													
Chironomidae	2	3										1	
Ablabesmyia													
Ablabesmyia annulata													
Ablabesmyia mallochi			3										2
Ablabesmyia simpsoni													
Chironominae										1			
Chironomini		3											
Chironomus	2												
Cladotanytarsus (early instar)									1		3		
Cladotanytarsus sp. grp. A		3											
Cladotanytarsus mancus grp.								11	1		8	3	
Cladotanytarsus vanderwulpi grp.	1												
Corynoneura											3		
Cricotopus									4				
Cricotopus/Orthocladius									3				
Cryptochironomus							3			1	5		2
Cryptotendipes	3	11						3				4	2
Demicryptochironomus	1		3										
Endochironomus													
Epoicocladius	1	3											

TAXA	SQT 3D	SQT 3E	SQT 4A	SQT 4B	SQT 4C	SQT 4D	SQT 4E	SQT 5A	SQT 5B	SQT 5C	SQT 5D	SQT 5E	SQT 6A
Glyptotendipes													
Harnischia curtilamellata													
Heterotrissocladius marcidus grp	1						1	8			8	1	
Hydrobaenus													
Microtendipes pedellus grp.											3		
Microtendipes rydalensis grp.	1												
Monodiamesa (cf. *bathyphila*)													
Monodiamesa depectinata													
Nilothauma		5							1			1	
Orthocladiinae									3				
Pagastia													
Pagastiella	18	14					1	11		3	24	5	
Parachironomus arcuatus grp.													
Paracladius	2	3						3			3	3	
Paracladopelma	1	3		3		4		5	1	1	16	1	
Parakiefferiella													2
Paralauterborniella nigrohalterale		11						5	1	2			5
Paratanytarsus													
Paratendipes													
Phaenopsectra													
Polypedilum flavum									1				
Polypedilum halterale grp.					2			11	9	4		1	2
Polypedilum scalaenum grp.		8	3	10		4	1			1	5	1	
Potthastia longimana											5		
Procladius	13	19		3	1	4	3	27	1	4	21	3	25
Psectrocladius										1			
Pseudochironomus		3			1								
Rheotanytarsus	1								3				
Stempellina											3	1	
Stempellinella										1	3		
Stictochironomus							3	3		1			
Synorthocladius													
Tanypodinae											3		
Tanytarsini											3		
Tanytarsus			5				3	13	1	2	45	10	
Thienemannniella									1				
Thienemannimyia grp.													
Tribelos jucundum			14	3					4			1	
Musculium		3					3				3		2
Pisidium	2	8		3	3		4	5	1	4	3	7	4
Sphaeriidae				7				11		4	8	8	7
Unionidae													
Amnicola limosa	3												
Gyraulus													
Helisoma anceps													
Hydrobiidae													
Physa													
Planorbidae													
Valvata tricarinata													
Total number of individuals	**87**	**292**	**316**	**347**	**98**	**480**	**137**	**275**	**135**	**87**	**280**	**138**	**176**

TAXA	SQT 6B	SQT 6C	SQT 6D	SQT 6E	SQT 7A	SQT 7B	SQT 7C	SQT 7D	SQT 7E	SQT 8A	SQT 8B	SQT 8C	SQT 8D
Nematoda	111	61	99	72	95	185	8	40	40				7
Turbellaria													
Manayunkia speciosa	5	115	125	88	8	90	456	704	368				
Aeolosoma													
Amphichaeta													
Arcteonais lomondi							8						
Aulodrilus americanus			10	3									
Aulodrilus limnobius										7	4	9	
Aulodrilus pigueti									8				
Aulodrilus pluriseta							24	16					
Limnodrilus hoffmeisteri													
Limnodrilus udekemianus													
Naidinae											4		
Nais bretscheri													
Nais simplex						5			8				
Nais variabilis								16	8	2		4	
Paranais													
Piguetiella													
Potamothrix moldaviensis								8		5			7
Potomothrix vejdovskyi											4		
Pristina aequiseta													
Pristina osborni													
Slavina appendiculata								8					
Specaria josinae													3
Spirosperma ferox	5	6		5	8	15	80	16	16	2	4	4	
Stylaria lacustris													
Vejdovskyella intermedia											8		
Tubificinae: bifid chaetae		3	19		8	15	56	48	72	27	52	34	27
Tubificinae: hair + pectinate chaetae								16	16	5	8	9	
Enchytraeidae	7	3											
Lumbricidae													
Lumbriculidae												4	
Erpobdellidae													
Gammarus	46	54	45	48		25					56		20
Gammarus fasciatus							16	48		16		81	33
Hyalella azteca													
Caecidotea	5				5								
Caecidotea racovitzai				5		80	72	24	48	41	164	223	127
Acariformes													
Amoenacarus			3	5									
Arrenurus				3									
Forelia								8	8				
Halacaridae		3											
Hygrobates													
Lebertia													
Limnesia	2												
Mideopsis													3
Piona	2					10			8				
Tyrrellia		3											
Caenis						15						13	7
Ephemera													
Hex[illegible]ia	7	6	10	3									

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 6B	SQT 6C	SQT 6D	SQT 6E	SQT 7A	SQT 7B	SQT 7C	SQT 7D	SQT 7E	SQT 8A	SQT 8B	SQT 8C	SQT 8D
Corixidae													
Dipseudopsidae													
Hydroptila								16					
Leptoceridae													
Mystacides sepulcharis													
Oecetis				3									
Phylocentropus	5		6	3				8					
Polycentropus													
Culicoides													
Mallochohelea	2		3		3	5			8				
Probezzia													
Hemerodromia													
Chironomidae		3			3	5					4		3
Ablabesmyia													
Ablabesmyia annulata	5	6											
Ablabesmyia mallochi												4	
Ablabesmyia simpsoni		3											
Chironominae		6											
Chironomini						5				2			
Chironomus													
Cladotanytarsus (early instar)					13	10							3
Cladotanytarsus sp. grp. A					3		8		16				
Cladotanytarsus mancus grp.					8	10			8				7
Cladotanytarsus vanderwulpi grp.				3	13	55	16	8	56				
Corynoneura													
Cricotopus													
Cricotopus/Orthocladius													
Cryptochironomus					8	10					4	4	7
Cryptotendipes	5	6		3									
Demicryptochironomus		3											
Endochironomus													
Epoicocladius	5	3											

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 6B	SQT 6C	SQT 6D	SQT 6E	SQT 7A	SQT 7B	SQT 7C	SQT 7D	SQT 7E	SQT 8A	SQT 8B	SQT 8C	SQT 8D
Glyptotendipes													
Harnischia curtilamellata	5		3										
Heterotrissocladius marcidus grp		3	19	5				16	16	43	28	17	33
Hydrobaenus													
Microtendipes pedellus grp.													
Microtendipes rydalensis grp.													
Monodiamesa (cf. *bathyphila*)													
Monodiamesa depectinata													
Nilothauma					3		8						
Orthocladiinae					8								
Pagastia													
Pagastiella	2	3	6					8					
Parachironomus arcuatus grp.	2							16					
Paracladius				3	13	40	16		16		8		7
Paracladopelma					5	20	16	32	32	18	24	13	20
Parakiefferiella	2				3				8				3
Paralauterborniella nigrohalterale	2	3	10	3		5							3
Paratanytarsus						5							3
Paratendipes													
Phaenopsectra													
Polypedilum flavum													
Polypedilum halterale grp.	2			3			8	8		5			
Polypedilum scalaenum grp.					10	10				9	4	4	
Potthastia longimana				3		10	8	8	8				
Procladius	14	16	13	19	3	10	8		8	5	4		
Psectrocladius													
Pseudochironomus								8					
Rheotanytarsus													
Stempellina								8					
Stempellinella										2		4	
Stictochironomus					8	35	8	8	16	7	4	9	3
Synorthocladius											4		
Tanypodinae													3
Tanytarsini					5								
Tanytarsus					20	85	16	32	72	25	4	9	17
Thienemannniella					3					2	4	4	
Thienemannimyia grp.													
Tribelos jucundum													
Musculium		3		3					8	5			
Pisidium		26	3		8		8	24					
Sphaeriidae	2	3	10	5	5	20	8	16	8		4	4	3
Unionidae													
Amnicola limosa	5	3			3		24	32	8				
Gyraulus													
Helisoma anceps													
Hydrobiidae						5							
Physa													
Planorbidae													
Valvata tricarinata		3			3				16				
Total number of individuals	**247**	**352**	**384**	**285**	**265**	**785**	**872**	**1200**	**904**	**229**	**400**	**454**	**350**

TAXA	SQT 8E	SQT 9A	SQT 9B	SQT 9C	SQT 9D	SQT 9E	SQT 10A	SQT 10B	SQT 10C	SQT 10D	SQT 10E	SQT 11A
Nematoda	5	9	8	23	18	28	32	37	60	96	102	
Turbellaria												
Manayunkia speciosa	5	24	13	2	51	16	32	32	24	126	12	
Aeolosoma												
Amphichaeta												
Arcteonais lomondi											6	
Aulodrilus americanus							4		4			
Aulodrilus limnobius												
Aulodrilus pigueti												
Aulodrilus pluriseta												
Limnodrilus hoffmeisteri												
Limnodrilus udekemianus												
Naidinae												
Nais bretscheri												
Nais simplex							4					
Nais variabilis												
Paranais												
Piguetiella												
Potamothrix moldaviensis	8							5	12			
Potomothrix vejdovskyi												
Pristina aequiseta												
Pristina osborni												
Slavina appendiculata												
Specaria josinae								5				
Spirosperma ferox	18	4	5		5		56	96	24	90	84	14
Stylaria lacustris												
Vejdovskyella intermedia												
Tubificinae: bifid chaetae	38		5		2		36	43	56	78	42	2
Tubificinae: hair + pectinate chaetae	5						8	5		6		
Enchytraeidae	3			2			4					
Lumbricidae		6	3	4	5				4			
Lumbriculidae												
Erpobdellidae												
Gammarus	8							5	4	6	12	
Gammarus fasciatus	8		29	23		12	8					11
Hyalella azteca		17	8	4	14	24	4	11	8		6	1
Caecidotea	55			15		8	4					
Caecidotea racovitzai	20	6	29		16							35
Acariformes												
Amoenacarus												
Arrenurus												
Forelia												
Halacaridae				2								
Hygrobates												
Lebertia												
Limnesia												
Mideopsis												
Piona												
Tyrrellia												
Caenis				4						6		1
Ephemera												
Hexagenia												

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TAXA	SQT 8E	SQT 9A	SQT 9B	SQT 9C	SQT 9D	SQT 9E	SQT 10A	SQT 10B	SQT 10C	SQT 10D	SQT 10E	SQT 11A
Corixidae												
Dipseudopsidae												
Hydroptila												
Leptoceridae												
Mystacides sepulcharis		4	3	8			4	5				
Oecetis							4		4			
Phylocentropus												2
Polycentropus		2										
Culicoides												
Mallochohelea		2		4		4		5	4		12	2
Probezzia												
Hemerodromia												
Chironomidae		2	3	2			4		8	12	12	
Ablabesmyia												
Ablabesmyia annulata												
Ablabesmyia mallochi												
Ablabesmyia simpsoni						4						
Chironominae												
Chironomini												
Chironomus	3											
Cladotanytarsus (early instar)	3											
Cladotanytarsus sp. grp. A	3	2	5		5	8	4		8	12	6	2
Cladotanytarsus mancus grp.		69	85	47	60	140	92	85	76	168	102	3
Cladotanytarsus vanderwulpi grp.			13	6	7	16	12	21	20	36	12	
Corynoneura				2								
Cricotopus												
Cricotopus/Orthocladius												
Cryptochironomus	3	2	3	2	12	8	4	5		12	12	1
Cryptotendipes												
Demicryptochironomus						4	4	11		12	6	1
Endochironomus												
Epoicocladius												

TAXA	SQT 8E	SQT 9A	SQT 9B	SQT 9C	SQT 9D	SQT 9E	SQT 10A	SQT 10B	SQT 10C	SQT 10D	SQT 10E	SQT 11A
Glyptotendipes												
Harnischia curtilamellata												
Heterotrissocladius marcidus grp	20											
Hydrobaenus												
Microtendipes pedellus grp.					2	4				6		
Microtendipes rydalensis grp.												
Monodiamesa (cf. *bathyphila*)				2								
Monodiamesa depectinata		2	3		2	8	4		12	6	6	
Nilothauma					2	4				12		
Orthocladiinae												
Pagastia												
Pagastiella												3
Parachironomus arcuatus grp.		2		2								
Paracladius	3							11		6	6	
Paracladopelma	8			2	2	4		5	4	6		
Parakiefferiella											6	
Paralauterborniella nigrohalterale												1
Paratanytarsus												
Paratendipes												1
Phaenopsectra				2								
Polypedilum flavum												
Polypedilum halterale grp.	5	2	3		9	4						1
Polypedilum scalaenum grp.	5	6	27	4	5	24	40	69	16	18	36	8
Potthastia longimana			3									
Procladius		4	29	9	5	12	8	43	52	36	54	9
Psectrocladius												
Pseudochironomus						8	4				12	
Rheotanytarsus												
Stempellina		2							4		6	
Stempellinella			3									1
Stictochironomus	15			2				5				
Synorthocladius												
Tanypodinae	3											
Tanytarsini												
Tanytarsus	5		3	2						12	12	
Thienemannniella												
Thienemannimyia grp.												
Tribelos jucundum	3				2							
Musculium	5	2	3				8		4	6	12	1
Pisidium		11	32	6	7	20	16	21	12	12	12	6
Sphaeriidae		11	3	8			8	16		12	12	11
Unionidae												
Amnicola limosa		19	16	19		60	20	5	4	12	6	1
Gyraulus												
Helisoma anceps												
Hydrobiidae												
Physa			3									
Planorbidae												
Valvata tricarinata											6	
Total number of individuals	**250**	**212**	**339**	**203**	**231**	**420**	**428**	**549**	**424**	**804**	**612**	**122**

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 11B	SQT 11C	SQT 11D	SQT 11E	SQT 12A	SQT 12B	SQT 12C	SQT 12D	SQT 12E	SQT 13A	SQT 13B	SQT 13C	SQT 13D
Nematoda			2		20	32	30	64	68	117	144	48	96
Turbellaria													
Manayunkia speciosa										149	128	53	44
Aeolosoma													
Amphichaeta											8		
Arcteonais lomondi													
Aulodrilus americanus													
Aulodrilus limnobius													
Aulodrilus pigueti													
Aulodrilus pluriseta													
Limnodrilus hoffmeisteri	1					16		5					
Limnodrilus udekemianus										16			
Naidinae													
Nais bretscheri													
Nais simplex													
Nais variabilis											8		4
Paranais													24
Piguetiella						16				16	48	13	4
Potamothrix moldaviensis						16							
Potomothrix vejdovskyi													
Pristina aequiseta													
Pristina osborni											8		
Slavina appendiculata													
Specaria josinae													
Spirosperma ferox	12	12	7	6						27	64	19	8
Stylaria lacustris													
Vejdovskyella intermedia													
Tubificinae: bifid chaetae	1	2	1	1				5		53	40	48	52
Tubificinae: hair + pectinate chaetae		1			4					11	8		12
Enchytraeidae					4	16			8	5	64	8	8
Lumbricidae													4
Lumbriculidae											8		
Erpobdellidae													
Gammarus				4						5	40		
Gammarus fasciatus	6	10	1	6								8	
Hyalella azteca		1											
Caecidotea					4								
Caecidotea racovitzai	11	30	17	27									
Acariformes													
Amoenacarus													
Arrenurus													
Forelia			1		4	16							
Halacaridae													
Hygrobates													
Lebertia								5					
Limnesia													
Mideopsis													
Piona													
Tyrrellia									8				
Caenis		1										3	
Ephemera													
Hexagenia										5	40	5	12

TAXA	SQT 11B	SQT 11C	SQT 11D	SQT 11E	SQT 12A	SQT 12B	SQT 12C	SQT 12D	SQT 12E	SQT 13A	SQT 13B	SQT 13C	SQT 13D
Corixidae													
Dipseudopsidae													
Hydroptila													
Leptoceridae													
Mystacides sepulcharis		1											
Oecetis													8
Phylocentropus	1		1	1						5	8		
Polycentropus													
Culicoides		1			4	16							
Mallochohelea			1			16				16		3	
Probezzia							10						
Hemerodromia							10	5					
Chironomidae					4	16							
Ablabesmyia													
Ablabesmyia annulata													
Ablabesmyia mallochi													
Ablabesmyia simpsoni	1	2		1	4								
Chironominae													
Chironomini													
Chironomus													
Cladotanytarsus (early instar)													
Cladotanytarsus sp. grp. A			2		56	224	100	75	90	27		11	4
Cladotanytarsus mancus grp.	2	2	4		244	688	590	309	503	5	32	11	24
Cladotanytarsus vanderwulpi grp.			1			96	20	27	30	16	32	5	8
Corynoneura													
Cricotopus													
Cricotopus/Orthocladius													
Cryptochironomus		1	1		16			27	15	11	16	5	
Cryptotendipes						16			15				
Demicryptochironomus		1			4				8		8		
Endochironomus													
Epoicocladius													

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 11B	SQT 11C	SQT 11D	SQT 11E	SQT 12A	SQT 12B	SQT 12C	SQT 12D	SQT 12E	SQT 13A	SQT 13B	SQT 13C	SQT 13D
Glyptotendipes								5					
Harnischia curtilamellata													
Heterotrissocladius marcidus grp										16	16		4
Hydrobaenus													
Microtendipes pedellus grp.													
Microtendipes rydalensis grp.													4
Monodiamesa (cf. *bathyphila*)													
Monodiamesa depectinata								5	8				
Nilothauma													
Orthocladiinae						16							
Pagastia							10	5					
Pagastiella	1	1		1		32	10	27	8				
Parachironomus arcuatus grp.											8	3	
Paracladius			1		4	32	20	5					
Paracladopelma												3	
Parakiefferiella		1	1		92	144	80	53	98			3	
Paralauterborniella nigrohalterale							10						
Paratanytarsus													
Paratendipes		1											
Phaenopsectra													
Polypedilum flavum													
Polypedilum halterale grp.									8				
Polypedilum scalaenum grp.		1			8	80	10	21	38	5	8	19	4
Potthastia longimana													
Procladius	4	3	1	1	60	64	70	80	68	5	24	5	8
Psectrocladius													
Pseudochironomus					4					5			
Rheotanytarsus													
Stempellina													
Stempellinella		2	1										
Stictochironomus			1							96	72	59	48
Synorthocladius													
Tanypodinae													
Tanytarsini													
Tanytarsus						32		5	8	11	32	3	12
Thienemannniella									8				
Thienemannimyia grp.	1	1		3	16	32	20	21	8				
Tribelos jucundum		1		1									4
Musculium										5	24	3	4
Pisidium	2	18	9	3						11	16	3	4
Sphaeriidae	5	13		4	8	16	10			11	8	5	
Unionidae											8		4
Amnicola limosa			1		44	32	30	16	30	11	80		20
Gyraulus													
Helisoma anceps										5			
Hydrobiidae													
Physa													
Planorbidae										5			
Valvata tricarinata										5	8		
Total number of individuals	**48**	**107**	**54**	**59**	**604**	**1664**	**1030**	**768**	**1020**	**677**	**1008**	**344**	**428**

TAXA	SQT 13E	SQT 14A	SQT 14B	SQT 14C	SQT 14D	SQT 14E
Nematoda	36	91	64	208	216	138
Turbellaria				8		
Manayunkia speciosa	72	261	128	216	488	288
Aeolosoma						
Amphichaeta						
Arcteonais lomondi	4					
Aulodrilus americanus						
Aulodrilus limnobius						
Aulodrilus pigueti						
Aulodrilus pluriseta						
Limnodrilus hoffmeisteri						
Limnodrilus udekemianus		5	4	8		
Naidinae						
Nais bretscheri						
Nais simplex					8	
Nais variabilis	4		4		8	
Paranais	8					
Piguetiella	12				8	
Potamothrix moldaviensis						
Potomothrix vejdovskyi					8	6
Pristina aequiseta					8	
Pristina osborni						
Slavina appendiculata						
Specaria josinae						
Spirosperma ferox	12	69	24	128	64	12
Stylaria lacustris						
Vejdovskyella intermedia						
Tubificinae: bifid chaetae	36	64	16	32	104	6
Tubificinae: hair + pectinate chaetae	4			8	16	12
Enchytraeidae	4	16				
Lumbricidae	4	5	4			
Lumbriculidae						
Erpobdellidae	16					
Gammarus			4			
Gammarus fasciatus	12			8		
Hyalella azteca						
Caecidotea						
Caecidotea racovitzai						
Acariformes						
Amoenacarus						
Arrenurus						
Forelia						
Halacaridae						
Hygrobates			4			
Lebertia		5		8		
Limnesia						
Mideopsis		5	4			
Piona		5		8		6
Tyrrellia						
Caenis		5	4			6
Ephemera			4		8	
Hexagenia	8				8	12

Appendix 1. Estimated Abundances of Taxa. Sediment Quality Triad Report.Ashland/Northern States Power Lakefront Superfund Site

TAXA	SQT 13E	SQT 14A	SQT 14B	SQT 14C	SQT 14D	SQT 14E
Corixidae						
Dipseudopsidae						
Hydroptila						
Leptoceridae						
Mystacides sepulcharis				8		
Oecetis				8	8	
Phylocentropus		11			8	
Polycentropus					8	
Culicoides						
Mallochohelea		5				
Probezzia						
Hemerodromia						
Chironomidae						
Ablabesmyia			12			
Ablabesmyia annulata						
Ablabesmyia mallochi						
Ablabesmyia simpsoni						
Chironominae						
Chironomini						
Chironomus						
Cladotanytarsus (early instar)						
Cladotanytarsus sp. grp. A		16	4	8	24	6
Cladotanytarsus mancus grp.	8	32	48	24	96	78
Cladotanytarsus vanderwulpi grp.		5	16		16	6
Corynoneura						
Cricotopus						
Cricotopus/Orthocladius						
Cryptochironomus		5	4		8	
Cryptotendipes						
Demicryptochironomus						
Endochironomus						12
Epoicocladius						

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 1A	SQT 1B	SQT 1C	SQT 1D	SQT 1E
Density (/sample)	317	336	307	186	173
Density (per square meter)	13797	14609	13333	8070	7513
Taxa Richness	25	23	27	23	25
ETO taxa richness	2	1	1	1	2
ETO/ETO+Chironomidae	4	11	2	3	8
Percent dominance	20	36	23	17	44
Percent Chironomidae	44	20	37	56	22
Percent Oligochaeta	2	6	3	2	3
Percent non-insects	54	78	61	42	74
Crustacea+Mollusca taxa	5	4	3	4	5
Percent Crustacea+Mollusca	14	45	16	15	53
Shannon-Weaver diversity	2.71	2.39	2.72	2.78	2.31
Shannon's Equitability	0.84	0.76	0.83	0.89	0.72
Biotic index (HBI)	6.39	6.03	6.20	6.46	6.25
Percent intolerant (<3.51)	1.7	4.0	1.7	0.9	2.8
Percent facultative (3.51-6.50)	63.0	77.0	75.7	61.2	71.3
Percent tolerant (>6.50)	35.3	19.0	22.6	37.9	25.9
Percent filterers	10.1	10.3	6.1	12.1	2.8
Percent gatherers	58.0	76.2	66.1	63.8	81.5
Percent parasites	20.2	8.7	14.8	6.0	1.9
Percent predators	1.7	1.6	7.8	5.2	5.6
Percent scrapers	5.9	1.6	2.6	8.6	5.6
Percent shredders	4.2	1.6	1.7	4.3	1.9

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 2A	SQT 2B	SQT 2C	SQT 2D	SQT 2E
Density (/sample)	199	377	184	238	22
Density (per square meter)	8641	16377	7979	10334	957
Taxa Richness	17	13	26	14	8
ETO taxa richness	1	1	2	1	0
ETO/ETO+Chironomidae	6	20	13	14	0
Percent dominance	35	29	20	49	32
Percent Chironomidae	15	4	19	6	9
Percent Oligochaeta	8	12	26	7	23
Percent non-insects	83	96	78	93	91
Crustacea+Mollusca taxa	4	4	4	3	3
Percent Crustacea+Mollusca	61	62	25	82	64
Shannon-Weaver diversity	2.26	1.85	2.87	1.49	1.73
Shannon's Equitability	0.80	0.72	0.88	0.56	0.83
Biotic index (HBI)	6.35	6.63	6.92	6.60	7.04
Percent intolerant (<3.51)	3.8	0.9	1.9	0.0	0.0
Percent facultative (3.51-6.50)	45.3	56.6	54.8	43.7	45.5
Percent tolerant (>6.50)	50.9	42.5	43.3	56.3	54.5
Percent filterers	10.4	4.4	9.6	1.0	4.5
Percent gatherers	75.5	89.4	76.0	94.2	95.5
Percent parasites	5.7	3.5	4.8	1.9	0.0
Percent predators	5.7	1.8	7.7	2.9	0.0
Percent scrapers	0.0	0.0	0.0	0.0	0.0
Percent shredders	1.9	0.9	1.9	0.0	0.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 3A	SQT 3B	SQT 3C	SQT 3D	SQT 3E
Density (/sample)	305	258	347	87	292
Density (per square meter)	13281	11217	15072	3783	12688
Taxa Richness	28	28	26	21	22
ETO taxa richness	4	3	2	2	2
ETO/ETO+Chironomidae	15	10	26	6	11
Percent dominance	19	27	35	21	29
Percent Chironomidae	47	41	25	52	29
Percent Oligochaeta	10	39	9	9	18
Percent non-insects	42	53	66	43	66
Crustacea+Mollusca taxa	3	4	4	4	3
Percent Crustacea+Mollusca	6	9	14	10	7
Shannon-Weaver diversity	2.82	2.77	2.59	2.60	2.60
Shannon's Equitability	0.85	0.83	0.79	0.86	0.84
Biotic index (HBI)	6.75	6.42	6.69	6.83	6.49
Percent intolerant (<3.51)	3.6	7.0	1.0	4.6	2.8
Percent facultative (3.51-6.50)	52.7	57.4	58.7	40.2	67.3
Percent tolerant (>6.50)	43.8	35.7	40.4	55.2	29.9
Percent filterers	4.5	4.7	6.7	6.9	6.5
Percent gatherers	64.3	71.3	70.2	59.8	71.0
Percent parasites	7.1	6.2	4.8	12.6	12.1
Percent predators	21.4	10.9	13.5	14.9	6.5
Percent scrapers	0.0	1.6	2.9	3.4	0.0
Percent shredders	1.8	4.7	1.9	0.0	2.8

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 4A	SQT 4B	SQT 4C	SQT 4D	SQT 4E
Density (/sample)	316	347	98	480	137
Density (per square meter)	13755	15072	4261	20869	5955
Taxa Richness	11	12	13	10	16
ETO taxa richness	1	0	2	1	2
ETO/ETO+Chironomidae	17	0	33	50	31
Percent dominance	61	49	55	69	33
Percent Chironomidae	9	6	4	3	10
Percent Oligochaeta	4	12	17	5	13
Percent non-insects	90	94	94	95	85
Crustacea+Mollusca taxa	2	3	6	2	4
Percent Crustacea+Mollusca	84	80	77	88	70
Shannon-Weaver diversity	1.24	1.57	1.55	1.10	1.90
Shannon's Equitability	0.52	0.63	0.60	0.48	0.69
Biotic index (HBI)	6.20	6.65	6.61	6.40	6.74
Percent intolerant (<3.51)	0.9	0.0	0.0	0.0	1.0
Percent facultative (3.51-6.50)	72.4	58.7	66.3	72.3	46.7
Percent tolerant (>6.50)	26.7	41.3	33.7	27.7	52.4
Percent filterers	1.7	2.9	4.1	0.0	7.6
Percent gatherers	95.7	92.3	92.9	97.3	87.6
Percent parasites	0.9	1.0	0.0	0.9	0.0
Percent predators	0.9	1.0	1.0	0.9	3.8
Percent scrapers	0.0	0.0	0.0	0.0	0.0
Percent shredders	0.9	2.9	2.0	0.9	1.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 5A	SQT 5B	SQT 5C	SQT 5D	SQT 5E
Density (/sample)	275	135	87	280	138
Density (per square meter)	11942	5855	3783	12174	5988
Taxa Richness	20	23	19	25	22
ETO taxa richness	1	2	1	2	2
ETO/ETO+Chironomidae	12	15	15	5	33
Percent dominance	26	32	32	16	23
Percent Chironomidae	36	28	25	57	27
Percent Oligochaeta	12	26	13	7	7
Percent non-insects	59	67	70	40	59
Crustacea+Mollusca taxa	3	3	3	4	3
Percent Crustacea+Mollusca	43	34	23	23	50
Shannon-Weaver diversity	2.61	2.55	2.49	2.92	2.64
Shannon's Equitability	0.87	0.81	0.85	0.91	0.86
Biotic index (HBI)	6.87	6.99	6.76	6.64	6.40
Percent intolerant (<3.51)	2.9	1.0	0.0	3.8	4.0
Percent facultative (3.51-6.50)	44.7	59.4	64.4	42.9	47.5
Percent tolerant (>6.50)	52.4	39.6	35.6	53.3	48.5
Percent filterers	10.7	9.9	16.1	23.8	19.8
Percent gatherers	72.8	70.3	40.2	54.3	74.3
Percent parasites	2.9	5.0	32.2	7.6	1.0
Percent predators	9.7	2.0	5.7	12.4	2.0
Percent scrapers	0.0	0.0	0.0	0.0	0.0
Percent shredders	3.9	12.9	5.7	1.9	2.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 6A	SQT 6B	SQT 6C	SQT 6D	SQT 6E
Density (/sample)	176	247	352	384	285
Density (per square meter)	7652	10736	15304	16696	12406
Taxa Richness	17	23	22	15	20
ETO taxa richness	2	2	1	2	3
ETO/ETO+Chironomidae	12	21	11	24	17
Percent dominance	36	45	33	33	31
Percent Chironomidae	22	18	15	13	14
Percent Oligochaeta	2	5	4	8	3
Percent non-insects	75	77	97	82	83
Crustacea+Mollusca taxa	4	4	5	2	3
Percent Crustacea+Mollusca	24	23	26	15	22
Shannon-Weaver diversity	2.05	2.10	2.29	2.04	2.08
Shannon's Equitability	0.72	0.67	0.74	0.75	0.70
Biotic index (HBI)	6.76	6.55	6.20	6.21	6.29
Percent intolerant (<3.51)	0.0	0.0	2.7	5.0	1.9
Percent facultative (3.51-6.50)	58.6	63.6	68.2	65.0	68.2
Percent tolerant (>6.50)	41.4	36.4	29.1	30.0	29.9
Percent filterers	8.1	2.8	9.1	5.0	3.7
Percent gatherers	38.4	38.3	61.8	64.2	59.8
Percent parasites	36.4	44.9	17.3	25.8	25.2
Percent predators	16.2	11.2	9.1	5.0	10.3
Percent scrapers	0.0	1.9	1.8	0.0	0.0
Percent shredders	1.0	0.9	0.0	0.0	0.9

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 7A	SQT 7B	SQT 7C	SQT 7D	SQT 7E
Density (/sample)	265	785	872	1200	904
Density (per square meter)	11522	34130	37913	52174	39304
Taxa Richness	22	24	20	26	26
ETO taxa richness	0	1	0	2	0
ETO/ETO+Chironomidae	0	5	0	14	0
Percent dominance	36	24	52	59	41
Percent Chironomidae	45	39	13	13	28
Percent Oligochaeta	6	4	19	11	14
Percent non-insects	53	57	87	85	71
Crustacea+Mollusca taxa	4	4	4	4	4
Percent Crustacea+Mollusca	8	7	15	12	10
Shannon-Weaver diversity	2.62	2.68	1.94	1.96	2.40
Shannon's Equitability	0.85	0.84	0.65	0.60	0.74
Biotic index (HBI)	6.32	6.46	6.45	6.38	6.57
Percent intolerant (<3.51)	1.9	0.6	0.9	2.0	1.8
Percent facultative (3.51-6.50)	69.8	67.5	77.1	74.0	67.3
Percent tolerant (>6.50)	28.3	31.8	22.0	24.0	31.0
Percent filterers	14.2	13.4	3.7	6.7	9.7
Percent gatherers	38.7	56.1	90.8	83.3	79.6
Percent parasites	35.8	23.6	0.9	3.3	4.4
Percent predators	4.7	4.5	0.9	2.0	3.5
Percent scrapers	1.9	0.6	2.8	4.0	2.7
Percent shredders	3.8	1.3	0.9	0.7	0.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 8A	SQT 8B	SQT 8C	SQT 8D	SQT 8E
Density (/sample)	229	400	454	350	250
Density (per square meter)	9938	17391	19751	15217	10870
Taxa Richness	17	18	19	18	21
ETO taxa richness	0	0	1	1	0
ETO/ETO+Chironomidae	0	0	16	6	0
Percent dominance	19	41	49	36	22
Percent Chironomidae	52	22	15	31	30
Percent Oligochaeta	21	21	14	10	29
Percent non-insects	48	77	82	66	70
Crustacea+Mollusca taxa	3	3	3	3	3
Percent Crustacea+Mollusca	27	56	68	52	38
Shannon-Weaver diversity	2.47	2.09	1.87	2.38	2.71
Shannon's Equitability	0.87	0.72	0.64	0.82	0.89
Biotic index (HBI)	5.72	6.38	6.49	6.04	6.61
Percent intolerant (<3.51)	19.0	9.0	3.8	10.5	8.0
Percent facultative (3.51-6.50)	44.0	50.0	56.6	48.6	51.0
Percent tolerant (>6.50)	37.0	41.0	39.6	41.0	41.0
Percent filterers	13.0	2.0	2.8	5.7	4.0
Percent gatherers	79.0	94.0	94.3	87.6	88.0
Percent parasites	0.0	0.0	0.0	1.9	2.0
Percent predators	2.0	2.0	1.9	3.8	2.0
Percent scrapers	0.0	0.0	0.0	0.0	0.0
Percent shredders	6.0	1.0	0.9	0.0	4.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 9A	SQT 9B	SQT 9C	SQT 9D	SQT 9E
Density (/sample)	212	339	203	231	420
Density (per square meter)	9224	14725	8804	10033	18261
Taxa Richness	21	24	25	20	22
ETO taxa richness	2	1	2	0	0
ETO/ETO+Chironomidae	7	1	12	0	0
Percent dominance	32	25	23	26	33
Percent Chironomidae	43	52	40	49	59
Percent Oligochaeta	5	4	3	5	0
Percent non-insects	52	46	52	51	40
Crustacea+Mollusca taxa	5	7	5	3	5
Percent Crustacea+Mollusca	31	36	36	16	30
Shannon-Weaver diversity	2.48	2.64	2.72	2.40	2.44
Shannon's Equitability	0.81	0.83	0.84	0.80	0.79
Biotic index (HBI)	6.80	6.73	6.87	6.64	6.83
Percent intolerant (<3.51)	2.0	0.8	0.9	1.0	1.9
Percent facultative (3.51-6.50)	34.3	37.8	31.5	49.0	26.7
Percent tolerant (>6.50)	63.6	61.4	67.6	50.0	71.4
Percent filterers	11.1	11.8	7.4	4.0	5.7
Percent gatherers	64.6	61.4	59.3	75.0	60.0
Percent parasites	4.0	2.4	11.1	8.0	6.7
Percent predators	6.1	9.4	9.3	7.0	6.7
Percent scrapers	9.1	5.5	10.2	0.0	14.3
Percent shredders	4.0	8.7	1.9	6.0	6.7

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 10A	SQT 10B	SQT 10C	SQT 10D	SQT 10E
Density (/sample)	428	549	424	804	612
Density (per square meter)	18609	23884	18435	34956	26609
Taxa Richness	25	21	21	23	25
ETO taxa richness	2	1	1	1	0
ETO/ETO+Chironomidae	4	2	2	2	0
Percent dominance	21	17	18	21	17
Percent Chironomidae	40	47	45	43	45
Percent Oligochaeta	26	28	24	22	22
Percent non-insects	57	51	51	55	51
Crustacea+Mollusca taxa	6	4	5	4	6
Percent Crustacea+Mollusca	16	11	8	6	11
Shannon-Weaver diversity	2.72	2.64	2.63	2.56	2.74
Shannon's Equitability	0.85	0.87	0.86	0.82	0.85
Biotic index (HBI)	6.82	6.81	7.17	6.70	6.62
Percent intolerant (<3.51)	1.9	1.9	2.8	4.5	3.9
Percent facultative (3.51-6.50)	45.8	51.5	34.0	45.5	51.0
Percent tolerant (>6.50)	52.3	46.6	63.2	50.0	45.1
Percent filterers	7.5	6.8	3.8	6.0	7.8
Percent gatherers	66.4	63.1	61.3	70.9	52.9
Percent parasites	7.5	6.8	14.2	11.9	16.7
Percent predators	3.7	9.7	14.2	6.0	12.7
Percent scrapers	4.7	1.0	0.9	1.5	2.0
Percent shredders	9.3	12.6	3.8	2.2	5.9

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 11A	SQT 11B	SQT 11C	SQT 11D	SQT 11E
Density (/sample)	122	48	107	54	59
Density (per square meter)	5317	2087	4652	2348	2565
Taxa Richness	22	11	22	19	11
ETO taxa richness	2	1	2	1	1
ETO/ETO+Chironomidae	9	10	11	7	13
Percent dominance	29	25	28	31	46
Percent Chironomidae	27	19	16	24	12
Percent Oligochaeta	13	29	14	15	12
Percent non-insects	68	79	81	72	86
Crustacea+Mollusca taxa	6	3	4	4	3
Percent Crustacea+Mollusca	55	50	67	52	75
Shannon-Weaver diversity	2.50	2.14	2.34	2.32	1.91
Shannon's Equitability	0.81	0.89	0.76	0.79	0.79
Biotic index (HBI)	6.58	6.74	6.34	6.05	6.34
Percent intolerant (<3.51)	0.9	0.0	0.9	0.0	0.0
Percent facultative (3.51-6.50)	57.9	56.3	62.6	75.9	69.5
Percent tolerant (>6.50)	41.1	43.8	36.4	24.1	30.5
Percent filterers	16.8	16.7	29.0	18.5	13.6
Percent gatherers	64.5	70.8	62.6	68.5	78.0
Percent parasites	0.0	0.0	0.0	3.7	0.0
Percent predators	10.3	12.5	7.5	7.4	8.5
Percent scrapers	0.9	0.0	0.0	1.9	0.0
Percent shredders	7.5	0.0	0.9	0.0	0.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 12A	SQT 12B	SQT 12C	SQT 12D	SQT 12E
Density (/sample)	604	1664	1030	768	1020
Density (per square meter)	26261	72347	44782	33391	44348
Taxa Richness	19	21	16	19	19
ETO taxa richness	0	0	0	0	0
ETO/ETO+Chironomidae	0	0	0	0	0
Percent dominance	40	41	57	40	49
Percent Chironomidae	84	88	91	87	89
Percent Oligochaeta	1	2	0	1	1
Percent non-insects	15	10	7	13	11
Crustacea+Mollusca taxa	3	2	2	1	1
Percent Crustacea+Mollusca	9	3	4	2	3
Shannon-Weaver diversity	2.05	2.23	1.68	2.16	1.92
Shannon's Equitability	0.69	0.73	0.60	0.73	0.65
Biotic index (HBI)	6.85	6.75	6.84	6.95	6.79
Percent intolerant (<3.51)	1.3	1.0	1.0	0.7	0.7
Percent facultative (3.51-6.50)	25.2	26.0	17.5	23.6	25.0
Percent tolerant (>6.50)	73.5	73.1	81.6	75.7	74.3
Percent filterers	1.3	2.9	1.0	1.4	0.7
Percent gatherers	68.9	78.8	81.6	67.4	75.7
Percent parasites	3.3	1.9	2.9	8.3	6.6
Percent predators	17.2	8.7	10.7	18.1	9.6
Percent scrapers	7.3	1.9	2.9	2.1	2.9
Percent shredders	1.3	4.8	1.0	2.8	4.4

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 13A	SQT 13B	SQT 13C	SQT 13D	SQT 13E
Density (/sample)	677	1008	344	428	460
Density (per square meter)	29449	43826	14956	18609	20000
Taxa Richness	26	30	23	26	23
ETO taxa richness	2	2	2	2	1
ETO/ETO+Chironomidae	5	16	6	14	4
Percent dominance	22	13	17	22	32
Percent Chironomidae	29	25	36	28	46
Percent Oligochaeta	19	25	26	27	19
Percent non-insects	67	71	60	67	52
Crustacea+Mollusca taxa	6	6	3	4	4
Percent Crustacea+Mollusca	9	18	5	7	6
Shannon-Weaver diversity	2.66	2.97	2.60	2.69	2.44
Shannon's Equitability	0.82	0.87	0.83	0.83	0.78
Biotic index (HBI)	6.95	6.95	7.39	7.38	7.46
Percent intolerant (<3.51)	2.4	2.4	0.0	0.9	3.5
Percent facultative (3.51-6.50)	55.9	52.4	49.6	45.8	40.0
Percent tolerant (>6.50)	41.7	45.2	50.4	53.3	56.5
Percent filterers	6.3	9.5	3.9	6.5	3.5
Percent gatherers	66.9	61.9	72.1	61.7	73.0
Percent parasites	17.3	14.3	14.0	22.4	7.8
Percent predators	4.7	4.8	4.7	3.7	8.7
Percent scrapers	3.9	8.7	0.0	4.7	1.7
Percent shredders	0.8	0.8	5.4	0.9	5.2

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	SQT 14A	SQT 14B	SQT 14C	SQT 14D	SQT 14E
Density (/sample)	757	420	824	1296	822
Density (per square meter)	32927	18261	35826	56347	35739
Taxa Richness	28	26	23	28	20
ETO taxa richness	2	2	2	5	2
ETO/ETO+Chironomidae	9	6	12	12	7
Percent dominance	35	30	26	38	35
Percent Chironomidae	21	30	15	22	31
Percent Oligochaeta	21	12	21	17	4
Percent non-insects	76	68	83	75	67
Crustacea+Mollusca taxa	4	5	5	2	3
Percent Crustacea+Mollusca	6	8	8	3	10
Shannon-Weaver diversity	2.51	2.52	2.31	2.31	2.20
Shannon's Equitability	0.75	0.77	0.74	0.69	0.74
Biotic index (HBI)	6.62	6.64	6.42	6.75	6.92
Percent intolerant (<3.51)	1.4	1.0	2.9	0.6	0.0
Percent facultative (3.51-6.50)	68.3	61.0	73.8	66.0	58.4
Percent tolerant (>6.50)	30.3	38.1	23.3	33.3	41.6
Percent filterers	6.3	2.9	1.0	4.9	8.0
Percent gatherers	70.4	64.8	61.2	73.5	58.4
Percent parasites	12.0	15.2	25.2	16.7	16.8
Percent predators	6.3	9.5	5.8	3.7	10.2
Percent scrapers	2.8	3.8	5.8	0.6	5.1
Percent shredders	2.1	3.8	1.0	0.6	0.0

Appendix 2. Biological Measures. Sediment Quality Triad Report.
Ashland/Northern States Power Lakefront Superfund Site

MEASURES	Maximum	Minimum	Mean	
Density (/sample)	1664	22.00	425.79	
Density (per square meter)	72347	956.52	18512.62	
Taxa Richness	30	8.00	20.91	
ETO taxa richness	5	0.00	1.33	
ETO/ETO+Chironomidae	50	0.00	9.39	
Percent dominance	69	13.00	32.54	
Percent Chironomidae	91	3.00	32.63	
Percent Oligochaeta	39	0.00	12.60	
Percent non-insects	97	7.00	64.53	
Crustacea+Mollusca taxa	7	1.00	3.77	
Percent Crustacea+Mollusca	88	2.00	29.41	
Shannon-Weaver diversity	3	1.10	2.33	
Shannon's Equitability	1	0.48	0.77	
Biotic index (HBI)	7	5.72	6.62	
Percent intolerant (<3.51)	19	0.00	2.29	
Percent facultative (3.51-6.50)	77	17.48	54.18	
Percent tolerant (>6.50)	82	19.05	43.53	
Percent filterers	29	0.00	7.54	
Percent gatherers	97	38.32	70.85	
Percent parasites	45	0.00	9.44	
Percent predators	21	0.00	6.90	
Percent scrapers	14	0.00	2.20	
Percent shredders	13	0.00	2.71	

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: LOGN   N: 70   Multiple R: 0.833   Squared multiple R: 0.694

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.000    1        0.000       0.001       0.978
STATION$                   18.931   13        1.456       5.402       0.000

Error                      14.828   55        0.270

------------------------------------------------------------------------------
*** WARNING ***
Case          10 is an outlier        (Studentized Residual =       -4.894)

Durbin-Watson D Statistic          2.490
First Order Autocorrelation       -0.247



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRS   N: 70   Multiple R: 0.797   Squared multiple R: 0.634

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.011    1        0.011       0.071       0.792
STATION$                   10.353   13        0.796       5.260       0.000

Error                       8.328   55        0.151

------------------------------------------------------------------------------
*** WARNING ***
Case           8 is an outlier        (Studentized Residual =        3.936)
Case          10 is an outlier        (Studentized Residual =       -3.267)

Durbin-Watson D Statistic          2.644
First Order Autocorrelation       -0.338



Effects coding used for categorical variables in model.
```

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRETO   N: 70   Multiple R: 0.798   Squared multiple R: 0.637

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      1.638    1        1.638      10.176       0.002
STATION$                   13.955   13        1.073       6.667       0.000

Error                       8.855   55        0.161

------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.673
First Order Autocorrelation       -0.341



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRETOC   N: 70   Multiple R: 0.764   Squared multiple R: 0.583

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                     10.596    1       10.596       6.593       0.013
STATION$                   92.061   13        7.082       4.406       0.000

Error                      88.395   55        1.607


------------------------------------------------------------------------------
*** WARNING ***
Case          17 is an outlier        (Studentized Residual =       -3.954)

Durbin-Watson D Statistic          2.591
First Order Autocorrelation       -0.297



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASDOM   N: 70   Multiple R: 0.766   Squared multiple R: 0.587

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.027    1        0.027       2.996       0.089
STATION$                    0.692   13        0.053       5.995       0.000
```

```
Error                    0.488    55        0.009

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.321
First Order Autocorrelation       -0.170


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASCHIRO   N: 70   Multiple R: 0.923   Squared multiple R: 0.852

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.013    1        0.013       1.150       0.288
STATION$                    2.749   13        0.211      19.014       0.000

Error                       0.612   55        0.011

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.600
First Order Autocorrelation       -0.313


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASOLIGO   N: 70   Multiple R: 0.834   Squared multiple R: 0.696

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.000    1        0.000       0.002       0.965
STATION$                    1.071   13        0.082       9.335       0.000

Error                       0.486   55        0.009

-------------------------------------------------------------------------------
*** WARNING ***
Case          12 is an outlier        (Studentized Residual =        3.644)

Durbin-Watson D Statistic          2.485
First Order Autocorrelation       -0.279


Effects coding used for categorical variables in model.
```

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASNSECT   N: 70   Multiple R: 0.918   Squared multiple R: 0.843

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.002    1        0.002       0.203       0.654
STATION$                    2.852   13        0.219      18.179       0.000

Error                       0.664   55        0.012

------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.481
First Order Autocorrelation       -0.250



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRCRUMOL   N: 70   Multiple R: 0.692   Squared multiple R: 0.478

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.025    1        0.025       0.365       0.548
STATION$                    3.314   13        0.255       3.699       0.000

Error                       3.790   55        0.069

------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.206
First Order Autocorrelation       -0.113



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASCRUMOL   N: 70   Multiple R: 0.935   Squared multiple R: 0.875

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.031    1        0.031       2.294       0.136
STATION$                    3.302   13        0.254      19.064       0.000

Error                       0.733   55        0.013
```

```
-------------------------------------------------------------------------------
*** WARNING ***
Case            8 is an outlier        (Studentized Residual =       -3.846)

Durbin-Watson D Statistic          2.603
First Order Autocorrelation       -0.324



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: HPRIME   N: 70   Multiple R: 0.788   Squared multiple R: 0.621

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                     29.777    1       29.777       0.151       0.699
STATION$                16510.289   13     1270.022       6.450       0.000

Error                   10830.223   55      196.913


-------------------------------------------------------------------------------
*** WARNING ***
Case            8 is an outlier        (Studentized Residual =        4.159)

Durbin-Watson D Statistic          2.375
First Order Autocorrelation       -0.195



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASEVEN   N: 70   Multiple R: 0.771   Squared multiple R: 0.595

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                     0.006    1         0.006       0.945       0.335
STATION$                   0.498   13         0.038       6.211       0.000

Error                      0.339   55         0.006


-------------------------------------------------------------------------------
*** WARNING ***
Case            9 is an outlier        (Studentized Residual =       -3.398)

Durbin-Watson D Statistic          2.559
First Order Autocorrelation       -0.282
```

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: HBI   N: 70   Multiple R: 0.796   Squared multiple R: 0.633

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.020    1        0.020       0.409       0.525
STATION$                    4.526   13        0.348       7.294       0.000

Error                       2.626   55        0.048

------------------------------------------------------------------------------
*** WARNING ***
Case          36 is an outlier        (Studentized Residual =       -3.276)

Durbin-Watson D Statistic          2.068
First Order Autocorrelation       -0.049


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASNTOL   N: 70   Multiple R: 0.758   Squared multiple R: 0.574

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.000    1        0.000       0.028       0.868
STATION$                    0.283   13        0.022       5.280       0.000

Error                       0.227   55        0.004

------------------------------------------------------------------------------

Durbin-Watson D Statistic          1.990
First Order Autocorrelation       -0.015


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11
```

Dep Var: ASFACUL N: 70 Multiple R: 0.897 Squared multiple R: 0.805

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.000	1	0.000	0.047	0.828
STATION$	1.283	13	0.099	17.407	0.000
Error	0.312	55	0.006		

Durbin-Watson D Statistic 2.278
First Order Autocorrelation -0.156

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASTOL N: 70 Multiple R: 0.899 Squared multiple R: 0.808

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.001	1	0.001	0.108	0.744
STATION$	1.280	13	0.098	17.639	0.000
Error	0.307	55	0.006		

Durbin-Watson D Statistic 2.245
First Order Autocorrelation -0.145

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASFILTR N: 70 Multiple R: 0.796 Squared multiple R: 0.633

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.000	1	0.000	0.032	0.859
STATION$	0.467	13	0.036	7.057	0.000
Error	0.280	55	0.005		

Durbin-Watson D Statistic 2.502

```
First Order Autocorrelation       -0.265


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASGATHR   N: 70   Multiple R: 0.805   Squared multiple R: 0.648

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.004    1        0.004       0.298       0.588
STATION$                    1.256   13        0.097       7.605       0.000

Error                       0.698   55        0.013


------------------------------------------------------------------------------
*** WARNING ***
Case          31 is an outlier        (Studentized Residual =       -3.644)

Durbin-Watson D Statistic          2.264
First Order Autocorrelation       -0.147


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASPARA   N: 70   Multiple R: 0.826   Squared multiple R: 0.682

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

NOCPAH                      0.000    1        0.000       0.001       0.979
STATION$                    1.374   13        0.106       8.243       0.000

Error                       0.705   55        0.013


------------------------------------------------------------------------------
*** WARNING ***
Case          23 is an outlier        (Studentized Residual =        3.562)
Case          31 is an outlier        (Studentized Residual =        3.390)

Durbin-Watson D Statistic          1.877
First Order Autocorrelation        0.044


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
```

Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASPRED N: 70 Multiple R: 0.794 Squared multiple R: 0.631

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.000	1	0.000	0.075	0.785
STATION$	0.413	13	0.032	7.200	0.000
Error	0.243	55	0.004		

Durbin-Watson D Statistic 2.491
First Order Autocorrelation -0.263

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASSCRAPE N: 70 Multiple R: 0.810 Squared multiple R: 0.656

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.007	1	0.007	1.430	0.237
STATION$	0.427	13	0.033	6.644	0.000
Error	0.272	55	0.005		

*** WARNING ***
Case 44 is an outlier (Studentized Residual = -4.472)

Durbin-Watson D Statistic 2.671
First Order Autocorrelation -0.341

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASSHRED N: 70 Multiple R: 0.673 Squared multiple R: 0.452

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
NOCPAH	0.018	1	0.018	3.301	0.075
STATION$	0.233	13	0.018	3.235	0.001
Error	0.305	55	0.006		

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
-------------------------------------------------------------------------------
*** WARNING ***
Case          51 is an outlier        (Studentized Residual =        3.201)

Durbin-Watson D Statistic          2.056
First Order Autocorrelation       -0.049



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: LOGN   N: 70   Multiple R: 0.834   Squared multiple R: 0.696

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.066    1        0.066       0.247       0.621
STATION$                   27.571   13        2.121       7.902       0.000

Error                      14.762   55        0.268

-------------------------------------------------------------------------------
*** WARNING ***
Case          10 is an outlier        (Studentized Residual =       -5.005)

Durbin-Watson D Statistic          2.533
First Order Autocorrelation       -0.268



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRS   N: 70   Multiple R: 0.803   Squared multiple R: 0.644

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.229    1        0.229       1.556       0.218
STATION$                   14.293   13        1.099       7.457       0.000

Error                       8.109   55        0.147

-------------------------------------------------------------------------------
*** WARNING ***
Case           8 is an outlier        (Studentized Residual =        3.858)
Case          10 is an outlier        (Studentized Residual =       -3.208)

Durbin-Watson D Statistic          2.598
First Order Autocorrelation       -0.316
```

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRETO   N: 70   Multiple R: 0.762   Squared multiple R: 0.580

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   0.245    1        0.245       1.312       0.257
STATION$                  14.137   13        1.087       5.836       0.000

Error                     10.248   55        0.186

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.561
First Order Autocorrelation       -0.285



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRETOC   N: 70   Multiple R: 0.740   Squared multiple R: 0.547

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   3.013    1        3.013       1.726       0.194
STATION$                 109.367   13        8.413       4.821       0.000

Error                     95.979   55        1.745

-------------------------------------------------------------------------------
*** WARNING ***
Case          17 is an outlier        (Studentized Residual =       -4.239)

Durbin-Watson D Statistic          2.504
First Order Autocorrelation       -0.253



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASDOM   N: 70   Multiple R: 0.774   Squared multiple R: 0.599

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   0.041    1        0.041       4.785       0.033
```

```
STATION$                    0.686    13        0.053       6.130       0.000

Error                       0.473    55        0.009

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.418
First Order Autocorrelation       -0.219


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASCHIRO   N: 70   Multiple R: 0.931   Squared multiple R: 0.867

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.077     1        0.077       7.722       0.007
STATION$                    3.425    13        0.263      26.462       0.000

Error                       0.548    55        0.010

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.805
First Order Autocorrelation       -0.418


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASOLIGO   N: 70   Multiple R: 0.843   Squared multiple R: 0.710

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.022     1        0.022       2.639       0.110
STATION$                    1.112    13        0.086      10.157       0.000

Error                       0.463    55        0.008

-------------------------------------------------------------------------------
*** WARNING ***
Case          12 is an outlier        (Studentized Residual =        3.328)

Durbin-Watson D Statistic          2.496
First Order Autocorrelation       -0.287
```

Appendix 3. ANCOVA Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASNSECT   N: 70   Multiple R: 0.927   Squared multiple R: 0.859

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.073    1        0.073       6.752       0.012
STATION$                    3.506   13        0.270      24.997       0.000

Error                       0.593   55        0.011

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.726
First Order Autocorrelation       -0.375



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: SRCRUMOL   N: 70   Multiple R: 0.690   Squared multiple R: 0.476

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.011    1        0.011       0.158       0.692
STATION$                    3.212   13        0.247       3.572       0.000

Error                       3.804   55        0.069

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.186
First Order Autocorrelation       -0.103



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASCRUMOL   N: 70   Multiple R: 0.933   Squared multiple R: 0.871

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                    0.008    1        0.008       0.596       0.443
STATION$                    4.326   13        0.333      24.236       0.000
```

```
Error                       0.755    55        0.014

-------------------------------------------------------------------------------
*** WARNING ***
Case           8 is an outlier        (Studentized Residual =       -3.674)

Durbin-Watson D Statistic          2.534
First Order Autocorrelation       -0.288


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: HPRIME   N: 70   Multiple R: 0.809   Squared multiple R: 0.654

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                977.248     1      977.248       5.439       0.023
STATION$              18693.190    13     1437.938       8.002       0.000

Error                  9882.752    55      179.686

-------------------------------------------------------------------------------
*** WARNING ***
Case           8 is an outlier        (Studentized Residual =        4.101)

Durbin-Watson D Statistic          2.464
First Order Autocorrelation       -0.242


Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASEVEN   N: 70   Multiple R: 0.775   Squared multiple R: 0.600

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                 0.010     1        0.010       1.636       0.206
STATION$                 0.503    13        0.039       6.347       0.000

Error                    0.335    55        0.006

-------------------------------------------------------------------------------
*** WARNING ***
Case           9 is an outlier        (Studentized Residual =       -3.448)
Case          38 is an outlier        (Studentized Residual =       -3.292)

Durbin-Watson D Statistic          2.634
First Order Autocorrelation       -0.320
```

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: HBI N: 70 Multiple R: 0.794 Squared multiple R: 0.631

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.007	1	0.007	0.136	0.713
STATION$	2.655	13	0.204	4.257	0.000
Error	2.639	55	0.048		

Durbin-Watson D Statistic 2.072
First Order Autocorrelation -0.051

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASNTOL N: 70 Multiple R: 0.758 Squared multiple R: 0.574

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.000	1	0.000	0.008	0.929
STATION$	0.288	13	0.022	5.371	0.000
Error	0.227	55	0.004		

Durbin-Watson D Statistic 1.981
First Order Autocorrelation -0.010

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASFACUL N: 70 Multiple R: 0.899 Squared multiple R: 0.808

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P

TOTALPAH	0.005	1	0.005	0.827	0.367
STATION$	1.068	13	0.082	14.698	0.000
Error	0.308	55	0.006		

Durbin-Watson D Statistic 2.304
First Order Autocorrelation -0.170

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASTOL N: 70 Multiple R: 0.900 Squared multiple R: 0.811

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.005	1	0.005	0.925	0.340
STATION$	1.012	13	0.078	14.149	0.000
Error	0.302	55	0.005		

Durbin-Watson D Statistic 2.243
First Order Autocorrelation -0.145

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASFILTR N: 70 Multiple R: 0.801 Squared multiple R: 0.641

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.006	1	0.006	1.303	0.259
STATION$	0.445	13	0.034	6.879	0.000
Error	0.274	55	0.005		

Durbin-Watson D Statistic 2.560
First Order Autocorrelation -0.295

Effects coding used for categorical variables in model.

```
Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASGATHR   N: 70   Multiple R: 0.821   Squared multiple R: 0.673

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   0.053    1        0.053       4.512       0.038
STATION$                   1.267   13        0.097       8.261       0.000

Error                      0.649   55        0.012

-------------------------------------------------------------------------------

Durbin-Watson D Statistic          2.382
First Order Autocorrelation       -0.208



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASPARA   N: 70   Multiple R: 0.827   Squared multiple R: 0.685

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   0.005    1        0.005       0.399       0.530
STATION$                   1.384   13        0.106       8.363       0.000

Error                      0.700   55        0.013

-------------------------------------------------------------------------------
*** WARNING ***
Case          23 is an outlier        (Studentized Residual =        3.692)
Case          31 is an outlier        (Studentized Residual =        3.381)

Durbin-Watson D Statistic          1.897
First Order Autocorrelation        0.034



Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
   Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
   Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASPRED   N: 70   Multiple R: 0.807   Squared multiple R: 0.652

Analysis of Variance
Source            Sum-of-Squares   df  Mean-Square     F-ratio       P

TOTALPAH                   0.014    1        0.014       3.444       0.069
```

STATION$	0.393	13	0.030	7.271	0.000
Error	0.229	55	0.004		

Durbin-Watson D Statistic 2.572
First Order Autocorrelation -0.304

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASSCRAPE N: 70 Multiple R: 0.806 Squared multiple R: 0.649

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.002	1	0.002	0.325	0.571
STATION$	0.404	13	0.031	6.169	0.000
Error	0.277	55	0.005		

*** WARNING ***
Case 44 is an outlier (Studentized Residual = -4.632)

Durbin-Watson D Statistic 2.701
First Order Autocorrelation -0.356

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
Sand01, Sand03, Sand06, Sand07, SandRed12, SandRef10, SandRef13, SandRef14,
Wood02, Wood04, Wood05, Wood08, WoodRef09, WoodRef11

Dep Var: ASSHRED N: 70 Multiple R: 0.667 Squared multiple R: 0.445

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
TOTALPAH	0.014	1	0.014	2.507	0.119
STATION$	0.245	13	0.019	3.350	0.001
Error	0.309	55	0.006		

*** WARNING ***
Case 51 is an outlier (Studentized Residual = 3.183)

Durbin-Watson D Statistic 2.177
First Order Autocorrelation -0.110

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Dep Var: ASDOM N: 70 Multiple R: 0.134 Squared multiple R: 0.018

Adjusted squared multiple R: 0.004 Standard error of estimate: 0.131

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.571	0.032	0.000	.	17.923	0.000
TOTALPAH	0.001	0.001	0.134	1.000	1.116	0.268

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.021	1	0.021	1.245	0.268
Residual	1.159	68	0.017		

Durbin-Watson D Statistic	1.220
First Order Autocorrelation	0.378

Dep Var: ASCHIRO N: 70 Multiple R: 0.189 Squared multiple R: 0.036

Adjusted squared multiple R: 0.021 Standard error of estimate: 0.242

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.675	0.059	0.000	.	11.453	0.000
TOTALPAH	-0.002	0.001	-0.189	1.000	-1.584	0.118

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.147	1	0.147	2.511	0.118
Residual	3.972	68	0.058		

Durbin-Watson D Statistic	0.855
First Order Autocorrelation	0.567

Dep Var: ASNSECT N: 70 Multiple R: 0.168 Squared multiple R: 0.028

Adjusted squared multiple R: 0.014 Standard error of estimate: 0.246

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.872	0.060	0.000	.	14.568	0.000
TOTALPAH	0.002	0.001	0.168	1.000	1.402	0.165

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.119	1	0.119	1.967	0.165

Residual	4.100	68	0.060

Durbin-Watson D Statistic 0.849
First Order Autocorrelation 0.571

Dep Var: HPRIME N: 70 Multiple R: 0.007 Squared multiple R: 0.000

Adjusted squared multiple R: 0.000 Standard error of estimate: 20.500

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	35.235	4.999	0.000	.	7.049	0.000
TOTALPAH	0.007	0.123	0.007	1.000	0.061	0.952

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.558	1	1.558	0.004	0.952
Residual	28575.942	68	420.234		

Durbin-Watson D Statistic 1.227
First Order Autocorrelation 0.374

Dep Var: ASGATHR N: 70 Multiple R: 0.188 Squared multiple R: 0.035

Adjusted squared multiple R: 0.021 Standard error of estimate: 0.168

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.959	0.041	0.000	.	23.430	0.000
TOTALPAH	0.002	0.001	0.188	1.000	1.574	0.120

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.070	1	0.070	2.479	0.120
Residual	1.916	68	0.028		

Durbin-Watson D Statistic 0.925
First Order Autocorrelation 0.525

Dep Var: SRETO N: 70 Multiple R: 0.255 Squared multiple R: 0.065

Adjusted squared multiple R: 0.051 Standard error of estimate: 0.579

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)

CONSTANT	1.255	0.140	0.000	.	8.958	0.000
NOCPAH	-0.007	0.003	-0.255	1.000	-2.175	0.033

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.587	1	1.587	4.732	0.033
Residual	22.809	68	0.335		

Durbin-Watson D Statistic	1.455
First Order Autocorrelation	0.257

Dep Var: SRETOC N: 70 Multiple R: 0.385 Squared multiple R: 0.149

Adjusted squared multiple R: 0.136 Standard error of estimate: 1.629

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	3.702	0.394	0.000	.	9.394	0.000
NOCPAH	-0.033	0.010	-0.385	1.000	-3.445	0.001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	31.493	1	31.493	11.867	0.001
Residual	180.456	68	2.654		

Durbin-Watson D Statistic	1.466
First Order Autocorrelation	0.265

Final results of step-wise regressions of biological metrics on substrate and sediment grain size (FINES=fines, FSAND=fine sand, MSAND= medium sand, CSAND=course sand, GRAVEL=gravel)

Minimum tolerance for entry into model = 0.000000
Backward stepwise with Alpha-to-Enter=0.150 and Alpha-to-Remove=0.150

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
SUBSTRATE$ (4 levels)
   Sand, SandRef, Wood, WoodRef

Dep Var: LOGN   N: 70   Multiple R: 0.76324   Squared multiple R: 0.58253

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

FINES                    4.45092     1      4.45092    14.06001     0.00038
MSAND                    0.78156     1      0.78156     2.46886     0.12105
SUBSTRATE$              11.24195     3      3.74732    11.83742     0.00000

Error                   20.26020    64      0.31657

------------------------------------------------------------------------------
*** WARNING ***
Case          10 is an outlier        (Studentized Residual =     -3.73089)

Durbin-Watson D Statistic        1.73655
First Order Autocorrelation      0.12177


COL/
ROW SUBSTRATE$
  1  Sand
  2  SandRef
  3  Wood
  4  WoodRef
Using least squares means.
Post Hoc test of LOGN


------------------------------------------------------------------------------
Using model MSE of 0.317 with 64 df.

Matrix of pairwise mean differences:
                    1           2           3           4
            1     0.00000
            2    -0.12668     0.00000
            3    -0.62656    -0.49989     0.00000
            4    -1.24438    -1.11771    -0.61782     0.00000


Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:
                    1           2           3           4
            1     1.00000
            2     1.00000     1.00000
            3     0.00782     0.63159     1.00000
            4     0.00002     0.00301     0.03471     1.00000
------------------------------------------------------------------------------
Dep Var: SRS   N: 70   Multiple R: 0.46230   Squared multiple R: 0.21372
```

Adjusted squared multiple R: 0.17798 Standard error of estimate: 0.52095

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	3.10316	0.45330	0.00000	.	6.84565	0.00000
FINES	0.01245	0.00583	0.48165	0.23390	2.13415	0.03655
FSAND	0.01713	0.00528	0.67895	0.27201	3.24424	0.00185
CSAND	0.78402	0.25466	0.40763	0.67958	3.07868	0.00303

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	4.86862	3	1.62287	5.97990	0.00114
Residual	17.91160	66	0.27139		

*** WARNING ***
Case 31 has large leverage (Leverage = 0.27848)
Case 38 has large leverage (Leverage = 0.23900)

Durbin-Watson D Statistic 1.67427
First Order Autocorrelation 0.15835

Dep Var: SRETO N: 70 Multiple R: 0.24131 Squared multiple R: 0.05823

Adjusted squared multiple R: 0.03012 Standard error of estimate: 0.58560

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	1.50686	0.26695	0.00000	.	5.64480	0.00000
FSAND	-0.00559	0.00327	-0.21419	0.89471	-1.70886	0.09211
MSAND	-0.00958	0.00598	-0.20059	0.89471	-1.60036	0.11422

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.42066	2	0.71033	2.07138	0.13401
Residual	22.97601	67	0.34293		

Durbin-Watson D Statistic 1.60015
First Order Autocorrelation 0.18631

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: SRETOC N: 70 Multiple R: 0.35975 Squared multiple R: 0.12942

Adjusted squared multiple R: 0.11662 Standard error of estimate: 1.64727

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	4.22899	0.57200	0.00000	.	7.39330	0.00000
FSAND	-0.02769	0.00871	-0.35975	1.00000	-3.17942	0.00222

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	27.43018	1	27.43018	10.10873	0.00222
Residual	184.51899	68	2.71351		

Durbin-Watson D Statistic 1.70511
First Order Autocorrelation 0.14568

Dep Var: ASDOM N: 70 Multiple R: 0.21523 Squared multiple R: 0.04632

Adjusted squared multiple R: 0.01786 Standard error of estimate: 0.12963

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.76547	0.09302	0.00000	.	8.22911	0.00000
FINES	-0.00176	0.00120	-0.29964	0.34293	-1.47074	0.14604
FSAND	-0.00211	0.00117	-0.36753	0.34293	-1.80397	0.07573

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.05469	2	0.02734	1.62726	0.20414
Residual	1.12586	67	0.01680		

Durbin-Watson D Statistic 1.14380
First Order Autocorrelation 0.41418

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASCHIRO N: 70 Multiple R: 0.57927 Squared multiple R: 0.33555

Adjusted squared multiple R: 0.31572 Standard error of estimate: 0.20211

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	0.00337	0.14503	0.00000	.	0.02324	0.98152
FINES	0.00332	0.00187	0.30175	0.34293	1.77442	0.08054
FSAND	0.00854	0.00182	0.79626	0.34293	4.68233	0.00001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.38209	2	0.69104	16.91782	0.00000
Residual	2.73675	67	0.04085		

Durbin-Watson D Statistic	1.09519
First Order Autocorrelation	0.44370

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASOLIGO N: 70 Multiple R: 0.40059 Squared multiple R: 0.16047

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
SUBSTRATE$	0.25651	3	0.08550	4.20510	0.00877
Error	1.34199	66	0.02033		

Durbin-Watson D Statistic 1.24197
First Order Autocorrelation 0.36476

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASOLIGO

Using model MSE of 0.020 with 66 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.13777	0.00000		
3	0.14787	0.01010	0.00000	
4	0.05453	-0.08324	-0.09334	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.03710	1.00000		
3	0.01366	1.00000	1.00000	
4	1.00000	0.81906	0.50911	1.00000

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASNSECT N: 70 Multiple R: 0.57836 Squared multiple R: 0.33450

Adjusted squared multiple R: 0.31464 Standard error of estimate: 0.20469

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	1.54246	0.14688	0.00000	.	10.50131	0.00000
FINES	-0.00336	0.00189	-0.30239	0.34293	-1.77680	0.08014
FSAND	-0.00864	0.00185	-0.79570	0.34293	-4.67537	0.00001

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	1.41100	2	0.70550	16.83814	0.00000
Residual	2.80723	67	0.04190		

Durbin-Watson D Statistic 1.09849
First Order Autocorrelation 0.44230

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: SRCRUMOL N: 70 Multiple R: 0.29178 Squared multiple R: 0.08513

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
SUBSTRATE$	0.61848	3	0.20616	2.04724	0.11575
Error	6.64628	66	0.10070		

Durbin-Watson D Statistic 1.48532
First Order Autocorrelation 0.25006

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of SRCRUMOL

Using model MSE of 0.101 with 66 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.07519	0.00000		
3	-0.15137	-0.07618	0.00000	
4	0.12753	0.20271	0.27889	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.89335	1.00000	1.00000	
4	1.00000	0.62295	0.13100	1.00000

Dep Var: ASCRUMOL N: 70 Multiple R: 0.77627 Squared multiple R: 0.60260

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.55318	1	0.55318	14.96243	0.00026
FSAND	0.63070	1	0.63070	17.05928	0.00011
CSAND	0.19383	1	0.19383	5.24287	0.02540
SUBSTRATE$	0.41413	3	0.13804	3.73383	0.01553
Error	2.32918	63	0.03697		

*** WARNING ***
Case 19 is an outlier (Studentized Residual = 3.23845)

Durbin-Watson D Statistic 1.41993
First Order Autocorrelation 0.28966

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASCRUMOL

Using model MSE of 0.037 with 63 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.09736	0.00000		
3	0.19690	0.09953	0.00000	
4	0.27240	0.17503	0.07550	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.06214	1.00000	1.00000	
4	0.02034	0.57817	1.00000	1.00000

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
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Dep Var: HPRIME N: 70 Multiple R: 0.21447 Squared multiple R: 0.04600

Adjusted squared multiple R: 0.03197 Standard error of estimate: 0.39692

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	2.09656	0.13783	0.00000	.	15.21141	0.00000
FSAND	0.00380	0.00210	0.21447	1.00000	1.81073	0.07460

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
Regression	0.51656	1	0.51656	3.27873	0.07460
Residual	10.71327	68	0.15755		

*** WARNING ***
Case 19 is an outlier (Studentized Residual = -3.40975)

Durbin-Watson D Statistic 1.17350
First Order Autocorrelation 0.40531

Dep Var: ASEVEN N: 70 Multiple R: 0.00000 Squared multiple R: 0.00000

Adjusted squared multiple R: 0.00000 Standard error of estimate: 0.11019

Effect	Coefficient	Std Error	Std Coef	Tolerance	t	P(2 Tail)
CONSTANT	1.07963	0.01317	0.00000	.	81.97407	0.00000

Durbin-Watson D Statistic 1.33043
First Order Autocorrelation 0.32949

Dep Var: HBI N: 70 Multiple R: 0.61508 Squared multiple R: 0.37832

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
GRAVEL	0.24154	1	0.24154	3.53102	0.06472
SUBSTRATE$	2.40928	3	0.80309	11.74001	0.00000
Error	4.44643	65	0.06841		

*** WARNING ***
Case 36 is an outlier (Studentized Residual = -3.81169)

Durbin-Watson D Statistic 1.58446
First Order Autocorrelation 0.20757

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of HBI

Using model MSE of 0.068 with 65 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.52196	0.00000		
3	0.23772	-0.28424	0.00000	
4	0.22270	-0.29926	-0.01502	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.00000	1.00000		
3	0.05042	0.00460	1.00000	
4	0.24563	0.02617	1.00000	1.00000

Dep Var: ASNTOL N: 70 Multiple R: 0.44750 Squared multiple R: 0.20025

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FSAND	0.01574	1	0.01574	2.36729	0.12883
GRAVEL	0.05173	1	0.05173	7.77808	0.00696
SUBSTRATE$	0.03825	3	0.01275	1.91713	0.13568
Error	0.42564	64	0.00665		

*** WARNING ***
Case 36 is an outlier (Studentized Residual = 4.42168)

Durbin-Watson D Statistic 1.46071
First Order Autocorrelation 0.25430

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASNTOL

Using model MSE of 0.007 with 64 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.05030	0.00000		
3	0.01090	0.06120	0.00000	
4	-0.06268	-0.01239	-0.07358	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	1.00000	0.69119	1.00000	
4	0.46600	1.00000	0.15891	1.00000

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASFACUL N: 70 Multiple R: 0.60454 Squared multiple R: 0.36547

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.05343	1	0.05343	3.36534	0.07123
FSAND	0.08463	1	0.08463	5.33017	0.02420
SUBSTRATE$	0.23370	3	0.07790	4.90622	0.00394
Error	1.01618	64	0.01588		

Durbin-Watson D Statistic 1.16107
First Order Autocorrelation 0.41300

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASFACUL

Using model MSE of 0.016 with 64 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.09840	0.00000		
3	-0.14777	-0.04936	0.00000	
4	-0.15333	-0.05493	-0.00557	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.00389	1.00000	1.00000	
4	0.03864	1.00000	1.00000	1.00000

Dep Var: ASTOL N: 70 Multiple R: 0.61526 Squared multiple R: 0.37855

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.05844	1	0.05844	3.76316	0.05680
FSAND	0.08227	1	0.08227	5.29782	0.02462
SUBSTRATE$	0.21672	3	0.07224	4.65175	0.00528
Error	0.99388	64	0.01553		

Durbin-Watson D Statistic 1.21888
First Order Autocorrelation 0.38513

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASTOL

Using model MSE of 0.016 with 64 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.10654	0.00000		
3	0.13270	0.02617	0.00000	
4	0.16762	0.06109	0.03492	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.92080	1.00000		
3	0.01081	1.00000	1.00000	
4	0.01657	1.00000	1.00000	1.00000

Dep Var: ASFILTR N: 70 Multiple R: 0.54954 Squared multiple R: 0.30199

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.05393	1	0.05393	6.48087	0.01332
MSAND	0.04175	1	0.04175	5.01740	0.02857
SUBSTRATE$	0.12084	3	0.04028	4.84053	0.00425
Error	0.53259	64	0.00832		

Durbin-Watson D Statistic 1.45005
First Order Autocorrelation 0.26709

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASFILTR

Using model MSE of 0.008 with 64 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.04572	0.00000		
3	-0.01030	-0.05602	0.00000	
4	0.12055	0.07483	0.13085	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	1.00000	1.00000	1.00000	
4	0.01868	0.80996	0.00245	1.00000

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASGATHR N: 70 Multiple R: 0.63971 Squared multiple R: 0.40923

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.25188	1	0.25188	13.52434	0.00049
FSAND	0.10452	1	0.10452	5.61238	0.02091
CSAND	0.06126	1	0.06126	3.28923	0.07450
SUBSTRATE$	0.25482	3	0.08494	4.56082	0.00591
Error	1.17331	63	0.01862		

Durbin-Watson D Statistic 1.46914
First Order Autocorrelation 0.25320

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASGATHR

Using model MSE of 0.019 with 63 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.06668	0.00000		
3	0.13807	0.07139	0.00000	
4	-0.03042	-0.09709	-0.16848	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.06759	1.00000	1.00000	
4	1.00000	1.00000	0.01674	1.00000

Dep Var: ASPARA N: 70 Multiple R: 0.68161 Squared multiple R: 0.46459

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.20467	1	0.20467	10.84333	0.00163
FSAND	0.09333	1	0.09333	4.94452	0.02977
CSAND	0.06198	1	0.06198	3.28386	0.07473
SUBSTRATE$	0.28153	3	0.09384	4.97181	0.00369
Error	1.18913	63	0.01888		

Durbin-Watson D Statistic 1.54066
First Order Autocorrelation 0.22153

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASPARA

Using model MSE of 0.019 with 63 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.09866	0.00000		
3	-0.18192	-0.08326	0.00000	
4	-0.21308	-0.11441	-0.03115	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.00667	1.00000	1.00000	
4	0.00863	0.76525	1.00000	1.00000

Dep Var: ASPRED N: 70 Multiple R: 0.50664 Squared multiple R: 0.25669

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
MSAND	0.07025	1	0.07025	9.34242	0.00325
SUBSTRATE$	0.05555	3	0.01852	2.46228	0.07034
Error	0.48877	65	0.00752		

Durbin-Watson D Statistic 1.89121
First Order Autocorrelation 0.04811
COL/

ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASPRED

Using model MSE of 0.008 with 65 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.00113	0.00000		
3	-0.03065	-0.02952	0.00000	
4	0.05719	0.05832	0.08784	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	1.00000	1.00000	1.00000	
4	0.66799	0.78383	0.05213	1.00000

Appendix 4. Stepwise Multiple Regression Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASSCRAPE N: 70 Multiple R: 0.68517 Squared multiple R: 0.46946

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FSAND	0.07299	1	0.07299	11.31813	0.00129
SUBSTRATE$	0.16639	3	0.05546	8.60024	0.00007
Error	0.41918	65	0.00645		

Durbin-Watson D Statistic 2.14765
First Order Autocorrelation -0.08492

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASSCRAPE

Using model MSE of 0.006 with 65 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.07316	0.00000		
3	-0.12411	-0.05096	0.00000	
4	-0.02576	0.04740	0.09835	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.45907	1.00000		
3	0.00008	1.00000	1.00000	
4	1.00000	1.00000	0.01584	1.00000

Dep Var: ASSHRED N: 70 Multiple R: 0.49286 Squared multiple R: 0.24291

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
FINES	0.01971	1	0.01971	2.85463	0.09622
FSAND	0.01996	1	0.01996	2.89058	0.09419
MSAND	0.01946	1	0.01946	2.81868	0.09829
CSAND	0.03061	1	0.03061	4.43337	0.03937
GRAVEL	0.01901	1	0.01901	2.75339	0.10218
SUBSTRATE$	0.04839	3	0.01613	2.33618	0.08254
Error	0.42117	61	0.00690		

*** WARNING ***
Case 22 is an outlier (Studentized Residual = 3.45625)

Durbin-Watson D Statistic 1.44724
First Order Autocorrelation 0.24630

COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASSHRED

Using model MSE of 0.007 with 61 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.02778	0.00000		
3	0.07120	0.09898	0.00000	
4	0.05020	0.07798	-0.02100	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.26128	0.29629	1.00000	
4	1.00000	0.60755	1.00000	1.00000

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: LOGN N: 70 Multiple R: 0.83334 Squared multiple R: 0.69446

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	11.85393	11	1.07763	4.06984	0.00022
SUBSTRATE$	0.08492	2	0.04246	0.16035	0.85223
Error	14.82792	56	0.26478		

*** WARNING ***
Case 10 is an outlier (Studentized Residual = -5.43060)

Durbin-Watson D Statistic 2.45124
First Order Autocorrelation -0.22656

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	3	10

Dep Var: SRS N: 70 Multiple R: 0.79621 Squared multiple R: 0.63395

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	10.60804	10	1.06080	7.12392	0.00000
SUBSTRATE$	2.21383	3	0.73794	4.95574	0.00403
Error	8.33880	56	0.14891		

*** WARNING ***
Case 8 is an outlier (Studentized Residual = 3.84073)
Case 10 is an outlier (Studentized Residual = -3.41685)

Durbin-Watson D Statistic 2.61010
First Order Autocorrelation -0.32296
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of SRS

Using model MSE of 0.149 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.59910	0.00000		
3	0.05772	-0.54139	0.00000	
4	-0.31630	-0.91540	-0.37401	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.10338	1.00000		
3	1.00000	0.50970	1.00000	
4	1.00000	0.00252	1.00000	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: SRETO N: 70 Multiple R: 0.75492 Squared multiple R: 0.56990

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	13.84934	11	1.25903	6.71933	0.00000
SUBSTRATE$	0.21372	2	0.10686	0.57030	0.56861
Error	10.49296	56	0.18737		

Durbin-Watson D Statistic	2.54200
First Order Autocorrelation	-0.27542

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: SRETOC N: 70 Multiple R: 0.73003 Squared multiple R: 0.53295

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	100.30982	11	9.11907	5.15873	0.00002
SUBSTRATE$	2.35120	2	1.17560	0.66504	0.51826
Error	98.99109	56	1.76770		

*** WARNING ***
Case 17 is an outlier (Studentized Residual = -4.30538)

Durbin-Watson D Statistic 2.48589
First Order Autocorrelation -0.24370

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	1	12
SUBSTRATE$	3	2	1

Dep Var: ASDOM N: 70 Multiple R: 0.75106 Squared multiple R: 0.56409

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.64884	12	0.05407	5.88388	0.00000
SUBSTRATE$	0.00011	1	0.00011	0.01158	0.91471
Error	0.51461	56	0.00919		

Durbin-Watson D Statistic	2.30517
First Order Autocorrelation	-0.16072

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASCHIRO N: 70 Multiple R: 0.92109 Squared multiple R: 0.84840

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	3.23412	11	0.29401	26.36837	0.00000
SUBSTRATE$	0.00329	2	0.00165	0.14759	0.86312
Error	0.62441	56	0.01115		

Durbin-Watson D Statistic 2.57466
First Order Autocorrelation -0.30018

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	3	10

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Dep Var: ASOLIGO N: 70 Multiple R: 0.83442 Squared multiple R: 0.69626

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.85646	10	0.08565	9.87818	0.00000
SUBSTRATE$	0.18543	3	0.06181	7.12885	0.00039
Error	0.48553	56	0.00867		

*** WARNING ***
Case 12 is an outlier (Studentized Residual = 3.60960)

Durbin-Watson D Statistic 2.43925
First Order Autocorrelation -0.25055
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASOLIGO

Using model MSE of 0.009 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.14766	0.00000		
3	0.23287	0.08521	0.00000	
4	0.23861	0.09095	0.00574	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.49000	1.00000		
3	0.00131	1.00000	1.00000	
4	0.00095	1.00000	1.00000	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASNSECT N: 70 Multiple R: 0.91763 Squared multiple R: 0.84205

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	3.31576	11	0.30143	25.33501	0.00000
SUBSTRATE$	0.11134	2	0.05567	4.67898	0.01321
Error	0.66628	56	0.01190		

Durbin-Watson D Statistic 2.45870
First Order Autocorrelation -0.23719
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASNSECT

Using model MSE of 0.012 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.02223	0.00000		
3	-0.06646	-0.08869	0.00000	
4	0.13315	0.11092	0.19961	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	1.00000	0.66087	1.00000	
4	1.00000	0.08047	0.03252	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: SRCRUMOL N: 70 Multiple R: 0.68910 Squared multiple R: 0.47486

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	2.89319	11	0.26302	3.86076	0.00036
SUBSTRATE$	0.02619	2	0.01310	0.19225	0.82564
Error	3.81505	56	0.06813		

Durbin-Watson D Statistic 2.18971
First Order Autocorrelation -0.10467

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASCRUMOL N: 70 Multiple R: 0.93260 Squared multiple R: 0.86975

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	3.19936	11	0.29085	21.33588	0.00000
SUBSTRATE$	0.89829	2	0.44914	32.94779	0.00000
Error	0.76339	56	0.01363		

*** WARNING ***
Case 8 is an outlier (Studentized Residual = -3.76703)

Durbin-Watson D Statistic 2.51859
First Order Autocorrelation -0.27925
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASCRUMOL

Using model MSE of 0.014 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.27226	0.00000		
3	0.01508	0.28734	0.00000	
4	0.31749	0.58975	0.30241	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.13040	1.00000		
3	1.00000	0.00001	1.00000	
4	0.02203	0.00000	0.00000	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: HPRIME N: 70 Multiple R: 0.82427 Squared multiple R: 0.67942

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	7.14848	11	0.64986	10.10866	0.00000
SUBSTRATE$	0.04516	2	0.02258	0.35124	0.70535
Error	3.60011	56	0.06429		

*** WARNING ***
Case 8 is an outlier (Studentized Residual = 5.73006)
Case 9 is an outlier (Studentized Residual = -3.42673)

Durbin-Watson D Statistic 2.53260
First Order Autocorrelation -0.27244

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	3	10

Dep Var: ASEVEN N: 70 Multiple R: 0.76693 Squared multiple R: 0.58817

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.46450	10	0.04645	7.53908	0.00000
SUBSTRATE$	0.02732	3	0.00911	1.47779	0.23043
Error	0.34503	56	0.00616		

*** WARNING ***
Case 9 is an outlier (Studentized Residual = -3.34613)

Durbin-Watson D Statistic 2.51167
First Order Autocorrelation -0.25834

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
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Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	3	10

Dep Var: HBI N: 70 Multiple R: 0.79383 Squared multiple R: 0.63016

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	2.04281	10	0.20428	4.32476	0.00017
SUBSTRATE$	0.37832	3	0.12611	2.66973	0.05625
Error	2.64517	56	0.04724		

Durbin-Watson D Statistic 2.09799
First Order Autocorrelation -0.06412

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASNTOL N: 70 Multiple R: 0.75759 Squared multiple R: 0.57394

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.29534	11	0.02685	6.63065	0.00000
SUBSTRATE$	0.00062	2	0.00031	0.07708	0.92591
Error	0.22676	56	0.00405		

Durbin-Watson D Statistic 1.97677
First Order Autocorrelation -0.00808

```
Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
    W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
   Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

                              Initial  Lost  Final
Effect                             df    df     df
STATION$                           13     2     11
SUBSTRATE$                          3     1      2


Dep Var: ASFACUL   N: 70   Multiple R: 0.89727   Squared multiple R: 0.80509

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

STATION$                  0.79055    11      0.07187    12.89328     0.00000
SUBSTRATE$                0.06238     2      0.03119     5.59521     0.00609

Error                     0.31215    56      0.00557


-------------------------------------------------------------------------------
*** WARNING ***
Case          14 is an outlier        (Studentized Residual =     -8.83463)
Case          15 is an outlier        (Studentized Residual =      6.37606)

Durbin-Watson D Statistic        2.27673
First Order Autocorrelation     -0.15412


Data for the following results were selected according to:
      (TYPE$= 'Sand')


Dep Var: ASFACUL   N: 35   Multiple R: 0.95260   Squared multiple R: 0.90745

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

SITE$                     0.50423     5      0.10085    28.21749     0.00000
SUBSTRATE$                0.05114     1      0.05114    14.30956     0.00075

Error                     0.10007    28      0.00357

Data for the following results were selected according to:
      (TYPE$= 'Wood')

Dep Var: ASFACUL   N: 35   Multiple R: 0.75069   Squared multiple R: 0.56354

Analysis of Variance
Source             Sum-of-Squares   df  Mean-Square     F-ratio       P

SITE$                     0.27557     4      0.06889     9.01904     0.00007
SUBSTRATE$                0.00090     1      0.00090     0.11727     0.73448

Error                     0.22152    29      0.00764
```

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	1	12
SUBSTRATE$	3	2	1

Dep Var: ASTOL N: 70 Multiple R: 0.89871 Squared multiple R: 0.80769

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	1.23192	12	0.10266	18.69179	0.00000
SUBSTRATE$	0.03981	1	0.03981	7.24758	0.00935
Error	0.30757	56	0.00549		

Durbin-Watson D Statistic 2.22564
First Order Autocorrelation -0.13267
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASTOL

Using model MSE of 0.005 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.07523	0.00000		
3	0.00000	-0.07523	0.00000	
4	-0.07523	-0.15046	-0.07523	0.00000

Appendix 5. Analysis of Variance Output. Sediment Quality Triad Report
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Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASFILTR N: 70 Multiple R: 0.79541 Squared multiple R: 0.63268

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.30894	11	0.02809	5.61165	0.00001
SUBSTRATE$	0.05837	2	0.02918	5.83115	0.00501
Error	0.28027	56	0.00500		

Durbin-Watson D Statistic 2.40223
First Order Autocorrelation -0.22064
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASFILTR

Using model MSE of 0.005 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.04263	0.00000		
3	-0.13892	-0.09629	0.00000	
4	0.18156	0.22419	0.32048	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	0.00718	0.21430	1.00000	
4	0.04095	0.15398	0.01490	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASGATHR N: 70 Multiple R: 0.80400 Squared multiple R: 0.64641

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	1.26792	11	0.11527	9.19176	0.00000
SUBSTRATE$	0.00714	2	0.00357	0.28483	0.75322
Error	0.70224	56	0.01254		

*** WARNING ***
Case 31 is an outlier (Studentized Residual = -3.78577)

Durbin-Watson D Statistic 2.26217
First Order Autocorrelation -0.14533

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	3	10

Dep Var: ASPARA N: 70 Multiple R: 0.82607 Squared multiple R: 0.68239

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.72518	10	0.07252	5.75694	0.00001
SUBSTRATE$	0.27921	3	0.09307	7.38863	0.00030
Error	0.70541	56	0.01260		

*** WARNING ***
Case 23 is an outlier (Studentized Residual = 3.36937)
Case 31 is an outlier (Studentized Residual = 3.27200)

Durbin-Watson D Statistic 1.85130
First Order Autocorrelation 0.05948
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASPARA

Using model MSE of 0.013 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.02211	0.00000		
3	-0.03332	-0.05543	0.00000	
4	-0.27028	-0.29238	-0.23696	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	1.00000	1.00000		
3	1.00000	1.00000	1.00000	
4	0.00210	0.01746	0.00902	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASPRED N: 70 Multiple R: 0.79387 Squared multiple R: 0.63023

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.34414	11	0.03129	7.20569	0.00000
SUBSTRATE$	0.05116	2	0.02558	5.89110	0.00476
Error	0.24314	56	0.00434		

Durbin-Watson D Statistic 2.48551
First Order Autocorrelation -0.26030
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASPRED

Using model MSE of 0.004 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	-0.05668	0.00000		
3	-0.15450	-0.09782	0.00000	
4	-0.01553	0.04115	0.13897	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.20635	1.00000		
3	0.01557	0.00682	1.00000	
4	1.00000	0.57769	0.02322	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASSCRAPE N: 70 Multiple R: 0.80440 Squared multiple R: 0.64705

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.22200	11	0.02018	4.05285	0.00022
SUBSTRATE$	0.08618	2	0.04309	8.65322	0.00053
Error	0.27887	56	0.00498		

*** WARNING ***
Case 44 is an outlier (Studentized Residual = -4.52960)

Durbin-Watson D Statistic 2.68385
First Order Autocorrelation -0.34857
COL/
ROW SUBSTRATE$
1 Sand
2 SandRef
3 Wood
4 WoodRef
Using least squares means.
Post Hoc test of ASSCRAPE

Using model MSE of 0.005 with 56 df.

Matrix of pairwise mean differences:

	1	2	3	4
1	0.00000			
2	0.05921	0.00000		
3	-0.12389	-0.18310	0.00000	
4	0.06467	0.00546	0.18856	0.00000

Bonferroni Adjustment.

Matrix of pairwise comparison probabilities:

	1	2	3	4
1	1.00000			
2	0.73522	1.00000		
3	0.02083	0.00080	1.00000	
4	1.00000	1.00000	0.40136	1.00000

Effects coding used for categorical variables in model.

Categorical values encountered during processing are:
STATION$ (14 levels)
W5, S1, S6, S7, SR10, SR12, SR13, SR14, W2, W3, W4, W8, WR11, WR9
SUBSTRATE$ (4 levels)
Sand, SandRef, Wood, WoodRef

The following effects have lost degrees of freedom.

Effect	Initial df	Lost df	Final df
STATION$	13	2	11
SUBSTRATE$	3	1	2

Dep Var: ASSHRED N: 70 Multiple R: 0.64762 Squared multiple R: 0.41942

Analysis of Variance

Source	Sum-of-Squares	df	Mean-Square	F-ratio	P
STATION$	0.21720	11	0.01975	3.42352	0.00111
SUBSTRATE$	0.00067	2	0.00033	0.05790	0.94380
Error	0.32298	56	0.00577		

*** WARNING ***
Case 51 is an outlier (Studentized Residual = 3.24247)

Durbin-Watson D Statistic 2.21546
First Order Autocorrelation -0.12727

MANOVA-Discriminant Function Analysis of Functional Groups on Different Substrates

Group frequencies

Sand	SandRef	Wood	WoodRef
15	20	25	10

Group means

	Sand	SandRef	Wood	WoodRef
ASFILTR	0.27572	0.20509	0.25322	0.36425
ASGATHR	0.93425	0.96685	1.12661	0.95493
ASPARA	0.40364	0.34232	0.16791	0.14381
ASPRED	0.23196	0.29015	0.20875	0.29351
ASSCRAPE	0.13942	0.16716	0.01929	0.14890
ASSHRED	0.10608	0.16694	0.13450	0.15200

Between groups F-matrix -- df = 6 61

	Sand	SandRef	Wood	WoodRef
Sand	0.00000			
SandRef	2.83776	0.00000		
Wood	7.15642	8.07869	0.00000	
WoodRef	6.88016	6.94200	7.25263	0.00000

Wilks' lambda

Lambda = 0.2341 df = 6 3 66
Approx. F= 6.4478 df = 18 173 prob = 0.0000

Classification functions

	Sand	SandRef	Wood	WoodRef
CONSTANT	-1323.08898	-1334.39697	-1338.66312	-1286.75102
ASFILTR	1140.19107	1136.33488	1145.72010	1134.71237
ASGATHR	1697.37831	1704.43588	1709.62904	1670.70419
ASPARA	1017.17023	1016.46323	1012.94119	984.25937
ASPRED	1021.40929	1035.92720	1032.94921	1021.46423
ASSCRAPE	316.97646	320.25207	302.87682	315.38338
ASSHRED	486.04612	497.02000	496.62772	484.76769

Variable	F-to-remove	Tolerance	Variable	F-to-enter	Tolerance
43 ASFILTR	0.41	0.190161			
44 ASGATHR	2.11	0.040219			
45 ASPARA	4.07	0.104831			
46 ASPRED	1.26	0.227081			
47 ASSCRAPE	4.49	0.781739			
48 ASSHRED	2.23	0.579596			

Classification matrix (cases in row categories classified into columns)

	Sand	SandRef	Wood	WoodRef	%correct
Sand	11	2	1	1	73
SandRef	6	13	1	0	65
Wood	1	3	18	3	72
WoodRef	0	1	1	8	80
Total	18	19	21	12	71

Jackknifed classification matrix

	Sand	SandRef	Wood	WoodRef	%correct
Sand	9	4	1	1	60
SandRef	6	12	1	1	60
Wood	1	4	17	3	68
WoodRef	0	2	1	7	70
Total	16	22	20	12	64

Eigenvalues

0.96131	0.70493	0.27740

Canonical correlations

0.70010	0.64301	0.46600

Cumulative proportion of total dispersion

0.49459	0.85728	1.00000

Wilks' lambda=	0.234					
Approx.F=	6.449	df=	18,	173	p-tail=	0.0000
Pillai's trace=	1.121					
Approx.F=	6.262	df=	18,	189	p-tail=	0.0000
Lawley-Hotelling trace=	1.944					
Approx.F=	6.443	df=	18,	179	p-tail=	0.0000

Canonical discriminant functions

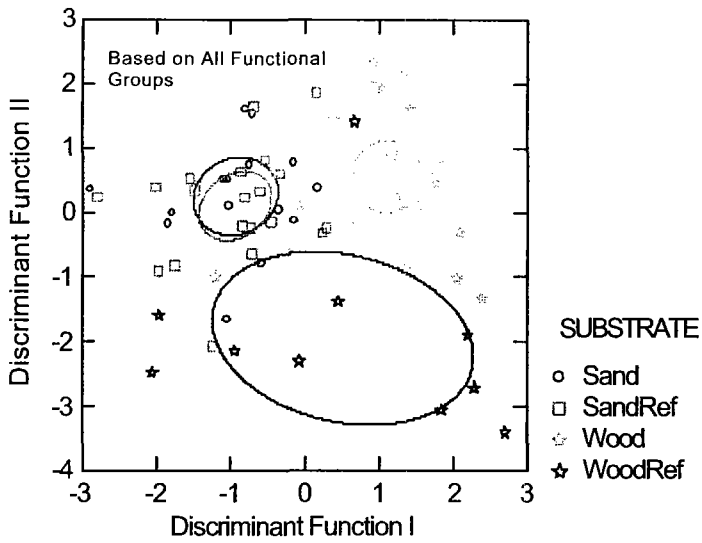
	1	2	3
Constant	-0.38606	-20.81150	9.98055
ASFILTR	3.09477	3.76649	2.26045
ASGATHR	1.09746	15.07821	-6.36971
ASPARA	-4.27671	12.47201	-0.77972
ASPRED	0.74464	4.01018	-10.36106
ASSCRAPE	-7.21497	-3.37608	-1.90055
ASSHRED	1.26385	4.13398	-7.94397

Canonical discriminant functions -- standardized by within variances

	1	2	3
ASFILTR	0.29240	0.35587	0.21357
ASGATHR	0.16514	2.26888	-0.95848
ASPARA	-0.62964	1.83620	-0.11480
ASPRED	0.06853	0.36907	-0.95356
ASSCRAPE	-0.62305	-0.29154	-0.16412
ASSHRED	0.11243	0.36777	-0.70671

Canonical scores of group means

	1	2	3
Sand	-0.93280	0.24611	0.82709
SandRef	-0.93332	0.09806	-0.63144
Wood	1.10213	0.55172	-0.02215
WoodRef	0.51052	-1.94460	0.07762



Ellipses are 95% confidence intervals around
goup centroids.

MANOVA-Discriminant Function Analysis of ETO, Chironomidae,Oligochaeta, Not Insect, & Crustacea+Mollusca

Group frequencies

Sand	SandRef	Wood	WoodRef
15	20	25	10

Group means

	Sand	SandRef	Wood	WoodRef
SRETO	1.01449	0.94820	1.01840	0.96569
ASCHIRO	0.53054	0.76369	0.48751	0.61312
ASOLIGO	0.23536	0.37314	0.38324	0.28989
ASNSECT	1.02575	0.77815	1.04031	0.92208
ASCRUMOL	0.45362	0.27092	0.73646	0.73010

Between groups F-matrix -- df = 5 62

	Sand	SandRef	Wood	WoodRef
Sand	0.00000			
SandRef	7.61412	0.00000		
Wood	13.65323	11.22660	0.00000	
WoodRef	9.40231	7.19655	0.95791	0.00000

Wilks' lambda

Lambda = 0.2429 df = 5 3 66
Approx. F= 7.6352 df = 15 171 prob = 0.0000

Classification functions

	Sand	SandRef	Wood	WoodRef
CONSTANT	-1064.06626	-1075.78185	-1056.93775	-1073.21836
SRETO	53.15736	54.15817	54.23660	55.04567

ASCHIRO	1390.72614	1401.46734	1385.78231	1397.91891
ASOLIGO	79.03779	96.12355	98.44256	96.42126
ASNSECT	1252.73803	1248.98548	1231.26425	1239.23512
ASCRUMOL	66.12612	71.56113	83.72541	85.98691

Variable	F-to-remove	Tolerance	Variable	F-to-enter	Tolerance
31 SRETO	0.89	0.574758			
34 ASCHIRO	0.74	0.022454			
35 ASOLIGO	11.73	0.576512			
36 ASNSECT	1.11	0.025591			
38 ASCRUMOL	22.14	0.421992			

Classification matrix (cases in row categories classified into columns)

	Sand	SandRef	Wood	WoodRef	%correct
Sand	12	1	1	1	80
SandRef	3	17	0	0	85
Wood	1	4	16	4	64
WoodRef	2	0	3	5	50
Total	18	22	20	10	71

Jackknifed classification matrix

	Sand	SandRef	Wood	WoodRef	%correct
Sand	12	1	1	1	80
SandRef	4	16	0	0	80
Wood	1	5	11	8	44
WoodRef	2	0	4	4	40
Total	19	22	16	13	61

Eigenvalues

1.41849	0.58104	0.07686

Canonical correlations

0.76584	0.60622	0.26716

Cumulative proportion of total dispersion

0.68315	0.96298	1.00000

Wilks' lambda=	0.243				
Approx.F=	7.660	df= 15,	171	p-tail=	0.0000
Pillai's trace=	1.025				
Approx.F=	6.647	df= 15,	192	p-tail=	0.0000
Lawley-Hotelling trace=	2.076				
Approx.F=	8.398	df= 15,	182	p-tail=	0.0000

Canonical discriminant functions

	1	2	3
Constant	2.86602	-7.09518	-18.84378
SRETO	0.37582	0.37112	0.92081
ASCHIRO	-2.53900	6.10723	14.19189
ASOLIGO	4.86360	6.67462	-3.01490
ASNSECT	-7.42470	0.62941	9.79752
ASCRUMOL	6.74890	0.49709	2.31866

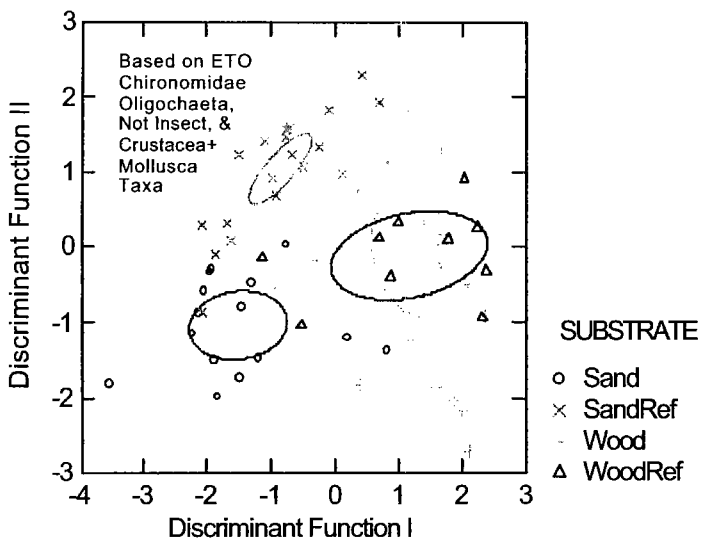
Canonical discriminant functions -- standardized by within variances

	1	2	3
SRETO	0.22816	0.22531	0.55903

ASCHIRO	-0.55867	1.34380	3.12269
ASOLIGO	0.69352	0.95176	-0.42991
ASNSECT	-1.66806	0.14141	2.20115
ASCRUMOL	1.43285	0.10554	0.49227

Canonical scores of group means

	1	2	3
Sand	-1.50952	-1.03649	0.01174
SandRef	-0.85096	1.03574	-0.00533
Wood	1.12115	-0.16106	-0.24270
WoodRef	1.16333	-0.11408	0.59980



Ellipses are 95% confidence intervals around
goup centroids.

MANOVA-Discriminant Function Analysis of Intolerant, Facultative, & Tolerant Taxa

Group frequencies

Sand	SandRef	Wood	WoodRef
15	20	25	10

Group means

	Sand	SandRef	Wood	WoodRef
ASNTOL	0.12272	0.12003	0.15180	0.07601
ASFACUL	0.97625	0.74037	0.82542	0.78718
ASTOL	0.57383	0.81218	0.70927	0.77466

Between groups F-matrix -- df = 3 64

	Sand	SandRef	Wood	WoodRef
Sand	0.00000			

SandRef	9.72749	0.00000		
Wood	5.38875	4.04158	0.00000	
WoodRef	5.79661	0.94016	2.58507	0.00000

Wilks' lambda

Lambda =	0.5667	df =	3	3	66	
Approx. F=	4.5272	df =	9	155	prob =	0.0000

Classification functions

	Sand	SandRef	Wood	WoodRef
CONSTANT	-9236.51908	-9225.17804	-9142.48729	-9181.98735
ASNTOL	3554.51868	3549.91184	3539.15345	3536.15641
ASFACUL	11684.62930	11671.05920	11621.19670	11645.15537
ASTOL	11548.58773	11549.83664	11494.37454	11522.03582

Variable	F-to-remove	Tolerance	Variable	F-to-enter	Tolerance
40 ASNTOL	1.31	0.165686			
41 ASFACUL	2.01	0.008097			
42 ASTOL	1.93	0.008463			

Classification matrix (cases in row categories classified into columns)

	Sand	SandRef	Wood	WoodRef	%correct
Sand	13	0	0	2	87
SandRef	4	13	1	2	65
Wood	4	7	7	7	28
WoodRef	2	5	0	3	30
Total	23	25	8	14	51

Jackknifed classification matrix

	Sand	SandRef	Wood	WoodRef	%correct
Sand	13	0	0	2	87
SandRef	4	12	2	2	60
Wood	4	7	7	7	28
WoodRef	3	6	0	1	10
Total	24	25	9	12	47

Eigenvalues

0.49733	0.13378	0.03953

Canonical correlations

0.57632	0.34350	0.19500

Cumulative proportion of total dispersion

0.74159	0.94106	1.00000

Wilks' lambda=	0.567				
Approx.F=	4.554	df= 9,	155	p-tail=	0.0000
Pillai's trace=	0.488				
Approx.F=	4.276	df= 9,	198	p-tail=	0.0000
Lawley-Hotelling trace=	0.671				
Approx.F=	4.670	df= 9,	188	p-tail=	0.0000

Canonical discriminant functions

	1	2	3
Constant	-7.56331	-100.91609	-90.21722

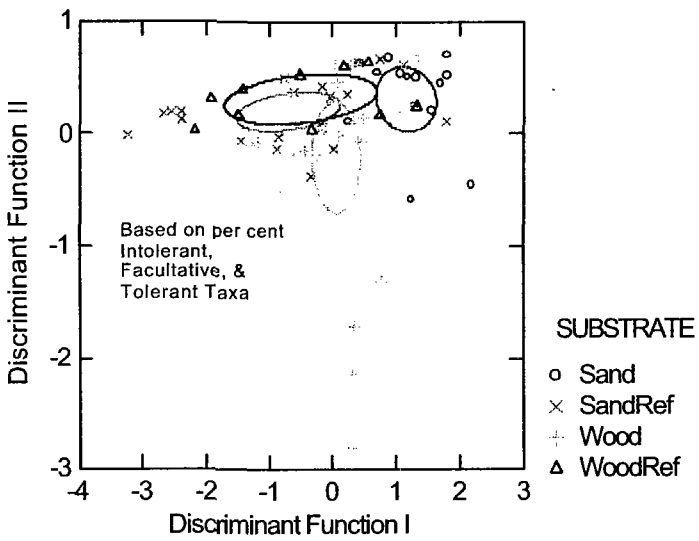
ASNTOL	3.93082	11.95346	25.59450
ASFACUL	8.22347	64.72559	56.06922
ASTOL	0.36230	63.73185	56.43580

Canonical discriminant functions -- standardized by within variances

	1	2	3
ASNTOL	0.33860	1.02966	2.20469
ASFACUL	1.06232	8.36131	7.24307
ASTOL	0.04626	8.13808	7.20643

Canonical scores of group means

	1	2	3
Sand	1.15516	0.31052	0.04589
SandRef	-0.70882	0.20152	0.20307
Wood	0.07818	-0.47283	-0.02319
WoodRef	-0.51055	0.31327	-0.41700



Ellipses are 95% confidence intervals around
goup centroids.

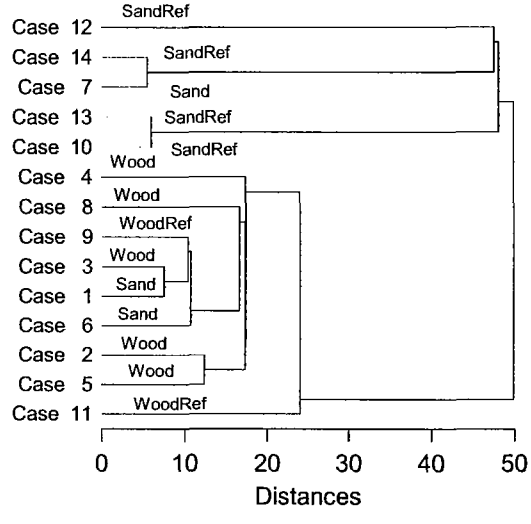
Appendix 7. Cluster Analysis. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

Using All Community Metrics

Distance metric is Euclidean distance
Single linkage method (nearest neighbor)

Cluster containing	and	Cluster containing	Were joined at distance	No. of members in new cluster
Case 14		Case 7	5.50606	2
Case 13		Case 10	5.96640	2
Case 3		Case 1	7.44632	2
Case 3		Case 9	10.30536	3
Case 6		Case 3	10.63202	4
Case 5		Case 2	12.30390	2
Case 8		Case 6	16.57448	5
Case 8		Case 5	17.28467	7
Case 4		Case 8	17.35778	8
Case 4		Case 11	24.03240	9
Case 12		Case 14	47.54293	3
Case 12		Case 13	48.09992	5
Case 12		Case 4	49.84903	14

Cluster Tree

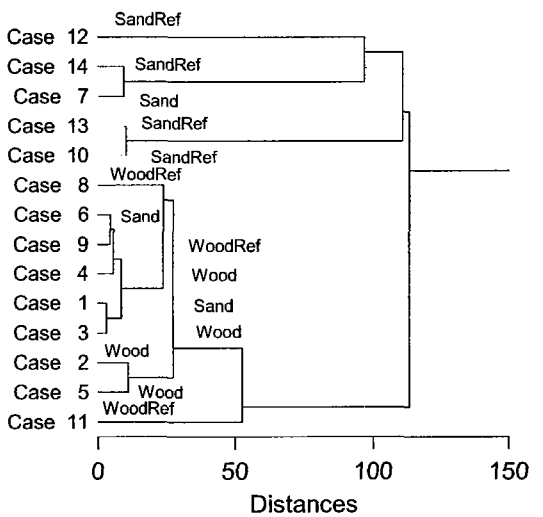


Density and Numbers of Taxa, ETO Taxa, Ratio of ETO/ETO+Chironomidae, Crustacea+Mollusca Taxa;

Distance metric is Euclidean distance
Single linkage method (nearest neighbor)

Cluster containing	and	Cluster containing	Were joined at distance	No. of members in new cluster
Case 3		Case 1	3.02808	2
Case 9		Case 6	4.37406	2
Case 4		Case 9	5.69719	3
Case 4		Case 3	8.53732	5
Case 14		Case 7	9.41333	2
Case 13		Case 10	10.09406	2
Case 5		Case 2	10.91353	2
Case 4		Case 8	23.87872	6
Case 5		Case 4	27.44734	8
Case 5		Case 11	52.43406	9
Case 12		Case 14	96.73029	3
Case 12		Case 13	110.87321	5
Case 12		Case 5	113.47375	14

Cluster Tree

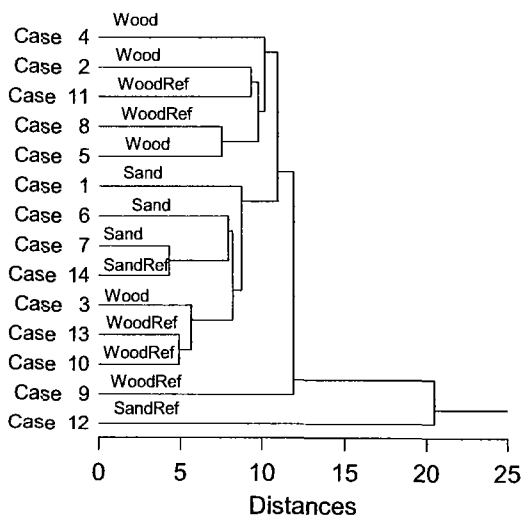


Percent chironomids, oligochaetes, crustaceans + molluscs, tolerant, facultative and intolerant;

```
Distance metric is Euclidean distance
Single linkage method (nearest neighbor)
```

Cluster containing	and	Cluster containing	Were joined at distance	No. of members in new cluster
Case 14		Case 7	4.28513	2
Case 13		Case 10	4.90767	2
Case 3		Case 13	5.65825	3
Case 8		Case 5	7.53306	2
Case 14		Case 6	7.93458	3
Case 14		Case 3	8.20903	6
Case 14		Case 1	8.75215	7
Case 11		Case 2	9.33966	2
Case 8		Case 11	9.76548	4
Case 4		Case 8	10.14856	5
Case 4		Case 14	10.93382	12
Case 4		Case 9	11.91111	13
Case 4		Case 12	20.47763	14

Cluster Tree



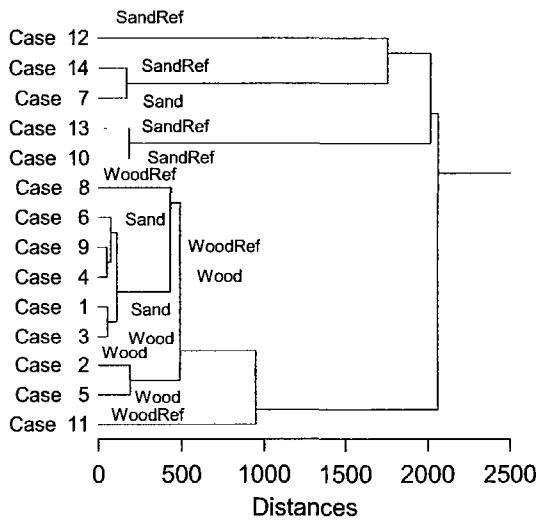
Appendix 7. Cluster Analysis. Sediment Quality Triad Report
Ashland/Northern States Power Lakefront Superfund Site

All Functional Groups

Distance metric is Euclidean distance
Single linkage method (nearest neighbor)

Cluster containing	and	Cluster containing	Were joined at distance	No. of members in new cluster
Case 9		Case 4	51.68380	2
Case 3		Case 1	53.91091	2
Case 6		Case 9	74.34677	3
Case 6		Case 3	109.36580	5
Case 14		Case 7	169.31383	2
Case 13		Case 10	181.40936	2
Case 5		Case 2	189.99751	2
Case 8		Case 6	432.93594	6
Case 8		Case 5	490.45740	8
Case 11		Case 8	949.97723	9
Case 12		Case 14	1753.33594	3
Case 12		Case 13	2010.73804	5
Case 12		Case 11	2057.56250	14

Cluster Tree

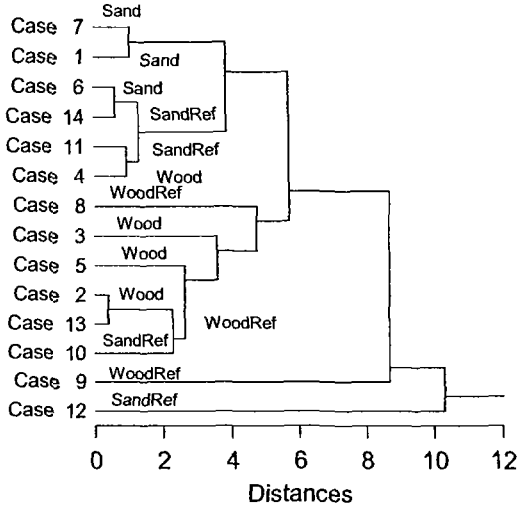


Per cent tolerant, facultative & tolerant

Distance metric is Euclidean distance
Single linkage method (nearest neighbor)

Cluster containing	and	Cluster containing	Were joined at distance	No. of members in new cluster
Case 13		Case 2	0.39209	2
Case 14		Case 6	0.62593	2
Case 11		Case 4	0.95914	2
Case 7		Case 1	1.05838	2
Case 11		Case 14	1.31709	4
Case 10		Case 13	2.28555	3
Case 5		Case 10	2.62991	4
Case 5		Case 3	3.58191	5
Case 11		Case 7	3.86417	6
Case 8		Case 5	4.74456	6
Case 8		Case 11	5.70121	12
Case 9		Case 8	8.67617	13
Case 9		Case 12	10.29951	14

Cluster Tree



Appendix C
Fish Tissue Investigation

FINAL REPORT

FISH TISSUE INVESTIGATION ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

Northern States Power Company - WI
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January 2007

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In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site), fish were collected from the Ashland, WI area and their tissue analyzed for polycyclic aromatic hydrocarbons (PAHs). The results of this analysis were used to support environmental impact studies and ecological and human health risk assessments for the Site.

Fish were collected at four locations, the Site itself and three reference areas near the Site: the NSP powerplant, near Bayview Park, Ashland, and near the AmericInn (Figure 1.1). The fish sampling was conducted during two periods in 2005, as described further below.

Northern States Power-Wisconsin (NSPW) proposed to implement the RI Work Plan developed by SEH (SEH 2003) for collection of fish tissue to support a baseline human health and ecological risk assessment. One of the target species, smelt, had been predetermined and the other two were to be selected from a list commonly consumed by recreational anglers and subsistence fishers.

The original SEH RI Work Plan (SEH 2003) proposed that the two other species would include walleye, lake trout, or round whitefish. Based upon discussions at several meetings with various natural resource trustees, including the Red Cliff and Bad River Bands of Lake Superior Chippewa Indians, it was determined that other species such as yellow perch, northern pike, and smallmouth bass should be added to the list of target species.

As a result the list of target species to meet the objectives of this investigation was:

- Walleye
- Northern pike
- Yellow perch
- Smallmouth bass
- Lake trout
- Round whitefish

Collection efforts for each target species occurred during the normal fishing season for Lake Superior waters for each particular species as described in the current Wisconsin Fishing Regulation

A summary of fish tissue sampling objectives is provided in Table 2.1:

Table 2.1 Summary of fish tissue sampling.

Species	Sampling Location	Sample Type	Number of Samples	Purpose of Data
Smelt	Site	Composite- Whole Body	8	BERA
	Site	Composite- less head and entrails	8	HHRA
	Reference	Composite- Whole Body	8	BERA
	Reference	Composite- less head and entrails	8	HHRA
Higher Trophic Species #1	Site	Individual-Whole Body	8	BERA
		Individual-Fillet	8	HHRA
	Reference	Individual-Whole Body	8	BERA
		Individual-Fillet	8	HHRA
Higher Trophic Species #2	Site	Individual-Whole Body	8	BERA
		Individual-Fillet	8	HHRA
	Reference	Individual-Whole Body	8	BERA
		Individual-Fillet	8	HHRA

2.1 FIELD METHODS

2.1.1 Smelt Sampling

During April 20 and 21, 2005, 572 smelt were collected by electroshocking at the Site and by fyke netting[1] at two reference areas (along the shoreline near Bayview Park and AmericInn, both east of the Site) in accordance with the USEPA-approved RI/FS Workplan and SOP 230.

Eight whole fish composite samples of smelt were collected from the Site and eight whole fish composite samples of smelt were collected at the reference locations. Eight "cleaned" fish[2] composite samples of smelt were collected from the Site and eight "cleaned" fish composite samples of smelt were collected at the reference locations. The number of individual smelt included in a composite sample was based on a minimum aggregate sample of 200 grams; however, the number of fish in each composite was as consistent as possible for each area. An effort was made to collect larger individuals of smelt, but the requirement to have all fish in all composites approximately the same size was the first priority.

The procedures for processing smelt samples are summarized as follows:

1) A number of larger-sized smelt individuals were selected until an aggregate weight of at least 200 grams was obtained.

[1] WDNR prohibited fyke netting at the Site to control the potential release of NAPL from disturbed sediments.
[2] Smelt in these composites were prepared as if for frying, i.e. their heads and entrails removed.

2) The length, weight, sex (if possible), and morphological or histopathological anomalies of selected fish were recorded on a field record form similar to the one provided in USEPA (2000) (Attached to SOP).

3) Smelt selected for the support of the baseline ecological risk assessment (BERA) were composited whole; those processed for the human health risk assessment (HHRA) were deheaded and eviscerated.

4) Sampling conditions, including water depth, time of sampling, general observations of the weather, etc., were noted on the field record form.

5) Composite samples of fish collected at each station were vacuum-packed, placed on dry ice, and sent to STL Laboratories in Burlington, Vermont for analysis of PAH concentrations in their tissues.

Field sampling documentation and field analytical/laboratory documentation was consistent with the approved Field Sampling Plan. Procedures for sample shipping are described in SOP 210.

2.1.2 Collection of Other Fish Species

During the week of June 17 through June 20, 2005 approximately 338 fish were collected by electroshocking at the Site and fyke netting at reference areas in accordance with the USEPA-approved RI/FS Workplan. However, not all fish species on the target species list were collected in sufficient numbers to make a rigorous comparison of PAH levels in fish caught at the Site to those caught at reference locations. Therefore, species of fish with similar numbers and sizes at both the Site and reference area were selected and processed.

A total of 160 fish that were caught were immediately returned alive to the water. The remaining species, i.e. either those on the target species list or those caught in adequate numbers at both the Site and reference locations, were frozen and kept until it could be determined that the sampling objective of having equal numbers from reference locations as from the Site was met. The following four species were selected for analysis:

- Walleye (HHRA);
- Smallmouth bass (BERA);
- Brown bullhead (BERA); and
- Shorthead redhorse (HHRA).

Specimens of brown bullhead and smallmouth bass were processed whole and analyzed for use in the BERA. Walleye were filleted (the skin was removed) and shorthead redhorse were processed as for smoking or pickling, i.e. only the head and entrails were removed; these last two species were analyzed for use in the HHRA. In addition to the samples sent to the laboratory for analysis, 65 rock bass were archived.

As with the smelt collection, information related to sampling conditions specified in SOP 230 was collected including:

- The length, weight, sex (if possible), and morphological or histopathological anomalies of processed specimens; and

- A description of sampling conditions including water depth, time of sampling, general observations of the weather, etc.

Samples of fish collected at each station were vacuum-packed, placed on dry ice, and sent to STL Laboratories in Burlington Vermont for analysis of PAHs and lipids in their tissues.

2.2 ANALYTICAL METHODOLOGY

Fish tissue was analyzed for lipids using a laboratory specific gravimetric method and PAHs analyzed by EPA Method 8270C SIM.

The following sections present the results of fish tissue analyses from the Site and reference areas. Tables 3.1 and 3.2 present the results of analyses conducted for the BERA for the Site and reference areas, respectively. Tables 3.3 and 3.4 present the results of HHRA analyses conducted for the Site and reference areas, respectively.

3.1 SMELT

In all, 572 smelt were collected from the Site area and reference areas. Attachment 1 summarizes the fish in each composite samples including their size, sex and the "ratio of size variation" (defined as the minimum size fish divided by the maximum size fish times 100) for the composite sample.

The results of chemical analysis of smelt tissue is provided in Appendix A where the concentrations of all PAHs are provided individually and by totaling all PAHs in each sample. When a specific PAH compound is reported as not detected in a sample, it was assigned a value of one-half the reporting limit. Figure 2.1 summarizes these results.

Levels of PAHs in smelt caught at the Site were elevated above levels in reference area fish. Levels of PAHs in all smelt caught at reference areas were less than 70 µg/kg and most were less than 50 µg/kg. Smelt caught at the Site were typically greater than 100 µg/kg, with a maximum concentration of 256 µg/kg.

3.2 OTHER SPECIES

Fish processed for the HHRA and BERA are tabulated in Appendix B (Tables B-1 and B-2), which lists individual fish processed and how they were prepared for analysis, i.e. filleted or whole body. Appendix B (Table B-3 through B-6) provides the concentrations of all PAHs in individual fish. When a specific PAH compound is reported as not detected in a sample, it was assigned a value of ½ the reporting limit.

3.2.1 Walleye

Levels of PAHs in walleye caught at the Site were elevated above levels in reference area fish (Figure 3.1). The maximum level of PAHs in a walleye caught in reference areas was less than 32.1 µg/kg and most were less than 30 µg/kg. Levels of PAHs in walleye caught at the Site ranged from 29.6 µg/kg to 511 µg/kg.

Table 3.1. Site Fish Data Summary for the BERA – Total PAHs

Sepcies	Units	Number of Samples	Minimum Concentration	Maximum Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Bullhead	ug/kg	8	56.6	487.4	204.2	Normal	Student's-t	310.2
Bass	ug/kg	7	44.2	150.1	95.8	Normal	Student's-t	130.5
Smelt	ug/kg	8	99.3	159.4	135.7	Non-parametric	Standard bootstrap	150.1
Combined Fish Data	ug/kg	23	44.2	487.4	147.4	Gamma	Standard bootstrap	182.6

Table 3.2. Reference Fish Data Summary for the BERA – Total PAHs

Sepcies	Units	Number of Samples	Minimum Concentration	Maximum Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Bullhead	ug/kg	8	29.2	46.2	38.3	Normal	Student's-t	42.2
Bass	ug/kg	7	42.7	57	51.0	Normal	Student's-t	54.3
Smelt	ug/kg	8	43.5	67.7	55.7	Normal	Student's-t	70.0
Combined Fish Data	ug/kg	23	29.2	67.7	48.2	Normal	Student's-t	51.7

Notes:

1. 95% UCL = 95% Upper Confidence Limit
2. PAHs = Polycyclic Aromatic Hydrocarbons

Table 3.3. Site Fish Data Summary for the HHRA – Total PAHs

Sepcies	Units	Number of Samples	Minimum Concentration	Maximum Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Walleye	ug/kg	8	29.6	511	211.1	Normal	Student's-t	307.6
Shorthead Redhorse	ug/kg	8	37	2603	729.6	Gamma	Standard bootstrap	1205.4
Smelt	ug/kg	8	82.6	255.9	141.5	Normal	Student's-t	178.1
Combined Fish Data	ug/kg	24	29.6	2603	360.7	Log-normal	Standard bootstrap	538.9

Table 3.4. Reference Fish Data Summary for the HHRA – Total PAHs

Sepcies	Units	Number of Samples	Minimum Concentration	Maximum Concentration	Average Concentration	Distribution	95% UCL Method	95% UCL
Walleye	ug/kg	8	26.2	32.1	29.2	Normal	Student's-t	30.6
Shorthead Redhorse	ug/kg	8	26.6	53.6	36.0	Normal	Student's-t	42.3
Smelt	ug/kg	8	34.2	52.5	41.8	Normal	Student's-t	46.0
Combined Fish Data	ug/kg	24	26.2	53.6	35.7	Gamma	Standard bootstrap	38.3

Notes:

1. 95% UCL = 95% Upper Confidence Limit
2. PAHs = Polycyclic Aromatic Hydrocarbons

3.2.2 Shorthead Redhorse

Levels of PAHs in shorthead redhorse caught at the Site were elevated above levels in reference area fish (Figure 4.1). The maximum level of PAHs in a shorthead redhorse caught in reference areas were less than 54 µg/kg and most were less than 40 µg/kg. Levels of PAHs in shorthead redhorse caught at the Site were ranged from 37 to 2473 µg/kg.

3.2.3 Brown Bullhead

Levels of PAHs in brown bullhead caught at the Site were elevated above levels in reference area fish (Figure 5.1). The maximum level of PAHs in a bullhead caught in reference areas was 46.2 µg/kg and most concentrations were less than 40 µg/kg. Levels of PAHs in bullhead caught at the Site ranged from 56.6 µg/kg to 487.4 µg/kg.

3.2.4 Smallmouth Bass

Levels of PAHs in smallmouth bass caught at the Site were elevated above levels in reference area fish (Figure 6.1). The levels of PAHs in smallmouth bass caught in reference areas ranged from 42.7 to 57 µg/kg. Leevls of PAHs in smallmouth bass caught at the Site ranged from 51.4 ug/kg to 160.1 ug/kg.

Based upon these results, all fish species collected in the Site area during this investigation had elevated levels of PAHs in their tissue or possibly associated with their skin. Regardless, this evidence indicates that fish caught at the Site were exposed to and in some manner incorporated PAHs from the Site into their tissue to levels that exceeded background.

The importance to either human health or to ecological receptors of some fish accumulating Site PAHs will be discussed further in the respective risk assessments.

Short, Elliot Henderson Inc (SEH). 2003. Remedial Investigation Work Plan. Ashland/NSP Lakefront Site.

FIGURES

Figure 2.1. PAHs in Smelt Caught in Ashland, Wisconsin.

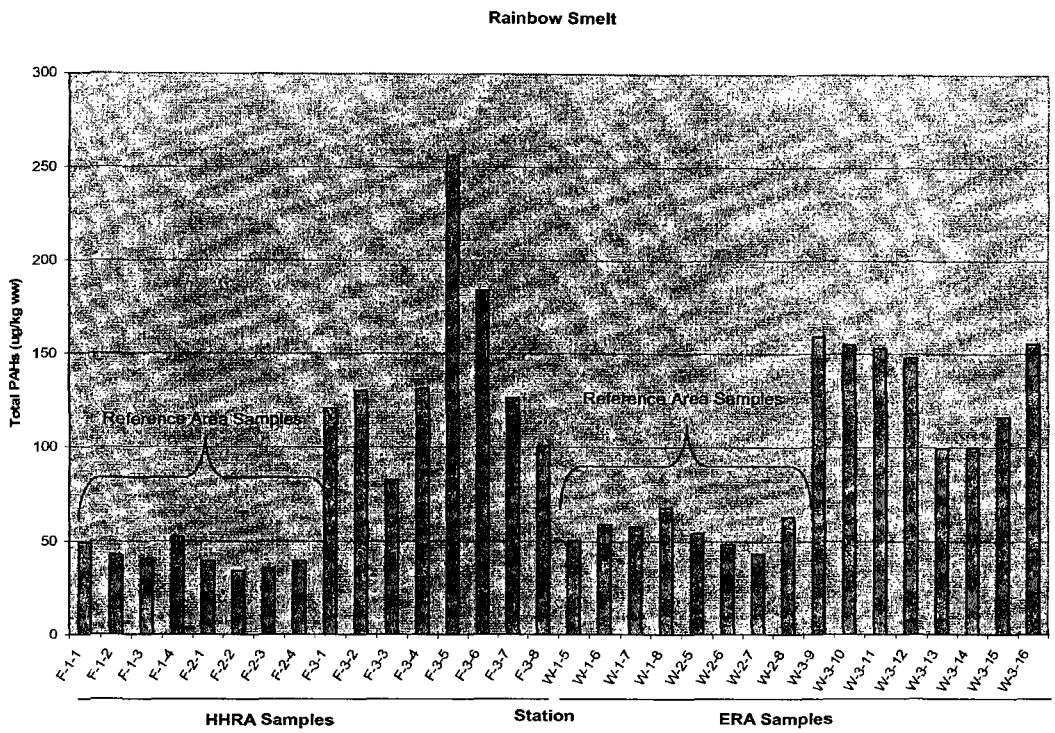


Figure 3.1. PAHs in Walleye Caught in Ashland, Wisconsin.

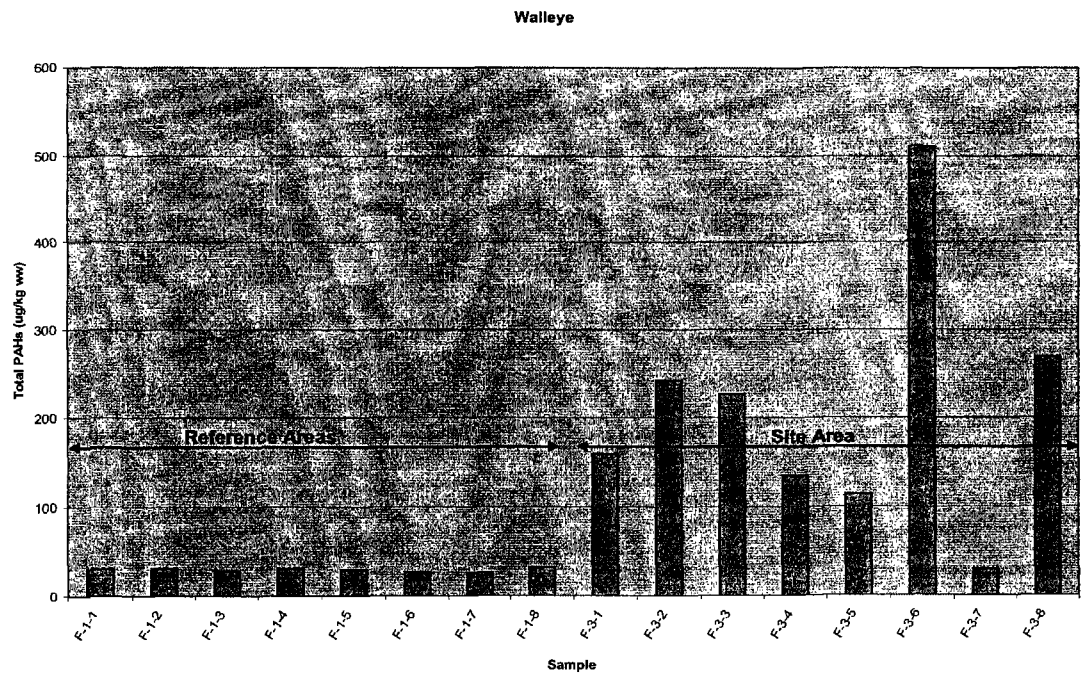


Figure 4.1. PAHs in Shorthead Redhorse Caught in Ashland, Wisconsin.

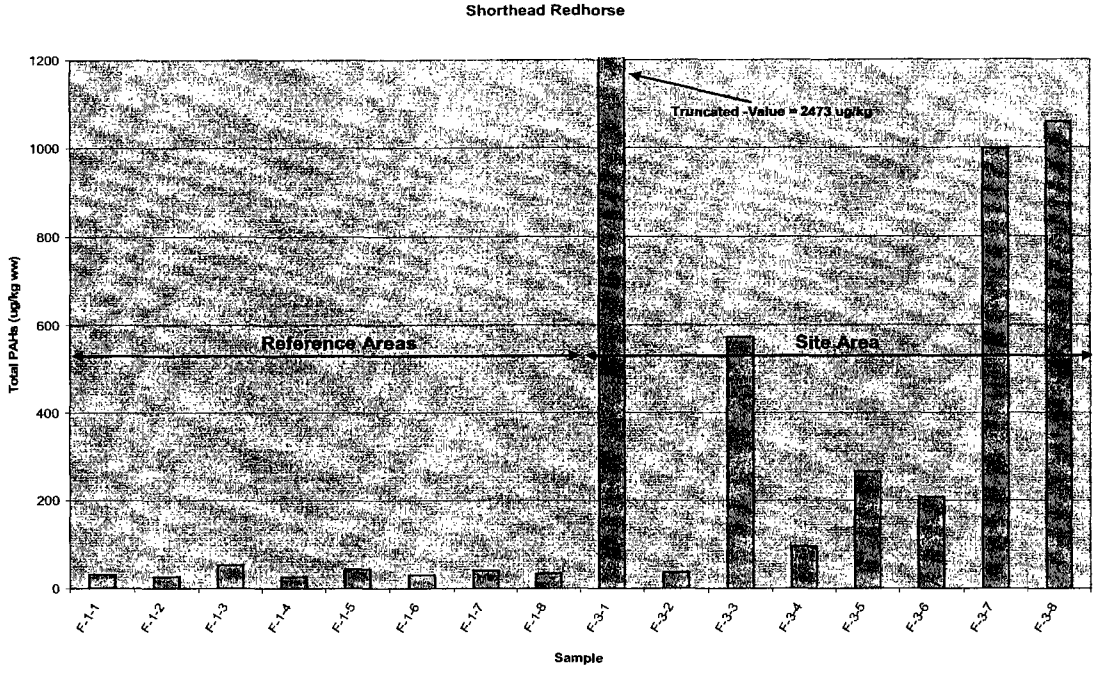


Figure 5.1. PAHs in Brown Bullhead Caught in Ashland, Wisconsin.

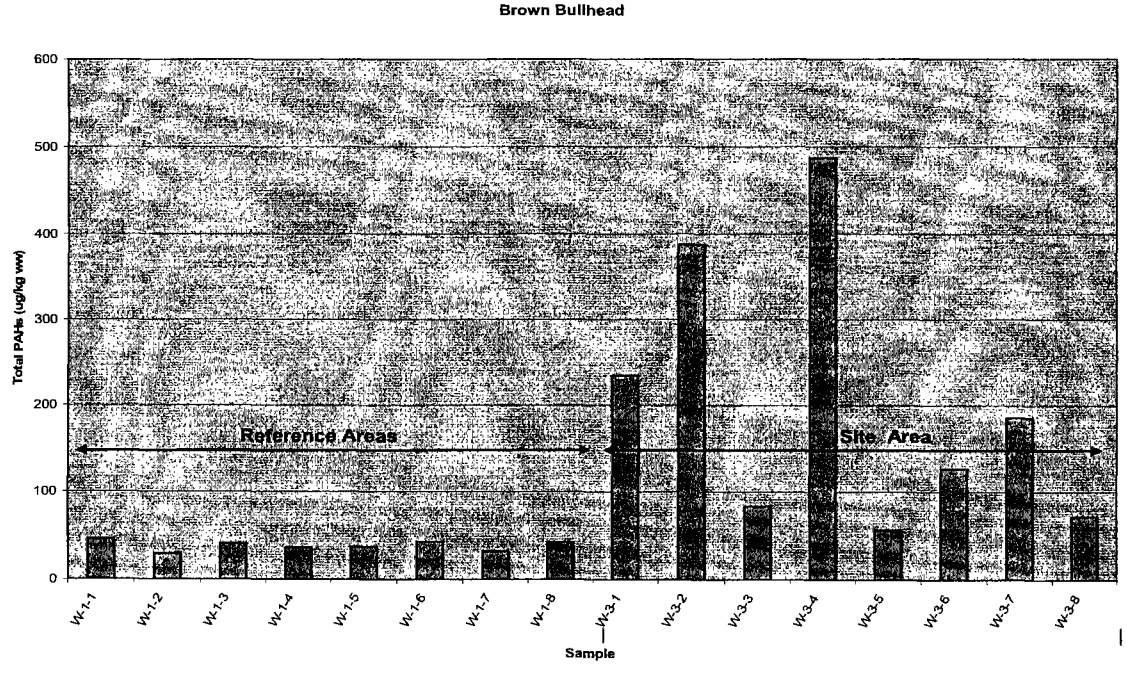
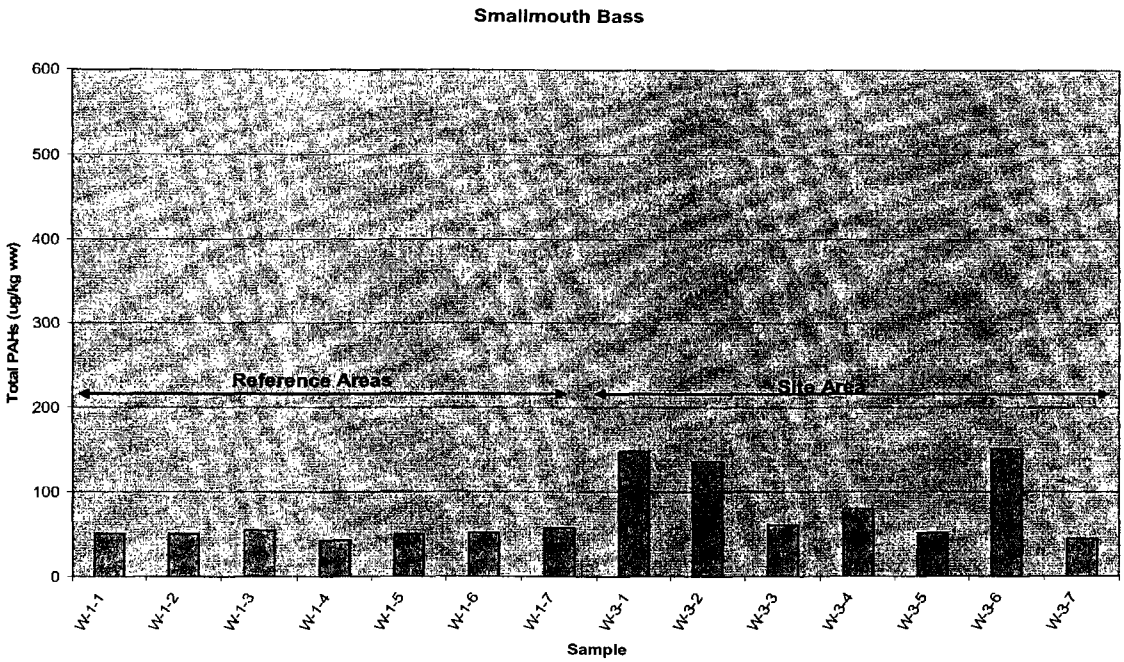


Figure 6.1. PAHs in Smallmouth Bass Caught in Ashland, Wisconsin.



Legend

● Fish Sample Location

0 625 1,250 2,500 3,750 5,000 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE ASHLAND, WISCONSIN		
TITLE: FIGURE 1.1 FISH SAMPLE LOCATIONS		
DRAWN BY: DDZ	SCALE: AS SHOWN	PROJ. NO. 25688375
CHECKED BY: WSB	DATE: 8.APRIL.2008	SHEET: 1 OF 1
APPROVED BY: DPT		

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Appendix A
Smelt Data

APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
Ashland, Wisconsin

Analyte	Lab	units	NS-TA-OMORDAX-F-2-1			NS-TA-OMORDAX-F-2-2			NS-TA-OMORDAX-F-2-3			NS-TA-OMORDAX-F-2-4			NS-TA-OMORDAX-F-2DUP		
		wet wt.	Result	Flag	Risk Result (if ND, the 1/2 RL)	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
2-METHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
1-METHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BIPHENYL	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	3.2		3.2	2.7		2.7	3		3	2.7		2.7	3.6		3.6
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORENE	STL	ug/kg	2.9		2.9	2.5		2.5	2.6		2.6	2.5		2.5	3.3		3.3
PHENANTHRENE	STL	ug/kg	6.9		6.9	5.3		5.3	6		6	8.1		8.1	7.3		7.3
ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	5.4		5.4	3.7		3.7	4		4	5.2		5.2	4.6		4.6
PYRENE	STL	ug/kg	2		2	2	U	1	2	U	1	2.1		2.1	2	U	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					39.4			34.2			35.6			39.6			38.8
LIPIDS	STL	%	2.8		2.8	1.8		1.8	2.2		2.2	2.5		2.5	2.5		2.5

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
J = Estimated concentration; result below reporting limit or quality control criteria were not met.
U = Compound not detected
ND = Not detected

APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
Ashland, Wisconsin

Analyte	Lab	units	NS-TA-OMORDAX-F-2			NS-TA-OMORDAX-W-2-5			NS-TA-OMORDAX-W-2-6			NS-TA-OMORDAX-W-2-7			NS-TA-OMORDAX-W-2-8			NS-TA-OMORDAX-F-1-1		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2.3		2.3	2		2	2.3		2.3	2.7		2.7
2-METHYLNAPHTHALENE	STL	ug/kg	2	U	1	2.2		2.2	2.2		2.2	2	U	1	2.4		2.4	2.4		2.4
1-METHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2.3		2.3	2	U	1	2.2		2.2	2	U	1
BIPHENYL	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	3.8		3.8	5		5	4.3		4.3	3.6		3.6	4.8		4.8	3.3		3.3
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORENE	STL	ug/kg	3.5		3.5	4.8		4.8	3.4		3.4	3.2		3.2	4.6		4.6	2.9		2.9
PHENANTHRENE	STL	ug/kg	9.4		9.4	13		13	9.2		9.2	10		10	18		18	12		12
ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	6.9		6.9	8.7		8.7	6.2		6.2	5.7		5.7	9.7		9.7	6.5		6.5
PYRENE	STL	ug/kg	2.9		2.9	2.7		2.7	2.6		2.6	2	U	1	3		3	2.4		2.4
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					45.5			54.4			48.5			43.5			63.0			49.2
LIPIDS	STL	%	2.3		2.3	4		4	4.2		4.2	3.8		3.8	4.2		4.2	2.2		2.2

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APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
Ashland, Wisconsin

Analyte	Lab	units	NS-TA-OMORDAX-F-1-2			NS-TA-OMORDAX-F-1-3			NS-TA-OMORDAX-F-1-4			NS-TA-OMORDAX-W-1-5			NS-TA-OMORDAX-W-1-6			NS-TA-OMORDAX-W-1-7		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2.2		2.2	2	U	1	2	U	1	2.2		2.2	2.8		2.8	2.9		2.9
2-METHYLNAPHTHALENE	STL	ug/kg	2.1		2.1	2	U	1	2	U	1	2.1		2.1	2.7		2.7	3.2		3.2
1-METHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2.5		2.5	2.9		2.9
BIPHENYL	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	3.6		3.6	3		3	3.8		3.8	3.1		3.1	4.8		4.8	5.4		5.4
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORENE	STL	ug/kg	3		3	2.6		2.6	3.8		3.8	2.9		2.9	4.4		4.4	4.7		4.7
PHENANTHRENE	STL	ug/kg	8.8		8.8	9.7		9.7	15		15	12		12	16		16	14		14
ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	4.9		4.9	5.6		5.6	8.4		8.4	7.7		7.7	7.7		7.7	6.6		6.6
PYRENE	STL	ug/kg	2	U	1	2	U	1	2.5		2.5	3.3		3.3	2.2		2.2	2.3		2.3
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	J	2	2	U	1	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					42.6			40.9			52.5			51.3			59.1			58.0
LIPIDS	STL	%	2.6		2.6	2.0		2.0	2.1		2.1	3.0		3.0	3.5		3.5	3.4		3.4

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APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
Ashland, Wisconsin

Analyte	Lab	units	NS-TA-OMORDAX-W-1-8			NS-TA-OMORDAX-W-1DUP			NS-TA-OMORDAX-W-1			NS-TA-OMORDAX-W-3-9			NS-TA-OMORDAX-W-3-10			NS-TA-OMORDAX-W-3-11		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2.8		2.8	2.5		2.5	2	U	1	26		26	28		28	26		26
2-METHYLNAPHTHALENE	STL	ug/kg	2.9		2.9	4		4	2.3		2.3	25		25	22		22	22		22
1-METHYLNAPHTHALENE	STL	ug/kg	2.5		2.5	3.4		3.4	2	U	1	24		24	23		23	23		23
BIPHENYL	STL	ug/kg	2	U	1	2	U	1	2	U	1	2.6		2.6	2.6		2.6	2.5		2.5
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	8.6		8.6	8.6		8.6	8.3		8.3
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	5.3		5.3	5.1		5.1	4.5		4.5	23		23	23		23	23		23
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2.1		2.1	2.1		2.1	2.1		2.1
FLUORENE	STL	ug/kg	5.3		5.3	5		5	4.2		4.2	8.4		8.4	7.6		7.6	7.7		7.7
PHENANTHRENE	STL	ug/kg	20		20	17		17	13		13	16		16	15		15	15		15
ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2.5		2.5	2.4		2.4	2.3		2.3
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	10		10	8.1		8.1	7.2		7.2	5.5		5.5	5.3		5.3	5.6		5.6
PYRENE	STL	ug/kg	2.9		2.9	2.2		2.2	2.2		2.2	3.7		3.7	3.4		3.4	3.4		3.4
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					67.7			63.3			51.4			159.4			155.0			152.9
LIPIDS	STL	%	4.1		4.1	2.9		2.9	3.3		3.3	2.4		2.4	3.7		3.7	3.7		3.7

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APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
Ashland, Wisconsin

Analyte	Lab	units	NS-TA-OMORDAX-W-3-12			NS-TA-OMORDAX-W-3-13			NS-TA-OMORDAX-W-3-14			NS-TA-OMORDAX-W-3-15			NS-TA-OMORDAX-W-3-16			NS-TA-OMORDAX-W-3DUP		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	27		27	18		18	17		17	21		21	21		21	27		27
2-METHYLNAPHTHALENE	STL	ug/kg	23		23	14		14	15		15	19		19	18		18	25		25
1-METHYLNAPHTHALENE	STL	ug/kg	22		22	14		14	16		16	18		18	17		17	24		24
BIPHENYL	STL	ug/kg	2.4		2.4	2	U	1	2	U	1	2		2	2.1		2.1	2.9		2.9
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	7.7		7.7	5.4		5.4	5.4		5.4	5.9		5.9	7.2		7.2	9		9
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	17		17	14		14	14		14	12		12	18		18	25		25
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2.5		2.5	2	U	1	2	U	1	2.3		2.3	2	U	1	2.3		2.3
FLUORENE	STL	ug/kg	7.8		7.8	5.2		5.2	5.2		5.2	6.3		6.3	6.1		6.1	8.5		8.5
PHENANTHRENE	STL	ug/kg	13		13	8.5		8.5	8.3		8.3	9		9	12		12	15		15
ANTHRACENE	STL	ug/kg	3.3		3.3	2	U	1	2	U	1	2.4		2.4	2.7		2.7	2.6		2.6
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	6.2		6.2	3		3	2.9		2.9	4.2		4.2	11		11	5.7		5.7
PYRENE	STL	ug/kg	3.8		3.8	2.2		2.2	2	U	1	2.2		2.2	9.5		9.5	3.7		3.7
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	4.1		4.1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	5.4		5.4	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	3.8		3.8	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	4		4	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2.6		2.6	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	3.8		3.8	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					147.7			99.3			99.8			116.3			155.3			162.7
LIPIDS	STL	%	3.3		3.3	3.6		3.6	4		4	4.7		4.7	1.7		1.7	2.7		2.7

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APPENDIX A
Omordax PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site,
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Analyte	Lab	units	NS-TA-OMORDAX-W-3			NS-TA-OMORDAX-F-3-1			NS-TA-OMORDAX-F-3-2			NS-TA-OMORDAX-F-3-3			NS-TA-OMORDAX-F-3-4			NS-TA-OMORDAX-F-3-5		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	28		28	15	J	15	22		22	14		14	21		21	15		15
2-METHYLNAPHTHALENE	STL	ug/kg	24		24	21	J	21	19		19	12		12	19		19	12		12
1-METHYLNAPHTHALENE	STL	ug/kg	24		24	21	J	21	19		19	12		12	19		19	12		12
BIPHENYL	STL	ug/kg	2.9		2.9	2.2		2.2	2.1		2.1	2	U	1	2.2		2.2	2	U	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	9.6		9.6	5.2		5.2	7.1		7.1	4		4	6.8		6.8	4.4		4.4
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	22		22	15		15	17		17	9.8		9.8	17		17	10		10
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2.8		2.8	2	U	1	2	U	1	2	U	1	2		2	2	U	1
FLUORENE	STL	ug/kg	9.5		9.5	6.5		6.5	7		7	4.1		4.1	6.9		6.9	4.5		4.5
PHENANTHRENE	STL	ug/kg	19		19	12		12	13		13	7.9		7.9	14		14	15		15
ANTHRACENE	STL	ug/kg	4.3	J	4.3	2.6		2.6	2.7		2.7	2	U	1	2.9		2.9	4.3		4.3
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2		2
FLUORANTHENE	STL	ug/kg	6.4		6.4	4.4		4.4	4.9		4.9	2.8		2.8	4.8		4.8	30		30
PYRENE	STL	ug/kg	4.9		4.9	3.2		3.2	3.4		3.4	2	U	1	3.5		3.5	27		27
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	17		17
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	17		17
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	19		19
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	17		17
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	9.8		9.8
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	15		15
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	4.2		4.2
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	7.6		7.6
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	2.6		2.6
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1	7.5		7.5
Total PAHs					169.4			121.1			130.2			82.6			131.1			255.9
LIPIDS	STL	%	3.3		3.3	2.1		2.1	1.8		1.8	2.4		2.4	NA		NA	1.9		1.9

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Analyte	Lab	units	NS-TA-OMORDAX-F-3-6			NS-TA-OMORDAX-F-3-7			NS-TA-OMORDAX-F-3-8			NS-TA-OMORDAX-F-3DUP			NS-TA-OMORDAX-F-3		
		wet wt.	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	26		26	20		20	14		14	20		20	18	J	18
2-METHYLNAPHTHALENE	STL	ug/kg	24		24	18		18	13		13	18		18	17	J	17
1-METHYLNAPHTHALENE	STL	ug/kg	32		32	19		19	12		12	19		19	15	J	15
BIPHENYL	STL	ug/kg	3.2		3.2	2.2		2.2	2	U	1	2.1		2.1	2	U	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	11		11	6.7		6.7	4.4		4.4	5.9		5.9	5.3		5.3
ACENAPHTHYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
ACENAPHTHENE	STL	ug/kg	28		28	16		16	9.7		9.7	15		15	12		12
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	3		3	2.2		2.2	2	U	1	2	U	1	2	U	1
FLUORENE	STL	ug/kg	10		10	6.6		6.6	4		4	6.3		6.3	5.7		5.7
PHENANTHRENE	STL	ug/kg	18		18	13		13	9.1		9.1	13		13	11		11
ANTHRACENE	STL	ug/kg	5.1		5.1	3		3	2.1		2.1	3.1		3.1	2.4	J	2.4
1-METHYLPHENANTHRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
FLUORANTHENE	STL	ug/kg	6.4		6.4	4.4		4.4	5.5		5.5	4.7		4.7	4.7		4.7
PYRENE	STL	ug/kg	5.4		5.4	3.2		3.2	4.4		4.4	3.2		3.2	2.5		2.5
BENZO(A)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2.1		2.1	2	U	1	2	U	1
CHRYSENE	STL	ug/kg	2	U	1	2	U	1	2.6		2.6	2	U	1	2	U	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	3.4		3.4	2	U	1	2	U	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	U	1	2	U	1	2.7		2.7	2	U	1	2	U	1
BENZO(E)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(A)PYRENE	STL	ug/kg	2	U	1	2	U	1	2.4		2.4	2	U	1	2	U	1
PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	U	1	2	U	1	2	U	1	2	U	1	2	U	1
Total PAHs					184.1			126.3			100.4			123.3			107.6
LIPIDS	STL	%	2.2		2.2	2		2	1.5		1.5	1.7		1.7	1.3		1.3

STL = Severn Trent Laboratories, Inc. Colchester, Vermor
ug/kg = micrograms per kilogram, wet weight
J = Estimated concentration; result below reporting limit or
U = Compound not detected
ND = Not detected

Appendix B
Tissue Analysis for Walleye, Shorthead Redhorse, Brown Bullhead and Smallmouth Bass

Appendix B -Table B-1. Fish Processed to Support the Human Health Risk Assessment.
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Human Health Risk Assessment

Species	Sample Area	Sample Name	Sample Number	Sample Preparation	Notes
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-1**	**F-3-1**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-2**	**F-3-2**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-3**	**F-3-3**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-4**	**F-3-4**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-5**	**F-3-5**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-F-3-6**	**F-3-6**	Filleted	
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-W-3-3**	**F-3-7**	Filleted	Rec'd whole and filleted in the lab
Walleye (*Stizostedion vitreum*)	Site	**NS-TA-Svitreum-W-3-4**	**F-3-8**	Filleted	Rec'd whole and filleted in the lab
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-1**	**F-1-1**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-2**	**F-1-2**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-3**	**F-1-3**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-4**	**F-1-4**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-5**	**F-1-5**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-F-1-6**	**F-1-6**	Filleted	
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-W-1-2**	**F-1-7**	Filleted	Rec'd whole and filleted in the lab
Walleye (*Stizostedion vitreum*)	Reference Areas	**NS-TA-Svitreum-W-1-4**	**F-1-8**	Filleted	Rec'd whole and filleted in the lab
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-1**	**F-3-1**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-2**	**F-3-2**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-3**	**F-3-3**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-4**	**F-3-4**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-5**	**F-3-5**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-6**	**F-3-6**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-7**	**F-3-7**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Site	**NS-TA-Mmacrolepidotum-F-3-8**	**F-3-8**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-1**	**F-1-1**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-2**	**F-1-2**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-3**	**F-1-3**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-4**	**F-1-4**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-5**	**F-1-5**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-6**	**F-1-6**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-7**	**F-1-7**	Heads and Entrails Removed	
Shorthead Redhorse (*Moxostoma macrolepitdotum*)	Reference Areas	**NS-TA-Mmacrolepidotum-F-1-8**	**F-1-8**	Heads and Entrails Removed	

Appendix B -Table B-2. Fish Processed to Support the Baseline Ecological Risk Assessment.
Ashland/Northern States Power Lakefront Superfund SIte
Ashland, WI

Ecological Risk Assessment

Species	Sample Area	**Sample Name**	**Sample Number**	Sample Preparation	Notes
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-1**	**W-3-1**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-2**	**W-3-2**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-3**	**W-3-3**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-4**	**W-3-4**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-5**	**W-3-5**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-6**	**W-3-6**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Site	**NS-TA-Mdolomieui-W-3-7**	**W-3-7**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-1**	**W-1-1**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-2**	**W-1-2**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-3**	**W-1-3**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-4**	**W-1-4**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-5**	**W-1-5**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-6**	**W-1-6**	Whole Body	Rinse with DI Water
Smallmouth Bass (*Micropterus dolomieui*)	Reference Areas	**NS-TA-Mdolomieui-W-1-7**	**W-1-7**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-1**	**W-3-1**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-2**	**W-3-2**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-3**	**W-3-3**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-4**	**W-3-4**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-5**	**W-3-5**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-6**	**W-3-6**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-7**	**W-3-7**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Site	**NS-TA-Anebulosus-W-3-8**	**W-3-8**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-1**	**W-1-1**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-2**	**W-1-2**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-3**	**W-1-3**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-4**	**W-1-4**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-5**	**W-1-5**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-6**	**W-1-6**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-7**	**W-1-7**	Whole Body	Rinse with DI Water
Brown Bullhead (*Ameiurus nebulosus*)	Reference Areas	**NS-TA-Anebulosus-W-1-8**	**W-1-8**	Whole Body	Rinse with DI Water

Table B-3.
Walleye PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	SVITREUM-F-1-1			SVITREUM-F-1-DUP1			SVITREUM-F-1-2			SVITREUM-F-1-3		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	3	J	3	2.9	J	2.9	3.2	J	3.2	2.5	J	2.5
2-METHYLNAPHTHALENE	STL	ug/kg	3.7	J	3.7	4.3	J	4.3	3.9	J	3.9	3	J	3
1-METHYLNAPHTHALENE	STL	ug/kg	2.4	J	2.4	2.9	J	2.9	2.6	J	2.6	2	UJ	1
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			30.1			31.1			30.7			27.5
LIPIDS	STL	%	2		2	2.3		2.3	2		2	1.5		1.5

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

Table B-3.
Walleye PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	SVITREUM-F-1-4			SVITREUM-F-1-5			SVITREUM-F-1-6			SVITREUM-W-1-2 (=F-1-7)			SVITREUM-W-1-4 (=F-1-8)		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2.1	J	2.1	2.6	J	2.6	2.1	J	2.1	2	J	2	3	J	3
2-METHYLNAPHTHALENE	STL	ug/kg	2.3	J	2.3	3.5	J	3.5	2.9	J	2.9	2.2	J	2.2	4.3	J	4.3
1-METHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2.2	J	2.2	2	UJ	1	2	UJ	1	2.6	J	2.6
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	2.5	J	2.5	2	UJ	1	2	UJ	1	2	UJ	1	2.2	J	2.2
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2.3	J	2.3	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PYRENE	STL	ug/kg	2.6	J	2.6	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			30.8			29.3			27.0			26.2			32.1
LIPIDS	STL	%	1.3		1.3	1.9		1.9	1.4		1.4	1		1	2.5		2.5

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

Table B-3.
Walleye PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	SVITREUM-F-3-1			SVITREUM-F-3-2			SVITREUM-F-3-3			SVITREUM-F-3-4		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	22	J	22	53	J	53	51	J	51	19	J	19
2-METHYLNAPHTHALENE	STL	ug/kg	17	J	17	30	J	30	28	J	28	15	J	15
1-METHYLNAPHTHALENE	STL	ug/kg	31	J	31	49	J	49	47	J	47	27	J	27
BIPHENYL	STL	ug/kg	3.3	J	3.3	4.6	J	4.6	4.7	J	4.7	2.8	J	2.8
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	12	J	12	14	J	14	13	J	13	8.4	J	8.4
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	30	J	30	37	J	37	35	J	35	25	J	25
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2.5	J	2.5	3.1	J	3.1	2.4	J	2.4	2	UJ	1
FLUORENE	STL	ug/kg	11	J	11	13	J	13	12	J	12	8.3	J	8.3
PHENANTHRENE	STL	ug/kg	11	J	11	14	J	14	13	J	13	8.5	J	8.5
ANTHRACENE	STL	ug/kg	2.6	J	2.6	3.6	J	3.6	3.1	J	3.1	2	J	2
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	3.2	J	3.2	5.3	J	5.3	3.3	J	3.3	3.1	J	3.1
PYRENE	STL	ug/kg	2.2	J	2.2	3.8	J	3.8	2.6	J	2.6	2.9	J	2.9
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			159.8			242.4			227.1			135.0
LIPIDS	STL	%	0.9		0.9	2.5		2.5	1.6		1.6	1.3		1.3

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

Table B-3.
Walleye PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	SVITREUM-F-3-5			SVITREUM-F-3-6			SVITREUM-W-3-3 (=F-3-7)			SVITREUM-W-3-4 (=F-3-8)		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	22	J	22	74	J	74	2.9	J	2.9	54	J	54
2-METHYLNAPHTHALENE	STL	ug/kg	14	J	14	61	J	61	2	J	2	31	J	31
1-METHYLNAPHTHALENE	STL	ug/kg	17	J	17	110	J	110	3.1	J	3.1	61	J	61
BIPHENYL	STL	ug/kg	2.1	J	2.1	11	J	11	2	UJ	1	5.6	J	5.6
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	5.8	J	5.8	44	J	44	2	UJ	1	17	J	17
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	3.1	J	3.1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	16	J	16	100	J	100	2.6	J	2.6	47	J	47
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	8	J	8	2	UJ	1	3.1	J	3.1
FLUORENE	STL	ug/kg	6.6	J	6.6	35	J	35	2	UJ	1	15	J	15
PHENANTHRENE	STL	ug/kg	8.7	J	8.7	31	J	31	2	UJ	1	14	J	14
ANTHRACENE	STL	ug/kg	2	J	2	7.9	J	7.9	2	UJ	1	3.1	J	3.1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	3.7	J	3.7	8.1	J	8.1	2	UJ	1	3.3	J	3.3
PYRENE	STL	ug/kg	3.6	J	3.6	6.9	J	6.9	2	UJ	1	3.1	J	3.1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			114.5			511.0			29.6			269.2
LIPIDS	STL	%	2.7		2.7	2.5		2.5	1		1	1.8		1.8

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-1-1			MMACROLEPIDOTUMF11DUP			MMACROLEPIDOTUM-F-1-2		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2.1	J	2.1	2.2	J	2.2	2.2	J	2.2
2-METHYLNAPHTHALENE	STL	ug/kg	5.3	J	5.3	5.5	J	5.5	2.4	J	2.4
1-METHYLNAPHTHALENE	STL	ug/kg	2.9	J	2.9	3.2	J	3.2	2	UJ	1
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			31.3			31.9			26.6
LIPIDS	STL	%	2.6		2.6			2.6			1.6

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-1-3			MMACROLEPIDOTUM-F-1-4			MMACROLEPIDOTUM-F-1-5		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	4.2	J	4.2	2.4	J	2.4	3.1	J	3.1
2-METHYLNAPHTHALENE	STL	ug/kg	9.8	J	9.8	2	UJ	1	7.1	J	7.1
1-METHYLNAPHTHALENE	STL	ug/kg	6.5	J	6.5	2	UJ	1	4.5	J	4.5
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	4.8	J	4.8	2	UJ	1	3.2	J	3.2
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	4.3	J	4.3	2	UJ	1	2.4	J	2.4
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2.2	J	2.2	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	4.8	J	4.8	2.2	J	2.2	4.3	J	4.3
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2.5	J	2.5
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			53.6			26.6			44.1
LIPIDS	STL	%			3.4	3.8		3.8	3.9		3.9

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-1-6			MMACROLEPIDOTUM-F-1-7			MMACROLEPIDOTUM-F-1-8		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	3	J	3	4.2	J	4.2	3.6	J	3.6
2-METHYLNAPHTHALENE	STL	ug/kg	4.1	J	4.1	7.4	J	7.4	4.9	J	4.9
1-METHYLNAPHTHALENE	STL	ug/kg	3	J	3	4.8	J	4.8	3.3	J	3.3
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2.8	J	2.8	2.1	J	2.1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	2	UJ	1	2.5	J	2.5	2	UJ	1
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			31.1			40.7			33.9
LIPIDS	STL	%	2.4		2.4	3.1		3.1	2.7		2.7

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the *reporting limit*. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-3-1			MMACROLEPIDOTUMF31DUP			MMACROLEPIDOTUM-F-3-2		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	330	J	330	300	J	300	3.1	J	3.1
2-METHYLNAPHTHALENE	STL	ug/kg	230	J	230	190	J	190	3.9	J	3.9
1-METHYLNAPHTHALENE	STL	ug/kg	620	J	620	510	J	510	3.3	J	3.3
BIPHENYL	STL	ug/kg	49	J	49	37	J	37	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	230	J	230	220	J	220	2.1	J	2.1
ACENAPHTHYLENE	STL	ug/kg	19	J	19	17	J	17	2	UJ	1
ACENAPHTHENE	STL	ug/kg	580	J	580	510	J	510	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	51	J	51	47	J	47	2	UJ	1
FLUORENE	STL	ug/kg	170	J	170	170	J	170	2	UJ	1
PHENANTHRENE	STL	ug/kg	240	J	240	270	J	270	5.6	J	5.6
ANTHRACENE	STL	ug/kg	43	J	43	39	J	39	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	4.3	J	4.3	3.7	J	3.7	2	UJ	1
FLUORANTHENE	STL	ug/kg	17	J	17	15	J	15	2	UJ	1
PYRENE	STL	ug/kg	9.7	J	9.7	9	J	9	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			2603.0			2347.7			37.0
LIPIDS	STL	%	4.2		4.2	3.1		3.1	5.7		5.7

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-3-3			MMACROLEPIDOTUM-F-3-4			MMACROLEPIDOTUM-F-3-5		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	71	J	71	13	J	13	33	J	33
2-METHYLNAPHTHALENE	STL	ug/kg	51	J	51	11	J	11	30	J	30
1-METHYLNAPHTHALENE	STL	ug/kg	120	J	120	15	J	15	52	J	52
BIPHENYL	STL	ug/kg	9.1	J	9.1	2	UJ	1	4.9	J	4.9
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	40	J	40	4.4	J	4.4	18	J	18
ACENAPHTHYLENE	STL	ug/kg	4.6	J	4.6	2	UJ	1	3.7	J	3.7
ACENAPHTHENE	STL	ug/kg	110	J	110	11	J	11	50	J	50
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	11	J	11	2.5	J	2.5	4.1	J	4.1
FLUORENE	STL	ug/kg	34	J	34	3.7	J	3.7	17	J	17
PHENANTHRENE	STL	ug/kg	75	J	75	13	J	13	28	J	28
ANTHRACENE	STL	ug/kg	19	J	19	2.9	J	2.9	7.2	J	7.2
1-METHYLPHENANTHRENE	STL	ug/kg	2.8	J	2.8	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	9.2	J	9.2	3.8	J	3.8	3.8	J	3.8
PYRENE	STL	ug/kg	6.3	J	6.3	2.6	J	2.6	2.5	J	2.5
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			573.0			95.9			265.2
LIPIDS	STL	%	2.6		2.6	1.6		1.6	1.4		1.4

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is *approximate*.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-4. Shorthead Redhorse PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MMACROLEPIDOTUM-F-3-6			MMACROLEPIDOTUM-F-3-7			MMACROLEPIDOTUM-F-3-8		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	30	J	30	180	J	180	210	J	210
2-METHYLNAPHTHALENE	STL	ug/kg	22	J	22	89	J	89	91	J	91
1-METHYLNAPHTHALENE	STL	ug/kg	25	J	25	270	J	270	290	J	290
BIPHENYL	STL	ug/kg	2.1	J	2.1	21	J	21	22	J	22
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	10	J	10	62	J	62	66	J	66
ACENAPHTHYLENE	STL	ug/kg	2.2	J	2.2	7.7	J	7.7	7.5	J	7.5
ACENAPHTHENE	STL	ug/kg	22	J	22	170	J	170	200	J	200
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	7.3	J	7.3	9.7	J	9.7	10	J	10
FLUORENE	STL	ug/kg	9.9	J	9.9	52	J	52	54	J	54
PHENANTHRENE	STL	ug/kg	37	J	37	98	J	98	63	J	63
ANTHRACENE	STL	ug/kg	7.7	J	7.7	16	J	16	20	J	20
1-METHYLPHENANTHRENE	STL	ug/kg	3	J	3	2	UJ	1	2.8	J	2.8
FLUORANTHENE	STL	ug/kg	12	J	12	7	J	7	7.5	J	7.5
PYRENE	STL	ug/kg	6.8	J	6.8	4.5	J	4.5	5.2	J	5.2
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1		R	0
Total PAHs		ug/kg			207.0			997.9			1058.0
LIPIDS	STL	%	3.6		3.6	1.9		1.9	1.0		1.0

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined

Table B-5.
Bullhead PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	ANEBULOSUS-W-1-1			ANEBULOSIS-W-1-DUP1			ANEBULOSIS-W-1-2			ANEBULOSIS-W-1-3			ANEBULOSIS-W-1-4		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	2	UJ	1	2.1	J	2.1	2	UJ	1	3	J	3	2.2	J	2.2
2-METHYLNAPHTHALENE	STL	ug/kg	3.2	J	3.2	3.6	J	3.6	2	UJ	1	2.5	J	2.5	3.1	J	3.1
1-METHYLNAPHTHALENE	STL	ug/kg	2.4	J	2.4	2.8	J	2.8	2	UJ	1	2	UJ	1	2.3	J	2.3
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2.2	J	2.2	2.6	J	2.6	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	3	J	3	3.2	J	3.2	2	UJ	1	2	UJ	1	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORENE	STL	ug/kg	2.3	J	2.3	2.6	J	2.6	2	UJ	1	2	UJ	1	2	UJ	1
PHENANTHRENE	STL	ug/kg	7.3	J	7.3	7.4	J	7.4	4.1	J	4.1	7.3	J	7.3	5.8	J	5.8
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	6.5	J	6.5	6.6	J	6.6	3.1	J	3.1	6	J	6	3.7	J	3.7
PYRENE	STL	ug/kg	3.3	J	3.3	3.1	J	3.1	2	UJ	1	2.6	J	2.6	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			46.2			49.0			29.2			40.4			36.1
LIPIDS	STL	%	3		3	2.1		2.1	0.9		0.9	1.2		1.2	2		2

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined
ND = Not detected

Table B-5.
Bullhead PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	ANEBULOSIS-W-1-5			ANEBULOSIS-W-1-6			ANEBULOSIS-W-1-7			ANEBULOSIS-W-1-8			ANEBULOSIS-W-3-1			ANEBULOSIS-W-3-DUP1			ANEBULO	
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag
NAPHTHALENE	STL	ug/kg	3.3	J	3.3	2.8	J	2.8	2	UJ	1	2.6	J	2.6	35	J	35	34	J	34	46	J
2-METHYLNAPHTHALENE	STL	ug/kg	3.3	J	3.3	3.4	J	3.4	2	UJ	1	3.3	J	3.3	16	J	16	17	J	17	21	J
1-METHYLNAPHTHALENE	STL	ug/kg	2.7	J	2.7	2.6	J	2.6	2	UJ	1	2.6	J	2.6	51	J	51	58	J	58	81	J
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	4.2	J	4.2	5.1	J	5.1	6.4	J
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2.3	J	2.3	2	UJ	1	2.5	J	2.5	17	J	17	13	J	13	30	J
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	J	2	2	UJ	1	2	UJ	1	4	J
ACENAPHTHENE	STL	ug/kg	2.1	J	2.1	2	J	2	2	UJ	1	2	UJ	2	43	J	43	40	J	40	77	J
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2.1	J	2.1	2	UJ	1	3	J	3	3.4	J	3.4	3.6	J	3.6	6.9	J
FLUORENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	14	J	14	17	J	17	25	J
PHENANTHRENE	STL	ug/kg	4.8	J	4.8	6.3	J	6.3	3.2	J	3.2	5.7	J	5.7	21	J	21	22	J	22	43	J
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	4.6	J	4.6	4.8	J	4.8	9.9	J
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	3.4	J
FLUORANTHENE	STL	ug/kg	3	J	3	4.5	J	4.5	5.2	J	5.2	3.6	J	3.6	7.8	J	7.8	8.5	J	8.5	13	J
PYRENE	STL	ug/kg	2	UJ	1	2	J	2	2.6	J	2.6	2	UJ	1	5.8	J	5.8	6	J	6	11	J
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ
Total PAHs		ug/kg			37.2			43.0			32.0			42.3			234.8			241.0		
LIPIDS	STL	%	2.6		2.6	1.6		1.6	1.4		1.4	1.6		1.6	3		3	3.1		3.1	2.5	

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined
ND = Not detected

Table B-5.
Bullhead PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	SIS-W-3-2	ANEBULOSIS-W-3-3			ANEBULOSIS-W-3-4			ANEBULOSIS-W-3-5			ANEBULOSIS-W-3-6			ANEBULOSIS-W-3-7			ANEBULOSIS-W-3-8		
			Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	46	8.4	J	8.4	53	J	53	6	J	6	12	J	12	17	J	17	9.7	J	9.7
2-METHYLNAPHTHALENE	STL	ug/kg	21	6.9	J	6.9	33	J	33	4.3	J	4.3	5.8	J	5.8	8	J	8	4.8	J	4.8
1-METHYLNAPHTHALENE	STL	ug/kg	81	15	J	15	100	J	100	7.6	J	7.6	12	J	12	26	J	26	13	J	13
BIPHENYL	STL	ug/kg	6.4	2	UJ	1	7.7	J	7.7	2	UJ	1	2	UJ	1	2.7	J	2.7	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	30	6.3	J	6.3	43	J	43	3.1	J	3.1	6.9	J	6.9	11	J	13	5.5	J	5.5
ACENAPHTHYLENE	STL	ug/kg	4	2	UJ	1	13	J	13	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	77	14	J	14	100	J	100	6.4	J	6.4	13	J	13	24	J	24	9.9	J	9.9
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	6.9	2.8	J	2.8	13	J	13	2	J	2	2.8	J	2.8	3.4	J	3.4	2	UJ	1
FLUORENE	STL	ug/kg	25	4.5	J	4.5	29	J	29	2.4	J	2.4	6	J	6	12	J	12	4	J	4
PHENANTHRENE	STL	ug/kg	43	7.5	J	7.5	41	J	41	5.4	J	5.4	11	J	11	36	J	36	6.8	J	6.8
ANTHRACENE	STL	ug/kg	9.9	2	UJ	1	13	J	13	2	UJ	1	2.1	J	2.1	4.7	J	4.7	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	3.4	2	UJ	1	4.1	J	4.1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	13	2.5	J	2.5	9.8	J	9.8	3.4	J	3.4	7.3	J	7.3	17	J	17	2.2	J	2.2
PYRENE	STL	ug/kg	11	2	UJ	1	9.6	J	9.8	2	J	2	33	J	33	10	J	10	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	1	2	UJ	1	2.2	J	2.2	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	1	2	UJ	1	3.3	J	3.3	2	UJ	1	2.9	J	2.9	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	1	2	UJ	1	2.2	J	2.2	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	1	2	UJ	1	4.3	J	4.3	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg	387.6			82.9			487.4			56.6			126.8			185.8			71.9
LIPIDS	STL	%	2.5	2.1		2.1	2.4		2.4	2.1		2.1	1.4		1.4	1.4		1.4	1.1		1.1

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight
U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met,
UJ = Not detected at or above the reporting limit. Reporting limit is approximate.
R = Result rejected. Presence or absence of compound cannot be determined
ND = Not detected

Table B-6. Smallmouth Bass PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MDOLOMIEUI-W-1-1			MDOLOMIEUI-W-1-2			MDOLOMIEUI-W-1-3			MDOLOMIEUI-W-1-4		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	5	J	5	5.8	J	5.8	5.9	J	5.9	6.4	J	6.4
2-METHYLNAPHTHALENE	STL	ug/kg	5	J	5	5.4	J	5.4	6.4	J	6.4	5.7	J	5.7
1-METHYLNAPHTHALENE	STL	ug/kg	3.4	J	3.4	3.7	J	3.7	4.4	J	4.4	3.4	J	3.4
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	3	J	3	2.6	J	2.6	3.3	J	3.3	2	UJ	1
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2.9	J	2.9	3	J	3	3.7	J	3.7	2	UJ	1
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2.3	J	2.3	2.3	J	2.3	2.3	J	2.3	2.1	J	2.1
FLUORENE	STL	ug/kg	2.9	J	2.9	2.7	J	2.7	3.1	J	3.1	2	UJ	1
PHENANTHRENE	STL	ug/kg	8.8	J	8.8	7.7	J	7.7	8.1	J	8.1	6.1	J	6.1
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2.4	J	2.4	2.1	J	2.1	2.2	J	2.2	2	UJ	1
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			50.7			50.3			54.4			42.7
LIPIDS	STL	%	NA		NA	3.4		3.4	3.8		3.8	1.3		1.3

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight

U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.

UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

R = Result rejected. Presence or absence of compound cannot be determined

ND = Not detected

Table B-6. Smallmouth Bass PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MDOLOMIEUI-W-1-5			MDOLOMIEUI-W-1-6			MDOLOMIEUI-W-1-7			MDOLOMIEUI-W-3-1			MDOLOMIEUI-W-3-DUP1			MDOLOMIEUI-W-3-2		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	6.9	J	6.9	6.4	J	6.4	6.9	J	6.9	11	J	11	11	J	11	11	J	11
2-METHYLNAPHTHALENE	STL	ug/kg	6.1	J	6.1	6.1	J	6.1	6.1	J	6.1	13	J	13	13	J	13	11	J	11
1-METHYLNAPHTHALENE	STL	ug/kg	3.9	J	3.9	3.9	J	3.9	3.9	J	3.9	25	J	25	24	J	24	24	J	24
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2.4	J	2.4	2.4	J	2.4	2.1	J	2.1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	3.1	J	3.1	3	J	3	2.9	J	2.9	16	J	16	16	J	16	14	J	14
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	2.8	J	2.8	3.2	J	3.2	3.8	J	3.8	31	J	31	31	J	31	30	J	30
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2.8	J	2.8	2.8	J	2.8	2.4	J	2.4	4.4	J	4.4	4.6	J	4.6	4	J	4
FLUORENE	STL	ug/kg	2.5	J	2.5	3.1	J	3.1	3.5	J	3.5	12	J	12	12	J	12	11	J	11
PHENANTHRENE	STL	ug/kg	6.3	J	6.3	7	J	7	9.7	J	9.7	15	J	15	15	J	15	12	J	12
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2.5	J	2.5	2.5	J	2.5	2.1	J	2.1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2.8	J	2.8	2.3	J	2.3	2.2	J	2.2	2.1	J	2.1
PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			50.4			51.5			57.0			147.6			146.7			136.3
LIPIDS	STL	%	2.0		2.0	3.1		3.1	2.5		2.5	3.1		3.1	3.1		3.1	2.9		2.9

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight

U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.

UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

R = Result rejected. Presence or absence of compound cannot be determined

ND = Not detected

Table B-6. Smallmouth Bass PAH Tissue Data - Wet Weight
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Lab	units	MDOLOMIEUI-W-3-3			MDOLOMIEUI-W-3-4			MDOLOMIEUI-W-3-5			MDOLOMIEUI-W-3-6			MDOLOMIEUI-W-3-7		
			Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result	Result	Flag	Risk Result
NAPHTHALENE	STL	ug/kg	6.9	J	6.9	8.4	J	8.4	4.8	J	4.8	21	J	21	2.4	J	2.4
2-METHYLNAPHTHALENE	STL	ug/kg	6	J	6	7.8	J	7.8	5	J	5	12	J	12	5.1	J	5.1
1-METHYLNAPHTHALENE	STL	ug/kg	8.5	J	8.5	8.1	J	8.1	6.1	J	6.1	33	J	33	3.5	J	3.5
BIPHENYL	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2.2	J	2.2	2	UJ	1
2,6 DIMETHYLNAPHTHALENE	STL	ug/kg	4.6	J	4.6	4.2	J	4.2	2.9	J	2.9	11	J	11	3.2	J	3.2
ACENAPHTHYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
ACENAPHTHENE	STL	ug/kg	9.1	J	9.1	8.5	J	8.5	6.5	J	6.5	27	J	27	3.2	J	3.2
2,3,5 TRIMETHYLNAPHTHALENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	3.2	J	3.2	2	UJ	1
FLUORENE	STL	ug/kg	3.2	J	3.2	3.4	J	3.4	2.3	J	2.3	8.7	J	8.7	2.2	J	2.2
PHENANTHRENE	STL	ug/kg	5.7	J	5.7	8.1	J	8.1	5.6	J	5.6	14	J	14	6.2	J	6.2
ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2.7	J	2.7	2	UJ	1
1-METHYLPHENANTHRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
FLUORANTHENE	STL	ug/kg	2	UJ	1	6.3	J	6.3	2.2	J	2.2	2.3	J	2.3	2.4	J	2.4
PYRENE	STL	ug/kg	2	UJ	1	4.2	J	4.2	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)ANTHRACENE	STL	ug/kg	2	UJ	1	2.6	J	2.6	2	UJ	1	2	UJ	1	2	UJ	1
CHRYSENE	STL	ug/kg	2	UJ	1	3	J	3	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(B)FLUORANTHENE	STL	ug/kg	2	UJ	1	2.5	J	2.5	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(K)FLUORANTHENE	STL	ug/kg	2	UJ	1	2	J	2	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(E)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(A)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
INDENO(1,2,3-CD)PYRENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
DIBENZO(A,H)ANTHRACENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
BENZO(G,H,I)PERYLENE	STL	ug/kg	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1	2	UJ	1
Total PAHs		ug/kg			61.0			80.1			51.4			150.1			44.2
LIPIDS	STL	%	1.3		3.4	1.7		1.7	1.6		1.6	2.7		2.7	2.5		2.5

STL = Severn Trent Laboratories, Inc. Colchester, Vermont
ug/kg = micrograms per kilogram, wet weight

U = Compound not detected

J = Estimated concentration; result below reporting limit or quality control criteria were not met.

UJ = Not detected at or above the reporting limit. Reporting limit is approximate.

R = Result rejected. Presence or absence of compound cannot be determined

ND = Not detected

Appendix D
Surface Water Investigation

FINAL REPORT

SURFACE WATER INVESTIGATION - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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January 2007

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Table 3.4 Filtered Surface Water Samples Water Chemistry, High Energy Event – BERA

Table 3.5 Conventional Surface Water Quality Parameters – BERA

Table 3.6 Unfiltered Surface Water Samples Water Chemistry, Low Energy Event – HHRA

Table 3.7 Unfiltered Surface Water Samples Water Chemistry, High Energy Event – HHRA

Table 3.8 Conventional Surface Water Quality Parameters – HHRA

Table 4.1 Surface Water Screening Criteria

In accordance with the approved RI/FS Work Plan for the Ashland /Northern States Power (NSP) Lakefront Superfund Site (Site), surface water samples were collected from the Ashland, WI area and analyzed for semivolatile organic compounds including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and dissolved organic carbon (DOC). The results of this analysis were used to support environmental impact studies and ecological and human health risk assessments for the Site.

Surface water samples were collected during both low- and high-energy events in Site waters in Chequamegon Bay. Sampling stations were established to collect surface water samples for supporting both the Baseline Ecological Risk Assessment (BERA) and the Human Health Risk Assessment (HHRA) (Figure 2.1). The samples were collected under two energy regimes, one low energy under conditions of low winds, small waves and/or wind chop, the other sampling event under higher energy conditions during a period where wave conditions exceeded 30 centimeters during the 24-hour period prior to sampling.

Low-energy surface water samples were collected at BERA sampling locations on June 17, 2005 and HHRA sampling locations on June 18, 2005 when waves were less than 30 centimeters for the 24-hour period prior to each respective sampling day. A high-energy sampling event was completed on November 14, 2005.

For the June low-energy event, samples were collected from the *R/V MustDu*, a 28-foot long twin-hulled pontoon vessel operated by a subcontractor, OSI, which was equipped with an integrated midship moon-pool and overhead derrick system. *R/V MustDu* was equipped with a Trimble 4000 Differential GPS system with United States Coast Guard differential correctors that was used to navigate to sampling locations and to record the positions where samples were collected. During the high-energy event, samples were collected from a 16-foot johnboat operated by URS. A hand-held Trimble GeoXT GPS unit was used to navigate the vessel to locations sampled in June and to record the positions where samples were collected. The following sections describe surface water sampling procedures used to collect samples for the BERA and HHRA.

2.1 BASELINE ECOLOGICAL RISK ASSESSMENT SAMPLES

Surface water samples to support the BERA were collected from eight study and reference stations (Figure 2.1). Six stations within Site waters were positioned on a transect extending from the shoreline offshore beyond the area of impacted sediment. One reference station was located within the Ashland Marina and another reference station was located offshore of Kreher Park. BERA surface water samples were collected from mid depth and near bottom (approximately one foot from the sediment-surface water interface) at all stations except for one Site station (ERA2) and one reference station (ERA8). Water depths station ERA2, nearest the shoreline in the study area and the reference location ERA8 offshore of Kreher Park were less than five feet; only mid depth samples were collected from these stations.

Filtered and unfiltered surface water samples were collected using a peristaltic pump deployed from the sampling vessel. The sampling vessel was navigated into position by GPS and was held over the sampling station while the sample was collected. One end of polyethylene tubing was attached to the peristaltic pump and the other end attached to a rubber coated mushroom anchor for stabilization. The mushroom anchor was lowered to the designated depth and the pump was turned on from the surface. Approximately three sample-tubing volumes were pumped through the line to thoroughly flush the tubing before sampling. Unfiltered samples were collected at each depth by directly filling laboratory-supplied containers for PAHs and VOCs. To collect filtered samples, dedicated 0.45-µm in-line filters were fitted to the pump end of the tubing. The pump was turned on and a sufficient volume of water was allowed to flush the filter. Once the filter was flushed, samples were collected directly from the end of the filter by filling laboratory-supplied containers for SVOCs, VOCs, and DOC. Vials supplied for VOCs were filled to the

top so that no headspace remained. Each vial was inspected for bubbles to ensure that no air remained in the sample. Prior to sampling a new station, the tubing was decontaminated with a mixture of potable water and Liquinox™ and the line was flushed with deionized water.

In situ water quality measurements were made at each station and depth where surface water samples were collected. The probe of an YSI-85 multi-meter was attached to the mushroom anchor adjacent to the sample tubing and lowered to the designated sampling depth. After the surface water sample was collected the meter was powered and the probe was allowed to equilibrate at the sampling depth. Once the meter readings stabilized, temperature, DO, and specific conductivity were recorded.

Surface water samples were placed on ice until delivery to the designated laboratory for analysis. All samples were received in satisfactory condition by the designated laboratory within prescribed analytical hold times.

2.2 HUMAN HEALTH RISK ASSESSMENT SAMPLES

Surface water samples to support the HHRA were collected from eight study and reference stations (Figure 2.1). Six stations within the Site waters were positioned along a shoreline transect in water less than five feet deep. HHRA surface water samples were collected at mid depth at all stations.

Unfiltered surface water samples were collected using a peristaltic pump deployed from the sampling vessel. The sampling vessel was navigated into position by GPS and was held over sampling station while the sample was collected. One end of polyethylene tubing was attached to the peristaltic pump and the other end attached to a rubber coated mushroom anchor for stabilization. The mushroom anchor was lowered to mid depth and the pump was turned on from the surface. Approximately three sample-tubing volumes were pumped through the line to thoroughly flush the tubing before sampling. Unfiltered samples were collected at each location by directly filling laboratory-supplied containers for PAHs, VOCs, and DOC. Vials supplied for VOCs were filled to the top so that no headspace remained; each vial was inspected for bubbles to ensure that no air remained in the sample. Prior to sampling a new station, the tubing was decontaminated with a mixture of potable water and Liquinox™ and the line was flushed with deionized water.

In situ water quality measurements were made at each station and depth where surface water samples were collected. The probe of an YSI-85 multi-meter was attached to the mushroom anchor adjacent to the sample tubing and lowered to the designated sampling depth. After the surface water sample was collected, as described the preceding paragraph, the meter was powered and the probe was allowed to equilibrate at the sampling depth. Once the meter readings stabilized, temperature, DO, and specific conductivity were recorded.

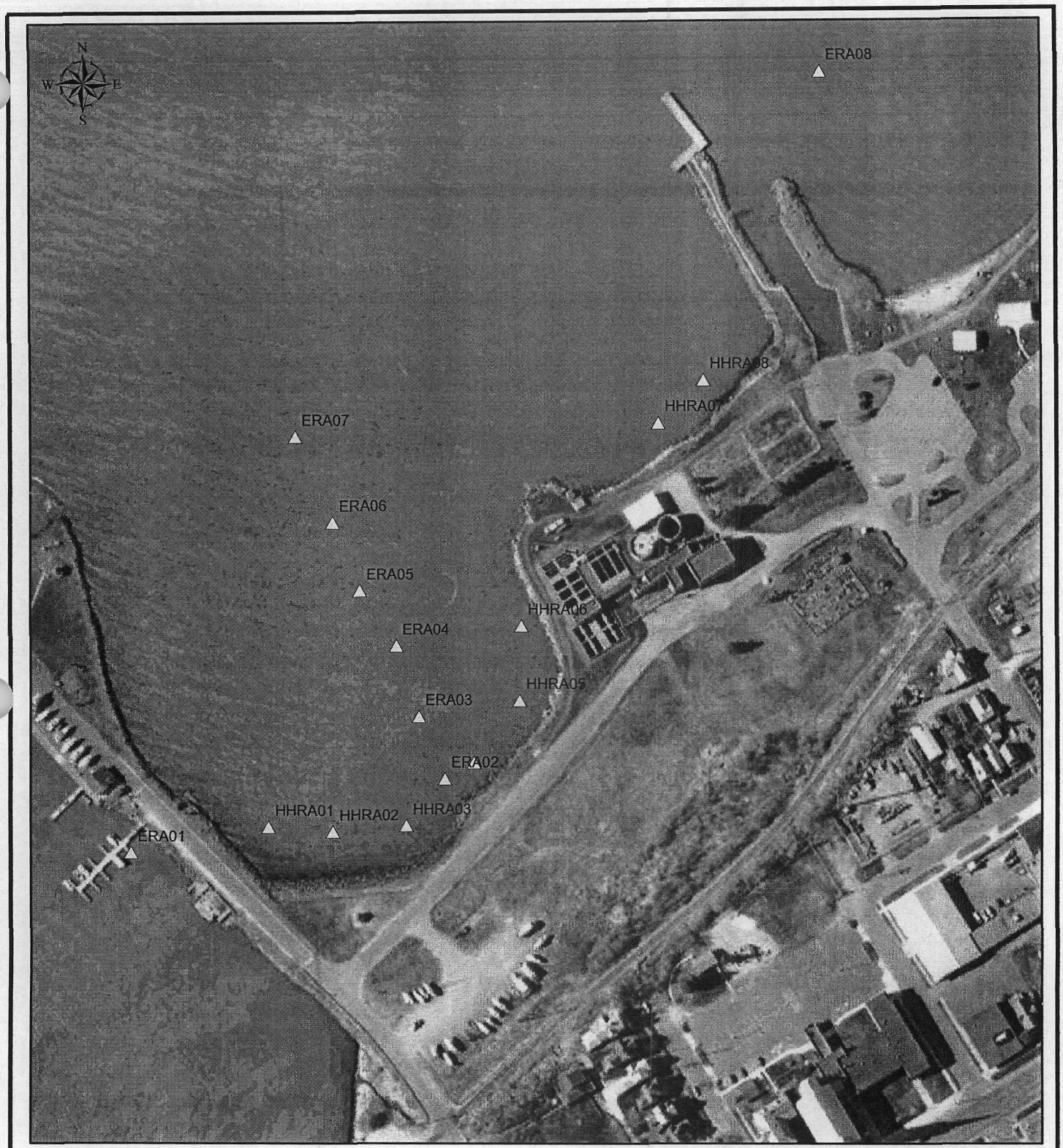
Surface water samples were placed on ice until delivery to the designated laboratory for analysis. All samples were received in satisfactory condition by the designated laboratory within prescribed analytical hold times.

The results of the surface water sampling are tabulated in Tables 3.1 through Table 3.8 as summarized in the following tables.

Table	Results for Baseline Ecological Risk Assessment Samples
3.1	Unfiltered samples – water chemistry – low energy event
3.2	Filtered samples – water chemistry – low energy event
3.3	Unfiltered samples – water chemistry – high energy event
3.4	Filtered samples – water chemistry – high energy event
3.5	Conventional surface water parameters – BERA
	Results for Human Health Risk Assessment Samples
3.6	Unfiltered samples – water chemistry – low energy event
3.7	Unfiltered samples – water chemistry – high energy event
3.8	Conventional surface water parameters – HHRA

For the most part no contaminants were detected in surface water samples, even including those collected during the high energy sampling event. There were some potential low level (</=1µg/L) detections for some VOCs but these compounds were reported as estimated values. Naphthalene was the only PAH detected in samples collected during the high energy event. All reported detections of naphthalene were estimated concentrations. The highest estimated concentration for naphthalene was 2 µg/L. No reported concentrations exceeded U.S. EPA Region V ecological screening levels (ESLs) or comparable screening criteria (Table 4.1).

FIGURES



Legend

△ Surface water locations

0 75 150 300 450 600 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE ASHLAND, WISCONSIN		
TITLE: **FIGURE 2-1** **BERA Surface Water Sample Locations**		
DRAWN BY:	SCALE:	PROJECT: 25688375
CHECKED BY:	DATE:	SHEET:
APPROVED BY:		
URS	10200 INNOVATION DRIVE, SUITE 500 MILWAUKEE, WISCONSIN 53226 414-831-4100	

TABLES

Table 3.1. Unfiltered Surface Water Samples Water Chemistry - Low Energy Event
Baseline Ecological Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	ERA01 NSP-SW-ERA01-0605-MID UNF-061705 6/17/2005	ERA01 NSP-SW-ERA01-0605-NB-UNF-061705 6/17/2005	ERA02 NSP-SW-ERA02-0605-MID UNF-061705 6/17/2005	ERA03 NSP-SW-ERA03-0605-MID UNF-061705 6/17/2005	ERA03 NSP-SW-ERA03-0605-NB UNF-061705 6/17/2005	ERA04 NSP-SW-ERA04-0605-MID UNF-061705 6/17/2005	ERA04 NSP-SW-ERA04-0605-NB UNF-061705 6/17/2005	ERA05 NSP-SW-ERA05-0605-MID UNF MS/MSD-061705 6/17/2005	ERA05 NSP-SW-ERA05-0605-NB UNF-061705 6/17/2005	ERA06 NSP-SW-ERA06-0605-MID UNFIL-061705 6/17/2005	ERA06 NSP-SW-ERA06-0605-NB UNFIL-061705 6/17/2005	ERA07 NSP-SW-ERA07-0605-MID UNFIL-061705 6/17/2005	ERA07 NSP-SW-ERA07-0605-NB UNFIL MS/MSD-061705 6/17/2005	ERA08 NSP-SW-ERA08-0605-MID UNFIL-061705 6/17/2005
PAHs															
1-Methylnaphthalene	ug/L	1.1 U	NA	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	NA	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	NA	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	NA	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.1 U	NA	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	NA	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	NA	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	NA	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	NA	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	NA	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	NA	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	NA	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	NA	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	NA	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	NA	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	NA	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.1 U	NA	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Perylene	ug/L	1.2 U	NA	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	NA	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	NA	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs															
Dibenzofuran	ug/L	1.1 U	NA	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 U	NA	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
o-Cresol	ug/L	0.9 U	NA	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	NA	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs															
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Benzene	ug/L	0.14 U	0.14 U	0.46 J	0.14 U	0.14 U	0.16 J	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Ethylbenzene	ug/L	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Toluene	ug/L	0.43 J	0.44 J	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U	0.25 U

Notes:
ug/L = Micrograms per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for not detected at listed concentration
UJ = Constituents analyzed for not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.2. Filtered Surface Water Samples Water Chemistry - Low Energy Event
Baseline Ecological Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	ERA01 NSP-SW-ERA01-0605-MID FIL-	ERA01 NSP-SW-ERA01-0605-NB FIL-061705	ERA02 NSP-SW-ERA02-0605-MID FIL-	ERA03 NSP-SW-ERA03-0605-MID FIL-	ERA03 NSP-SW-ERA03-0605-NB FIL-061705	ERA04 NSP-SW-ERA04-0605-MID FIL-	ERA04 NSP-SW-ERA04-0605-NB FIL-061705	ERA05 NSP-SW-ERA05-0605-MID FIL-	ERA05 NSP-SW-ERA05-0605-NB FIL-061705	ERA06 NSP-SW-ERA06-0605-MID FIL-	ERA06 NSP-SW-ERA06-0605-NB FIL-061705	ERA07 NSP-SW-ERA07-0605-MID FIL-	ERA07 NSP-SW-ERA07-0605-NB FIL-061705	ERA08 NSP-SW-ERA08-0605-MID FIL-
OTHER															
Dissolved Organic Carbon (DOC)	mg/L	1.6 J	1.4 J	2.2	1.7 J	1.8	1.3 J	1.8	1.3 J	1.2 J	1.3 J	1.1 J	1.4 J	1.5 J	1.7 J
PAHs															
1-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Perylene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs															
Dibenzofuran	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
o-Cresol	ug/L	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs															
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Benzene	ug/L	0.14 U	0.14 U	0.35 J	0.14 U	0.14 U	0.15 J	0.37 J	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Ethylbenzene	ug/L	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Toluene	ug/L	1	0.49 J	0.38 J	0.37 J	0.37 J	0.51 J	0.25 U	0.38 J	0.49 J	0.3 J	0.31 J	0.33 J	0.25 U	0.45 J

Notes:
ug/l = Micrograms per liter
mg/l = Milligrams per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for not detected at listed concentration
UJ = Constituents analyzed for not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.3. Unfiltered Surface Water Samples Water Chemistry - High Energy Event
Baseline Ecological Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	ERA01 NSP-SW-ERA01-1105-MID-UNF-	ERA01 NSP-SW-ERA01-1105-NB-UNF-	ERA02 NSP-SW-ERA02-1105-MID-UNF-	ERA03 NSP-SW-ERA03-1105-MID-UNF-	ERA03 NSP-SW-ERA03-1105-NB-UNF-	ERA04 NSP-SW-ERA04-1105-MID-UNF-	ERA04 NSP-SW-ERA04-1105-NB-UNF-	ERA05 NSP-SW-ERA05-1105-MID-UNF-	ERA05 NSP-SW-ERA05-1105-NB-UNF-	ERA06 NSP-SW-ERA06-1105-MID-UNF-	ERA06 NSP-SW-ERA06-1105-NB-UNF-	ERA07 NSP-SW-ERA07-1105-MID-UNF-	ERA07 NSP-SW-ERA07-1105-NB-UNF-	ERA08 NSP-SW-ERA08-1105-MID-UNF-
PAHs															
1-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.4 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.4 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	1.1 U	1.3 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.1 U	1.1 U	2 J	0.55 J	0.55 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Perylene	ug/L	1.2 U	1.2 U	1.2 UJ	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs															
Dibenzofuran	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ
o-Cresol	ug/L	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs															
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Benzene	ug/L	0.14 U	0.14 U	0.23 J	0.15 J	0.17 J	0.21 J	0.23 J	0.14 U	0.07 J	0.16 J	0.17 J	0.47 J	0.53 J	0.14 U
Ethylbenzene	ug/L	0.17 U	0.17 U	0.44 J	0.39 J	0.4 J	0.22 J	0.39 J	0.17 U	0.2 J	0.23 J	0.24 J	0.17 U	0.17 J	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.4 J	0.35 U	0.35 U	0.35 J	0.35 U	0.35 U	0.35 U	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Toluene	ug/L	0.125 J	0.25 U	0.25 U	0.25 U	0.125 J	0.51 J	0.39 J	0.125 J	0.25 U	0.38 J	0.3 J	0.25 U	0.28 J	0.25 U

Notes:
ug/l = Micrograms per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for not detected at listed concentration
UJ = Constituents analyzed for not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.4. Filtered Surface Water Samples Water Chemistry - High Energy Event
Baseline Ecological Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	ERA01 NSP-SW-ERA01-1105-MID-FIL-	ERA01 NSP-SW-ERA01-1105-NB-FIL-111405	ERA02 NSP-SW-ERA02-1105-MID-FIL-	ERA03 NSP-SW-ERA03-1105-MID-FIL-	ERA03 NSP-SW-ERA03-1105-NB-FIL-111505	ERA04 NSP-SW-ERA04-1105-MID-FIL-	ERA04 NSP-SW-ERA04-1105-NB-FIL-	ERA05 NSP-SW-ERA05-1105-MID-FIL-	ERA05 NSP-SW-ERA05-1105-NB-FIL-111505	ERA06 NSP-SW-ERA06-1105-MID-FIL-	ERA06 NSP-SW-ERA06-1105-NB-FIL-111505	ERA07 NSP-SW-ERA07-1105-MID-FIL-	ERA07 NSP-SW-ERA07-1105-NB-FIL-111505	ERA08 NSP-SW-ERA08-1105-MID-FIL-
OTHER															
Dissolved Organic Carbon (DOC)	mg/L	0.54 U	0.54 U	0.54 U	2.2	2.6	0.54 U	0.54 U	2	2	0.54 U	0.75 J	1.8	2.3	2.3
PAHs															
1-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.1 U	1.1 U	2.2 J	1.6 J	2 J	1.1 U	1.1 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Perylene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs															
Dibenzofuran	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ
o-Cresol	ug/L	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs															
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 UJ	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 UJ	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 UJ	0.15 U
Benzene	ug/L	0.14 U	0.14 U	0.19 J	0.15 J	0.16 J	0.14 U	0.25 J	0.14 U	0.14 J	0.14 U	0.18 J	0.14 U	0.33 J	0.14 U
Ethylbenzene	ug/L	0.17 U	0.17 U	0.17 UJ	0.22 J	0.21 J	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 UJ	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 UJ	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 UJ	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 UJ	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 UJ	0.15 U
Toluene	ug/L	0.36 J	0.25 U	0.3 J	0.25 U	0.27 J	0.39 J	0.54 J	0.41 J	0.6 U	0.36 J	0.4 J	0.46 U	0.57 J	0.54 U

Notes:
ug/l = Micrograms per liter
mg/l = Milligrams per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.5. Conventional Surface Water Quality Parameters
Baseline Ecological Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Sample Location ID	Date Sampled	Total Water Depth (feet)	Mid Column Sample				Near Bottom Sample			
			Depth of Sample (feet)	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	Depth of Sample (feet from bottom)	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)
ERA-01	06/17/05	7.4	3.9	18.4	5.4	95	1	17.4	4.9	95
ERA-02	06/17/05	4.1	2.1	28.2	6.74	95.5	-	-	-	-
ERA-03	06/17/05	5.9	2.9	20	6.77	95.5	1	19.3	6.23	94.8
ERA-04	06/17/05	7.6	3.8	19.2	6.59	94.5	1	18.5	6.25	98.4
ERA-05	06/17/05	7.9	3.9	19.7	7.27	57	1	18.3	6.74	54
ERA-06	06/17/05	8.8	4.4	18.4	6.86	66.8	1	18.2	6.81	67.1
ERA-07	06/17/05	9.7	4.9	18.6	6.42	54.4	1	17.9	6.59	55.2
ERA-08	06/17/05	4.61	2.3	19.8	6.85	56.2	-	-	-	-
ERA-01	11/14/05	6.8	3.4	6.3	10.55	0.116	1	-	-	-
ERA-02	11/14/05	4.1	2.1	6.2	9.95	0.114	-	-	-	-
ERA-03	11/14/05	5.9	3.0	6.1	10.22	0.114	1	-	-	-
ERA-04	11/14/05	7.0	3.5	6.3	10.5	0.11	1	-	-	-
ERA-05	11/14/05	7.5	3.75	6.3	10.8	0.11	1	-	-	-
ERA-06	11/14/05	8.8	4.4	6.3	9.9	0.11	1	-	-	-
ERA-07	11/14/05	9.7	4.85	6.3	10.3	0.11	1	-	-	-
ERA-08	11/14/05	4.5	2.25	6.3	10.4	0.11	-	-	-	-

- Only mid column data collected at these locations.

Table 3.6. Unfiltered Surface Water Samples Water Chemistry - Low Energy Event
Human Health Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	*HHRA01* NSP-SW-HHRA01-0605-UNF-061805	*HHRA02* NSP-SW-HHRA02-0605-UNF-061805	*HHRA03* NSP-SW-HHRA03-0605-UNF-061805	*HHRA04* NSP-SW-HHRA04-0605-UNF-061805	*HHRA05* NSP-SW-HHRA05-0605-UNF-061805	*HHRA06* NSP-SW-HHRA06-0605-UNF-061805	*HHRA07* NSP-SW-HHRA07-0605-UNF-061805	*HHRA08* NSP-SW-HHRA08-0605-UNF-061805
OTHER									
Dissolved Organic Carbon (DOC)	mg/L	1.9	1.7 J	2.7	2	1.3 J	2	1.8	2.4
PAHs									
1-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Perylene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs									
Dibenzofuran	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
o-Cresol	ug/L	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs									
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Benzene	ug/L	0.14 U	0.26 J	0.28 J	0.14 U	0.14 U	0.14 U	0.14 U	0.47 J
Ethylbenzene	ug/L	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Toluene	ug/L	0.25 U	0.31 J	0.25 U	0.26 J	0.33 J	0.34 J	0.25 J	0.25 U

Notes:
ug/l = Micrograms per liter
mg/l = Milligrams per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for
not detected at listed concentration
UJ = Constituents analyzed for
not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.7. Unfiltered Surface Water Samples Water Chemistry - High Energy Event
Human Health Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Analyte	Units	HHRA01 NSP-SW-HHRA1-1105-UNF-111405 11/14/2005	HHRA02 NSP-SW-HHRA2-1105-UNF-111405 11/14/2005	HHRA03 NSP-SW-HHRA3-1105-UNF-MSMSD-111505 11/15/2005	HHRA04 NSP-SW-HHRA4-1105-UNF-111505 11/15/2005	HHRA05 NSP-SW-HHRA5-1105-UNF-111505 11/15/2005	HHRA06 NSP-SW-HHRA6-1105-UNF-111505 11/15/2005	HHRA07 NSP-SW-HHRA7-1105-UNF-111505 11/15/2005	HHRA08 NSP-SW-HHRA8-1105-UNF-111505 11/15/2005
OTHER									
Dissolved Organic Carbon (DOC)	mg/L	1.4 J	0.75 J	2.1	1.2 J	0.63 J	0.54 U	0.59 J	0.72 J
PAHs									
1-Methylnaphthalene	ug/L	1.1 J	1.1 J	1.1 UJ	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1-Methylphenanthrene	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2,3,5-Trimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2,6-Dimethylnaphthalene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
2-Methylnaphthalene	ug/L	1.2 J	1.1 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthene	ug/L	1.1 U	1.1 J	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Acenaphthylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Anthracene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Benzo(a)anthracene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(a)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(b)fluoranthene	ug/L	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U	0.92 U
Benzo(e)pyrene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(g,h,i)perylene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Benzo(k)fluoranthene	ug/L	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Biphenyl	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Chrysene	ug/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibenzo(a,h)anthracene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Fluoranthene	ug/L	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U	0.97 U
Fluorene	ug/L	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U	0.99 U
Indeno(1,2,3-cd)pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
Naphthalene	ug/L	1.8 J	1.8 J	1.3 J	1.1 U	1.7 J	1.1 J	1.1 U	1.1 U
Perylene	ug/L	1.2 U	1.2 U	1.2 UJ	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Phenanthrene	ug/L	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U	0.98 U
Pyrene	ug/L	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U	0.94 U
SVOCs									
Dibenzofuran	ug/L	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m & p-cresols	ug/L	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ	1.4 UJ
o-Cresol	ug/L	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U	0.9 U
Phenol	ug/L	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U	0.51 U
VOCs									
1,2,3-Trimethylbenzene	ug/L	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U	0.21 U
1,2,4-Trimethylbenzene	ug/L	0.16 U	0.16 U	0.17 J	0.16 U	0.16 U	0.16 U	0.16 U	0.16 U
1,3,5-Trimethylbenzene	ug/L	0.15 U	0.15 UJ	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Benzene	ug/L	0.15 J	0.18 J	0.74	0.19 J	0.28 J	0.14 U	0.14 U	0.14 U
Ethylbenzene	ug/L	0.34 J	0.34 J	0.46 J	0.33 J	0.48 J	0.19 J	0.17 U	0.17 U
m & p-Xylenes	ug/L	0.35 U	0.35 U	0.44 J	0.35 U	0.39 J	0.35 U	0.35 U	0.35 U
o-Xylene	ug/L	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U	0.22 U
sec-Butyl benzene	ug/L	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U	0.14 U
Styrene	ug/L	0.15 U	0.15 U	0.15 UJ	0.15 U	0.15 U	0.15 U	0.15 U	0.15 U
Toluene	ug/L	0.25 U	0.25 U	0.31 J	0.25 U	0.29 J	0.25 U	0.25 U	0.25 U

Notes:
ug/l = Micrograms per liter
mg/l = Milligrams per liter
PAHs = Polycyclic Aromatic Hydrocarbons
SVOCs = Semi-volatile Organic Compounds
VOCs = Volatile Organic Compounds
U = Constituents analyzed for not detected at listed concentration
UJ = Constituents analyzed for not detected at estimated concentration
J = Estimated concentration
NA = Not analyzed for this constituent

Table 3.8. Conventional Surface Water Quality Parameters
Human Health Risk Assessment
Ashland /Northern States Power (NSP) Lakefront Superfund Site
Ashland, Wisconsin

Sample Location ID	Date Sampled	Total Water Depth (feet)	Mid Column Sample			
			Depth of Sample (feet)	Temperature (degrees C)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)
HHRA-01	06/18/05	3.4	1.7	20.2	5.79	96
HHRA-02	06/18/05	2.7	1.35	20	6.06	98.4
HHRA-03	06/18/05	2.4	1.2	20.1	5.89	99.6
HHRA-04	06/18/05	3.7	1.85	20.2	6.22	98.4
HHRA-05	06/18/05	4.6	2.3	20.3	5.25	98.2
HHRA-06	06/18/05	5	2.5	20.2	5.5	97.9
HHRA-07	06/18/05	3.4	1.7	20.6	6.45	100.2
HHRA-08	06/18/05	3.1	1.55	20.9	6.8	102.1
HHRA-01	11/14/05	3.0	1.5	6.0	10.3	0.11
HHRA-02	11/14/05	2.7	1.4	6.3	10.1	0.11
HHRA-03	11/14/05	2.5	1.25	6.4	10.0	0.12
HHRA-04	11/14/05	3.8	1.6	6.3	10.1	0.11
HHRA-05	11/14/05	4.3	2.15	6.3	10.4	0.11
HHRA-06	11/14/05	5.0	2.5	6.3	10.4	0.11
HHRA-07	11/14/05	4.0	2.0	6.3	10.4	0.11
HHRA-08	11/14/05	3.25	1.65	6.3	10.2	0.11

Table 4.1
Surface Water Criteria
Ashland/Northern States Power Superfund Site
Ashland, WI

Analyte	Criteria (µg/L)	Source[1]
VOCs		
1,2,4-Trimethylbenzene	438	ECOSAR ChV (fish)
1,3,5-Trimethylbenzene	438	ECOSAR ChV (fish)
Benzene	11.4	Region V ESL
Ethybenzene	14	Region V ESL
Sec-Butylbenzene	263	ECOSAR ChV (fish)
Styrene	32	Region V ESL
Toluene	253	Region V ESL
Total Xylenes	27	Region V ESL (sum of isomers)
PAHs		
1-Methylnaphthalene	433	ECOSAR ChV (fish)
1-Methlyphenanthrene	56	ECOSAR ChV (fish)
2,3,5-Trimethylnaphthalene	58	ECOSAR ChV (fish)
2,6-Dimethylnaphthalene	161	ECOSAR ChV (fish)
2-Methylnaphthalene	433	ECOSAR ChV (fish)
Acenaphthene	38	Region V ESL
Acenaphthylene	4840	Region V ESL
Anthracene	0.035	Region V ESL
Benzo(a)anthracene	0.025	Region V ESL
Benzo(a)pyrene	0.014	Region V ESL
Benzo(b)fluoranthene	0.42	Reg IV WQS
Benzo(e)pyrene	0.014	same as B(a)P
Benzo(g,h,i)perylene	7.64	Region V ESL
Benzo(k)fluoranthene	0.14	Reg IV WQS
Biphenyl	14	OSWER Tier II
Chrysene	0.07	Reg IV WQS
Dibenz(a,h,)anthracene	0.04	Reg IV WQS
Fluoranthene	1.9	Region V ESL
Fluorene	19	Region V ESL
Indeno(1,2,3-cd)pyrene	4.31	Region V ESL
Naphthalene	13	Region V ESL
Perylene	0.006	ECOSAR ChV (fish)
Phenanthrene	3.6	Region V ESL
Pyrene	0.3	Region V ESL

Notes:

1, Region V ESL, USEPA Region V Ecological Screening Levels
Region IV WQS, USEPA Region IV Water Management Division Screening List
ECOSAR, Structure-activity relationships using chronic values for fish

Appendix E
Wetland and Terrestrial Habitat Characterization

FINAL REPORT

CHARACTERIZATION OF WETLANDS AND TERRESTRIAL HABITATS - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

Northern States Power Company - WI
1414 West Hamilton Avenue
Eau Claire, WI 54701

January 2007

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Appendix B Wetland Data Forms and Photographs

A URS environmental scientist made field observations of upland portions of the Ashland Lakefront Superfund Site in Ashland Wisconsin on June 15, 2005.The total upland area of the site is approximately seven square blocks or 23 acres. It is bordered by US Highway 2 to the south, Prentice Avenue to the east, Ellis Avenue to the west, and Chequamegon Bay (part of Lake Superior) to the north (Figure1.1).

Within the boundaries of the site, Canadian National Railroad tracks run parallel and just north of the top of a bluff, with a flat open field/lawn area to the north leading to Chequamegon Bay, and a flat, developed plateau landward to the south. The bluff slopes north down to a flat open field/lawn area bordered on the north by Marina Drive. North of Marina Drive is primarily grassy, which gives way to the shoreline of Chequamegon Bay. A former wastewater treatment plant also lies along the shoreline to the north of Marina Drive (Figure 1.2).

Land uses north of the bluff along the shoreline include the Kreher Park boat launch, public swimming beach, and campground to the east, and Ellis Avenue Marina to the west/northwest. To the south, between the project site and US Highway 2, is an area developed as residential. Land uses south of the bluff include residential homes, light industry, and a church and school. In general, the site is fairly disturbed and provides minimal wildlife habitat.

2.1 COVER TYPES AND VEGETATION

There are five main habitat types on the 23 acre site (Figure 1.2 and 2.1). These include wooded/shrub, open field, developed/lawn, wetland and lake edge. The Canadian National Railroad runs parallel to the bluff, approximately 30 feet lakeward of the bluff. Vegetation between the tracks and the top of the bluff is a 30- to 50-year-old strip of woodland consisting of green ash, oak, boxelder and cottonwood. Down slope of the tracks prior to the flat grassy area, woody vegetation parallels the railroad tracks for the most part, and consists of 10- to 20-year-old boxelder and shrubs such as raspberry, dogwood, willow, honeysuckle, red elderberry, green ash, and grape. A similar tree/shrub area to the area down slope of the tracks is along the Chequamegon Bay east/northeast of the former wastewater treatment plant. The two wood/shrub areas comprise approximately 3.8 acres.

The open field between the wooded area and Chequamegon Bay is approximately 7.5 acre and consists primarily of open field made up of brome, thistle, dandelion and timothy. A lawn area that contains some park amenities, such as picnic tables and benches traverse this area. The marina parking lot on the western edge of the site is gravel (Figure 1.2 and 2.1). There is one wetland area located east of the parking lot, near the border of the wooded/shrub and open field areas (Figure 1.2 and 2.1).

North of Marina Drive consists of primarily grassy area with lawn inclusions, which gives way to the sandy/rocky shore edge. Lake edge habitat consists of a fairly narrow strip of sand and rocks along Chequamegon Bay in some areas, with lawn vegetation going all the way to the water's edge in others.

2.2 WILDLIFE

Wildlife species that would typically inhabit the wooded/shrub habitat are summarized in Table 2.1. Species that would typically utilize the open field habitat are summarized in Table 2.2.

Table 2.1 Common Wildlife Species Typical for Wooded/shrub Habitats.

Common Name	Scientific Name
Gray catbird	*Dumetella carolinensis*
Eastern wood-pewee	*Contopus virens*
Least flycatcher	*Empidonax minimus*
Great crested flycatcher	*Myiarchus crinitus*
Black-capped chickadee	*Parus atricapillus*
White-breasted nuthatch	*Sitta carolinensis*
Yellow-throated vireo	*Vireo flavifrons*
Red-eyed vireo	*Vireo olivaceus*
Scarlet tanager	*Piranga olivacea*

Common Name	Scientific Name
Ovenbird	*Seiurus aurocapillus*
White-footed mouse	*Peromyscus leucopus*
Gray squirrel	*Sciurus carolinensis*
Eastern chipmunk	*Tamias minimus*
Southern flying squirrel	*Glaucomys volans*
White-tailed deer	*Odocoileus virginianus*
Stripped Skunk	*Mephitis mephitis*
Raccoon	*Procyon lotor*

Table 2.2 Common Wildlife Species in Open Field Habitats

Common Name	Scientific Name
Red-winged blackbird	*Agelaius phoeniceus*
Pigeon	*Columba fasciata*
Mourning dove	*Zenaida macroura*
Common crow	*Corvus brachyrhynchos*
Blue jay	*Cyanocitta cristata*
Indigo bunting	*Passerina cyanea*
Chipping sparrow	*Spizella passerina*
Field sparrow	*Spizella pusilla*
Song sparrow	*Melospiza melodia*
Brown-headed cowbird	*Molothrus ater*
Thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*
Meadow jumping mouse	*Zapus hudsonius*
Prairie voles	*Microtus ochrogaster*
Meadow voles	*Microtus pennsylvanicus*
Northern short-tailed shrew	*Blarina brevicauda*

The developed/lawn areas would typically be home to songbirds, squirrels, rabbits, and other small rodents that are adapted to an urban setting. Chequamegon Bay typically provides habitat

for a wide range of birds and fish. It is a diverse and productive fishery, and common sport fishes include bass, walleye, northern pike, trout, and Chinook salmon. However, in the immediate project site area, fish and lakeshore habitat is limited due to the location of the marina (high boat traffic area) and shoreline development.

Wildlife during the field visit on June 15, 2005 observed included several birds and a few small rodents. Table 3 lists these species and the habitat in which they were observed.

Table2.3 Wildlife Species Observed On Site

Common Name	Scientific Name	Site Habitat
Gray catbird	*Dumetella carolinensis*	Shrub/wooded
Common crow	*Corvus brachyrhynchos*	Developed
House sparrow	*Passer domesticus*	Developed
American robin	*Turdus migratorius*	Wooded
Brown-headed cowbird	*Molothrus ater*	Wooded
Herring gull	*Larus argentatus*	Lake edge
Cedar waxwing	*Bombycilla cedrorum*	Wooded
Common starling	*Sturnus vulgaris*	Developed
Ovenbird	*Seiurus aurocapillus*	Wooded
Red-winged blackbird	*Agelaius phoeniceus*	Open field and Wetland
Pigeon	*Columba fasciata*	Developed
Mourning dove	*Zenaida macroura*	Developed
Chipmunk	*Tamias minimus*	Developed
Woodchuck	Marmota monax	Developed

2.3 CONCLUSION

In general, the site is fairly disturbed and provides minimal wildlife habitat for species other than those acclimated to an urban environment. Songbirds and small rodents are the primary extent of wildlife species diversity on the site. This is largely due to the disturbed nature of he site and the low diversity of vegetation on site.

The Endangered Species Act (ESA) of 1973 requires Federal agencies to determine the effects of their actions on threatened and endangered species of fish, wildlife, and plants and on their habitats, and to take steps to conserve and protect these species. States also require that consultation take place regarding species of state significance.

Letters requesting information on rare, threatened and endangered species were sent to the U.S. Fish and Wildlife Service (USFWS) and Wisconsin Department of Natural Resources (WDNR) on July 29, 2005. The USFWS maintains a list of federally-protected species, while the WDNR maintains a list of state-protected species. These agencies are responsible for identifying and enforcing necessary mitigation measures should any species be affected by a proposed project.

WDNR was contacted for information regarding known occurrences of threatened, endangered, or otherwise significant plant and animal species, natural plant communities, and other natural features. In a letter dated August 17, 2005 (Appendix A), the WDNR concluded that there are 7 known occurrences of rare species or natural communities within an approximate 2-mile radius around the project site and within five miles for aquatic species. The species listed includes two birds, one diving beetle and four plants.

The birds were the merlin (*Falco columbarius*) and the common tern (*Sterna hirundo*), which were the only species found just outside of the project area. Neither bird species has habitat within the project area and further surveys or protocols for these species is not necessary. The diving beetle is recorded in Bay City Creek, which will not be impacted by this project. The plants are all wetland species and were not in the project site or adjoining properties.

The United States Fish and Wildlife Service responded by letter on August 23, 2005 for federally threatened or endangered species. The USFWS provided a list of species that are known to occur within Ashland County, but responded that no federally-listed species or critical habitat is known to occur in the project site or within a 2-mile radius (Appendix A). A URS environmental scientist made field observations of the site area on June 15, 2005 and concluded that no habitat is available for the listed species that the USFWS provided for Ashland County.

The Coastal Zone Management Act encourages states to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. The Coastal Zone Management Act is administered through the Department of Administration, under the Wisconsin Coastal Management Program (WCMP). A letter was sent to the WCMP on August 1, 2005 requesting comments relative to coastal zone management. WCMP responded that "No Determination is needed at this time" due to that fact that no federal action is required yet. When this project moves onto other phases with known plans of mitigation, permits, or other federal actions, we will need to contact them again.

A wetland is defined by state and federal regulations as an area that exhibits three distinct characteristics: 1) hydric soils; 2) inundation or saturation at or near the ground surface for a period of the growing season; and, 3) a prevalence of vegetation adapted to wet soil conditions. Wetlands are recognized, in general, as having important functions, including flood storage, water quality, wildlife and fisheries habitat, vegetation diversity, shoreland protection, aesthetics, and public recreation.

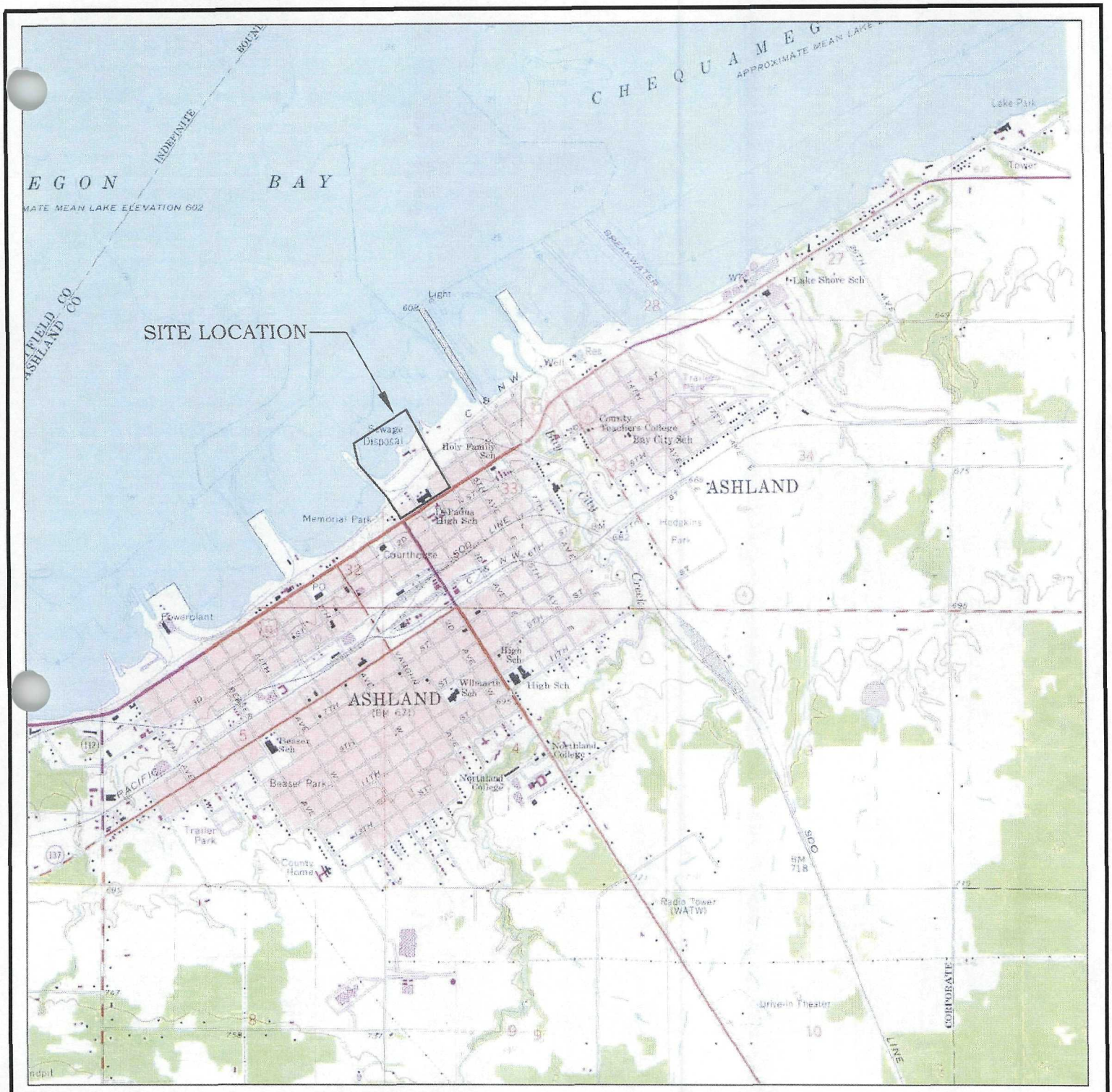
No wetlands were identified on National Wetland Inventory or Wisconsin Wetlands Inventory maps within the project site. There is no soil survey data for the project site, as it consists of dredge and fill material deposited in the 1900s. Field observations of site wetlands were made on June 15, 2005 a URS environmental scientist. Based upon a survey conducted in accordance with the U.S. Corps of Engineers Wetlands Delineation Manual one wetland was identified on site.

The wetland is located east of the Ellis Avenue Marina parking lot, along the edge of the wooded/shrub area (Figure 2.1). A small part of the wetland is south of the railroad tracks connecting to the remainder of the wetland to the north of the railroad tracks by a culvert. This wetland is approximately 0.24 acre in size with a majority (90%) of the wetland consisting of the area north of the railroad tracks. Dominant plant species included reed canary grass *(Phalaris arundinacea)*, stinging nettle *(Urtica dioica)*, sandbar willow *(Salix interior)* and Canada thistle *(Cirsium arvense)*. All but the thistle are considered wetland species. Depth to saturated soil was approximately six inches and hydric, clayey soils were present. The wetland appears to be receiving water through a seep south of the tracks. It runs through a small ditch on the south side of the tracks passing through a culvert and flowing into the north basin. The basin is primarily a wetmeadow wetland with a fringe of sandbar willow. It had a drain tile beneath the wetland, though now that drain tile has been exposed and broken allowing water to freely flow to the north toward Lake Superior. The wetland boundary was determined by presence of vegetation and hydric soils.

This wetland had been previously disturbed by grading as a result of digging test pits the day prior to the visit. The test pit was three feet by five feet wide and broke a drain tile below the wetland. This breakage allowed the water from the wetland and water entering the wetland to flow through and away from the basin. The plant material within the basin for the wetland was cut and left. These plants were identified to determine relative dominance and the soils were examined to differentiate wetland versus upland soils and thus delineate the wetland boundary. Hydrology was observed and could be approximated but had been modified due to the test pit. Photos and a completed data form for this wetland are included in Appendix B. A wetland and upland plot and data sheet were completed along a transect between the two areas to provide a delineation between them

A functional values assessment was completed for this wetland. The wetland scored low in significance for Floral Diversity, Wildlife Habitat, Fishery Habitat, Groundwater and Aesthetics/Recreation/Education. The wetland does provide a high function for Water Quality Protection from upslope runoff and provides moderate flood/stormwater attenuation. Documentation of this assessment is also included in Appendix B.

FIGURES



BASE MAP SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE, ASHLAND, WISCONSIN, DATED 1964, PHOTOREVISED 1975.

QUADRANGLE LOCATION

NORTH

0 1320 2640 5280

SCALE IN FEET

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: FIGURE 1.1
SITE LOCATION MAP

DRAWN BY: DDZ	SCALE: 1" = 2640'	PROJ. NO. 25688375
CHECKED BY: PJS	DATE: 6.APRIL.2006	SHEET: 1 OF 3
APPROVED BY: DPT		

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

0 125 250 500 750 1,000 Feet

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: **FIGURE 1.2**
2004 Aerial Photograph of the General Area of the Site

DRAWN BY:	DDZ	SCALE:	AS SHOWN	PROJECT:	25688375
CHECKED BY:	PJS	DATE:	6.APRIL.2006	SHEET:	3 OF 3
APPROVED BY:	DPT				

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

NORTH

GRAPHIC SCALE

0 62.5 125 250

(IN FEET)
1 inch = 125 ft.

LEGEND

- NPL SITE BOUNDARY
- SURFACE CONTOUR MAJOR
- SURFACE CONTOUR MINOR
- FENCE LINE
- VEGETATION AREAS
- WETLAND AREAS

Boat Launch
Bench
Interpretive Rock
Bench
Trees/shrubs
2.07 acres
Stairs
Bench
Field/meadow
GARDEN
AREA
PRENTICE AVENUE
RES.
RES.
RES.
GARAGES
RES.
RES.
RES.
ST CLAIRE STREET
XCEL
ENERGY
GARAGE
ASPHALT
PARKING LOT
Shed
GRAVEL
Lawn
Bench
Grass
Area
RES.
Interpretive Rock
Garage
GRAVEL
6" PVC
Well
Bench
BITUMINOUS WALK
Lawn
BITUMINOUS
XCEL
ENERGY
GARAGE
ASPHALT
PARKING LOT
XCEL ENERGY
MAIN OFFICE
1" PVC
3RD AVENUE
Bench
Concrete Retaining Wall
Field/meadow
FENCE LINE
Lawn
Trees/shrubs
1.8 acres
OUR LADY
OF THE
LAKE
SCHOOL
1" PVC
PLAYGROUND
PARKING LOT
CHURCH
U.S. HIGHWAY NO. 2
Total Lawn/field/meadow
area is 7.5 acres
Bridge
1" PVC
BLDG.
2ND AVENUE
EDGE OF GRASS / EDGE OF RIP-RAP
TOP OF WATER – 601.52 FEET (5/5/2005)
MARINA DRIVE
WETLAND #1
EDGE OF TAG
SHED
CANADIAN NATIONAL RAILROAD
(NON-ACTIVE)
RES.
RES.
RES.
RES.
RES.
RES.
GARAGE
WALK RAMP
BITUMINOUS WALK
WETLAND #2
RES.
Garden
GARAGE
Culvert
MARINA
PARKING
Patio
RES.
HOTEL
Gazebo
Stairs
Interpretive Rock
Sign
Bench
ELLIS AVENUE
BITUMINOUS WALK
Gazebo
Bench
Bench
Fenced Area
ELLIS AVENUE

PROJECT: ASHLAND/NSP LAKEFRONT SITE
ASHLAND, WISCONSIN

TITLE: FIGURE 2.1
COVER TYPES

DRAWN BY:	DDZ	SCALE: AS SHOWN	PROJECT: 25688375
CHECKED BY:	PJS	DATE: 6.APRIL.2006	SHEET: 2 OF 3
APPROVED BY:	DPT		

URS
10200 INNOVATION DRIVE, SUITE 500
MILWAUKEE, WISCONSIN 53226
414-831-4100

Appendix A
Agency Letters

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Green Bay ES Field Office
2661 Scott Tower Drive
New Franken, Wisconsin 54229-9565
Telephone 920/866-1717
FAX 920/866-1710

August 23, 2005

Ms. Jessica Overmohle, AICP
URS Corporation
700 Third Street South, Suite 600
Minneapolis, Minnesota 55415

re: Remedial Investigation/Feasibility Study
Ashland/NSP Lakefront Superfund Site
City of Ashland
Ashland County, Wisconsin

Dear Ms. Overmohle:

The U.S. Fish and Wildlife Service (Service) has received your letter dated July 29, 2005, requesting comments on the subject project. You requested a list of federally-listed species known from within a two-mile radius of the above-referenced project site. The project entails formulation of a work plan for field investigations and remedial actions at the Ashland/NSP Lakefront Superfund Site in Section 33, T48N, R4W, in the City of Ashland, Ashland County, Wisconsin. Our comments follow.

Federally-listed Species, Candidate Species, and Critical Habitat

According to our records, the following federally-listed threatened or endangered species, candidate species, or critical habitats are known to occur in Ashland County:

Classification	Common Name	Scientific Name	Habitat
threatened	bald eagle	Haliaeetus leucocephalus	breeding
endangered	piping plover	Charadrius melodus	sandy beaches; bare alluvial and dredge spoil islands
endangered	piping plover	Charadrius melodus	Critical habitat
endangered	gray wolf	Canis lupus	northern and central forested areas

In addition, the following species has been documented in Ashland County, but is not known to be resident or breeding within the county at this time:

Classification	Common Name	Scientific Name	Habitat
threatened	Canada lynx	Lynx canadensis	potential habitat

Currently, our records indicate that there are no federally-listed threatened or endangered species or critical habitat known within two miles of your project site. However, there may be state-listed species and sensitive natural communities in or near the project area. In addition, over time, habitats at or near the project site may be utilized by listed or proposed species not present at this time. Further, fish, wildlife or plant species occurring within the project area may become federally-listed as threatened or endangered or proposed for listing; it is also possible that critical habitat could be proposed or designated for a species. Therefore, if there is a time lag between plan completion and execution, it is important to reassess the impact of the project on federally-listed or proposed species or designated critical habitat prior to completion of the final project design and start of construction. In such instances, this office should be contacted for updated species and critical habitat information. Our species/critical habitat list is updated every 6 months.

If this project involves a Federal action (i.e., funding) and/or activity (i.e., permits), the lead Federal agency (e.g., U.S. Environmental Protection Agency), or its designated agent, is responsible for contacting the Service regarding that agency's determination as to whether the selected project alternative may affect federally-listed threatened or endangered species or adversely modify designated critical habitat. Section 7 of the Endangered Species Act of 1973, as amended (ESA), directs Federal agencies to consult with the Service on such matters. The Service would respond as to whether we concur with the determination of the Federal agency or its designated agent. If the proposed project may adversely affect federally-listed threatened or endangered species or adversely modify designated critical habitat, the Federal action agency should initiate formal consultation with the Service in accordance with section 7 of the ESA. Information on the section 7 consultation process can be obtained by contacting the staff person identified at the end of this letter.

Wetland Mitigation

In refining and selecting project alternatives, efforts should be made to select an alternative that does not adversely impact wetlands. If no other alternative is feasible and it is clearly demonstrated that project construction resulting in wetland disturbance or loss cannot be avoided, a wetland mitigation plan should be developed that identifies measures proposed to minimize adverse impacts and replace lost wetland habitat values and other wetland functions and values. Any project that impacts wetlands or waterways, including seasonally ephemeral and intermittent streams, should include design features such as culverts to retain hydrological connection between areas fragmented by the project.

We appreciate the opportunity to respond. Questions pertaining to these comments can be directed to Mr. Joel Trick at 920-866-1737.

Sincerely,

for Janet M. Smith
Field Supervisor

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Scott Hassett, Secretary

101 S. Webster St.
Box 7921
Madison, Wisconsin 53707-7921
Telephone 608-266-2621
FAX 608-267-3579
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August 17, 2005

Jessica Overmohle
URS
700 3rd Street South, Ste 700
Minneapolis, MN 55415

SUBJECT: Endangered Resources Review (ERIR Log # 05 - 213)
Remedial investigation/Feasibility Study on Ashland NSP Lakefront Superfund Site

Dear Ms. Overmohle,

The Bureau of Endangered Resources has reviewed the project area described in your letter received August 11, 2005 for the Remedial investigation/feasibility study on Ashland NSP Lakefront Superfund site.

Our Natural Heritage Inventory (NHI) data files contain the following information for the project site located in T48N R4W Section 33, Ashland County. In addition to the proposed project site, endangered resource information is provided for an area within two miles of the project's location (and within five miles for aquatic species). This information is provided both so impacts to nearby endangered resources can be assessed and to assist in determining which rare species may occur in the project's impact area. If the described habitat types exist in the project's impact area, then species that occur nearby may be present at the proposed location. Endangered resources occurring within or near the project site include:

Common tern (*Sterna hirundo*), a bird presently listed as a Special Concern species by the US Fish and Wildlife Service and Endangered in Wisconsin, is found on the Great Lakes' shorelines, bays, sand bars of large lakes and rivers, sandy or rocky coastal islands, and marshes. The breeding season extends from mid-May through late September.

Merlin (*Falco columbarius*), a State Special Concern bird, is found in coniferous forests, especially stands of spruce, along lakeshores, but may be observed in agricultural areas. The breeding season extends from early June through mid-August.

A Predaceous Diving Beetle (*Hydroporus vittatus*) a Special Concern beetle.

Marsh willow-herb (*Epilobium palustre*), a plant of Special Concern in Wisconsin. This plant prefers bog and fen mats. Blooming occurs from mid-June through late July. Optimal identification period is from early July to mid-September.

Our data files also contain historical records (generally, records that are 25 years old or older) of rare species known to occur within the vicinity of the project site. Unfortunately, the Bureau does not have more current survey information documenting the continued existence of this species in this area. These older records are included, however, as an indication of species which may occur in the project area if appropriate habitat still exists:

Small yellow water crowfoot (*Ranunculus gmelinii var. hookeri*), a plant listed as Endangered in Wisconsin. This aquatic species prefers cold brooks and springs, and the shallow water and muddy shores of ditches, streams, and lakes. Blooming occurs from mid-June through late August. Optimal identification period is from mid-June to mid-September.

Large roundleaf orchid (*Platanthera orbiculata*), a plant of Special Concern in Wisconsin. This species prefers moist hardwood or mixed conifer-hardwood forests. Blooming occurs from mid-June through late July. Optimal identification period is from mid-June to mid-August.

Northern black currant (*Ribes hudsonianum*), a plant of Special Concern in Wisconsin. This plant prefers cold, neutral to calcareous conifer woods and swamps, and algific talus slopes. Flowering occurs from mid-May through late June. Optimal identification period is from mid-May to mid-August.

> Endangered and Threatened species are provided protection under the Wisconsin Endangered Species Law (29.604 State Stats.). Special Concern (Watch) species are those about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become endangered or threatened.

Follow-up Actions:

- The **merlin** was recorded just outside the project area. Please contact our office for additional information on survey protocols if you suspect that suitable habitat for this bird exists within the project site. The **common tern** was recorded within a mile of the project area. If suitable habitat will be impacted by this project, contact our office in order to determine how to avoid impacts to this species.
- The plant species are from records within the vicinity of the project area. Please contact our office for additional information on survey protocols if you suspect that suitable habitat for the plants exists within the project site.
- The diving beetle is recorded in Bay City Creek. If the project will impact the creek, attention to water quality issues will be important.

Comprehensive endangered resource surveys have not been completed for the project area. As a result, our data files may be incomplete. The lack of additional known occurrences does not preclude the possibility that other endangered resources may be present.

The specific location of endangered resources is sensitive information that has been provided to you for the analysis and review of this project. Exact locations should not be released or reproduced in any publicly disseminated documents.

This letter is for informational purposes and only addresses endangered resource issues. This letter does not constitute Department of Natural Resources authorization of the proposed project and does not exempt the project from securing necessary permits and approvals from the Department.

Please contact me at (608) 267-2771 if you have any questions about this information.

Sincerely,

Jamelle Schlangen

Jamelle Schlangen
Bureau of Endangered Resources

CC: Ted Gostomski – DNR/Park Falls

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Please note – The Natural Heritage Information Review Request Form (1700-047) has been revised. When requesting Heritage information in the future please use the revised form (Rev. 3/05) located at http://dnr.wi.gov/org/land/er/forms/1700-047.pdf . Submittal of the old form may delay your review. Thank.you.

Appendix B
Wetland Data Forms and Photographs

DATA FORM

ROUTINE WETLAND DETERMINATION

(1987 COE Wetlands Delineations Manual)

Project/Site: ASHLAND			Date: 6/15/05
Applicant/Owner:			County: ASHLAND
Investigator(s): R - SCHMIDT			State: WI
Do Normal Circumstances exist on the site?	☒ Yes	☐ No	Community ID: W-#1
Is the site significantly disturbed (Atypical Situation)?	☒ Yes	☐ No	Transect ID:
Is the area a potential Problem Area? (If needed, explain on reverse)	☐ Yes	☒ No	Plot ID:
			GPS Coordinates:

SITE HAS BEEN DISTURBED BY GRADING.

VEGETATION

Dominant Plant Species	% Cover	Stratum	Indicator	Dominant Plant Species	% Cover	Stratum	Indicator
1. RCG	70	H	FW+	9.			
2. S.B. WILLOW	60	S	OBL	10.			
3. STINGING NETTLE	20	H	F+	11.			
4. THISTLE	40	H	FU-	12.			
5.				13.			
6.				14.			
7.				15.			
8.				16.			

Percent of Dominant Species that are OBL, FACW, or FAC (excluding FAC-):

Remarks: 3/4 WETLAND SPECIES

HYDROLOGY

☐ Recorded Data (Describe in Remarks)
- ☐ Stream, Lake, or Tide Gauge
- ☐ Aerial Photographs
- ☐ Other

☐ No Recorded Data Available

Field Observations:

Depth of Surface Water: _____ (In.)

Depth to Saturated Soil: 6 (In.)

Depth to Saturated Soil: _____ (In.)

Wetland Hydrology Indicators:

Primary Indicators:
- ☐ Inundated
- ☒ Saturated in Upper 12 Inches
- ☐ Water Marks
- ☐ Drift Lines
- ☐ Sediment Deposits
- ☐ Drainage Patterns in Wetlands

Secondary Indicators (2 or more Required):
- ☐ Oxidized Root Channels in Upper 12 Inches
- ☐ Water-Stained Leaves
- ☐ Local Soil Survey Data
- ☐ FAC-Neutral Test
- ☐ Other (Explain in Remarks)

Remarks:

GRADING WAS COMPLETED FOR TEST PITS. SEEMS TO BE IN BOTTOM OF BASIN, SO DELINEATION BOUNDARY WAS PLACED ON EDGE OF BASIN WHERE WETLAND VEGETION BECOMES DOMINATE.

X-section

ROUTINE WETLAND DETERMINATION

(1987 COE Wetlands Delineations Manual)

SOILS

Map Unit Name (Series and Phase): | Drainage Class:

Taxonomy (Subgroup): | Field Observations Confirm Mapped Type? ☐ Yes ☐ No

Profile Description:

Depth (Inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle (Abundance/Contrast)	Texture, Concretions, Structure, etc.
0-7	A	10YR 3/2	10R 3/1	FEW/DIST.	FINE/CLAY
7-18	B	10YR 3/1	10R 3/1	MANY/DIST.	CLAY

Hydric Soil Indicators:
- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture regime
- ☐ Reducing Conditions
- ☒ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed on Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	☒ Yes	☐ No	Is this Sampling Point Within a Wetland?
Wetland Hydrology Present?	☒ Yes	☐ No	☐ Yes ☐ No
Hydric Soils Present?	☒ Yes	☐ No	

Remarks:

Wetland Type:
Stakes:
Photos:

plan view

N/4

DATA FORM

ROUTINE WETLAND DETERMINATION

(1987 COE Wetlands Delineations Manual)

Project/Site:	Date: 6/15/05
Applicant/Owner:	County: ASHLAND
Investigator(s): R. SCHMIDT	State: WI
Do Normal Circumstances exist on the site? ☐ Yes ☐ No	Community ID: U-#1
Is the site significantly disturbed (Atypical Situation)? ☐ Yes ☐ No	Transect ID:
Is the area a potential Problem Area? (If needed, explain on reverse) ☐ Yes ☐ No	Plot ID:
	GPS Coordinates:

VEGETATION

Dominant Plant Species	% Cover	Stratum	Indicator	Dominant Plant Species	% Cover	Stratum	Indicator
1. THISTLE	70	H	FU-	9.			
2. CANADA GOLD	50	H	FU	10.			
3.				11.			
4.				12.			
5.				13.			
6.				14.			
7.				15.			
8.				16.			

Percent of Dominant Species that are OBL, FACW, or FAC (excluding FAC-):

Remarks: 0/2 WETLAND SPECIES

HYDROLOGY

☐ Recorded Data (Describe in Remarks)
- ☐ Stream, Lake, or Tide Gauge
- ☐ Aerial Photographs
- ☐ Other

☐ No Recorded Data Available

Field Observations:

Depth of Surface Water: _____ (In.)

Depth to Saturated Soil: _____ (In.)

Depth to Saturated Soil: _____ (In.)

Wetland Hydrology Indicators:

Primary Indicators:
- ☐ Inundated
- ☐ Saturated in Upper 12 Inches
- ☐ Water Marks
- ☐ Drift Lines
- ☐ Sediment Deposits
- ☐ Drainage Patterns in Wetlands

Secondary Indicators (2 or more Required):
- ☐ Oxidized Root Channels in Upper 12 Inches
- ☐ Water-Stained Leaves
- ☐ Local Soil Survey Data
- ☐ FAC-Neutral Test
- ☐ Other (Explain in Remarks)

Remarks: NOT SAT

ROUTINE WETLAND DETERMINATION

(1987 COE Wetlands Delineations Manual)

SOILS

Map Unit Name (Series and Phase): Drainage Class:

Taxonomy (Subgroup): Field Observations Confirm Mapped Type? ☐ Yes ☐ No

Profile Description:

Depth (Inches)	Horizon	Matrix Color (Munsell Moist)	Mottle Colors (Munsell Moist)	Mottle (Abundance/Contrast)	Texture, Concretions, Structure, etc.
0-20	A	10YR 3/2	—	—	FILL CLAY

Hydric Soil Indicators:
- ☐ Histosol
- ☐ Histic Epipedon
- ☐ Sulfidic Odor
- ☐ Aquic Moisture regime
- ☐ Reducing Conditions
- ☐ Gleyed or Low-Chroma Colors
- ☐ Concretions
- ☐ High Organic Content in Surface Layer in Sandy Soils
- ☐ Organic Streaking in Sandy Soils
- ☐ Listed on Local Hydric Soils List
- ☐ Listed on National Hydric Soils List
- ☐ Other (Explain in Remarks)

Remarks:

WETLAND DETERMINATION

Hydrophytic Vegetation Present?	☐ Yes	☒ No
Wetland Hydrology Present?	☐ Yes	☒ No
Hydric Soils Present?	☐ Yes	☒ No

Is this Sampling Point Within a Wetland? ☐ Yes ☐ No

Remarks:

W:\WP\TEMPLATE\EMD TEMPLATES\WETLAND DELIN.XLS\9/19/2003\SDG

January, 2001

File or Docket Number

Wisconsin Department of Natural Resources

RAPID ASSESSMENT METHODOLOGY FOR EVALUATING WETLAND FUNCTIONAL VALUES

GENERAL INFORMATION

Name of Wetland/Owner:	
Location: County ASHLAND ; ¼, ¼, Section , Township , Range	
Project Name: THE ASHLAND / NSP LAKEFRONT SUPERFUND SITE	
Evaluator(s): RUSTY SCHMIDT	
Date(s) of Site Visit(s): 6/15/05	

Description of seasonality limitations of this inspection due to time of year of the evaluation and/or current hydrologic and climatologic conditions (e.g. after heavy rains, snow or ice cover, during drought year, during spring flood, during bird migration):

WETLAND DESCRIPTION

Wisconsin Wetlands Inventory classification:					
Wetland Type:	shallow open water	deep marsh	shallow marsh	seasonally flooded basin	bog
	floodplain forest	alder thicket	sedge meadow	coniferous swamp	fen
	(wet meadow)	shrub-carr	low prairie	hardwood swamp	
Estimated size of wetland in acres: 0.24 Ac.					

SUMMARY OF FUNCTIONAL VALUES

Based on the results of the attached functional assessment, rate the significance of each of the functional values for the subject wetland and check the appropriate box. Complete the table as a summary.

FUNCTION	SIGNIFICANCE				
	Low	Medium	High	Exceptional	N/A
Floral Diversity	X				
Wildlife Habitat	X				
Fishery Habitat	X				
Flood/Stormwater Attenuation		X			
Water Quality Protection			X		
Shoreline Protection					X
Groundwater	X				
Aesthetics/Recreation/Education	X				

List any Special Features/"Red Flags": WETLAND IS W/IN THE STATE COASTAL ZONE MGMT. PROGRAM, NEAR LAKE SUPERIOR WHICH IS AN ENV. SENSITIVE AREA.

SITE DESCRIPTION

I. HYDROLOGIC SETTING

A. Describe the geomorphology of the wetland:

☒ Depressional (includes slopes, potholes, small lakes, kettles, etc.)
☐ Riverine
☐ Lake Fringe
☐ Extensive Peatland

B. (Y) N Has the wetland hydrology been altered by ditching, tiles, dams, culverts, well pumping, diversion of surface flow, or changes to runoff within the watershed (circle those that apply)?

C. (Y) N Does the wetland have an inlet, outlet, or both (circle those that apply)?

D. (Y) N Is there any field evidence of wetland hydrology such as buttressed tree trunks, adventitious roots, drift lines, water marks, water stained leaves, soil mottling/gleying, organic soils layer, or oxidized rhizospheres (circle those that apply)?

E. (Y) N Does the wetland have standing water, and if so what is the average depth in inches? 6 "
Approximately how much of the wetland is inundated? 30 %

F. How is the hydroperiod (seasonal water level pattern) of the wetland classified?

☐ Permanently Flooded
☒ Seasonally Flooded (water absent at end of growing season)
☐ Saturated (surface water seldom present)
☐ Artificially Flooded
☐ Artificially Drained

G. Y (N) Is the wetland a navigable body of water or is a portion of the wetland below the ordinary high-water mark of a navigable water body? List any surface waters associated with the wetland or in proximity to the wetland (note approximate distance from the wetland and navigability determination). Note if there is a surface water connection to other wetlands.

IT IS NEXT TO AND DISCHARGES TO LAKE SUPERIOR APPROXIMATELY 300' AWAY

II. VEGETATION

A. Identify the vegetation communities present and the dominant species.

	floating leaved community dominated by:
	submerged aquatic community dominated by:
X	emergent community dominated by: REED CANARY GRASS w/ SAND BAR WILLOW FRINGE
	shrub community dominated by:
	deciduous broad-leaved tree community dominated by:
	coniferous tree community dominated by:
	open sphagnum mat or bog
	sedge meadow/wet prairie community dominated by:
	other (explain)

B. Other plant species identified during site visit:

WILLOW IS ON EDGE OF WETLAND - MOST OF THE WETLAND WAS DISTURBED BY CLEARING TO DO A TEST PIT. ALL VEGETATION WAS CUT BUT LEFT ON SITE.

ALSO W/IN THE SAND BAR WILLOW FRINGE WAS STINGING NETTLE AND CANADA THISTLE IN HIGH ABUNDANCE

THE WILLOW IS A FRINGE OF APPROXIMATELY 30% OF WETLAND.

III. SOILS

A. NRCS Soil Map Classification: FILL AND DREDGE MATERIAL

B. Field description:

☐ Organic (histosol)? If so, is it a muck or a peat?

☒ Mineral soil?

- Mottling, gleying, sulfidic materials, iron or manganese concretions, organic streaking (circle those that apply)
- Soil Description: FILL / CLAY
- Depth of mottling/gleying: TOP 18" INCHES
- Depth of A Horizon: 0-7 INCHES
- Munsell Color of matrix and mottles
  - -Matrix below the A horizon (10"depth): 10 YR 3/1
  - -Mottles: 10 R 3/1

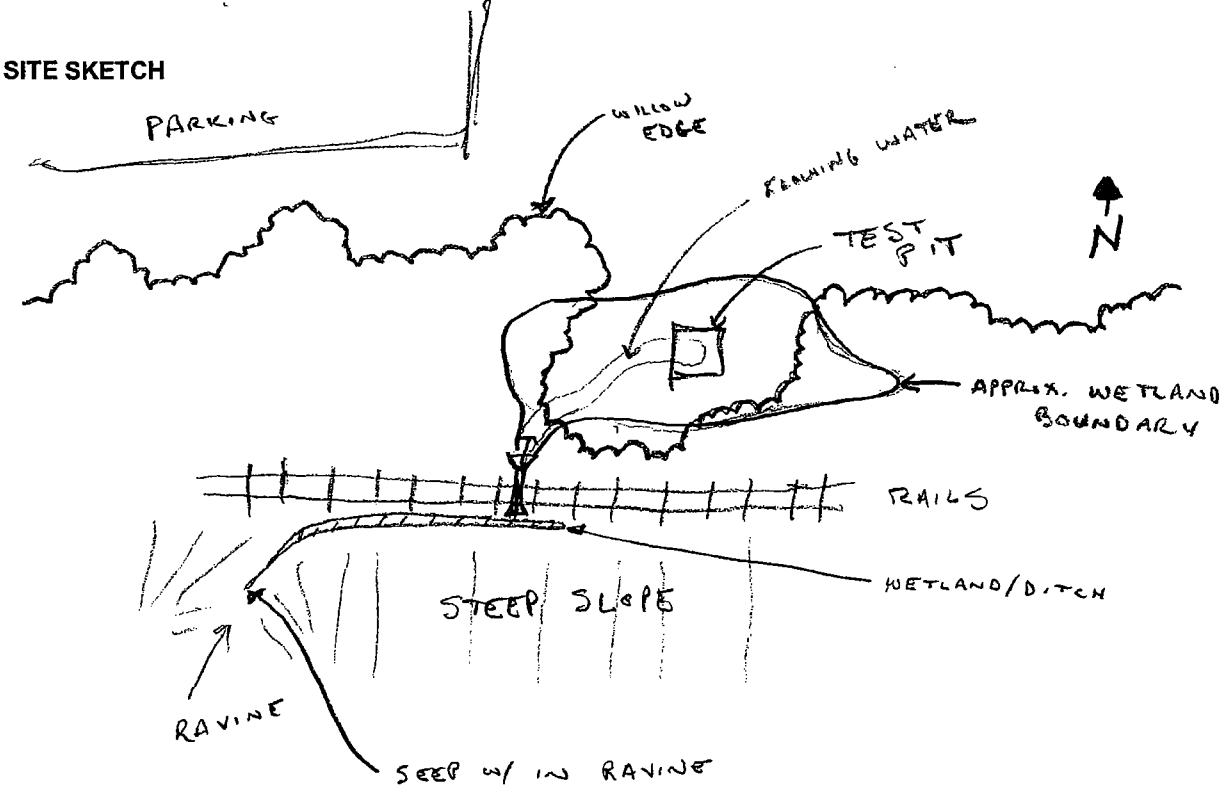
V. SURROUNDING LAND USES

A. What is the estimated area of the wetland watershed in acres? UNKNOWN - GROUND WATER FED THROUGH SEEP. THOUGH RUNNING COLD & FAST

B. What are the surrounding land uses?

LAND-USE	ESTIMATED % OF WETLAND WATERSHED
Developed (Industrial/Commercial/Residential)	PROBABLY 90%
Agricultural/cropland	
Agricultural/grazing	
Forested	
Grassed recreation areas/parks	
Old field	
Highways or roads	10%
Other (specify)	

VI. SITE SKETCH



FUNCTIONAL ASSESSMENT

The following assessment requires the evaluator to examine site conditions that provide evidence that a given functional value is present and to assess the significance of the wetland to perform those functions. Positive answers to questions indicate the presence of factors important for the function. The questions are not definitive and are only provided to guide the evaluation. After completing each section, the evaluator should consider the factors observed and use best professional judgement to rate the significance. The ratings should be recorded on page 1 of the assessment.

SPECIAL FEATURES/"RED FLAGS"

1. (Y) **N** Is the wetland in or adjacent to an area of special natural resource interest (NR 103.04, Wis. Adm. Code)? If so, check those that apply:

- ☐ Cold water community as defined in s. NR 102.04(3)(b), Wis. Adm. Code, including trout streams, their tributaries, and trout lakes
- ☒ Lakes Michigan and Superior and the Mississippi River
- ☐ State or federal designated wild and scenic river
- ☐ Designated state riverway
- ☐ Designated state scenic urban waterway
- ☒ Environmentally sensitive area or environmental corridor identified in an area-wide water quality management plan, special area management plan, special wetland inventory study, or an advanced delineation and identification study
- ☐ Calcareous fen
- ☐ State park, forest, trail or recreation area
- ☐ State and federal fish and wildlife refuges and fish and wildlife management areas
- ☐ State or federal designated wilderness area
- ☐ Designated or dedicated state natural area
- ☐ Wild rice water listed in ch. NR 19.09, Wis. Adm. Code
- ☐ Surface water identified as an outstanding or exceptional resource water in ch. NR 102, Wis. Adm. Code

2. **Y** (N) According to the Natural Heritage Inventory (Bureau of Endangered Resources) or direct observations, are there any rare, endangered, or threatened plant or animal species in, near, or using the wetland or adjacent lands? If so, list the species of concern:

A LETTER HAS BEEN SENT TO THE U.S. FISH & WILDLIFE SERVICE, THE WDNR, & THE NATIONAL MARINE FISHERIES SERVICE

NO OBSERVATIONS OF T&E SPECIES OR HABITAT WERE @ THE SITE OR SURROUNDING AREA.

3. (Y) **N** Is the project located in an area that requires a State Coastal Zone Management Plan consistency determination?

Floral Diversity

1. **Y** (N) Does the wetland support a variety of native plant species (i.e. not a monotypic stand of cattail or giant reed grass and/or not dominated by exotic species such as reed canary grass, brome grass, buckthorn, purple loosestrife, etc.)?

2. **Y** (N) Is the wetland plant community regionally scarce or rare?

Wildlife and Fishery Habitat

1. List any species observed, evidenced (e.g. tracks, scat, nest/burrow, calls), or expected to utilize the wetland: RED WINGED BLACKBIRDS

2. Y (N) Does the wetland contain a number of diverse vegetative cover types and a high degree of interspersion of those vegetation types?

3. Y (N) Is the estimated ratio of open water to cover between 30 and 70 percent? What is the estimated ratio? 10 %

4. Y (N) Does the surrounding upland habitat likely support a variety of animal species?

5. (Y) N Is the wetland part of or associated with a wildlife corridor or designated environmental corridor? CORRIDOR ALONG THE SHORE OF LAKE SUPERIOR

6. Y (N) Is the surrounding habitat and/or the wetland itself a large tract of undeveloped land important for wildlife that requires large home ranges (e.g. bear, woodland passerines)?

7. (Y) N Is the surrounding habitat and/or the wetland itself a relatively large tract of undeveloped land within an urbanized environment that is important for wildlife? LAKE SUPERIOR

8. Y (N) Are there other wetland areas near the subject wetland that may be important to wildlife?

9. Y (N) Is the wetland contiguous with a permanent waterbody or periodically inundated for sufficient periods of time to provide spawning/nursery habitat for fish?

10. Y (N) Can the wetland provide significant food base for fish and wildlife (e.g. insects, crustaceans, voles, forage fish, amphibians, reptiles, shrews, wild rice, wild celery, duckweed, pondweeds, watermeal, bulrushes, bur reeds, arrowhead, smartweeds, millets...)?

11. Y (N) Is the wetland located in a priority watershed/township as identified in the Upper Mississippi and Great Lakes Joint Venture of the North American Waterfowl Management Plan?

12. Y (N) Is the wetland providing habitat that is scarce to the region?

Flood and Stormwater Storage/Attenuation

1. (Y) N Are there steep slopes, large impervious areas, moderate slopes with row cropping, or areas with severe overgrazing within the watershed (circle those that apply)?

2. Y (N) Does the wetland significantly reduce run-off velocity due to its size, configuration, braided flow patterns, or vegetation type and density?

3. Y (N) Does the wetland show evidence of flashy water level responses to storm events (debris marks, erosion lines, stormwater inputs, channelized inflow)?

4. Y (N) Is there a natural feature or human-made structure impeding drainage from the wetland that causes backwater conditions?

5. (Y) N Considering the size of the wetland area in relation to the size of its watershed, at any time during the year is water likely to reach the wetland's storage capacity (i.e. the level of easily observable wetland vegetation)? [For some cases where greater documentation is required, one should determine if the wetland has capacity to hold 25% of the run-off from a 2 year-24 hour storm event.]

6. (Y) N Considering the location of the wetland in relation to the associated surface water watershed, is the wetland important for attenuating or storing flood or stormwater peaks (i.e. is the wetland located in the mid or lower reaches of the watershed)?

Water Quality Protection

1. (Y) N Does the wetland receive overland flow or direct discharge of stormwater as a primary source of water (circle that which applies)?

2. Y (N) Do the surrounding land uses have the potential to deliver significant nutrient and/or sediment loads to the wetland?

3. (Y) N Based on your answers to the flood/stormwater section above, does the wetland perform significant flood/stormwater attenuation (residence time to allow settling)?

4. (Y) N Does the wetland have significant vegetative density to decrease water energy and allow settling of suspended materials?

5. (Y) N Is the position of the wetland in the landscape such that run-off is held or filtered before entering a surface water?

6. Y (N) Are algal blooms, heavy macrophyte growth, or other signs of excess nutrient loading to the wetland apparent (or historically reported)?

Shoreline Protection

1. Y (N) Is the wetland in a lake fringe or riverine setting? If NO, STOP and enter "not applicable" for this function. If YES, then answer the applicable questions.

2. Y N Is the shoreline exposed to constant wave action caused by long wind fetch or boat traffic?

3. Y N Is the shoreline and shallow littoral zone vegetated with submerged or emergent vegetation in the swash zone that decrease wave energy or perennial wetland species that form dense root mats and/or species that have strong stems that are resistant to erosive forces?

4. Y N Is the stream bank prone to erosion due to unstable soils, land uses, or ice floes?

5. Y N Is the stream bank vegetated with densely rooted shrubs that provide upper bank stability?

Groundwater Recharge and Discharge

1. (Y) N Related to discharge, are there observable (or reported) springs located in the wetland, physical indicators of springs such as marl soil, or vegetation indicators such as watercress or marsh marigold present that tend to indicate the presence of groundwater springs?

2. Y (N) Related to discharge, may the wetland contribute to the maintenance of base flow in a stream?

3. Y (N) Related to recharge, is the wetland located on or near a groundwater divide (e.g. a topographic high)?

Aesthetics/Recreation/Education and Science

1. Y N Is the wetland visible from any of the following kinds of vantage points: roads, public lands, houses, and/or businesses? (Circle all that apply.)

2. Y N Is the wetland in or near any population centers?

3. Y N Is any part of the wetland is in public or conservation ownership?

4. Y N Does the public have direct access to the wetland from public roads or waterways? (Circle those that apply.)

5. Is the wetland itself relatively free of obvious human influences, such as:

   a. Y N Buildings? e. Y N Pollution?
   b. Y N Roads? f. Y N Filling?
   c. Y N Other structures? g. Y N Dredging/draining?
   d. Y N Trash? h. Y N Domination by non-native vegetation?

6. Is the surrounding viewshed relatively free of obvious human influences, such as:
   a. Y N Buildings?
   b. Y N Roads?
   c. Y N Other structures?

7. Y N Is the wetland organized into a variety of visibly separate areas of similar vegetation, color, and/or texture (including areas of open water)?

8. Y N Does the wetland add to the variety of visibly separate areas of similar vegetation, color, and/or texture (including areas of open water) within the landscape as a whole?

9. Does the wetland encourage exploration because any of the following factors are present:
   a. Y N Long views within the wetland?
   b. Y N Long views in the viewshed adjacent to the wetland?
   c. Y N Convoluted edges within and/or around the wetland border?
   d. Y N The wetland provides a different (and perhaps more natural/complex) kind of environment from the surrounding land covers?

10. Y N Is the wetland currently being used for (or does it have the potential to be used for) the following recreational activities? (Check all that apply.)

ACTIVITY	CURRENT USE	POTENTIAL USE
Nature study/photography		
Hiking/biking/skiing		
Hunting/fishing/trapping		
Boating/canoeing		
Food harvesting		
Others (list)		

11. Y N Is the wetland currently being used, and/or does it have the potential for use for educational or scientific study purposes (circle that which applies)?

URS

PHOTOGRAPHIC LOG

Client Name:		Project No.
Northern States Power Co. – WI	Ashland/NSP Lakefront Site – Ashland, WI	25688375

Photo No. 1

Direction Photo Taken: North

Description View from railroad tracks looking north into wetland.

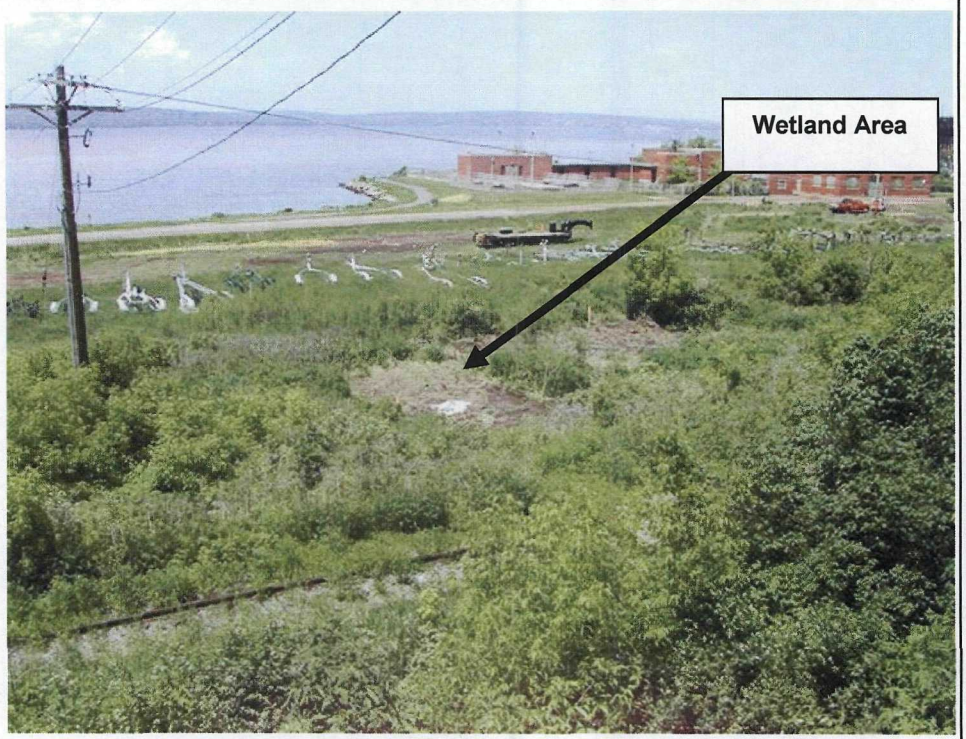


Photo No. 2

Direction Photo Taken: Southwest

Description: View within wetland facing southwest.

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Dose Rate Modeling for Wildlife Receptors

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The purpose of this appendix is to present and describe development of several aspects of the dose rate modeling for wildlife receptors identified in the Baseline Ecological Risk Assessment (BERA) of the Ashland/NSP Lakefront Superfund Site located in Ashland, Wisconsin. The following sections provide a detailed description of the development of species-specific exposure parameters, bioaccumulation factors (BAFs), biota sediment accumulation factors (BSAFs), bioavailability adjustments, area use factors (AUFs), and toxicity reference values (TRVs).

Simplified food web models were developed to calculate average daily doses (ADDs) of COPCs that selected receptor groups experience through exposure to sediment and surface soil at the Ashland/NSP Lakefront Superfund Site. The ADD represents the dose of a chemical that a receptor may ingest if it foraged within aquatic and terrestrial habitats at the site. ADDs for wildlife receptors are calculated using (1) exposure-point concentrations for prey and media and (2) receptor-specific exposure parameters and food chain model assumptions. These ADDs can then be compared to TRVs, which represent no observable adverse effects levels (NOAELs) or lowest observable adverse effects levels (LOAELs). The following sections describe the calculation of ADDs including the derivation of exposure parameters, BAFs, BSAF, bioavailability adjustments, and AUFs.

The dose rate modeling results for terrestrial and aquatic exposure units at the Ashland Site are presented in Appendix I.

The simplified food web model considers the primary routes of exposure to wildlife receptors: the direct ingestion of prey and the incidental ingestion of media. Chemical concentrations in prey are expressed as a function of chemical concentrations in exposure media (i.e., soil and sediment) using BAFs for terrestrial prey items and BSAF for aquatic prey items. Other important parameters in the model include, receptor body weight, food and water ingestion rates, and an estimate of area use.

The total dose (ADD_{total}) experienced by each selected receptor is the sum of the doses obtained from the two primary routes of exposure:

$$ADD_{total} = ADD_{diet} + ADD_{substrate}$$

In the model, the total dose from each route of exposure is calculated individually as follows:

Dietary Dose:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (C_{food} \times DF_i) \times AUF}{BW}$$

where:

ADD_{diet}	= Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet}	= Ingestion rate of food (kg food ingested per day, dry weight)
C_{food}	= Concentration of COPCs in food item *i* (mg COPC/kg food item, dry weight)
DF_i	= Dietary fraction of food item *i* (proportion of food type in the diet)
AUF	= Area use factor includes, when appropriate, seasonal use rates, area use rates, and COPC assimilation rate
BW	= Body weight of the receptor, wet weight (kg)

Substrate Dose:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

$ADD_{substrate}$	= Dose of COPC obtained from drinking water (mg COPC/kg receptor body weight-day)
IR_S	= Incidental ingestion rate of soil (kg substrate ingested per day, dry weight)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)
AUF	= Area use factor includes, when appropriate, seasonal use rates, area use rates, and COPC assimilation rate
BW	= Body weight of the receptor, wet weight (kg)

The receptor dose of COPCs from diet and incidental substrate ingestion is modeled using dry weight parameters. To avoid introducing unnecessary uncertainty into the model by converting parameters from dry weight to wet weight based on approximate moisture contents of dietary items, model parameters for food ingestion rates, substrate ingestion rates, and substrate-to-biota accumulation rates are expressed on a dry weight basis.

The model includes parameters relating to receptor-specific exposure factors, bioaccumulation factors, and area use factors. The following sections describe the estimation of these parameters and the major assumptions of parameterization.

3.1 RECEPTOR-SPECIFIC EXPOSURE PARAMETERS

A BERA cannot specifically evaluate the potential for adverse effects to every plant, animal, and microbial species that may be present and potentially exposed in the area around the former Site and associated water bodies. As a result, receptors that are representative of high ecological or societal value, or those believed to be representative of broader groups of organisms, were selected as "receptors of concern (ROC)" for evaluation in the BERA.

Each species selected as an ROC reflects an assessment endpoint and considers trophic category and particular feeding behaviors (e.g., fish-eating birds versus worm-eating birds) that represent different modes of exposure to COPCs. Consequently, the species that were chosen for evaluation may represent several similarly exposed species in the area.

The following criteria were used to select potential receptors:

- The receptor does or could use habitats that are present around the Site; ?
- The receptor is important to either the structure or function of the ecosystem;
- The receptor is statutorily protected (i.e., threatened or endangered species, migratory birds) or is otherwise highly valued by society (i.e., species of cultural importance);
- The receptor is reflective and representative of the assessment endpoints for the Site area; and
- The receptor is known to be either sensitive or highly exposed to COPCs around the Site.

Aquatic and semi-aquatic wildlife receptors selected to characterize exposure from the Ashland Site include:

- Piscivorous birds: double-crested cormorant (*Phalacrocorax auritus*);
- Piscivorous birds: osprey (*Pandion haliaetus*);
- Aerial insectivorous birds: tree swallow (*Tachycineta bicolor*);
- Omnivorous birds: black duck (*Anas rubripes*);
- Aerial insectivorous mammals: big brown bat (*Eptesicus fuscus*);
- Semi-aquatic piscivorous mammals: mink (*Mustela vison*); and

Terrestrial wildlife receptors selected to characterize exposure from the Ashland Site include:

- Omnivorous birds: red-winged blackbird (*Agelaius phoeniceus*);
- Omnivorous mammals: white-footed mouse (*Peromyscus leucopus*);

Exposure parameters used to determine the ADD for each receptor include body weight (kg, wet weight), food ingestion rate (kg dry weight/day), incidental substrate ingestion rate (kg dry weight/day), dietary composition, and area use factor. Typical body weights for receptors were obtained from various literature sources for use in the models (Table F-1). Food ingestion rates

were estimated as a function of body weight using allometric regression models developed by Nagy (2001) for various types of mammalian and avian receptors. Incidental substrate ingestion rates were obtained from Beyer et al. (1994) and Sample and Suter (1994). Dietary composition and area use information (i.e., typical home range) were obtained from literature sources, including USEPA (1993), Sample and Suter (1994), and various receptor-specific sources. Exposure information for each receptor species is summarized in Table F-1. Detailed species accounts for each receptor are provided in section 3.1.1.

3.1.1 Receptor of Concern Life Histories

Species profiles for each of the representative species are presented in the following sections. Exposure parameters for each ROC are summarized in Table F-1.

DOUBLE-CRESTED CORMORANT (*PHALACROCORAX AURITUS*)

Double-crested cormorant (Order: Pelecaniformes, Family: Phalacrocoracidae) is the most numerous and widespread North American cormorant (Cornell 2003). Double-crested cormorants generally feed in shallow water, diving underwater to catch their prey. They feed primarily on fish, but occasionally eat insects, amphibians, and crustaceans (Kirschbaum and Ward 2000).

Status:

Double-crested cormorants are an unmanaged, migratory non-game species.

Distribution:

Double-crested cormorants breed across North America, from Alaska to Nova Scotia. They winter in North America as far south as Mexico. They are commonly found on marine and inland waters throughout their range (Kirschbaum and Ward 2000).

Habitat and Home Range:

Double-crested cormorants are found in a variety of brackish and freshwater habitats. They rest and dry out during the day on perches such as rocks, pilings, sandbars, wires, trees, or docks (Kirschbaum and Ward 2000). Custer and Bunck (1992) reported that double-crested cormorants from two breeding colonies in Wisconsin foraged an average of 2.0 and 2.4 km from the colonies.

Population Density:

Double-crested cormorants are monogamous and breed in colonies of up to three thousand pair and often feed in large flocks. Breeding birds typically use the same colony and nesting location year after year.

Reproduction/Breeding:

Double-crested cormorants breeds between April and August. Males arrive at the colony first and choose a nesting site. Nests are built in trees, on structures, or on the ground and are made up of twigs, sticks, and seaweed (Kirschbaum and Ward 2000). The female lays from 2 to 6 eggs that are bluish to white in color with a chalky coating. The eggs are incubated by both parents for 25-29 days. The young are altricial and are cared for by both parents. Young

cormorants are able to swim before they can fly, usually between 3 and 6 weeks of age (Mitchell 1977). Cormorant chicks become independent at approximately 10 weeks of age (Palmer 1988).

Physiological Parameters:

The body weight of double-crested cormorants is 1.7 kg (Sibley 2000). Based on allometric equations developed for carnivorous birds (Nagy 2001), double-crested cormorants consume food at an approximate rate of 0.118 kg dry weight per day and water at an approximate rate of 0.084 L per day (estimated from allometric regression in Sample and Suter 1994). Sample and Suter (1994) assumes the incidental ingestion of sediment by piscivores to be negligible.

OSPREY (*PANDION HALIAETUS*)

Osprey (Order: Falconiformes, Family: Pandionidae) are summer residents in Wisconsin (WDNR 2003). Osprey consume primarily fish 10 to 30 centimeters long and rarely small mammals, reptiles or birds (Peterson 1995). They concentrate on fish common to the area and hunt by hovering 15 to 30 meters and then diving for their prey.

Status:

Osprey is a protected (Wisconsin-Threatened), non-game species.

Distribution:

Osprey are found worldwide. Their breeding range along the East Coast is from Maine to Florida; osprey winter in Florida and the Gulf states (DeGraaf et al. 1986).

Habitat and Home Range:

Osprey are found near larger bodies of fresh or salt water where fish are abundant (DeGraaf et al.1986). Nesting habitat is adjacent to rivers, reservoirs, lakes and particularly in estuarine and coastal areas. Shallow water allows them to hunt for fish close to the surface. Osprey have a home range that varies from 3 to 10 kilometers (USEPA 1993).

Population Density:

Distance between nests has been reported from a minimum of 20 meters (Ogden 1975 in DeGraaf et al 1986) to 32 kilometers (Singer 1974 in DeGraaf et al. 1986).

Reproduction/Breeding:

Osprey typically nest in tall trees and tall man-made structures including utility poles, channel markers and dedicated platforms. Rocky ledges and sand dunes may also be used. Pairs may use the same nests for numerous years. In New York, eggs are laid late April to the end of June

(Bull 1984 in DeGraaf et al 1986). Clutch size is typically two to four creamy white eggs, blotched with brown (Peterson 1995). Incubation responsibilities are primarily for the female (Peterson 1995) and the incubation period is about 28 days (DeGraaf et al 1986). Young ospreys fledge at about 8 to 10 weeks and mature in about 3 years.

Physiological Parameters:

The body weight of osprey is 1.6 kg (Sample and Suter 1994). Based on allometric equations developed for carnivorous birds (Nagy 2001), osprey consume food at an approximate rate of 0.113 kg dry weight per day and water at an approximate rate of 0.081 L per day (estimated from

allometric regression in Sample and Suter 1994). Sample and Suter (1994) assumes the incidental ingestion of sediment by piscivores to be negligible.

TREE SWALLOW (*TACHYCINETA BICOLOR*)

Tree swallows (Order: Passeriformes, Family: Hirundinidae) are abundant throughout Wisconsin. Their primary forage in summer is flying insects which they catch on-the-wing in their bills or from skimming the water surface. They may also consume other invertebrates such as spiders, winged ants and beetles (Peterson 1995). Berries and seeds supplement their winter diet when they may feed on the ground.

Status:

Tree swallows are an unmanaged, migratory non-game species.

Distribution:

The breeding range of tree swallows extends from Newfoundland west to northern Alaska, south to Maryland, Virginia, Colorado and California. Their winter range is coastal areas from Virginia south Mexico, Central America, and southern California. Tree swallows may winter as far north as Long Island (DeGraaf et al. 1986).

Habitat and Home Range:

While on their breeding grounds, tree swallows are found in open areas including farmland, river bottomlands, beaver ponds, wooded swamps and marshes where dead standing trees provide nesting habitat. They require open areas for feeding as found in meadows, marshes, or water. Nest boxes are also used for nesting in the Northeast due to increased competition for nesting space in natural settings (DeGraaf et al 1986). For nesting, they require a minimum tree size of 25 centimeters diameter-at-breast-height (DBH). In winter they prefer bayberry thickets and coastal areas (Peterson 1995). The home range of tree swallows is large, possibly up to 60 kilometers prior to incubation (Robertson et al. 1992). However, tree swallows only defend territories that are restricted to the area surrounding the nest site (DeGraaf et al. 1986).

Population Density:

Tree swallows tolerate proximity to each other. Where food is plentiful, they have been known to nest within two meters of each other in Illinois (Beecher 1942 in DeGraaf et al. 1986). Where nest boxes have been placed, densities of up to 150 pairs can be found where the boxes are no less than two meters apart (Whittle 1926 in DeGraaf et al 1986).

Reproduction/Breeding:

In New York, eggs are laid from early May to late June (Bull 1974 as cited in DeGraaf et al. 1986). One clutch of 4 to 7 eggs is laid per year. The incubation period is 13 – 16 days. Nestlings are altricial and leave the nest at 16 – 24 days. Sexual maturity is reached at 1 year (DeGraaf et al. 1986). Both adults tend to the young until they fledge. They nest alone or in colony and, outside of the breeding season, often forms large flocks up to several hundred thousand birds.

Physiological Parameters:

Tree swallows weigh approximately 0.02 kg (Sibley 2000). They consume food at an approximate rate of 0.012 kg dry weight per day (Nagy 2001) and water at an approximate rate

of 0.004 L per day (estimated from allometric regression in Sample and Suter 1994). Incidental ingestion of soil is assumed to be negligible for tree swallows because they are aerial feeders with limited contact with the ground.

BLACK DUCK (*ANAS RUBRIPES*)

Black ducks (Order: Anseriformes, Family: Anatidae) are common throughout Wisconsin. Black ducks feed on seeds, roots, tubers, stems, aquatic insects, crustaceans, mollusks, and fish, especially in marine habitats (Longcore et al 2000).

Status:

The black duck is an unmanaged, non-game species.

Distribution:

Black ducks breed from the upper Mississippi River across to the northeastern United States through the eastern Canadian provinces. Their winter range includes the southern portion of their breeding range south to the Gulf Coast and northern half of Florida (Longcore et al 2000).

Habitat and Home Range:

Black ducks breed in a variety of wetland habitats from saltwater marshes to freshwater impoundments to boreal bogs and swamps. The black duck winters mostly in salt water even though it is primarily a freshwater breeder (Longcore et al 2000).

Population Density:

Population densities of nests on St Louis Island ranged from 0.4-2.2 nests per hectare (Longcore et al 2000).

Reproduction/Breeding:

Black ducks form pairs in the fall and winter before spring breeding. Nests are built by the female and are typically made of vegetation and lined with down. Nest sites are typically in vegetation near an edge or break in cover and sometimes on brush piles or duck blinds (Longcore et al 2000). One to 17 white to greenish buff eggs are laid. Incubation ranges from 23-33 days. Young are born covered in down and leave the nest soon after hatching (Longcore et al 2000).

Physiological Parameters:

The mean body weight of a black duck is 1.2 kg. Based on allometric equations developed for omnivorous birds (Nagy 2001), black ducks consume food at an approximate rate of 0.057 kg dry weight per day; water is consumed at an approximate rate of 0.067 L per day (estimated from allometric regression in Sample and Suter 1994). Black ducks are omnivorous birds similar to mallards; therefore, the proportion of sediment in the diet estimated for mallards was used to estimate the sediment ingestion rate of black ducks. Beyer et al (1994) estimated that the proportion of sediment in the diet of mallards is 3.3 percent (based on dry mass). The sediment ingestion rate for black ducks was estimated by multiplying this proportion to the food ingestion rate (dry weight) stated above. Based on these calculations, the sediment ingestion rate for a black duck is estimated to be 0.0019 kg dry weight per day.

BIG BROWN BAT (*EPTESICUS FUSCUS*)

The big brown bat is one of the most common and widespread species in North America (WDNR 2003). They feed primarily on beetles, and hymenopterans, and dipterans (Burt 1957).

Status:

The big brown bat is an unmanaged, non-game species.

Distribution:

Big brown bats species range from southeastern Canada and New England west through the midwestern United States to Eastern Washington, south the Mexico and west to Texas and northern Georgia (DeGraaf et al. 1986).

Habitat and Home Range:

Big brown bats are found near cities, towns, woodlands, and buildings. They hibernate in caves, old mines and man-made structures. They prefer cool temperatures and can tolerate conditions many other bats cannot (Mulheisena and Berry 2000). Banding studies that most remain within a 50-kilometer radius of their summer and winter roosts (Merritt 1987).

Population Density:

Maternity colonies are set up by females to rear young. These colonies can vary in size from 5 to 700 animals. During this time, the males will roost alone or in small groups. In late summer both sexes will roost together again (Mulheisena and Berry 2000).

Reproduction/Breeding:

Big brown bats are polygamous. Breeding takes place in late summer/early autumn. Normally two young are born in June following a gestation period of about two months. Young are born altricial and are weaned and able to fly alone by three to four weeks of age (Merritt 1987). Most males and about 50-75% of females are sexually mature by autumn.

Physiological Parameters:

Big brown bats weigh approximately 0.011 kg. Based on allometric equations developed for Chiroptera (Nagy 2001), big brown bats consume food at an approximate rate of 0.0023 kg dry weight per day; water is consumed at an approximate rate of 0.002 L per day (estimated from allometric regression in Sample and Suter 1994). Incidental ingestion of soil is assumed to be negligible for big brown bats because they are aerial feeders with limited contact with the ground.

MINK (*MUSTELA VISON*)

Mink (Order: Carnivora, Family: Mustelidae) are found throughout Wisconsin. Mink forage on aquatic and terrestrial prey including small mammals (muskrats), voles, rabbits, fish, frogs, salamanders, crayfish, clams and insects (DeGraaf et al. 1986). The selection of prey items varies with season and habitat.

Status:

Mink is a managed, game (furbearer) species.

Distribution:

Mink are found from Canada west to Alaska and south throughout the United States, except in desert areas of the southwest (DeGraaf et al. 1986).

Habitat and Home Range:

Mink are found along streambanks, lakeshores, and marshes. They prefer forested wetlands with abundant cover from thickets, rocks, or windfalls (DeGraaf et al. 1986). Mink create dens inside hollow logs, natural cavities under tree roots, or in burrows along stream, marsh, or lake edges. The home range for male mink in Sweden averaged 2.63 kilometers of shoreline (Gerell 1970 as cited in USEPA 1993).

Population Density:

Densities of mink ranged from 0.03 to 0.085 per hectare along a Montana river (Mitchell 1961 as cited in Sample and Suter 1994).

Reproduction/Breeding:

Mink typically reach sexual maturity in 10 months and breed from late February to early April, with peak breeding occurring in March. Gestation lasts from 40 to 75 days period; therefore, young are born in April or May. Litter sizes range from two to 10 kits, with an average of three to four kits per litter (DeGraaf et al. 1986).

Physiological Parameters:

The mean body weight of mink is 1.0 kg. Based on allometric equations developed for Carnivora (Nagy 2001), mink consume food at an approximate rate of 0.04 kg dry weight per day; water is consumed at an approximate rate of 0.099 L per day (estimated from allometric regression in Sample and Suter 1994). Incidental ingestion of soil while foraging is assumed to be negligible (Sample and Suter 1994).

RED-WINGED BLACKBIRD (*AGELAIUS PHOENICEUS*)

The red-winged blackbird (Order: Passeriformes, Family: Fringillidae) is an abundant songbird found throughout Wisconsin (DeGraaf et al. 1986). Red-winged blackbirds feed on insects, weed seeds, and grain.

Status:

Red-winged blackbird is an unmanaged, migratory non-game species.

Distribution:

The breeding range of red-winged blackbird extends from Nova Scotia west to Alaska and south to Florida and Mexico (DeGraaf et al. 1986). From December through mid February, some red-winged blackbirds are found in southern New England, but most migrate south to the mid-Atlantic.

Habitat and Home Range:

Red-winged blackbirds are often found in marshes, swamps, wet meadows, and ponds; however, red-winged blackbirds can also be found in dry fields (DeGraaf et al. 1986). Average territories range from 0.02 to 0.06 hectares (0.05 to 0.15 acres).

Population Density:

Reported densities of red-winged blackbirds range from 11 pairs per 100 acres in uplands to 16 pairs per 100 acres in a marsh (DeGraaf et al. 1986).

Reproduction/Breeding:

Red-tailed blackbirds typically nest near or above water in almost any kind of low herbaceous vegetation, shrubs, or low trees (DeGraaf et al. 1986). Female blackbirds are sexually mature in one year; males reach maturity in two years. From late April to early July, females produce two to three broods of three to five eggs. The eggs are incubated for 10 to 12 days until the eggs hatch; nestling lasts an additional 10 to 11 days (DeGraaf et al. 1986).

Physiological Parameters:

An adult red-winged blackbird weighs approximately 0.052 kg (Sibley 2000). Based on allometric equations developed for omnivorous birds (Nagy 2001), red-winged blackbirds consume food at an approximate rate of 0.008 kg dry weight per day; water is consumed at an approximate rate of 0.008 L per day (estimated from allometric regression in Sample and Suter 1994). Red-winged blackbirds are ground gleaning birds similar to doves; therefore, the proportion of soil in the diet estimated for doves was used to estimate the soil ingestion rate of red-winged blackbirds. USEPA (2005) estimated that the median proportion of soil in the diet of doves is 8.77 percent (based on dry mass). The soil ingestion rate for red-winged blackbirds was estimated by multiplying this proportion to the food ingestion rate (dry weight) stated above. Based on these calculations, the soil ingestion rate for red-winged blackbirds is estimated to be 0.0007 kg dry weight per day.

WHITE-FOOTED MOUSE (*PEROMYSCUS LEUCOPUS*)

The white-footed mouse (Order: Rodentia, Family: Muridae) is an opportunistic omnivore that is common throughout Wisconsin. It forages primarily on insects, seeds, fruit, and other vegetation (Sample and Suter 1994). The white-footed mouse is nocturnal, but active in all seasons (DeGraaf et al. 1986).

Status:

White-footed mouse is an unmanaged, non-game species.

Distribution:

The white-footed mouse is found throughout the eastern United States, except northern Maine, Minnesota, and Wisconsin (DeGraaf et al. 1986).

Habitat and Home Range:

The white-footed mouse is found in the interiors and edges of deciduous, mixed, and coniferous forests. The mouse may also be found in clearcuts, pastures, and along streams. The home range of the white-footed mouse varied from 0.06 to 0.22 hectares for adult females in southern Michigan (DeGraaf et al. 1986).

Population Density:

Densities of white-footed mouse ranged from six to 57 per hectare in a Virginia mixed deciduous forest (Sample and Suter 1994).

Reproduction/Breeding:

White-footed mouse typically reach sexual maturity within seven weeks of birth. The breeding period lasts from late February to November. After a gestation period of 22 to 25 days, litters of one to seven pups are produced between March and December (DeGraaf et al. 1986).

Physiological Parameters:

A typical adult white-footed mouse weighs approximately 0.022 kg. Based on allometric equations developed for Rodentia (Nagy 2001), white-footed mouse consume food at an approximate rate of 0.008 kg dry weight per day; water is consumed at an approximate rate of 0.003 L per day (estimated from allometric regression in Sample and Suter 1994). Incidental ingestion of soil while foraging is estimated as 0.0002 kg dry weight per day based on 2% percent dry weight soil in the diet (Sample and Suter 1994).

3.2 TERRESTRIAL BIOACCUMULATION FACTORS (BAFS)

Exposure-point concentrations in dietary items for terrestrial receptors are estimated using terrestrial BAFs. BAFs provide quantitative indicators of the tendency for a chemical to partition into terrestrial organisms relative to the concentrations present in terrestrial exposure media. BAFs used to calculate exposure-point concentrations of chemicals in terrestrial food items (terrestrial plants and soil invertebrates) were derived from the literature as indicated below. Terrestrial dietary concentrations based on BAFs and hypothetical exposure point concentrations in media are presented in Table F-2.

3.2.1 Plants

The concentrations of selected PAHs in terrestrial plants are estimated using the recommended applications of terrestrial plant bioaccumulation models developed for non-ionic organic compounds developed by USEPA (2005). The regression model equation and input variables used to estimate PAH concentrations in plants are presented in the notes for Table F-2.

The concentrations of selected metals in terrestrial plants are estimated using the recommended applications of terrestrial plant bioaccumulation models developed by Efroymson et al. (2001) using data compiled in Bechtel (1998a). Single-variable regression models are the recommended application for general estimates of cadmium, lead, mercury, selenium, and zinc concentrations in plants (Efroymson et al. 2001). Regression model equations and input variables developed in Efroymson et al. (2001) are presented in the notes for Table F-2. With the exception of antimony, uptake factors for vegetated portions of food crops reported in Baes et al. (1984) are used as BAFs for metals not evaluated in Efroymson et al. (2001). Concentrations of antimony in terrestrial plants are estimated using a single-variable regression model developed by USEPA (2005).

3.2.2 Soil Invertebrates

The concentrations of PAHs in soil invertebrates are estimated using BAFs for non-ionic organic compounds developed by USEPA (2005). The BAFs used to estimate PAH concentrations in soil invertebrates are presented in the notes for Table F-2.

The concentrations of selected metals in soil invertebrates are estimated using the recommended applications of earthworm bioaccumulation models developed by Sample et al. (1999) and Neuhauser et al. (1995). Simple regression models are used to estimate soil invertebrate concentrations of cadmium, lead, mercury, manganese, selenium, and zinc; regression model equations and input variables are presented in the notes for Table F-2. No BAF could be identified in the literature for antimony; therefore, a conservative BAF of 1.0 is assumed for uptake of antimony by soil invertebrates.

3.3 AQUATIC BIOTA-SEDIMENT ACCUMULATION FACTORS (BSAFS)

Exposure-point concentrations in aquatic prey are estimated using BSAFs for metals and VOCs in benthic invertebrates and site-specific measurements for PAH concentrations in benthic invertebrates and fish tissues. BSAFs provide quantitative indicators of the tendency for a chemical to partition into organisms relative to the concentrations present in sediment. BSAFs used to calculate exposure-point concentrations of chemicals in benthic invertebrates are derived from the literature as indicated below. Aquatic dietary concentrations based on BSAFs and hypothetical exposure point concentrations in media are presented in Table F-3. A discussion of how exposure point concentrations for piscivorous wildlife were developed is also provided.

3.3.1 Aquatic Life Stage Benthic Invertebrates

Doses of PAHs to invertivorous wildlife, i.e., tree swallow, big brown bat, and black duck[1] were calculated using concentrations of PAHs measured in the freshwater benthic worm, *L. variegatus*, chronically exposed to Site sediments in the laboratory. BSAFs for PAHs were calculated as the ratio of the lipid normalized concentrations of PAHs in *L. variegatus* to the organic carbon normalized concentrations of PAHs in the bioassay sediments. This approach was used to calculate normalized BSAFs[2] for 23 individual PAHs evaluated in the 17 samples included in the 28-day *L. variegatus* bioaccumulation study (Table F-4). The geometric mean of normalized BSAFs calculated for each individual PAH compound was used to estimate the concentration of PAHs in benthic invertebrates as follows:

1) Site-wide BSAFs were calculated for each individual PAH compound from the normalized BSAFs based on the UCL95 concentration of sediment organic carbon calculated for the Site area and the geometric mean lipid concentration measured in the bioaccumulation study. Site-specific BSAFs were calculated for each compound as follows:

$$BSAF_{Site\text{-}wide} = BSAF_{norm} \times f_{lipid} \div f_{oc}$$

where: $BSAF_{Site\text{-}wide}$ = BSAF based on site-wide fraction of sediment organic carbon and estimated lipid fraction in benthic invertebrates;

[1] For the purposes of the BERA, it was assumed that the black duck feeds exclusively on benthic macroinvertebrates
[2] Henceforth, 'normalized BSAFs' refers BSAFs normalized by the geometric mean lipid fraction of *L. variegatus* and the geometric mean organic carbon fraction in the test sediment from the 28-day bioaccumulation study.

$BSAF_{norm}$ = Normalized BSAF for each individual PAH compound (kg sediment organic carbon / kg lipid);

f_{lipid} = Fraction of lipids (0.0785, geometric mean calculated for *L. variegatus* on a dry weight basis); and

f_{oc} = Site-specific fraction of sediment organic carbon (0.1857, UCL95 calculated from sediment samples in the Site area).

2) Concentrations of PAHs in prey at the Site were estimated by multiplying the Site-wide BSAF and the dry weight sediment concentration:

$$C_{prey} = BSAF_{Site-wide} \times C_{sediment}$$

where: C_{prey} = Estimated concentration of PAHs in prey (mg PAH/kg prey, dry weight)

$BSAF_{specific}$ = BSAF based on site-specific fraction of sediment organic carbon and estimated lipid fraction in benthic invertebrates; and

$C_{sediment}$ = Concentration of PAH in sediment (mg PAH/kg sediment, dry weight)

The 28-day *L. variegates* bioaccumulation study did not evaluate bioaccumulation of dibenzofuran, biphenyl, and the VOCs that have been identified as COPCs in the BERA: benzene, m, p and o-cresols, ethylbenzene, toluene, and total xylenes. The normalized BSAF developed for acenaphthene from the *L. variegatus* bioaccumulation study was used to estimate concentrations of dibenzofuran and biphenyl in benthic invertebrate tissue due to similar log K_{ow}s and molecular weights between compounds. The normalized BSAF for naphthalene was used as a conservative surrogate to estimate concentrations of VOCs in benthic invertebrates based on the assumption that VOCs do not bioaccumulate at a greater rate than naphthalene (Roubal et al. 1977).

Concentrations of metals in aquatic life stage benthic invertebrate tissues were estimated based on BSAFs or regression models developed or obtained from the literature. The BSAF for barium was estimated as the UCL95 BSAF calculated from co-located sediment and tissue data reported by Hamilton and Buhl (2003a and 2003b) (Table F-5). Concentrations of copper were estimated as the 95 percent upper prediction limit (95UPL) of regression models developed by Bechtel (1998b). Concentrations of selenium in benthic invertebrates were based on a significant regression ($p < 0.001$) of sediment and benthic invertebrates concentrations of selenium developed from co-located sediment and tissue data reported by Hamilton and Buhl (2003a and 2003b). A weighted-average of thallium BSAFs reported in Borgmann et al. (1998) for the amphipod *H. azteca* was used to estimate concentrations of thallium in benthic invertebrates.

3.3.2 Emergent Life Stage Aquatic Invertebrates

Correction factors were applied to estimated aquatic life stage concentrations of copper, selenium, and PAHs/VOCs to estimate concentrations present in emergent insects. Bechtel (1998b) indicates that the regression model they developed based on depurated organisms was the best estimate of adult concentrations of copper. For selenium, a correction factor of 0.4 was applied to concentrations in aquatic stage invertebrates to estimate concentrations in emergent stage invertebrates. This correction factor was based on Reinfelder and Fisher (1994) who found

that 59.2% of ^{75}Se that was found to be bound to the exoskeleton of copepods. Reinfelder and Fisher (1994) also cite Bertine and Goldberg (1972) who reported that 61% of the selenium in shrimp was due to exoskeleton binding. Since the exoskeletons of copepods, shrimp, and aquatic insects are composed of chitin, these findings are directly applicable to insects. Assuming a similar partitioning of selenium in aquatic insects (i.e. 59.2 to 61% associated with the exoskeleton in the final molt), approximately 40% of selenium found in aquatic stage invertebrates would remain in emergent invertebrates following molting. A correction factor of 0.135 was applied to concentrations of PAHs/VOCs estimated for aquatic life stage invertebrates to estimate concentrations in emergent insects. Bell et al. (2004) exposed fourth-instar midge larvae to fluoranthene for 72 to 96-hr. and the emergent adults were collected in traps. Larvae, exuvae (the exoskeleton shed by the pupa when molting to the adult stage), and adults tissues were collected and analyzed for fluoranthene. The larvae exhibited a concentration-dependent uptake of fluoranthene and contained significantly greater concentrations of fluoranthene than the emergent adults. In three different exposure concentrations, the emergent adults contained 0.78, 1.29, and 13.5% of the larval fluoranthene concentration and the exuvae contained more fluoanthene than the emergent adult. The highest proportion of retained fluoranthene, 13.5% was applied to the *L. variegates* data to estimate the doses received by flying insectivores at the Site. For the remaining COPCs, concentrations estimated for aquatic life stages were used to conservatively estimate concentrations for emergent life stages.

3.4 FISH TISSUE ANALYSES

Doses to piscivorous wildlife, i.e., osprey, double-crested cormorant, and mink, were calculated based on site-specific tissue measurements and normalized BSAFs estimated from site data. The UCL95 tissue concentration of the 24 PAHs measured from all fish collected at the site was used as the exposure point concentration for total PAH concentrations in fish tissue. Site-specific tissue measurements were not available for dibenzofuran and the VOCs identified as COPCs in the BERA: benzene, m, p and o-cresols, ethylbenzene, toluene, and total xylenes. The geometric mean normalized BSAF for the 24 PAH compounds measured in fish tissue was calculated and the resultant normalized BSAF was used to calculate the concentrations of the unmeasured COPCs in fish tissue. This calculation was based on the UCL95 sediment concentrations of individual PAHs and the brown bullhead sample (W-3-4) containing the greatest concentrations of PAHs (Table F-6). The geometric mean of normalized BSAFs calculated for the individual PAH compounds was 0.0146, which is an order of magnitude greater than other BSAFs that have been reported for PAHs in fish. Burkhard and Lukasewycz of U.S. EPA's National Health and Environmental Effects Research Laboratory (Burkhard and Lukasewycz 2000) state that "an extensive but unsuccessful literature search was performed for field-measured bioaccumulation factors (BAFs) and biota-sediment accumulation factors (BSAFs) for polycyclic hydrocarbons (PAHs); no reported values were found for fish." The lack of BAFs and BSAFs for PAHs occurs in part because PAHs are metabolized by fish, resulting in very low or non detectable concentrations of the parent PAHs in fish tissues [Varanasi et al. 1989]." Using data from several studies they calculated BSAFs for phenanthrene (0.00011), fluoranthene (0.00016), pyrene (0.0071) benzo(a)pyrene (0.0054), and chrysene/triphenylene (0.00033). Based on comparisons of BSAFs provided by Burkhard and Lukasewycz (2000), it was concluded that the normalized BSAFs calculated from the site-specific fish data provided a conservative estimate of dibenzofuran and VOC concentrations in fish tissue.

The normalized BSAF calculated from the site-specific fish tissue data was used to estimate the concentration of PAHs in fish tissue by calculating a site-specific BSAF based on the UCL95 concentration of sediment organic carbon for the site area and the lipid fraction of fish. This site-specific BSAF was multiplied to the COPC concentration in sediment to estimate the concentrations of unmeasured COPCs in fish tissue:

$$BSAF_{Site\text{-}wide} = BSAF_{norm} \times f_{lipid} \div f_{oc}$$

$$C_{prey} = BSAF_{Site\text{-}wide} \times C_{sediment}$$

where: $BSAF_{Site\text{-}wide}$ = BSAF based on Site-wide fraction of sediment organic carbon and estimated lipid fraction in benthic invertebrates;

$BSAF_{norm}$ = Normalized BSAF for each individual PAH compound (kg sediment organic carbon / kg lipid);

f_{lipid} = Fraction of lipids (0.12, geometric mean calculated for fish measured at the site on a dry weight basis);

f_{oc} = Site-specific fraction of sediment organic carbon (0.1857, UCL95 calculated from sediment samples in the site area).

C_{prey} = Estimated concentration of PAHs in prey (mg PAH/kg prey, dry weight); and

$C_{sediment}$ = Concentration of PAH in sediment (mg PAH/kg sediment, dry weight)

3.5 AREA USE FACTORS (AUFS)

AUF values estimate the proportion of time a receptor would likely be actively foraging in each of the exposure AOIs associated with the Ashland Site. The use of an AUF is appropriate since it incorporates a more realistic assumption that reduces the overall uncertainty of the risk assessment, while retaining the conservative nature of the model. For all receptors an AUF of 100% is used to calculate the ADD for each of the modelled receptors in order to provide the most conservative dose estimation.

3.6 TOXICITY REFERENCE VALUES (TRVS)

The dose-response relationships for COPCs are expressed as receptor-specific NOAEL- and LOAEL- based TRVs, which are defined as a daily ingested amount (mg/kg body weight-day) that is associated with a specified effect. Development of TRVs involves the determination of a "test species dose" for a critical endpoint from a particular experimental combination of exposure concentration, exposure duration, test species, and chemical. Endpoints may be based on growth, reproductive, developmental, and survival effects. Such effects are important because they may affect the abundance or reproductive success of receptor populations. The NOAEL and LOAEL-based TRVs used to evaluate ADDs calculated in the model are presented in Table F-7.

There is inherent uncertainty in estimating the exposure of ecological receptors to COPCs in environmental media. Uncertainty in model parameters may result from a lack of knowledge of COPC-specific bioaccumulation rates or site-specific exposure parameters. Model parameters that tend to overestimate, underestimate, or have an unknown effect on the estimation of exposure to ecological receptors are presented below with a discussion of their uncertainty.

4.1 EXPOSURE PARAMETERS

Exposure parameters in dose rate models represent typical physiological parameters reported in the literature for the selected receptors. These parameters are intended to be representative of typical populations of selected receptors, but may not be exactly representative of receptor populations inhabiting the Site and surrounding areas. For example, the availability (or lack) of site-specific forage or cover resources may increase or decrease the estimated home range of a receptor. An increased home range may result in decreased exposure, while a decreased home range may increase exposure. The availability of forage resources may also underestimate or overestimate the dietary composition included in the model, particularly for opportunistic foragers that may concentrate their diet on the food source that is abundant at a given time. Dietary composition may also vary seasonally with forage resource availability or specific dietary requirements (e.g., wood duck require a higher portion of invertebrates to satisfy protein requirements during the early spring molt and egg-laying).

Estimated ingestion rates of food, and substrate represent additional uncertainties in the dose rate models. As discussed in Section 3.1, food ingestion rates are based on allometric regression equations developed by Nagy (2001). Nagy (2001) expanded on earlier models of food ingestion (Nagy 1987) by developing models for 90 different taxonomic, dietary, and habitat groupings of species. However, the average error rate of these models ranges from 5 to 60 percent depending on the group and may underestimate the feeding rates of free-living animals that are growing, reproducing, or storing up fat (Nagy, 2001). Estimated percentages of soil in the diet reported by Beyer et al. (1994) and other studies summarized in Sample and Suter (1994) were the primary sources of substrate ingestion rates used in the dose rate models. Actual site-specific substrate ingestion rates may vary by habitat and dietary components.

4.2 BIOACCUMULATION FACTORS

Site-specific measurements of tissue concentrations are the best data to reduce uncertainty in estimating exposure point concentrations in dietary components. However, the collection of tissue for all dietary components is not practical in most ecological risk assessments. Therefore, bioaccumulation factors or models must be applied and a level of uncertainty in estimated concentrations must be accepted.

As discussed in Sections 3.2 and 3.3, bioaccumulation factors provide quantitative indicators of the tendency for a chemical to partition into biological organisms relative to the concentrations present in environmental exposure media. The bioavailability of metals may be influenced by chemical and physical properties, such as their affinity to partition as soluble free ions, organic and inorganic complexes, precipitates of metal hydroxides, precipitates with insoluble organic complexes, or insoluble sulfide complexes. Metals may partition into these forms as a function of substrate-associated factors including organic carbon content, cation exchange capacity, pH, temperature, grain size, and acid-volatile sulfide content (in sediments). The complexity and

limited site-specific understanding of these interactions lead to uncertainties in estimating the bioaccumulation of metals from environmental media to biological organisms. The following sections evaluate the relative uncertainty associated with bioaccumulation factors and models selected to estimate dietary concentrations of metals for terrestrial and aquatic receptors.

4.2.1 Terrestrial Plants

Single-variable regression models developed by Efroymson et al. (2001) and USEPA (2005) create less uncertainty in estimating metal concentrations in plant tissue relative to estimations using single uptake factors. Single-variable regression models are developed from significant relationships determined between metal concentrations in surface soil and collocated aboveground plant tissue data obtained from a literature review of field and greenhouse studies (Bechtel 1998a). These models proved to be better than single uptake factors in estimating metal concentrations in plants and are recommended for general estimates (Bechtel 1998a). More uncertainty is associated with plant tissue concentrations of metals estimated using BAFs selected for from Baes et al. (1984), which are single uptake factors that do not consider changing rates of accumulation with varying soil concentrations.

Because PAHs can occur in soils as a mixture of several analytes, an evaluation of total polycyclic aromatic hydrocarbons (TPAHs) was deemed an appropriate measure of exposure for these constituents. Bioaccumulation of PAHs from soil to plants was estimated using regression models provided in USEPA (2005).

4.2.2 Terrestrial Prey – Soil Invertebrates

Less uncertainty is associated with metal concentrations in soil invertebrates estimated using simple regression models developed by Sample et al. (1999) relative to estimates using single uptake factors. Bioaccumulation by earthworms is non-linear, decreasing with increasing soil concentrations (Bechtel 1998b). Uptake factors implicitly assume that accumulation is linear and constant across all soil concentrations, which may overestimate accumulation at higher soil concentrations. Therefore, less uncertainty is associated with soil invertebrate concentrations of cadmium, lead, manganese, selenium, and zinc, which were estimated using simple regression models recommended for general estimates (Sample et al. 1999). The most uncertainty is associated with the bioaccumulation of antimony for which relevant bioaccumulation data were not available in the literature. A conservative default uptake factor of 1.0 is used for antimony, which creates substantial uncertainty associated with estimated concentrations of these elements in soil invertebrates.

Because PAHs can occur in soils as a mixture of several analytes, an evaluation of TPAHs was deemed an appropriate measure of exposure for these constituents. Bioaccumulation of PAHs from soil to invertebrates was estimated based on uptake factors provided in USEPA (2005).

4.2.3 Aquatic Life Stage Benthic Invertebrates

The BSAFs developed from the 28-day *L. variegates* bioaccumulation study provide conservative estimates of PAH and VOC concentrations in aquatic stage benthic invertebrates. The normalized BSAFs used in the BERA were compared to two other sources of BSAFs: the TLM of DiToro and McGrath (2000) and the U.S. Army Corps of Engineers (USACE)

Environmental Residue Effects Database (ERED). DiToro and McGrath (2000) rearranged the TLM to predict the BSAF for PAHs:

$$BSAF = \frac{[PAH]_{lipid}}{[PAH]_{organiccarbon}} = Kow^{-0.38}$$

and concluded that BSAFs for PAHs should be less than 1.0 (Table F-8). The ERED also contains BSAFs for *L. variegatus* exposed to PAHs, which range from 0.45 for benzo(a)pyrene to 6.8 for naphthalene (Table F-9).

Based on comparisons with normalized BSAFs calculated by DiToro and McGrath (2000) and compiled in ERED, it was concluded that the normalized BSAFs calculated from the 28-day *L. variegates* bioaccumulation study provide conservative estimations of PAH and VOC concentrations in benthic invertebrate tissue at the site. For most compounds, the normalized BSAFs used in the BERA were an order of magnitude greater than those estimated by the TLM. Normalized BSAFs developed for the BERA were greater than those compiled in ERED.

Relationships between metal concentrations in sediment and tissue developed by Bechtel (1998b) provide the most appropriate method to estimate concentrations of metals in benthic invertebrates. Metal concentrations in benthic invertebrates estimated based on the recommended bioaccumulation models for invertebrates (Bechtel 1998b) are less uncertain than metal concentrations estimated based on BSAFs. Bechtel (1998b) demonstrated that few metals have a linear relationship between concentrations in biota and concentrations in sediment. Therefore, regression models likely provide better estimates of tissue concentrations of copper, as a function of sediment concentrations when compared to BSAFs; the use of the 95_{UPL} regression models provides a conservative estimate of the model result.

Greater uncertainty exists for metals not evaluated in Bechtel (1998b) because bioaccumulation data was limited for these metals. As a result, invertebrate concentrations of these metals are estimated based on less robust datasets with less defined relationships. For example, invertebrate tissue concentrations of thallium are based on the results of a single bioaccumulation study. Bioaccumulation of metals not addressed in Bechtel (1998b) or direct bioaccumulation studies, are estimated based on two datasets (Hamilton and Buhl 2003 and 2003b). Although sediment and tissue samples in these datasets were generally collocated (at the same site), it is uncertain whether these samples were collected from the same microhabitat. Therefore, these data may provide an assessment of the general relationships between sediment and tissue concentrations on a broader spatial scale, but may be limited in assessing direct accumulation.

Baes, C.F., R. Sharp, A. Sjoreen, and R. Shor. 1984. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for U.S. Dept. of Energy. 150 pp.

Bechtel Jacobs Company LLC. 1998a. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Bechtel Jacobs Company LLC, Oak Ridge, TN. BJC/OR-133.

Bechtel Jacobs Company LLC. 1998b. Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation. Bechtel Jacobs Company LLC, Oak Ridge, TN. BJC/OR-112.

Bell, H., K. Liber, D. Call, and G. Ankley. 2004. Evaluation of bioaccumulation and photo-induced toxicity of fluoranthene in larval and adult life-stages of *Chironomus tentans*. Arch, Env. Contam. Toxicol. 47: 297-303.

Bertine, K. and E. Goldberg. 1972. Trace elements in clams, mussels, and shrimp. Limnol. Oceanogr. 17: 877-884.

Beyer, W.N., Connor, E.E., and S. Gerould. 1994. Estimates of soil ingestion by wildlife. Journal of Wildlife Management 58(2):375-382.

Borgmann, U., Cheam, V., Norwood, W.P., and J. Lechner. 1998. Toxicity and bioaccumulation of thallium in *Hyalella azteca* with comparison to other metals and prediction of environmental impact. Environmental Pollution, 99:105-114.

Burkhard, L.P. and M.T. Lukasewycz. 2000. Some Bioaccumulation Factors and Biota-Sediment Accumulation Factors for Polycyclic Aromatic Hydrocarbons in Lake Trout; Environmental Toxicology and Chemistry: Vol. 19, No. 5, pp. 1427–1429.

Burt, W.H. 1957. Mammals of the Great Lakes Region. Ann Arbor Paperbacks. The University of Michigan Press. 246p.

Cornell. 2003. Cornell Lab of Ornithology Online Bird Guide. Available at:http://www.birds.cornell.edu/programs/AllAboutBirds/BirdGuide/

Custer, T.W. and C. Bunck. 1992. Feeding flights of breeding double-crested cormorants at two Wisconsin colonies. J.Field Ornithol. 63(2):203-211.

DeGraaf, Richard M., Rudis, Deborah D.; 1986. New England wildlife: habitat, natural history, and distribution. General Technical Report NE-108. Broomall, PA: USDA, Forest Service, Northeastern Forest Experiment Station. 491 p

DiToro, D. and J. McGrath. 2000. Technical basis for narcotic chemicals and polycyclic aromatic hydrocarbon criteria. II. Mixtures and sediments. Env. Toxicol. Chem. 19: 1970- 1982.

Efroymson, R.A., Sample, B.E., and G.W. Suter. 2001. Uptake of inorganic chemicals from soil by plant leaves: Regressions of field data. Environmental Toxicology and Chemistry 20:2561-2571.

Hamilton, S.J. and K.J. Buhl. 2003a. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates, and fish from streams in southeaster Idaho near phosphate mining operations: September 2000. U.S. Geological Survey, Columbia Environmental Research Center.

Hamilton, S.J. and K.J. Buhl. 2003b. Selenium and other trace elements in water, sediment, aquatic plants, aquatic invertebrates, and fish from streams in southeaster Idaho near phosphate mining operations: May 2001. U.S. Geological Survey, Columbia Environmental Research Center.

Kirschbaum, K. and E.Ward. 2000. "*Phalacrocorax auritus*" (on-line), Animal Diversity Web. Accessed April 27, 2006 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Phalacrocorax_auritus.html.

Longcore, J.R., D. G. McAuley, G.R. Hepp, and J.M. Rhymer. 2000. American Black Duck (*Anas rubripes*). *In* The Birds of North America, No. 481 (A. Poole and F. Gill, eds.). The Birds of North America, Inc., Philadelphia, PA.

Merritt, J.F. 1987. Guide to the Mammals of Pennsylvania. University of Pittsburg Press. 408p.

Mitchell, R.M. 1977. Breeding biology of the double-crested cormorant on a Utah lake. Great Basin Naturalist. 37(1): 1-23.

Mulheisen, M. and K. Berry. 2000. "*Eptesicus fuscus*" (On-line), Animal Diversity Web. Accessed April 2006 at http://animaldiversity.ummz.umich.edu/site/accounts/information/Eptesicus_fuscus.html.

Nagy, K.A., 2001. Food requirements of wild animals: Predictive equations for free-living mammals, reptiles, and birds. Nutrition Abstracts and Reviews, Series B: Livestock Feeds and Feeding, Volume 71, No. 10.

Nagy, K.A. 1987. Field metabolic rate and food requirement scaling in mammals and birds. Ecological Monographs 57: 111-128.

Neuhauser, E.F., Z.V. Cukic, M.R. Malecki, R.C. Loehr and P.R. Durkin. 1995. Bioconcentration and biokinetics of heavy metals in the earthworm. *Environ. Pollut.* 89:293–301.

Palmer, R.S. 1988. Handbook of North American Birds, Volumes 4 and 5. New Haven, CT, Yale University Press. 567pp.

Peterson, R.T. 1995. A Field Guide to the Birds of Eastern and Central North America. Houghton Mifflin Co. NY, NY. 428p.

Reinfelder, J. and N. Fisher. 1994. Retention of elements by juvenile fish (Menidia menidia, Menidia beryllina) from zooplankton prey. Limnol. Ocaeanogr. 39: 1783-1789.

Robertson, R. J., B. J. Stutchbury, and R. R. Cohen. 1992. Tree swallow (*Tachycineta bicolor*). The Birds of North America, No. 11 (A. Poole and F. Gill, eds.). The Academy ofNatural Sciences, Philadelphia, and the American Ornithologists' Union, Washington,D.C.

Roubal, W., T. Collier, and D. Malins. 1977. Accumulation and metabolism of carbon-14 labeled benzene, naphthalene, and anthracene by young coho salmon (*Oncorhynchus kisutsh*). Arch. Env. Contam. Toxicol. 5: 513-529.

Sample, B.E. and G.W. Suter. 1994. Estimating Exposure of Terrestrial Wildlife to Contaminants. ES/ER/TN-125. Oak Ridge National Laboratory, Oak Ridge, TN.

Sample, B., G. Suter, J. Bueachamp ad R. Efroymson. 1999. Literature-derived bioaccumulation models for earthworms: development and validation. Env. Toxicol. Chem. 18: 2110-2120.

Sibley, D.A. 2000. The Sibley guide to birds. New York: Alfred A Knopf. 544 p.

USEPA. 2005. Ecological soil screening level (Eco-SSL) (various metals) guidance and documents. http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm

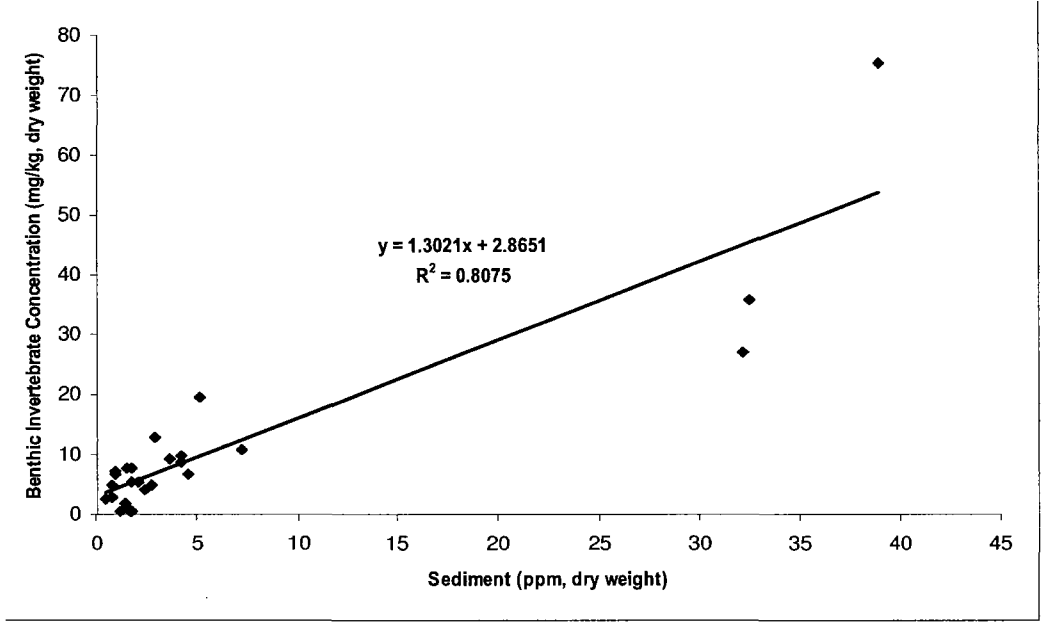
USEPA. 1993. Wildlife Exposure Factors Handbook. Volumes I and II. EPA/600/R-93/187a&b. U.S. Environmental Protection Agency, Office of Health and Environmental Assessment, Office of Research and Development, Washington, D.C.

Varanasi U, Stein JE and Nishimoto M. 1989. Biotransformation and disposition of polycyclic aromatic hydrocarbons (PAH) in fish. In: Metabolism of Polycyclic Aromatic Hydrocarbons in the Aquatic Environment (U Varanasi, Ed). CRC Press, Boca Raton, FL, pp. 94-149.

Wisconsin Department of Natural Resources (WDNR). 2003. Osprey (*Pandion haliaetus*). The Endangered and Threatened Vertebrate Species of Wisconsin: Endangered Resource Reports. http://dnr.wi.gov/org/land/er/factsheets/birds/Osprey.htm.

FIGURES

FIGURE F-1
RELATIONSHIP BETWEEN SELENIUM CONCENTRATIONS IN SEDIMENT AND COMPOSITE BENTHIC INVERTEBRATE SAMPLES
DATA SOURCE: HAMILTON AND BUHL (2003a and 2003b)
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN



Regression Statistics:

Multiple R	0.899
R Square	0.807
Adjusted R Square	0.799
Standard Error	7.013
Observations	25

ANOVA					
	df	SS	MS	F	Significance F
Regression	1	4744.18	4744.18	96.47	1.07E-09
Residual	23	1131.11	49.18		
Total	24	5875.30			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	2.865	1.636	1.751	0.093	-0.519	6.249
Sediment	1.302	0.133	9.822	0.000	1.028	1.576

TABLES

TABLE F-1
SUMMARY OF EXPOSURE PARAMETERS FOR RECEPTORS OF CONCERN
TERRESTRIAL AND AQUATIC
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Representative Species			Home Range[a]	Home Range Reference	Area Use Factor (AUF)		Body Weight (kg wet weight)	Dietary Composition					Ingestion Rates				
													Food			Substrate	
Common Name	Scientific Name	Food-web classification			Preliminary Exposure Estimate	Refined Exposure Estimate		Plant Material	Invertebrates	Fish	Small Mammals	References	kg dry weight/day	Reference	% of Dry Intake	kg dry wt./day	Reference
Avian Receptors																	
Black duck	*Anas rubripes*	aquatic omnivore	249 ha	Longcore et al 2000	1.0	1.0	1.2		100%			Sibley (2000)	0.057	Nagy (2001)[b]	3.3%	0.002	Estimated[h]
Double crested Cormorant	*Phalacrocorax auritus*	aquatic piscivore	2.0-2.4 km	Custer and Bunck (1992)	1.0	1.0	1.7			100%		Sibley (2000)	0.118	Nagy (2001)[c]	0%	0	Assumption[i]
Osprey	*Pandion haliaetus*	large aquatic piscivore (protected)	3 to 10 km	USEPA (1993)	1.0	1.0	1.6			100%		USEPA (1993)	0.113	Nagy (2001)[c]	0%	0	Assumption[i]
Red-winged blackbird	*Agelaius phoeniceus*	medium omnivore	0.02 ha	DeGraaf et al. (1986)	1.0	1.0	0.052	50%	50%			DeGraaf et al. (1986)	0.008	Nagy (2001)[b]	8.8%	0.0007	Estimated[d]
Tree swallow	*Tachycineta bicolor*	aerial insectivore	60 km	Robertson et al. (1992)	1.0	0.75	0.02		100%			Sibley (2000)	0.012	Nagy (2001)[g]	0%	0	Assumption[k]
Mammalian Receptors																	
Big brown Bat	*Eptesicus fuscus*	aerial insectivore	ND	--	1.0	1.0	0.011		100%			Merritt (1987)	0.00182	Nagy (2001)[e]	0%	0	Assumption[l]
Mink	*Mustela vison*	medium semi-aquatic piscivore	2.63 km	Sample and Suter (1994)	1.0	1.0	1			100%		USEPA (1993); Sample and Suter (1994)	0.0399	Nagy (2001)[f]	0%	0	Sample and Suter (1994)[j]
White-footed mouse	*Peromyscus leucopus*	small terrestrial omnivore	0.06 ha	DeGraaf et al. (1986)	1.0	1.0	0.022	50%	50%			Sample and Suter (1994)	0.002	Nagy (2001)[g]	2%	0.00004	Sample and Suter (1994)[j]

Notes:

a, ND, no data available for this parameter; km, kilometers; ha, hectares;

b, Estimated food ingestion rate (kg/day dry weight) for omnivorous birds = (0.670[Body Weight in grams]$^{0.627}$)/1000 (Nagy 2001);

c, Estimated food ingestion rate (kg/day dry weight) for carnivorous birds = (0.849[Body Weight in grams]$^{0.663}$)/1000 (Nagy 2001);

d, Calculated from measured field metabolic rates in free-living animals.

e, Estimated food ingestion rate (kg/day dry weight) for Chiroptera = (0.365[Body Weight in grams]$^{0.671}$)/1000 (Nagy 2001);

f, Estimated food ingestion rate (kg/day dry weight) for Carnivora = (0.102[Body Weight in grams]$^{0.864}$)/1000 (Nagy 2001);

g, Estimated food ingestion rate (kg/day dry weight) for Rodentia = (0.774[Body Weight in grams]$^{0.752}$)/1000 (Nagy 2001);

h, Estimated based on soil ingestion rate reported for the mallard (Beyer et al 1994).

i, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for piscivores.

j, Estimated based on median soil ingestion rate for similar ground gleaning bird (dove) reported by USEPA (2003).

k, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for aerial insectivores;

l, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for the little brown bat.

TABLE F-2
ESTIMATED TERRESTRIAL PREY CONCENTRATIONS
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Theoretical Soil Exposure Point Concentration (mg/kg, dry weight)[i]	Estimated Concentrations in Dietary Items of Terrestrial Receptors (mg/kg, dry weight)					
		Plants			Soil Invertebrates		
		Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference	Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference
Metals							
Antimony	100.0	Regression[a]	3.0E+00	USEPA (2003a)[a]	1.0E+00	1.0E+02	Assumption[b]
Cadmium	100.0	Regression[a]	7.8E+00	Efroymson et al. (2001)[a]	Regression[d]	3.4E+02	Neuhauser et al. (1995)
Lead	100.0	Regression[a]	3.5E+00	Efroymson et al. (2001)[a]	Regression[d]	3.4E+01	Sample et al. (1999a)[c]
Manganese	100.0	2.50E-01	2.5E+01	Baes et al. (1984)	Regression[d]	1.0E+01	Sample et al. (1999a[c]
Mercury	100.0	Regression[a]	4.4E+00	Efroymson et al. (2001)[a]	Regression[d]	4.9E+00	Sample et al. (1999a)[c]
Selenium	100.0	Regression[a]	8.0E+01	Efroymson et al. (2001)[a]	Regression[d]	2.7E+01	Sample et al. (1999a)[c]
Zinc	100.0	Regression[a]	6.4E+01	Efroymson et al. (2001)[a]	Regression[d]	3.9E+02	Sample et al. (1999a)[c]
PAHs							
Total PAHs	100.0		1.5E+03	Assumption[d]		6.6240E+03	Assumption[d]
Acenaphthene	100.0	Regression[a]	7.5E-05	USEPA (2005)	1.47E+00	1.47E+02	USEPA (2005)
Acenaphthylene	100.0	Regression[a]	8.3E-03	USEPA (2005)	2.29E+01	2.29E+03	USEPA (2005)
Anthracene	100.0	Regression[a]	1.3E+01	USEPA (2005)	2.42E+00	2.42E+02	USEPA (2005)
Benzo(a)anthracene	100.0	Regression[a]	1.0E+00	USEPA (2005)	1.59E+00	1.59E+02	USEPA (2005)
Benzo(a)pyrene	100.0	Regression[a]	1.1E+01	USEPA (2005)	1.33E+00	1.33E+02	USEPA (2005)
Benzo(b)fluoranthene	100.0	3.10E-01	3.1E+01	USEPA (2005)	2.60E+00	2.60E+02	USEPA (2005)
Benzo(e)pyrene	100.0	1.90E-01	1.9E+01	USEPA (2005)	2.76E+00	2.76E+02	USEPA (2005)
Benzo(g,h,i)perylene	100.0	Regression[a]	9.1E+01	USEPA (2005)	2.94E+00	2.94E+02	USEPA (2005)
Benzo(k)fluoranthene	100.0	Regression[a]	6.1E+00	USEPA (2005)	2.60E+00	2.60E+02	USEPA (2005)
Chrysene	100.0	Regression[a]	1.0E+00	USEPA (2005)	2.29E+00	2.29E+02	USEPA (2005)
Fluoranthene	100.0	5.00E-01	5.0E+01	USEPA (2005)	3.04E+00	3.04E+02	USEPA (2005)
Fluorene	100.0	Regression[a]	7.5E-05	USEPA (2005)	9.57E+00	9.57E+02	USEPA (2005)
Indeno(1,2,3-cd)pyrene	100.0	1.10E-01	1.1E+01	USEPA (2005)	2.86E+00	2.86E+02	USEPA (2005)
Naphthalene	100.0	1.22E+01	1.2E+03	USEPA (2005)	4.40E+00	4.40E+02	USEPA (2005)
Phenanthrene	100.0	Regression[a]	1.5E+01	USEPA (2005)	1.72E+00	1.72E+02	USEPA (2005)
Pyrene	100.0	7.20E-01	7.2E+01	USEPA (2005)	1.75E+00	1.75E+02	USEPA (2005)

Notes:

a, Plant tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]). Slopes (B1) and intercepts (B0) are as follows

Metal	B0	B1	Data Source for Model
Antimony	-3.233	0.937	USEPA 2003a
Cadmium	-0.48	0.55	Efroymson et al. (2001)
Lead	-1.33	0.56	Efroymson et al. (2001)
Mercury	-1	0.54	Efroymson et al. (2001)
Selenium	-0.68	1.1	Efroymson et al. (2001)
Zinc	1.58	0.56	Efroymson et al. (2001)
Acenaphthene	-5.562	-0.8556	USEPA 2005
Acenaphthylene	-1.144	0.791	USEPA 2005
Anthracene	-0.9887	0.7784	USEPA 2005
Benzo(a)anthracene	-2.7078	0.5944	USEPA 2005
Benzo(a)pyrene	-2.0615	0.975	USEPA 2005
Benzo(g,h,i)perylene	-0.9313	1.1829	USEPA 2005
Benzo(k)fluoranthene	-2.1579	0.8595	USEPA 2005
Chrysene	-2.7078	0.5944	USEPA 2005
Fluorene	-5.562	0.8556	USEPA 2005
Phenanthrene	-0.1665	0.6203	USEPA 2005

b, Soil-invertebrate bioaccumulation factor could not be identified; therefore, a default accumulation factor of 1.0 was assummed

c, Soil invertebrate tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]), except for Cd which follows the form log([tissue]) = B0 + B1(log[soil]). Slopes (B1) and intercepts (B0) are as follows:

Metal	B0	B1	Data Source for Model
Cadmium	1.21	0.66	Neuhauser et al. (1995)
Lead	-0.21	0.81	Sample et al. (1999)
Mercury	-0.078	0.33	Sample et al. (1999)
Manganese	-0.8	0.68	Sample et al. (1999)
Selenium	-0.075	0.73	Sample et al. (1999)
Zinc	4.44	0.33	Sample et al. (1999)

d, Soil-invertebrate and plant bioaccumulation factors could not be identified for Total PAHs therefore the sum of the individual PAH concentrations estimated using soil-to-plant or soil-to-invertebrate uptake factors provided in USEPA (2005).

TABLE F-3
ESTIMATED AQUATIC PREY CONCENTRATIONS
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Theoretical Sediment Concentration (mg/kg, dry weight)	Normalized BSAF (kg OC/kg lipid)[f]	Concentrations in Dietary Items of Aquatic Receptors (mg/kg, dry weight)								
			Aquatic Life Stage Benthic Invertebrates			Emergent Life Stage Benthic Invertebrates			Fish		
			Site-Specific BSAF[a]	Estimated Concentration[f]	BSAF Reference	Biota-Sediment Accumulation Factor (BSAF)	Estimated Concentration	BSAF Reference	Biota-Sediment Accumulation Factor (BSAF)	Estimated Concentration	Reference
Metals											
Barium	100.0	NA	9.51E-01	9.51E+01	Developed[c]	9.51E-01	9.51E+01	Developed[c]	NA	NA	NA
Copper	100.0	NA	95% UPL[d]	1.40E+02	Bechtel (1998b)[d]	Regression[e]	2.44E+01	Bechtel (1998b)	NA	NA	NA
Selenium	100.0	NA	Regression[e]	1.42E+02	Developed[c]	Regression * 0.4[e]	5.69E+01	Developed[c]	NA	NA	NA
Thallium	100.0	NA	7.10E-01	7.10E+01	Borgmann et al. (1998)[d]	7.10E-01	7.10E+01	Borgmann et al. (1998)[d]	NA	NA	NA
PAHs											
Total PAHs & VOCs	100			5.48E+03	Calculated[g]		7.40E+02	Calculated		1.07E+02	Calculated[h]
PAHs:											
1-Methylnaphthalene	100.0	1.61E+00	4.26E-01	4.25E+01	Site-specific[b]						
1-Methylphenanthrene	100.0	9.31E+00	3.93E+00	3.93E+02	Site-specific[b]						
2,3,5-Trimethylnaphthalene	100.0	6.80E+00	2.87E+00	2.87E+02	Site-specific[b]						
2,6-Dimethylnaphthalene	100.0	2.96E+00	1.25E+00	1.25E+02	Site-specific[b]						
2-Methylnaphthalene	100.0	1.43E+00	6.03E-01	6.03E+01	Site-specific[b]						
Acenaphthene	100.0	1.27E+00	5.37E-01	5.37E+01	Site-specific[b]						
Acenaphthylene	100.0	3.44E+00	1.45E+00	1.45E+02	Site-specific[b]						
Anthracene	100.0	3.00E+00	1.27E+00	1.27E+02	Site-specific[b]						
Benzo(a)anthracene	100.0	6.38E+00	2.70E+00	2.70E+02	Site-specific[b]						
Benzo(a)pyrene	100.0	3.31E+00	1.40E+00	1.40E+02	Site-specific[b]						
Benzo(b)fluoranthene	100.0	5.63E+00	2.38E+00	2.38E+02	Site-specific[b]						
Benzo(e)pyrene	100.0	7.31E+00	3.09E+00	3.09E+02	Site-specific[b]						
Benzo(g,h,i)perylene	100.0	2.71E+00	1.14E+00	1.14E+02	Site-specific[b]						
Benzo(k)fluoranthene	100.0	9.01E+00	3.81E+00	3.81E+02	Site-specific[b]						
Biphenyl	100.0	1.27E+00	5.37E-01	5.37E+01	Site-specific[b]						
Chrysene	100.0	7.32E+00	3.10E+00	3.10E+02	Site-specific[b]						
Dibenz(a,h)anthracene	100.0	7.69E+00	3.25E+00	3.25E+02	Site-specific[b]						
Dibenzofuran	100.0	1.27E+00 (diversity/1.46E-02 (fish)[i]	5.37E-01	5.37E+01	Site-specific[b]				9.43E-03	9.43E-01	Site-specific[b]
Fluoranthene	100.0	7.18E+00	3.03E+00	3.03E+02	Site-specific[b]						
Fluorene	100.0	2.42E+00	1.02E+00	1.02E+02	Site-specific[b]						
Indeno(1,2,3-cd)pyrene	100.0	1.95E+00	8.23E-01	8.23E+01	Site-specific[b]						
Naphthalene	100.0	3.12E+00	1.32E+00	1.32E+02	Site-specific[b]						
Perylene	100.0	7.01E+00	2.96E+00	2.96E+02	Site-specific[b]						
Phenanthrene	100.0	6.87E+00	2.90E+00	2.90E+02	Site-specific[b]						
Pyrene	100.0	7.48E+00	3.15E+00	3.15E+02	Site-specific[b]						
Total PAHs	100.0			4.95E+03	Calculated		6.68E+02	Calculated		1.0E+02	Site-specific[b]
VOCs:											
Benzene	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]
Toluene	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]
Ethylbenzene	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]
Xylenes (total)	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]
m & p-cresols	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]
o-cresol	100.0	3.12E+00 (inverts)/1.46E-02 (fish)[i]	1.32E+00	1.32E+02	Site-specific[b]		1.78E+01	Calculated[f]	9.43E-03	9.43E-01	Site-specific[b]

Notes:

a. 95% upper confidence level (UCL) BSAF calculated from Hamilton and Buhl (2003a) and Hamilton and Buhl (2003b)

b. Invertebrate concentrations (mg/kg dry weight) calculated based on regression models, where slopes (B1) and intercepts (B0) are as follow

Metal	Model	B0	B1	Data Source for Model
Copper	y = B0 + B1*(log sediment)	1.23	0.079	Bechtel (1998b)
Selenium	y = B1*(sediment)	-	1.422	Hamilton and Buhl (2002a and 2003b)

c. 95% upper prediction limit (UPL) of regressions calculated by Bechtel (1998b); calculated according to Appendix A in Bechtel (1998)

d. Bioaccumulation study

e. Estimated concentration in aquatic stage benthic invertebrates multiplied by a correction factor of 0.4 to account for the approximately 60% of selenium that remains in the intact exoskeleton (Reinfelder and Fisher 1991)

f. Normalized BSAF (kg OC / kg lipid) calculated based on the site-specific 28-day Lumbriculus variegatus bioaccumulation study. A normalized BSAF was calculated as the geometric mean of BSAFs for each individual PAH compound (BSAFs were normalized by organic carbon content [geometric mean of all samples])

g. Calculated as the sum of estimated concentrations for listed PAH and VOC compounds

h. Normalized BSAF estimated as the geometric mean of sediment organic carbon and lipid normalized BSAFs calculated from the site-specific 28-day L. variegatus study

i. Calculated as the sum of estimated concentrations for listed PAH compounds

j. Normalized BSAF for acenaphthene used as a surrogate BSAF for biphenyl based on similar log K_{ow}

k. Normalized BSAF for naphthalene used as a surrogate for VOCs based on the assumption that VOCs are not accumulated at a greater rate than naphthalene (Roubal et al. 1977)

l. Calculated as 13.5% of the total PAH and VOC concentration estimated in aquatic life stage invertebrates. Assumption based on Bell et al. (2004) who found that no more than 13.5% of the fluoranthene body burden in aquatic life stage insects was rel

m. Calculated as the sum of the UCL_{95} concentration of IPAHs measured from fish at the site (all species) and estimated concentrations of dibenzofuran and the listed VOCs

n. A sediment-to-fish normalized BSAF was calculated based on site-specific concentrations in brown bullhead. The BSAF was estimated as the geometric mean of the sediment organic carbon and lipid normalized BSAFs calculated for each PAH compound based sample with the highest concentration of PAH

o. Calculated as the sum of the UCL_{95} concentration of IPAHs measured from fish at the site (all species)

p. Calculated as 13.5% of the total PAH or individual VOC concentration estimated in aquatic life stage invertebrates. Assumption based on Bell et al. (2004) who found that no more than 13.5% of the fluoranthene body burden in aquatic life stage inse

q. For organic constituents, site-specific BSAF calculated from sediment organic carbon and lipid normalized BSAF as follow

$$BSAF_{ww\text{-}sq} = BSAF_{oc\text{-}sq} \times f_{lipid} + f_{oc}$$

where $BSAF_{ww\text{-}sq}$ = Normalized BSAF (kg OC/kg lipid)

f_{lipid} = Fraction of lipids in prey item expressed on a dry weight basis (0.0785, invertebrates; 0.012, fish)

f_{oc} = Fraction of sediment organic carbon expressed on a dry weight basis (0.1957)

r. Unless otherwise indicated, estimated concentration in prey calculated as the product of the site-specific BSAF and the dry weight constituent concentration in sedimen

TABLE F-4
ESTIMATION OF BSAFs BASED ON 28-DAY L. VARIEGATUS BIOACCUMULATION STUDY
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Compound	Log K_{ow}	Normalized BSAFs (kg sediment organic carbon/kg lipid)		
		Minimum	Maximum	Geometric Mean
1-Methylnaphthalene	3.84	0.01	9.26	1.01
1-Methylphenanthrene	5.04	2.40	124.78	9.31
2,3,5-Trimethylnaphthalene	4.86	0.91	49.42	6.80
2,6-Dimethylnaphthalene	4.37	0.14	25.87	2.96
2-Methylnaphthalene	3.86	0.01	19.17	1.43
Acenaphthene	4.01	0.07	13.80	1.27
Acenaphthylene	3.22	0.46	33.36	3.44
Anthracene	4.53	0.47	27.36	3.02
Benzo(a)anthracene	6.71	1.70	66.60	6.38
Benzo(a)pyrene	6.11	0.55	40.86	3.31
Benzo(b)fluoranthene	6.27	0.93	64.01	5.63
Benzo(e)pyrene	6.14	2.26	73.04	7.31
Benzo(g,h,i)perylene	6.51	0.66	22.87	2.71
Benzo(k)fluoranthene	6.29	2.35	86.32	9.01
Chrysene	5.71	2.45	80.35	7.32
Dibenzo(a,h)anthracene	6.71	1.64	56.19	7.69
Fluoranthene	5.08	1.84	88.26	7.18
Fluorene	4.21	0.17	26.69	2.42
Indeno(1,2,3-cd)pyrene	6.72	0.28	18.69	1.95
Naphthalene	3.36	0.02	42.97	3.12
Perylene	6.14	1.65	34.56	7.01
Phenanthrene	4.57	1.34	64.80	6.87
Pyrene	4.92	2.34	106.96	7.45

TABLE F-5
METAL CONCENTRATIONS IN SEDIMENT AND COMPOSITE BENTHIC INVERTEBRATE SAMPLES
DATA SOURCE: HAMILTON AND BUHL (2003a and 2003b)
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Barium			Selenium[1]		
Sediment (mg/kg, dry weight)	Invertebrates (mg/kg, dry weight)	BSAF	Sediment (mg/kg, dry weight)	Invertebrates (mg/kg, dry weight)	BSAF
25	104	4.160	0.5	2.6	5.200
78	28	0.359	0.8	2.9	3.625
90	80	0.889	0.8	4.9	6.125
97	112	1.155	1	7.2	7.200
100	14	0.140	1	6.7	6.700
111	17	0.153	1.2	0.5	0.417
111	91	0.820	1.5	1.9	1.267
111	24	0.216	1.6	7.8	4.875
113	18	0.159	1.7	0.5	0.294
132	15	0.114	1.8	0.5	0.278
150	32	0.213	1.8	7.7	4.278
153	37	0.242	1.8	5.4	3.000
157	196	1.248	2.1	5.4	2.571
169	25	0.148	2.5	4.1	1.640
228	23	0.101	2.8	5	1.786
229	56	0.245	3	12.8	4.267
237	14	0.059	3.7	9.3	2.514
240	60	0.250	4.3	9.7	2.256
	95_{UCL}:	0.951	4.3	8.7	1.786
			4.6	6.7	1.457
			5.2	19.5	3.750
			7.2	10.8	1.500
			32.2	26.9	0.835
			32.5	35.7	1.098
			38.9	75.2	1.933

Notes:
Bold and italicized values indicate that the actual concentration was below the detection limit shown.
1, Additional samples from Hamilton and Buhl (2002) were included in the evalution of selenium.

TABLE F-6
BSAFs CALCULATED FOR SITE FISH
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Sediment Concentration (ug/kg sediment OC)	Brown Bullhead Concentration (ug/kg lipid)	Normalized BSAF (kg sediment organic carbon/kg lipid)
1-Methylnaphthalene	18920	4166.7	0.2202
1-Methylphenanthrene	4202	541.7	0.1289
2,3,5-Trimethylnaphthalene	1928	541.7	0.2810
2,6-Dimethylnaphthalene	14233	1791.7	0.1259
2-Methylnaphthalene	295705	1375.0	0.0046
Acenaphthene	129733	4166.7	0.0321
Acenaphthylene	12269	541.7	0.0441
Anthracene	47707	1708.3	0.0358
Benzo(a)anthracene	26674	400.0	0.0150
Benzo(a)pyrene	21619	45.8	0.0021
Benzo(b)fluoranthene	12696	41.7	0.0033
Benzo(e)pyrene	5641	41.7	0.0074
Benzo(g,h,i)perylene	9313	179.2	0.0192
Benzo(k)fluoranthene	13434	41.7	0.0031
Biphenyl	6367	320.8	0.0504
Chrysene	24357	91.7	0.0038
Dibenzo(a,h)anthracene	5135	41.7	0.0081
Fluoranthene	53194	170.8	0.0032
Fluorene	57275	1208.3	0.0211
Indeno(1,2,3-cd)pyrene	8610	41.7	0.0048
Naphthalene	370582	2208.3	0.0060
Perylene	1435	41.7	0.0290
Phenanthrene	149411	258.3	0.0017
Pyrene	73452	408.3	0.0056
		Geometric Mean:	0.0146

TABLE F-7
TOXICITY REFERENCE VALUES
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analytes	Avian Receptors				Mammalian Receptors			
	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source
Metals								
Antimony	NA	NA	--	--	13.3	66.5	Geometric Mean	USEPA 2005
Barium	208.3	416.5	1-d old chicks	Johnson et al. 1960	51.8	259	Geometric Mean	USEPA 2003
Cadmium	1.9	21.1	Mallard	White and Finley 1978	5.1	7.1	Various	USEPA 2003
Copper	47	62	Chicken	Mehring et al. 1960	11.7	15.1	Mink	Aulerich et al. 1982
Lead	7.4	37	Dove	Kendall and Scanlon 1981	34	80	Rat	Kimmel et al. 1980 (NOAEL); Azar et al. 1973 (LOAEL)
Manganese	977	4885	1-d old Japanese quail	Laskey and Edens 1985	88	284	Rat	Laskey et al. 1982
Mercury	0.45	0.91	Japanese quail	Hill and Schaffer 1976	13.2	56	Mouse/Rat	Revis et al. 1989 (NOAEL); Fitzhugh et al. 1950 (LOAEL)
Selenium	0.4	0.8	Mallard[c]	Heinz et al. 1989	0.35	1.05	Rat	Rosenfeld and Beath 1954
Thallium	NA	NA	--	--	0.2	1	Rat	USEPA 1996
Zinc	54.4	131	Chicken	Stahl et al. 1990	160	320	Rat	Schlicker and Cox 1968
Organic Compounds								
Total PAHs & VOCs	161	NA	mallard	Patton and Dieter 1980	129	NA	Rat	Shopp et al 1995a; Plasterer et al 1985
Benzene	NA	NA			52.8	NA	Mouse	Nawrot and Staples 1979
Ethylbenzene	NA	NA			97	NA	Rat	Wolf et al 1956
Toluene	NA	NA			156	NA	Mouse	Nawrot and Staples 1979
Xylenes (total)	NA	NA			357	NA	Rat	NTP 1986
m & p-cresols	NA	NA			10	NA	rat	MBA 1988[d]
o-cresol	NA	NA			21	NA	mink	MBA 1988

Notes:
a, NOAEL is no observable adverse effects level.
b, LOAEL is low observable adverse effects level.
c, Mallard-based TRV is multplied by correction factors of 4.0 and 4.5 for tree swallow and belted kingfisher per ESAT (2005)
d, Lower TRV for p-cresol selected as a conservative TRV for m & p-cresols.
-- Appropriate data are not available from published literature to derive NOAEL and LOAEL values.
ORNL (1996) as found in Sample, et. al. 1996.
NA, Toxicity Reference Value not available.

TABLE F-8
ESTIMATION OF BSAFs USING TARGET LIPID MODEL (DiTORO AND McGRATH 2000)
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Compound	Log K_{ow}	K_{ow}	Normalized BSAF (kg sediment organic carbon/kg lipid)
1-Methylnaphthalene	3.84	6918	0.715
1-Methylphenanthrene	5.04	109648	0.643
2,3,5-Trimethylnaphthalene	4.86	72444	0.654
2,6-Dimethylnaphthalene	4.37	23442	0.682
2-Methylnaphthalene	3.86	7244	0.713
Acenaphthene	4.01	10233	0.704
Acenaphthylene	3.22	1660	0.754
Anthracene	4.53	33884	0.673
Benzo(a)anthracene	6.71	5128614	0.556
Benzo(a)pyrene	6.11	1288250	0.586
Benzo(b)fluoranthene	6.27	1862087	0.578
Benzo(e)pyrene	6.14	1380384	0.584
Benzo(g,h,i)perylene	6.51	3235937	0.566
Benzo(k)fluoranthene	6.29	1949845	0.577
Biphenyl	4.17	14791	0.694
Chrysene	5.71	512861	0.607
Dibenzo(a,h)anthracene	6.71	5128614	0.556
Fluoranthene	5.08	120226	0.641
Fluorene	4.21	16218	0.692
Indeno(1,2,3-cd)pyrene	6.72	5248075	0.555
Naphthalene	3.36	2291	0.745
Perylene	6.14	1380384	0.584
Phenanthrene	4.57	37154	0.670
Pyrene	4.92	83176	0.650

TABLE F-9
BSAFs FOR L. VARIEGATUS FROM USACE ERED DATABASE
ASHLAND/NSP LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Normalized BSAF (kg sediment organic carbon/kg lipid)
Benzo(a)pyrene	0.37
Benzo(a)pyrene	0.23
Benzo(a)pyrene	0.5
Benzo(a)pyrene	0.13
Benzo(a)pyrene	1
Benzo(a)pyrene	0.5
Benzo(a)pyrene	1.34
Geometric Mean:	0.45
Benzo(a)anthracene	0.97
Chrysene	1.5
Chrysene	1.1
Geometric Mean:	1.28
Fluoranthene	1.8
Fluoranthene	1.6
Geometric Mean:	1.70
Naphthalene	5.3
Naphthalene	8.8
Geometric Mean:	6.83
Perylene	2.2
Perylene	1
Geometric Mean:	1.48
Pyrene	2.3
Pyrene	2.2
Pyrene	0.52
Pyrene	0.29
Pyrene	0.74
Pyrene	0.29
Pyrene	1.34
Pyrene	0.66
Pyrene	2.03
Geometric Mean:	0.87
2-Methyl naphthalene	2.6
2-Methyl naphthalene	6.7
Geometric Mean:	4.17

Appendix G
Data Quality Objectives

STEP 6: Evaluate Decision Errors
1. Inadequate coverage of any portion of the Site could result in missing an area with elevated COPC concentrations at the surface or at depth (false negative). This potential error should be addressed in the sampling design. 2. Uncertainty is associated with measurement error and comparison of substrate chemistry data with sediment quality criteria/benchmarks developed for the protection of wildlife and fish and other aquatic organisms. 3. In general, if risk is overestimated (false positive), a potential consequence is unnecessary remedial work that itself could be biologically detrimental. If risks are underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems could continue to be detrimentally impacted.
STEP 7: Optimize the Design for Obtaining Data
The sampling design will be prepared as part of the RI work plan and will address optimizing the sample design.

Table 2. Data Quality Objectives for Surface Water Chemistry

Surface Water Chemistry Line Of Evidence
STEP 1: State the Problem To assess the current level of ecological risk at the Site, and determine if the concentrations of COPCs in the surface water pose an unacceptable risk. That is, COPC concentrations are greater than water quality criteria/benchmarks for the protection of wildlife and fish and other aquatic organisms, and if necessary literature values that associate COPC concentrations with effects.
STEP 2: Identify the Decision 1. Are COPC concentrations in the dissolved fraction of surface water at the Site elevated above ambient water quality criteria/benchmarks (NRWQC) for the protection of wildlife and fish and other aquatic organisms or , if necessary, literature values that associate COPC concentrations with effects? 2. Where are the locations of surface water with unacceptable COPC concentrations? 3. Do surface water COPC concentrations increase with disturbance of surface substrates? Are these COPC concentrations associated with unacceptable risk?
STEP 3: Identify Inputs to the Decision 1. COPC concentrations in the dissolved fraction of surface water (measured using appropriate methods to achieve necessary detection limits) during calm and rough water conditions. 2. Applicable water quality data. 3. Station location and water sample depth. 4. Satisfactory data quality of the analytical results based on an approved QAPP.
STEP 4: Define the Study Boundaries Step 2 questions will be based on surface water samples collected in Site locations from approximately mid water column and near bottom.
STEP 5: Develop a Decision Rule Surface water COPC concentrations at Site locations that exceed applicable ambient water quality criteria/benchmarks would indicate a potential for unacceptable ecological risks.
STEP 6: Evaluate Decision Errors 1. Inadequate coverage of any portion of the Site could result in missing an area with elevated COPC concentrations in the surface water (false negative). This potential error should be addressed in the sampling design. 2. Uncertainty is associated with measurement error and comparison of surface water chemistry data with surface water benchmarks developed or derived in the BERA for the protection of wildlife and fish and other aquatic organisms. 3. In general, if risk is overestimated (false positive), a potential consequence is unnecessary remedial work that itself could be biologically detrimental. If risks are underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems could continue to be detrimentally impacted.
STEP 7: Optimize the Design for Obtaining Data The sampling design will be prepared as part of the work plan and will address optimizing the sample design.

Table 3. Data Quality Objectives for Benthic Community Analysis

BENTHIC COMMUNITY LINE OF EVIDENCE
STEP 1: State the Problem To assess the current level of ecological risk at the Site, and determine if COPCs in the surface sediment are impacting the benthic community at the Site.
STEP 2: Identify the Decision 1. Is the benthic community structure at the Site different from the reference areas? 2. Can any observed differences in benthic structure be correlated with COPC concentrations in surface substrates? 3. What Site locations exhibit impaired benthic community structure?
STEP 3: Identify Inputs to the Decision 1. Identification to the lowest possible taxonomic unit and quantification of the number of individuals of benthic macroinvertebrates found in grab samples in the top 6 inches of substrate from comparable locations at the Site and the reference area. 2. Community metrics to define diversity and abundance of benthic community structure, including taxa richness, Shannon Weiner Diversity Index, and various community health indices.
STEP 4: Define the Study Boundaries Step 2 questions will require data from reference substrate sites. Reference sites will include similar presence and absence of wood debris and grain-size and TOC characteristics as Site sediments and will not be affected by known point sources of contamination.
STEP 5: Develop a Decision Rule 1. Comparisons will be made between the community metrics derived from the Site and reference locations to evaluate if there are significant differences. 2. Correlations between community metrics and COPC concentrations will also be evaluated.
STEP 6: Evaluate Decision Errors 1. Use of benthic community metrics could over- or underestimate impacts. 2. In general, if risk is overestimated (false positive), a possible consequence is unnecessary remedial work that itself could be biologically detrimental. If risk is underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems could continue to be detrimentally impacted. 3. Heterogeneity in the benthic community samples or low populations at the Site or reference areas may complicate interpretation.
STEP 7: Optimize the Design for Obtaining Data The sampling design will be prepared as part of the work plan and will address optimizing the sample design.

Table 4. Data Quality Objectives for 28 day *Hyalella azteca* (Amphipod) with and without UV Light and 20-day *Chironomus dilutus* (formerly *C. tentans) (Midge) Sediment* Bioassay

SEDIMENT BIOASSAY LINE OF EVIDENCE
STEP 1: State the Problem
To assess the current level of ecological risk at the Site, and determine if the concentrations of COPCs in the surface sediments result in an unacceptable risk; that is, toxicity results indicate greater toxicity at Site stations compared to reference conditions.
STEP 2: Identify the Decision
1. Is surface sediment from the Site toxic to benthic invertebrates?
2. What is the extent and magnitude of unacceptable risk associated with *Hyalella azteca* and *Chironomous dilutus* bioassay line of evidence, and can causality be associated with COPCs and observed toxicity?
3. Does UV light result in incremental effects to bioassay organisms?
4. What are the locations exhibiting toxicity?
5. Are confounding factors contributing to any observed toxicity?
6. Is observed toxicity due to COPCs?
STEP 3: Identify Inputs to the Decision
1. Amphipod and midge survival after exposure to Site sediment.
2. Amphipod and midge survival after exposure to control sediment (=80% survival in control is required to validate test) with normal daylight and UV light.
3. Grain-size distribution and TOC content of test sediment
4. Measurement of overlying water quality during test duration: conductivity, hardness, ammonia, pH, temperature and dissolved oxygen.
5. Appropriate test organism acclimation.
6. Satisfactory data quality of the analytical results based on established QAAP.
STEP 4: Define the Study Boundaries
1. Step 2 will be based on the results of exposure of the amphipod and midge to surface substrates defined as the top 6 inches of substrate.
2. Surface substrate from each sample station may be represented by a localized composite sample, if necessary, to allow collection of sufficient sediment volume to support all required evaluations.
STEP 5: Develop a Decision Rule
1. Amphipod and midge survival in Site substrate samples will be compared with the reference station results.
2. If control survival is =80%, and the difference between Site survival or growth and reference station survival or growth is =20% (statistically significant difference at a= 0.1) it is indicative of unacceptable risks.
3. If control survival is <80% then the bioassay test will not have met minimum quality control standards and the results will not be considered usable for assessing impacts to benthic invertebrates.
4. If water chemistry measurements, grain size distribution in the sample, ammonia levels in the pore and overlying water, are within acceptable limits, then any

observed toxicity will not be attributed to confounding factors
STEP 6: *Evaluate Decision Errors*
1. Data from the amphipod and midge bioassays could over- or under estimate amphipod toxicity when laboratory results are extrapolated to field populations of the same genus or other species of equal sensitivity and habitats. 2. In general, if toxicological risk is overestimated (false positive), a possible consequence is unnecessary remedial work that itself could be biologically detrimental. If toxicological risk is underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems could continue to be detrimentally impacted.
STEP 7: Optimize the Design for Obtaining Data
The sampling design will be prepared as part of the work plan and will address optimizing the sample design.

Table 5. Data Quality Objectives for *Pimephales promelas* (Fathead Minnow) with and without UV Light

FATHEAD MINNOW AND DAPHNIA LINE OF EVIDENCE
STEP 1: State the Problem
To assess the current level of ecological risk at the Site, and determine if the concentrations of COPCs in the surface water result in an unacceptable risk; that is, toxicity results indicate greater toxicity at the Site compared to reference conditions.
STEP 2: Identify the Decision
1. Are COPCs concentrations in surface water from the Site causing impacts to fish?
2. What is the extent and magnitude of unacceptable risk associated with fish bioassay line of evidence, and can causality be associated with COPCs and observed impacts?
3. Does UV light result in incremental effects to fish?
4. What are the locations exhibiting impacts to fish?
5. Are confounding factors contributing to any observed impacts?
6. Are observed impacts due to COPCs?
STEP 3: Identify Inputs to the Decision
1. Survival of fish after exposure to Site and reference sediment with and without UV exposure.
2. Survival of fish after exposure to control sediment (=80% survival in control is required to validate test).
3. Grain-size distribution of test sediment.
4. Appropriate test organism acclimation.
5. Overlying water quality conditions during testing period: dissolved oxygen, pH, and temperature measured at beginning and end of test in all containers.
6. Measurement of water ammonia concentrations during the test.
7. COPC concentrations of sediment (measured using appropriate methods to achieve necessary detection limits.
STEP 4: Define the Study Boundaries
1. Step 2, Questions 1 and 2 will be based on the results of exposure of test organism to surface water. .
STEP 5: Develop a Decision Rule
1. Fish survival in site substrates will be compared with the reference station results.
2. The test design will include exposures to Site samples and reference samples.
3. If control survival is =80%, and the difference between Site exposed fish reproductive/developmental metrics and ambient results is >20% (statistically significant difference (a = 0.1) indicates unacceptable risks.
4. If control survival is <80% then the bioassay test will not have met minimum quality control standards and the results will not be considered usable for assessing impacts.
5. If interstitial water chemistry, grain size distribution, ammonia sensitivity, and acclimation rates are within acceptable limits, then any observed toxicity will not be attributed to confounding factors.

STEP 6: Evaluate Decision Errors

1. Data from the bioassay test could over- or underestimate reproductive/developmental impacts.
2. In general, if risk is overestimated (false positive), a possible consequence is unnecessary remedial work that itself could be biologically detrimental. If risk is underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems could continue to be detrimentally impacted.

STEP 7: Optimize the Design for Obtaining Data

The sampling design will be prepared as part of the work plan and will address the specifics of this bioassay test including species, exposure, and reproductive/developmental metrics and optimizing the design.

Table 6. Data Quality Objectives for Food Web Model to Upper Trophic Level Organisms

STEP 1: State the Problem To assess the current level of ecological risk the Site, and determine if the concentrations of COPCs in the surface soil, sediment, surface water or prey result in an unacceptable risk from contaminants bioaccumulating through the food web and adversely effecting the health of representative receptors..
STEP 2: Identify the Decision Do COPCs in surface substrates, surface water or prey pose an unacceptable risk to upper trophic level receptors?
STEP 3: Identify Inputs to the Decision 1. COPC concentrations in invertebrate or fish tissue from Site locations and reference locations. 2. Estimates using representative bioaccumulations factors of COPC concentrations in other organisms preyed upon by wildlife. 3. Food chain exposure parameters, including area use factors for representative receptors. 4. COPC-specific TRVs for representative receptors.
STEP 4: Define the Study Boundaries 1. Chemical analysis of the whole body fish tissue concentrations and aquatic worm (*Lumbriculous)* tissue. 2. Fish species to be analyzed will be limited to those that are within the prey size class for piscivorous birds and mammals.
STEP 5: Develop a Decision Rule COPC concentrations in field-collected organisms will be used to evaluate whether consumption of these organisms poses a potential risk to representative receptors.. If HQs calculated using a food chain model exceed LOAEL TRVs, then potential risk will be inferred.
STEP 6: Evaluate Decision Errors In general, if bioaccumulation and risk from consumption of contaminated prey is overestimated (false positive), a potential consequence is unnecessary remedial work that itself could be biologically detrimental. If bioaccumulation and food-chain risks are underestimated (false negative), a possible consequence is to fail to conclude that remedial action is required and biological systems continue to be detrimentally impacted. Field-collected fish tissues will be analyzed to help reduce uncertainty in estimates of food-chain risk.
STEP 7: Optimize the Design for Obtaining Data The sampling design will be prepared as part of the work plan and will address optimizing the sample design.

Appendix H
Toxicological Reference Values and Benchmarks

Table H-1.
Sources of Avian Benchmarks
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	EPA ECO-SSL NOAEL (mg chemical/kg BW/day)	NOAEL Dose (mg chemical/kg BW/day)	LOAEL Dose (mg chemical/kg BW/day)	Species	Life Stage	Chemical Form	Exposure Time	Endpoint	Reference	Rejected Studies	Comments
Antimony	NA	NA	NA	--	--	--	--	--	--	--	No data available
Barium	NA	208.3	416.5	chickens	1 day old	BaCl	4 weeks	mortality	Johnson, et al. 1960	--	ORNL Default
Cadmium	1.47	1.47[2]	6.32[3]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Copper	4.05[1]	18.4[2]	34.8[3]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Lead	1.63[1]	10.9[2]	44.6[3]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Manganese	NA	977	NA	Japanese quail	Adult	MnO	75 days	Growth	Laskey and Edens 1985	--	ORNL Default
Mercury	NA	0.45	0.91	Japanese quail	Adult	--	1 year	egg production, fertility, hatchability	Hill and Schaffer 1976	--	ORNL Default
Selenium	NA	0.4[4]	0.8[4]	--	--	--	--	--	Heinz, et al. 1989	--	ORNL Default
Thallium	NA	NA	NA	--	--	--	--	--	--	--	No data
Zinc	NA	54.4		Chicken	Chick	--	Early life stage	Minimal Daily Requirement	NAS 1994	--	--
		--	131	Chicken	Adult	--	44-weeks	Hatchability as measured by fertility, egg hatchability and body mass of 3-wk old progeny	Stahl et al. 1990	Jackson, et al. 1986	Shorter duration, similar LOAEL
										Gasaway and Bus 1972	Shorter duration, higher doses
LMW PAHs	NA	16.1 / 161	NA	Mallard	Adult	LMW PAH mixture	7-months	Mortality, body weight, toxic symptoms	Patton and Deiter 1980	--	Only Chronic NOAEL
HMW PAHs	NA	2,120	NA	Mallard	Duckling	Weathered crude oil	20-weeks	Reproduction, hatchability	Stubblefield et al. 1995	--	Only Chronic NOAEL
Benzene	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
Ethylbenzene	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
Toluene	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
Trimethylbenzenes (total)	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
Xylenes (total)	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
m-Cresol	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
o-Cresol	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available
p-Cresol	NA	NA	NA	--	--	--	--	--	--	--	No Chronic data available

Notes:

-- - Information not provided or applicable

1)

2) This is the geometric mean of the data included in the Eco-SSL compilation of NOAELs.

3) This is the geometric mean of the data included in the Eco-SSL compilation of LOAELs.

4) Class-specific TRVs, based on interspecies acute toxicity values, were derived from these chronic TRVs. See section 5 text and text table.

Table H-2.
Sources of Mammalian Benchmarks
Baseline Ecological Risk Assessment
Ashland/Northern States Power Lakefront Superfund Site
Ashland, Wisconsin

Analyte	EPA ECO-SSL (mg chemical/kg BW/day)	NOAEL Dose (mg chemical/kg BW/day)	LOAEL Dose (mg chemical/kg BW/day)	Species	Life Stage	Chemical Form	Exposure Time	Endpoint	Reference	Rejected Studies	Comments
Antimony	0.059[1]	13.3[2]	NA[3]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Barium	51.8	51.8[2]	82.7[4]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Cadmium	0.77[1]	1.86[2]	6.9[4]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Copper	5.82[1]	23.7[2]	82.7[4]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Lead	4.7[1]	40.7[2]	182.4[4]	Various	Various	Various	Various	Reproduction, Growth	U.S. EPA 2005a	--	Geometric mean
Manganese	NA	88	284	Rat	Adult	MnO	224 days	Reproduction	Laskey et al. 1982	--	ORNL Default
Mercury	NA	13.2	--	Mouse	6-month estrous cycle	Mercuric chloride	20 months	Reproduction	Revis, et al. 1989	Aulerich, et al. 1974	Single, no effect dose; shorter exposure period
		--	56	Rat	Adult	Mercuric chloride	2 years	Growth	Fitzhugh, et al. 1950		
Selenium	NA	0.35	1.05	Rat	Adult	Potassium selenate	3 generation	number of young, reproduction in succesive generations	Rosenfeld and Beath 1954	Schroeder and Mitchener 1971	Single dose
										NTP 1994	Non-reproductive endpoints
Thallium	NA	0.2	1.0[5]	Rat	Adult	Thallium sulfate	90 days	Body weight, organ weight, clinical chemistry	U.E. EPA 1986	Formigli et al. 1986	Shorter exposure period
										Downs et al. 1960	Non-reproductive endpoint
										Manzo et al. 1983	Non-reproductive endpoint
Zinc	NA	160	320	Rat	Adult	Zinc oxide	16 days	Mating, fertilization, implantation, fetal development	Schlicker and Cox 1968	Aulerich, et al. 1991	Higher NOAEL
										Ketcheson, et al. 1969	Similar NOAEL, no LOAEL
										Aughey et al. 1977	Similar NOAEL, no LOAEL
										Maita, et al. 1981	Similar NOAEL, no LOAEL
LMW PAHs	NA	129	--	Mouse	Adult	Naphthalene	90-d	Body weight, anemia, immunotoxicity, histopathology	Shopp et al. 1984;	--	Lowest NOAEL
					Adult	Naphthalene	7-14 gestation	Maternal and pup lethality	Plasterer et al. 1995	--	Short-term Chronic
HMW PAHs	NA	462	--	Mouse	Adult	MPG residue	185-d	Multiple organ systems	Weyand et al. 1994	Springer et al. 1989	Toxic to pups
										Culp et al. 1998	No dose-response, food avoidance
Benzene	NA	52.8	264	Mouse	Adult	Benzene	6-12 gestation	Maternal mortality, embryo resorptio	Nawrot and Staples 1979	Exon	Single higher dose
										Wolf et al. 1956	Non-reproductive endpoint
Ethylbenzene	NA	97	--	Rat	Adult	Ethylbenzene	182-days	Nephropathy	Wolf et al. 1956	Smyth et al. 1962	Lethal only
										Ungvary 1986	*Fewer doses, no statistics*
Toluene	NA	156	779	Mouse	Adult	Toluene	6-15 gestation	Maternal mortality, embryo resorption	Nawrot and Staples 1979	Smith 1983, Seidenberg et al. 1982, NTP 1990	Higher NOAELs
										Kimura et al.1971; Smyth et al. 1969; Withey and Hall 1975; Wolf et al. 1956	Lethal only
Trimethylbenzenes (total)	NA	250	500	Rat	Adult	Mixed xylenes	2 years	Growth, Survival	IRIS 2005	--	No value available therefore xylenes were used as a surrogate
Xylenes (total)	NA	357	--	Rat	Adult	Xylenes	103-weeks	Reproductive histopathology	NTP 1986	Seidenberg et al. 1986; Marks et al. 1982	Lower doses only
m-Cresol	NA	100	--	Rabbit	Adult	m-cresol	6-15 gestation	Development, reproduction	BRCC 1988	--	Lowest NOAEL
o-Cresol	NA	21	--	Mink	Adult	o-cresol	6-months	Reproduction	Hornshaw et al. 1986	--	Site-specific receptor
p-Cresol	NA	10	50	Rat	Adult	p-cresol	13-weeks	Nephropathy	MBA 1988	--	Lowest NOAEL

Notes:

1)

2) This is the geometric mean of the data included in the Eco-SSL compilation of NOAELs.

3) Insufficient data available, the geometric mean LOAEL is lower than the geometric mean NOAEL

4) This is the geometric mean of the data included in the Eco-SSL compilation of LOAELs.

5) No LOAEL/NOAEL available; estimated by multiplying/dividing NOAEL by a factor of 5 (Lewis, et al. 1990)

Appendix I
Exposure and Risk Estimates

TABLE I-1
SUMMARY OF EXPOSURE PARAMETERS FOR RECEPTORS OF CONCERN
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Representative Species			Home Range[a]	Home Range Reference	Area Use Factor (AUF)		Body Weight (kg wet weight)	Dietary Composition					Ingestion Rates				
													Food			Substrate	
Common Name	Scientific Name	Food-web classification			Preliminary Exposure Estimate	Refined Exposure Estimate		Plant Material	Invertebrates	Fish	Small Mammals	References	kg dry weight/day	Reference	% of Dry Intake	kg dry wt./day	Reference
Avian Receptors																	
Black duck	*Anas rubripes*	aquatic omnivore	249 ha	Longcore et al 2000	1.0	1.0	1.2		100%			Sibley (2000)	0.057	Nagy (2001)[b]	3.3%	0.002	Estimated[h]
Double crested Cormorant	*Phalacrocorax auritus*	aquatic piscivore	2.0-2.4 km	Custer and Bunck (1992)	1.0	1.0	1.7			100%		Sibley (2000)	0.118	Nagy (2001)[c]	0%	0	Assumption[i]
Osprey	*Pandion haliaetus*	large aquatic piscivore (protected)	3 to 10 km	USEPA (1993)	1.0	1.0	1.6			100%		USEPA (1993)	0.113	Nagy (2001)[c]	0%	0	Assumption[i]
Red-winged blackbird	*Agelaius phoeniceus*	medium omnivore	0.02 ha	DeGraaf et al. (1986)	1.0	1.0	0.052	50%	50%			DeGraaf et al. (1986)	0.008	Nagy (2001)[b]	8.8%	0.0007	Estimated[j]
Tree swallow	*Tachycineta bicolor*	aerial insectivore	60 km	Robertson et al. (1992)	1.0	0.75	0.02		100%			Sibley (2000)	0.012	Nagy (2001)[d]	0%	0	Assumption[k]
Mammalian Receptors																	
Big brown Bat	*Eptesicus fuscus*	aerial insectivore	ND	–	1.0	1.0	0.011		100%			Merritt (1987)	0.00182	Nagy (2001)[e]	0%	0	Assumption[l]
Mink	*Mustela vison*	medium semi-aquatic piscivore	2.63 km	Sample and Suter (1994)	1.0	1.0	1			100%		USEPA (1993); Sample and Suter (1994)	0.0399	Nagy (2001)[f]	0%	0	Sample and Suter (1994)
White-footed mouse	*Peromyscus leucopus*	small terrestrial omnivore	0.06 ha	DeGraaf et al. (1986)	1.0	1.0	0.022	50%	50%			Sample and Suter (1994)	0.002	Nagy (2001)[g]	2%	0.00004	Sample and Suter (1994)

Notes:

a, ND, no data available for this parameter; km, kilometers; ha, hectares;

b, Estimated food ingestion rate (kg/day dry weight) for omnivorous birds = (0.670[Body Weight in grams]$^{0.827}$)/1000 (Nagy 2001);

c, Estimated food ingestion rate (kg/day dry weight) for carnivorous birds = (0.849[Body Weight in grams]$^{0.663}$)/1000 (Nagy 2001);

d, Calculated from measured field metabolic rates in free-living animals.

e, Estimated food ingestion rate (kg/day dry weight) for Chiroptera = (0.365[Body Weight in grams]$^{0.671}$)/1000 (Nagy 2001);

f, Estimated food ingestion rate (kg/day dry weight) for Carnivora = (0.102[Body Weight in grams]$^{0.864}$)/1000 (Nagy 2001);

g, Estimated food ingestion rate (kg/day dry weight) for Rodentia = (0.774[Body Weight in grams]$^{0.727}$)/1000 (Nagy 2001);

h, Estimated based on soil ingestion rate reported for the mallard (Beyer et al 1994).

i, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for piscivores.

j, Estimated based on median soil ingestion rate for similar ground gleaning bird (dove) reported by USEPA (2003).

k, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for aerial insectivores;

l, Assumption based on assumption from Sample and Suter 1994 that substrate ingestion is neglible for the little brown bat.

TABLE I-2
ESTIMATED TERRESTRIAL PREY CONCENTRATIONS - UCL_{95} MEDIA CONCENTRATIONS
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	UCL_{95} Soil Exposure Point Concentration (mg/kg, dry weight)[i]	Estimated Concentrations in Dietary Items of Terrestrial Receptors (mg/kg, dry weight)					
		Plants			Soil Invertebrates		
		Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference	Bioaccumulation Factor (BAF)	Estimated Concentration	BAF Reference
Metals							
Antimony	1.10	Regression[a]	4.3E-02	USEPA (2005a)[a]	1.0E+00	1.1E+00	Assumption[b]
Cadmium	1.3	Regression[a]	7.2E-01	Efroymson et al. (2001)[a]	Regression[c]	1.9E+01	Neuhauser et al. (1995)
Lead	153.3	Regression[a]	4.4E+00	Efroymson et al. (2001)[a]	Regression[c]	4.8E+01	Sample et al. (1999)[c]
Manganese	348.2	2.50E-01	8.7E+01	Baes et al. (1984)	Regression[c]	2.4E+01	Sample et al. (1999)[c]
Mercury	0.2	Regression[a]	1.5E-01	Efroymson et al. (2001)[a]	Regression[c]	6.4E-01	Sample et al. (1999)[c]
Selenium	1.0	Regression[a]	4.8E-01	Efroymson et al. (2001)[a]	Regression[c]	8.9E-01	Sample et al. (1999)[c]
Zinc	445.9	Regression[a]	1.5E+02	Efroymson et al. (2001)[a]	Regression[c]	6.3E+02	Sample et al. (1999)[c]
PAHs							
Total PAHs	49.34		2.3E+01	Assumption[d]		2.0999E+02	Assumption[d]
Acenaphthene	0.49	Regression[a]	7.1E-03	USEPA (2005c)	1.47E+00	7.20E-01	USEPA (2005c)
Acenaphthylene	3.37	Regression[a]	1.2E-01	USEPA (2005c)	2.29E+01	7.71E+01	USEPA (2005c)
Anthracene	0.70	Regression[a]	2.8E-01	USEPA (2005c)	2.42E+00	1.70E+00	USEPA (2005c)
Benzo(a)anthracene	3.68	Regression[a]	1.4E-01	USEPA (2005c)	1.59E+00	5.85E+00	USEPA (2005c)
Benzo(a)pyrene	6.82	Regression[a]	8.3E-01	USEPA (2005c)	1.33E+00	9.08E+00	USEPA (2005c)
Benzo(b)fluoranthene	6.82	3.10E-01	2.1E+00	USEPA (2005c)	2.60E+00	1.77E+01	USEPA (2005c)
Benzo(e)pyrene	5.98	1.90E-01	1.1E+00	USEPA (2005c)	2.76E+00	1.65E+01	USEPA (2005c)
Benzo(g,h,i)perylene	7.29	Regression[a]	4.1E+00	USEPA (2005c)	2.94E+00	2.14E+01	USEPA (2005c)
Benzo(k)fluoranthene	1.94	Regression[a]	2.0E-01	USEPA (2005c)	2.60E+00	5.04E+00	USEPA (2005c)
Chrysene	4.28	Regression[a]	1.6E-01	USEPA (2005c)	2.29E+00	9.79E+00	USEPA (2005c)
Fluoranthene	4.00	5.00E-01	2.0E+00	USEPA (2005c)	3.04E+00	1.22E+01	USEPA (2005c)
Fluorene	0.55	Regression[a]	6.4E-03	USEPA (2005c)	9.57E+00	5.24E+00	USEPA (2005c)
Indeno(1,2,3-cd)pyrene	4.70	1.10E-01	5.2E-01	USEPA (2005c)	2.86E+00	1.35E+01	USEPA (2005c)
Naphthalene	0.51	1.22E+01	6.3E+00	USEPA (2005c)	4.40E+00	2.26E+00	USEPA (2005c)
Phenanthrene	0.88	Regression[a]	7.8E-01	USEPA (2005c)	1.72E+00	1.51E+00	USEPA (2005c)
Pyrene	5.95	7.20E-01	4.3E+00	USEPA (2005c)	1.75E+00	1.04E+01	USEPA (2005c)

Notes:

a, Plant tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]). Slopes (B1) and intercepts (B0) are as follows:

Metal	B0	B1	Data Source for Model
Antimony	-3.233	0.937	USEPA 2003a
Cadmium	-0.48	0.55	Efroymson et al. (2001)
Lead	-1.33	0.56	Efroymson et al. (2001)
Mercury	-1	0.54	Efroymson et al. (2001)
Selenium	-0.68	1.1	Efroymson et al. (2001)
Zinc	1.58	0.56	Efroymson et al. (2001)
Acenaphthene	-5.562	-0.8556	USEPA 2005c
Acenaphthylene	-1.144	0.791	USEPA 2005c
Anthracene	-0.9887	0.7784	USEPA 2005c
Benzo(a)anthracene	-2.7078	0.5944	USEPA 2005c
Benzo(a)pyrene	-2.0615	0.975	USEPA 2005c
Benzo(g,h,i)perylene	-0.9313	1.1829	USEPA 2005c
Benzo(k)fluoranthene	-2.1579	0.8595	USEPA 2005c
Chrysene	-2.7078	0.5944	USEPA 2005c
Fluorene	-5.562	0.8556	USEPA 2005c
Phenanthrene	-0.1665	0.6203	USEPA 2005c

b, Soil-invertebrate bioaccumulation factor could not be identified; therefore, a default accumulation factor of 1.0 was assummed.

c, Soil invertebrate tissue concentrations (mg/kg dry weight) calculated based on regression models, where ln([tissue]) = B0 + B1(ln[soil]), except for Cd which follows the form log([tissue]) = B0 + B1(log[soil]). Slopes (B1) and intercepts (B0) are as follows:

Metal	B0	B1	Data Source for Model
Cadmium	1.21	0.66	Neuhauser et al. (1995)
Lead	-0.21	0.81	Sample et al. (1999)
Mercury	-0.078	0.33	Sample et al. (1999)
Manganese	-0.8	0.68	Sample et al. (1999)
Selenium	-0.075	0.73	Sample et al. (1999)
Zinc	4.44	0.33	Sample et al. (1999)

d, Soil-invertebrate and plant bioaccumulation factors could not be identified for Total PAHs therefore the sum of the individual PAH concentrations estimated using soil-to-plant or soil-to-invertebrate uptake factors provided in USEPA (2005c).

TABLE I-3
ESTIMATED AQUATIC PREY CONCENTRATIONS - UCL_{95} MEDIA CONCENTRATIONS
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Normalized BSAF (kg OC/kg lipid)[f]	Concentrations in Dietary Items of Aquatic Receptors (mg/kg, dry weight)								
			Aquatic Life Stage Benthic Invertebrates			Emergent Life Stage Benthic Invertebrates			Fish		
			Site-Wide BSAF[g]	Estimated Concentration[f]	BSAF Reference	Site-Wide BSAF[g]	Estimated Concentration	BSAF Reference	Site-Wide BSAF[g]	Estimated Concentration	Reference
Metals											
Barium	52.6	NA	9.51E-01	5.00E+01	Developed[a]	9.51E-01	5.00E+01	Developed[a]	NA	NA	NA
Copper	91.4	NA	95% UPL[c]	1.37E+02	Bechtel (1998b)[c]	Regression[b]	2.43E+01	Bechtel (1998b)	NA	NA	NA
Selenium	2.0	NA	Regression[b]	2.83E+00	Developed[a]	Regression * 0.4[e]	1.13E+00	Developed[a]	NA	NA	NA
Thallium	1.6	NA	7.10E-01	1.14E+00	Borgmann et al. (1998)[d]	7.10E-01	1.14E+00	Borgmann et al. (1998)[d]	NA	NA	NA
PAHs											
Total PAHs & VOCs	411			6.16E+02	Calculated[a]		8.32E+01	Calculated[a]		1.03E+00	Calculated[m]
PAHs:											
1-Methylnaphthalene	5.5	1.01E+00	4.25E-01	2.33E+00	Site-specific[h]						
1-Methylphenanthrene	1.2	9.31E+00	3.93E+00	4.79E+00	Site-specific[h]						
2,3,5-Trimethylnaphthalene	0.6	6.80E+00	2.87E+00	1.61E+00	Site-specific[h]						
2,6-Dimethylnaphthalene	4.1	2.96E+00	1.25E+00	5.17E+00	Site-specific[h]						
2-Methylnaphthalene	85.8	1.43E+00	6.03E-01	5.17E+01	Site-specific[h]						
Acenaphthene	37.6	1.27E+00	5.37E-01	2.02E+01	Site-specific[h]						
Acenaphthylene	3.6	3.44E+00	1.46E+00	5.18E+00	Site-specific[h]						
Anthracene	13.8	3.02E+00	1.27E+00	1.76E+01	Site-specific[h]						
Benzo(a)anthracene	7.7	6.38E+00	2.70E+00	2.09E+01	Site-specific[h]						
Benzo(a)pyrene	6.3	3.31E+00	1.40E+00	8.77E+00	Site-specific[h]						
Benzo(b)fluoranthene	3.7	5.63E+00	2.38E+00	8.76E+00	Site-specific[h]						
Benzo(e)pyrene	1.6	7.31E+00	3.09E+00	5.06E+00	Site-specific[h]						
Benzo(g,h,i)perylene	2.7	2.71E+00	1.14E+00	3.09E+00	Site-specific[h]						
Benzo(k)fluoranthene	3.9	9.01E+00	3.81E+00	1.48E+01	Site-specific[h]						
Biphenyl	1.8	1.27E+00	5.37E-01	9.92E-01	Site-specific[h]						
Chrysene	7.1	7.32E+00	3.10E+00	2.19E+01	Site-specific[h]						
Dibenzo(a,h)anthracene	1.5	7.69E+00	3.25E+00	4.84E+00	Site-specific[h]						
Dibenzofuran	0.3	1.27E+00 (inverts)/1.46E-02 (fish)[n]	5.37E-01	1.63E-01	Site-specific[h]				9.43E-03	2.86E-03	Site-specific[n]
Fluoranthene	15.4	7.18E+00	3.03E+00	4.68E+01	Site-specific[h]						
Fluorene	16.6	2.42E+00	1.02E+00	1.70E+01	Site-specific[h]						
Indeno(1,2,3-cd)pyrene	2.5	1.95E+00	8.23E-01	2.05E+00	Site-specific[h]						
Naphthalene	107.5	3.12E+00	1.32E+00	1.42E+02	Site-specific[h]						
Perylene	0.4	7.01E+00	2.96E+00	1.23E+00	Site-specific[h]						
Phenanthrene	43.3	6.87E+00	2.90E+00	1.26E+02	Site-specific[h]						
Pyrene	21.3	7.45E+00	3.15E+00	6.70E+01	Site-specific[h]						
Total PAHs	364.0			6.00E+02	Calculated[f]		8.10E+01	Calculated[e]		9.1E-01	Site-specific[o]
VOCs:											
Benzene	0.5	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	7.12E-01	Site-specific[k]		9.61E-02	Calculated[e]	9.43E-03	5.09E-03	Site-specific[n]
Toluene	1.6	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	2.07E+00	Site-specific[k]		2.79E-01	Calculated[e]	9.43E-03	1.48E-02	Site-specific[n]
Ethylbenzene	2.3	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	3.07E+00	Site-specific[k]		4.14E-01	Calculated[e]	9.43E-03	2.19E-02	Site-specific[n]
Xylenes (total)	4.4	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	5.76E+00	Site-specific[k]		7.77E-01	Calculated[e]	9.43E-03	4.12E-02	Site-specific[n]
m & p-cresols	0.4	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	4.96E-01	Site-specific[k]		6.69E-02	Calculated[e]	9.43E-03	3.55E-03	Site-specific[n]
o-cresol	0.1	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	8.44E-02	Site-specific[k]		1.14E-02	Calculated[e]	9.43E-03	6.04E-04	Site-specific[n]
1,2,4-Trimethylbenzene	1.8	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	2.37E+00	Site-specific[k]		3.20E-01	Calculated[e]	9.43E-03	1.70E-02	Site-specific[n]
1,3,5-Trimethylbenzene	1.3	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	1.71E+00	Site-specific[k]		2.31E-01	Calculated[e]	9.43E-03	1.23E-02	Site-specific[n]
Trimethylbenzenes (total)	3.1	3.12E+00 (inverts)[k]/1.46E-02 (fish)[n]	1.32E+00	4.09E+00	Site-specific[k]		5.52E-01	Calculated[e]	9.43E-03	2.92E-02	Site-specific[n]

TABLE I-3
ESTIMATED AQUATIC PREY CONCENTRATIONS - UCL_{95} MEDIA CONCENTRATIONS
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Notes:

a. 95% upper confidence level (UCL) BSAF calculated from Hamilton and Buhl (2003a) and Hamilton and Buhl (2003b)

b. Invertebrate concentrations (mg/kg dry weight) calculated based on regression models, where slopes (B1) and intercepts (B0) are as follows:

Metal	Model	B0	B1	Data Source for Model
Copper	y = B0 + B1*(log[sediment	1.23	0.079	Bechtel (1998b)
Selenium	y =B1*[sediment]	--	1.422	Hamilton and Buhl (2003a and 2003b)

c. 95% upper prediction limit (UPL) of regressions calculated by Bechtel (1998b); calculated according to Appendix A in Bechtel (1998b)

d. Bioaccumulation study

e. Estimated concentration in aquatic stage benthic invertebrates multiplied by a correction factor of 0.4 to account for the approximately 60% of selenium that remains in the molted exoskelton (Reinfelder and Fisher 1994).

f. Normalized BSAF (kg OC / kg lipid) calculated based on the site-specific 28-day *Lumbriculus variegatus* bioaccumulation study. A normalized BSAF was calculated as the geometric mean of BSAFs for each individual PAH compound (BSAFs were normalized by lipid content [geometric mean of all organisms] and sediment organic carbon content [geometric mean of all samples]) .

g. Calculated as the sum of estimated concentrations for listed PAH and VOC compounds.

h. Normalized BSAF estimated as the geometric mean of sediment organic carbon and lipid normalized BSAFs calculated from the site-specific 28-day *L. variegatus* study.

i. Calculated as the sum of estimated concentrations for listed PAH compounds.

j. Normalized BSAF for acenaphthene used as a surrogate BSAF for biphenyl based on similar log K_{ow}.

k. Normalized BSAF for naphthalene used as a surrogate for VOCs based on the assumption that VOCs are not accumulated at a greater rate than naphthalene (Roubal et al. 1977).

l. Calculated as 13.5% of the tota

m. Calculated as the sum of the UCL_{95} concentration of tPAHs measured from fish at the site (all species) and estimated concentrations of dibenzofuran and the listed VOCs.

n. A sediment-to-fish normalized BSAF was calculated based on site-specific concentrations in brown bullhead. The BSAF was estimated as the sample with the highest concentration of tPAH.

o. Calculated as the UCL_{95} concentration of tPAHs measured from fish at the site (all species). Fish tissue was reported by the laboratory as wet weight (Appendix C) and converted to dry weight assuming a moisture content of 80% in fish.

p. Calculated as 13.5% of the total PAH or i

q. For organic constituents, Site-wide BSAF calculated from sediment organic carbon and lipid normalized BSAF as follows.

$$BSAF_{Site-wide} = BSAF_{norm} \times f_{lipid} + f_{oc}$$

where: $BSAF_{norm}$ = Normalized BSAF (kg OC/kg lipid)

f_{lipid} = Fraction of lipids in prey item expressed on a dry weight basis (0.0785, invertebrates; 0.012, fish)

f_{oc} = Fraction of sediment organic carbon expressed on a dry weight basis (0.1857)

r. Unless otherwise indicated, estimated concentration in prey calculated as the product of the site-specific BSAF and the dry weight constituent concentration in sediment.

TABLE I-4
TOXICITY REFERENCE VALUES
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analytes	Avian Receptors				Mammalian Receptors			
	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source	Chronic NOAEL[a] (mg/kg-bw/d)	Chronic LOAEL[b] (mg/kg-bw/d)	Test Animal	Source
Metals								
Antimony	NA	NA	–	–	13.3	NA	Geometric Mean	USEPA 2005a
Barium	208.3	416.5	1-d old chicks	Johnson et al. 1960	51.8	82.7	Geometric Mean	USEPA 2005a
Cadmium	1.47	6.3	Geometric Mean	USEPA 2005a	0.77	6.9	Geometric Mean	USEPA 2005a
Copper	18.4	34.8	Geometric Mean	USEPA 2005a	23.7	82.7	Geometric Mean	USEPA 2005a
Lead	10.9	44.6	Geometric Mean	USEPA 2005a	40.7	182.4	Geometric Mean	USEPA 2005a
Manganese	977	4885	1-d old Japanese quail	Laskey and Edens 1985	88	284	Rat	Laskey et al. 1982
Mercury	0.45	0.91	Japanese quail	Hill and Schaffer 1976	13.2	56	Mouse/Rat	Revis et al. 1989 (NOAEL); Fitzhugh et al. 1950 (LOAEL)
Selenium	0.4	0.8	Mallard[c]	Heinz et al. 1989	0.35	1.05	Rat	Rosenfeld and Beath 1954
Thallium	NA	NA	–	--	0.2	1	Rat	USEPA 1996
Zinc	54.4	131	Chicken	Stahl et al. 1990	160	320	Rat	Schlicker and Cox 1968
Organic Compounds								
Total PAHs & VOCs	16.1 / 161	NA	mallard	Patton and Dieter 1980	129	NA	Rat	Shopp et al 1984; Plasterer et al 1985
Benzene	NA	NA	--	--	52.8	264	Mouse	Nawrot and Staples 1979
Ethylbenzene	NA	NA	–	--	97	NA	Rat	Wolf et al 1956
Toluene	NA	NA	–	--	156	779	Mouse	Nawrot and Staples 1979
Xylenes (total)	NA	NA	–	--	357	NA	Rat	NTP 1986
m & p-cresols	NA	NA	--	--	10	NA	rat	MBA 1988[d]
o-cresol	NA	NA	--	--	21	NA	mink	MBA 1988
Trimethylbenzenes (total)	NA	NA	–	--	250	500	rat	IRIS 2003

Notes:
a, NOAEL is no observable adverse effects level.
b, LOAEL is low observable adverse effects level.
c, Mallard-based TRV is multplied by correction factors of 4.0 for tree swallow.
d, Lower TRV for p-cresol selected as a conservative TRV for m & p-cresols.
– Appropriate data are not available from published literature to derive NOAEL and LOAEL values.
NA, Toxicity Reference Value not available.

TABLE I-5
UCL_{95} EXPOSURE ESTIMATE -- BLACK DUCK
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Metal	Exposure Point Concentration	*Black Duck Dose (mg/kg bw-day)*				*TRV (mg/kg bw-day)*				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates[d]	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0	2.38	2.38	0.083	2.46	208.3	<1	416.5	<1
Copper	91.4	0	6.50	6.50	0.144	6.65	18	<1	35	<1
Selenium	2.0	0	0.13	0.13	0.003	0.138	0.4	<1	0.8	<1
Thallium	1.6	0	0.05	0.05	0.003	0.057	NA	--	NA	--
Organics										
Total PAHs & VOCs	411	0	29.3	29.3	0.65	30.0	16.1 / 161	**1.9 / <1**	NA	--

Notes:

a, Dietary dose calculated as:

where:
ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.057 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-3)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (1.2 kg)
IR_s = Incidental Ingestion Rate of soil (0.002 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

b, Substrate dose calculated as:

c, Total dose calculated as:

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.
d, Assumption: Concentrations of COPCs in aquatic stage invertebrates are equal to COPC concentrations in the adult stage invertebrate.

TABLE I-6
UCL_{95} EXPOSURE ESTIMATE -- RED-WINGED BLACKBIRD
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Metal	Exposure Point Concentration	Red-Winged Blackbird Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Soil Concentration (mg/kg, dry weight)	Plant Material	Invertebrates	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metal										
Antimony	1.1	0.003	0.08	0.09	0.01	0.10	NA	--	NA	--
Cadmium	1.3	0.06	1.5	1.54	0.02	1.56	1.5	**1.1**	6.3	<1
Lead	153.3	0.340	3.66	4.00	2.07	6.07	10.9	<1	45	<1
Manganese	348.2	6.68	1.84	8.52	4.70	13.2	977	<1	4885	<1
Mercury	0.2	0.01	0.05	0.06	0.003	0.06	0.45	<1	0.91	<1
Selenium	1.0	0.04	0.07	0.11	0.013	0.12	0.4	<1	0.8	<1
Zinc	445.9	11.3	48.7	60.0	6.02	66.1	54.4	**1.2**	131	<1
PAH										
Total PAHs	49.3	1.76	16.1	17.88	0.666	18.54	16.1 / 161	**1.2 / <1**	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

ADD_{diet}	= Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet}	= Ingestion rate of food (0.008 kg food ingested per day, dry weight)
B(S)AF	= Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i	= Dietary fraction of food item *i* (50% plant material and 50% invertebrates in the diet)
AUF	= Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW	= Body weight of the receptor, wet weight (0.052 kg)
IR_s	= Incidental Ingestion Rate of soil (0.0007 kg substrate ingested per day, dry weight)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.

--, HQ could not be calculated because TRV was not available or total dose was not adjusted for bioavailability.

TABLE I-7
UCL_{95} EXPOSURE ESTIMATE -- TREE SWALLOW
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	Tree Swallow Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates[d]	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0.0	30.03	30.03	0.0	30.03	208.3	<1	416.5	<1
Copper	91.4	0.0	14.56	14.56	0.0	14.56	18	<1	35	<1
Selenium	2.0	0.0	0.68	0.68	0.0	0.68	1.6	<1	3.2	<1
Thallium	1.6	0.0	0.68	0.68	0.0	0.68	NA	--	NA	--
Organics										
Total PAHs & VOCs	411.3	0.0	49.9	49.9	0.0	49.9	16.1 / 161	**3.1 / <1**	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.012 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (0.02 kg)
IR_s = Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; *Total dose was not adjusted for bioavailability.*

--, HQ could not be calculated because TRV was not available or total dose was not adjusted for bioavailability.

d, Assumption: Concentrations of COPCs in aquatic stage invertebrates are equal to COPC concentrations in the adult stage invertebrate.

TABLE I-8
UCL_{95} EXPOSURE ESTIMATE -- DOUBLE CRESTED CORMORANT
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Metal	Exposure Point Concentration	Double Crested Cormorant Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Fish	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Organics										
Total PAHs & VOCs	411	0.0	0.071	0.071	0.0	0.071	16.1 / 161	<1 / <1	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

ADD_{diet}	= Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet}	= Ingestion rate of food (0.118 kg food ingested per day, dry weight)
B(S)AF	= Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-3)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i	= Dietary fraction of food item *i* (100% fish in the diet)
AUF	= Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW	= Body weight of the receptor, wet weight (1.7 kg)
IR_s	= Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.

TABLE I-9
UCL_{95} EXPOSURE ESTIMATE -- OSPREY
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Metal	Exposure Point Concentration	Osprey Dose (mg/kg bw-day)			TRV (mg/kg bw-day)				
		Diet		Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Fish	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Organics									
Total PAHs & VOCs	411	0.073	0.073	0.0	0.073	16.1 / 161	<1 / <1	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum(B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

- ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
- IR_{diet} = Ingestion rate of food (0.113 kg food ingested per day, dry weight)
- B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-3)
- $C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
- DF_i = Dietary fraction of food item *i* (100% fish in the diet)
- AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
- BW = Body weight of the receptor, wet weight (1.6 kg)
- IR_s = Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
- $C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.

TABLE I-10
UCL_{95} EXPOSURE ESTIMATE -- WHITE-FOOTED MOUSE
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	White-Footed Mouse Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Soil Concentration (mg/kg, dry weight)	Plant Material	Invertebrates	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Antimony	1.1	0.002	0.05	0.06	0.002	0.06	13.300	<1	NA	--
Cadmium	1.3	0.04	0.95	0.99	0.003	0.99	0.8	**1.3**	6.9	<1
Lead	153.3	0.217	2.34	2.6	0.30	2.9	41	<1	182	<1
Manganese	348.2	4.27	1.18	5.5	0.68	6.1	88	<1	284	<1
Mercury	0.2	0.01	0.03	0.04	0.0004	0.04	13.2	<1	56	<1
Selenium	1.0	0.02	0.04	0.07	0.002	0.07	0.35	<1	1.05	<1
Zinc	445.9	7.3	31.2	38.4	0.88	39.3	160	<1	320	<1
PAHs										
Total PAHs	49.3	1.1	10.3	11.44	0.10	11.5	129	<1	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

ADD_{diet}	= Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet}	= Ingestion rate of food (0.002 kg food ingested per day, dry weight)
B(S)AF	= Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i	= Dietary fraction of food item *i* (50% plant material and 50% invertebrates in the diet)
AUF	= Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW	= Body weight of the receptor, wet weight (0.022 kg)
$ADD_{substrate}$	= Dose of COPC obtained from drinking water (mg COPC/kg receptor body weight-day)
IR_s	= Incidental Ingestion Rate of soil (0.00004 kg substrate ingested per day, dry weight)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.

TABLE I-11
UCL_{95} EXPOSURE ESTIMATE -- BIG BROWN BAT
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	Big Brown Bat Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0.0	8.3	8.3	0.0	8.3	51.8	<1	83	<1
Copper	91.4	0.0	4.0	4.0	0.0	4.0	23.7	<1	82.7	<1
Selenium	2.0	0.0	0.19	0.19	0.0	0.19	0.35	<1	1.05	<1
Thallium	1.6	0.0	0.19	0.19	0.0	0.19	0.2	<1	1	<1
PAHs										
Total PAHs	364	0.0	13.4	13.4	0.0	13.4	129	<1	NA	--
VOCs										
Benzene	0.5	0.0	0.02	0.02	0.0	0.02	52.80	<1	NA	--
Toluene	1.6	0.0	0.05	0.05	0.0	0.05	156.00	<1	NA	--
Ethylbenzene	2.3	0.0	0.07	0.07	0.0	0.07	97.00	<1	NA	--
Xylenes (total)	4.4	0.0	0.13	0.13	0.0	0.13	357.00	<1	NA	--
m & p-cresols	0.4	0.0	0.01	0.01	0.0	0.01	10.00	<1	NA	--
o-cresol	0.1	0.0	0.002	0.002	0.0	0.002	21	<1	NA	--
Trimethylbenzenes (total)	3.1	2.0	0.091	2.091	0.0	2.091	250	<1	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.00182 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (0.011 kg)
IR_s = Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

TABLE I-12
UCL_{95} EXPOSURE ESTIMATE -- MINK
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	Mink Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Invertebrates	Fish	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
PAHs										
Total PAHs	364	0.0	0.04	0.04	0.0	0.04	129	<1	NA	--
VOCs										
Benzene	0.5	0.0	0.0002	0.0002	0.0	0.0002	52.8	<1	264.0	<1
Toluene	1.6	0.0	0.0006	0.0006	0.0	0.0006	156.0	<1	779.0	<1
Ethylbenzene	2.3	0.0	0.0009	0.0009	0.0	0.0009	97.0	<1	NA	--
Xylenes (total)	4.4	0.0	0.002	0.0016	0.0	0.002	357.0	<1	NA	--
m & p-cresols	0.4	0.0	0.00014	0.0001	0.0	0.0001	10.0	<1	NA	--
o-cresol	0.1	0.0	0.00002	0.00002	0.0	0.00002	21.0	<1	NA	--
Trimethylbenzenes (total)	3.1	0.0	0.00117	0.00117	0.0	0.00117	250.0	<1	500.0	<1

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

ADD_{diet}	= Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet}	= Ingestion rate of food (0.0399 kg food ingested per day, dry weight)
B(S)AF	= Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-3)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i	= Dietary fraction of food item *i* (100% fish in the diet)
AUF	= Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW	= Body weight of the receptor, wet weight (1.0 kg)
IR_s	= Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$	= COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
–, HQ not calculated because total dose was not adjusted for bioavailability.

TABLE 1-13
ESTIMATED AQUATIC PREY CONCENTRATIONS - UCL_{95} MEDIA CONCENTRATIONS AND UCL_{95} BSAFs
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Normalized BSAF (kg OC/kg lipid)[f]	Concentrations in Dietary Items of Aquatic Receptors (mg/kg, dry weight)								
			Aquatic Life Stage Benthic Invertebrates			Emergent Life Stage Benthic Invertebrates			Fish		
			Site-Wide BSAF[g]	Estimated Concentration[f]	BSAF Reference	Site-Wide BSAF[g]	Estimated Concentration	BSAF Reference	Site-Wide BSAF[g]	Estimated Concentration	Reference
Metals											
Barium	52.6	NA	9.51E-01	5.00E+01	Developed[e]	9.51E-01	5.00E+01	Developed[e]	NA	NA	NA
Copper	91.4	NA	95% UPL[c]	1.37E+02	Bechtel (1998b)[c]	Regression[b]	2.43E+01	Bechtel (1998b)	NA	NA	NA
Selenium	2.0	NA	Regression[b]	2.83E+00	Developed[e]	Regression * 0.4[e]	1.13E+00	Developed[e]	NA	NA	NA
Thallium	1.6	NA	7.10E-01	1.14E+00	Borgmann et al. (1998)[d]	7.10E-01	1.14E+00	Borgmann et al. (1998)[d]	NA	NA	NA
PAHs											
Total PAHs & VOCs	408.2			2.30E+03	Calculated[g]		3.11E+02	Calculated[l]		1.03E+00	Calculated[m]
PAHs:											
1-Methylnaphthalene	5.5	4.09E+00	1.73E+00	9.49E+00	Site-specific[h]						
1-Methylphenanthrene	1.2	3.82E+01	1.61E+01	1.97E+01	Site-specific[h]						
2,3,5-Trimethylnaphthalene	0.6	1.82E+01	7.71E+00	4.31E+00	Site-specific[h]						
2,6-Dimethylnaphthalene	4.1	8.33E+00	3.52E+00	1.45E+01	Site-specific[h]						
2-Methylnaphthalene	85.8	5.72E+00	2.42E+00	2.07E+02	Site-specific[h]						
Acenaphthene	37.6	4.37E+00	1.85E+00	6.95E+01	Site-specific[h]						
Acenaphthylene	3.6	1.05E+01	4.43E+00	1.58E+01	Site-specific[h]						
Anthracene	13.8	1.03E+01	4.35E+00	6.02E+01	Site-specific[h]						
Benzo(a)anthracene	7.7	2.31E+01	9.75E+00	7.54E+01	Site-specific[h]						
Benzo(a)pyrene	6.3	1.22E+01	5.14E+00	3.22E+01	Site-specific[h]						
Benzo(b)fluoranthene	3.7	2.32E+01	9.80E+00	3.61E+01	Site-specific[h]						
Benzo(e)pyrene	1.6	2.46E+01	1.04E+01	1.70E+01	Site-specific[h]						
Benzo(g,h,i)perylene	2.7	8.45E+00	3.57E+00	9.65E+00	Site-specific[h]						
Benzo(k)fluoranthene	3.9	2.76E+01	1.17E+01	4.55E+01	Site-specific[h]						
Biphenyl	1.8	4.37E+00	1.85E+00	3.41E+00	Site-specific[h]						
Chrysene	7.1	2.55E+01	1.08E+01	7.62E+01	Site-specific[h]						
Dibenzo(a,h)anthracene	1.5	2.22E+01	9.36E+00	1.39E+01	Site-specific[h]						
Dibenzofuran	0.3	4.37E+00 (inverts)/1.46E-02 (fish)[n]	1.85E+00	5.60E-01	Site-specific[i]				9.43E-03	2.86E-03	Site-specific[n]
Fluoranthene	15.4	2.81E+01	1.19E+01	1.83E+02	Site-specific[h]						
Fluorene	16.6	7.95E+00	3.36E+00	5.58E+01	Site-specific[h]						
Indeno(1,2,3-cd)pyrene	2.5	6.69E+00	2.83E+00	7.06E+00	Site-specific[h]						
Naphthalene	107.5	1.25E+01	5.29E+00	5.68E+02	Site-specific[h]						
Perylene	0.4	1.25E+01	5.28E+00	2.20E+00	Site-specific[h]						
Phenanthrene	43.3	2.04E+01	8.63E+00	3.74E+02	Site-specific[h]						
Pyrene	21.3	3.73E+01	1.58E+01	3.36E+02	Site-specific[h]						
Total PAHs	364.0			2.24E+03	Calculated[j]		3.02E+02	Calculated[p]		9.1E-01	Site-specific[o]
VOCs:											
Benzene	0.5	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	2.86E+00	Site-specific[k]		3.86E-01	Calculated[p]	9.43E-03	5.09E-03	Site-specific[n]
Toluene	1.6	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	8.30E+00	Site-specific[k]		1.12E+00	Calculated[p]	9.43E-03	1.48E-02	Site-specific[n]
Ethylbenzene	2.3	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	1.23E+01	Site-specific[k]		1.66E+00	Calculated[p]	9.43E-03	2.19E-02	Site-specific[n]
Xylenes (total)	4.4	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	2.31E+01	Site-specific[k]		3.12E+00	Calculated[p]	9.43E-03	4.12E-02	Site-specific[n]
m & p-cresols	0.4	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	1.99E+00	Site-specific[k]		2.68E-01	Calculated[p]	9.43E-03	3.55E-03	Site-specific[n]
o-cresol	0.1	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	3.38E-01	Site-specific[k]		4.57E-02	Calculated[p]	9.43E-03	6.04E-04	Site-specific[n]
1,2,4-Trimethylbenzene	1.8	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	9.51E+00	Site-specific[k]		1.28E+00	Calculated[p]	9.43E-03	1.70E-02	Site-specific[n]
1,3,5-Trimethylbenzene	1.3	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	6.87E+00	Site-specific[k]		9.28E-01	Calculated[p]	9.43E-03	1.23E-02	Site-specific[n]
Trimethylbenzenes (total)	3.1	1.25E+01 (inverts)[k]/1.46E-02 (fish)[n]	5.29E+00	1.64E+01	Site-specific[k]		2.21E+00	Calculated[p]	9.43E-03	2.92E-02	Site-specific[n]

TABLE I-13
ESTIMATED AQUATIC PREY CONCENTRATIONS - UCL_{95} MEDIA CONCENTRATIONS AND UCL_{95} BSAFs
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Notes:

a, 95% upper confidence level (UCL) BSAF calculated from Hamilton and Buhl (2003a) and Hamilton and Buhl (2003b)

b, Invertebrate concentrations (mg/kg dry weight) calculated based on regression models, where slopes (B1) and intercepts (B0) are as follows:

Metal	Model	B0	B1	Data Source for Model
Copper	y = B0 + B1*[log]sediment	1.23	0.079	Bechtel (1998b)
Selenium	y =B1*[sediment]	--	1.422	Hamilton and Buhl (2003a and 2003b)

c, 95% upper prediction limit (UPL) of regressions calculated by Bechtel (1998b); calculated according to Appendix A in Bechtel (1998b)

d, Bioaccumulation study

e, Estimated concentration in aquatic stage benthic invertebrates multiplied by a correction factor of 0.4 to account for the approximately 60% of selenium that remains in the molted exoskelton (Reinfelder and Fisher 1994).

f, Normalized BSAF (kg OC / kg lipid) calculated based on the site-specific 28-day *Lumbriculus variegatus* bioaccumulation study. A normalized BSAF was calculated as the geometric mean of BSAFs for each individual PAH compound (BSAFs were normalized by li organic carbon content [geometric mean of all samples])

g, Calculated as the sum of estimated concentrations for listed PAH and VOC compounds.

h, Normalized BSAF estimated as the UCL95 of sediment organic carbon and lipid normalized BSAFs calculated from the site-specific 28-day *L. variegatus* study.

i, Calculated as the sum of estimated concentrations for listed PAH compounds.

j, Normalized BSAF for acenaphthene used as a surrogate BSAF for biphenyl based on similar log K_{ow}.

k, Normalized BSAF for naphthalene used as a surrogate for VOCs based on the assumption that VOCs are not accumulated at a greater rate than naphthalene (Roubal et al. 1977).

m, Calculated as the sum of the UCL_{95} concentration of tPAHs measured from fish at the site (all species) and estimated concentrations of dibenzofuran and the listed VOCs.

sample with the highest concentration of tPAH.

o, Calculated as the UCL_{95} concentration of tPAHs measured from fish at the site (all species). Fish tissue was reported by the laboratory as wet weight (Appendix C) and converted to dry weight assuming a moisture content of 80% in fish.

q, For organic constituents, Site-wide BSAF calculated from sediment organic carbon and lipid normalized BSAF as follows:

$$BSAF_{Site-wide} = BSAF_{norm} \times f_{lipid} + f_{oc}$$

where: $BSAF_{norm}$ = Normalized BSAF (kg OC/kg lipid)

f_{lipid} = Fraction of lipids in prey item expressed on a dry weight basis (0.0785, invertebrates; 0.012, fish)

f_{oc} = Fraction of sediment organic carbon expressed on a dry weight basis (0.1857)

r, Unless otherwise indicated, estimated concentration in prey calculated as the product of the site-specific BSAF and the dry weight constituent concentration in sediment.

TABLE I-14
EXPOSURE ESTIMATE BASED ON UCL_{95} MEDIA CONCENTRATIONS AND BSAFs -- BLACK DUCK
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Metal	Exposure Point Concentration	Black Duck Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates[d]	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0	2.38	2.38	0.083	2.46	208.3	<1	416.5	<1
Copper	91.4	0	6.50	6.50	0.144	6.65	47	<1	62	<1
Selenium	2.0	0	0.13	0.13	0.003	0.138	0.4	<1	0.8	<1
Thallium	1.6	0	0.05	0.05	0.003	0.057	NA	--	NA	--
Organics										
Total PAHs & VOCs	408.1699	0	109.6	109.6	0.64	110.2	16.1 / 161	**6.8 / <1**	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum(B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

where:

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.057 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-3)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (1.2 kg)
IR_s = Incidental Ingestion Rate of soil (0.002 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.
d, Assumption: Concentrations of COPCs in aquatic stage invertebrates are equal to COPC concentrations in the adult stage invertebrate.

TABLE I-15
EXPOSURE ESTIMATE BASED ON UCL95 MEDIA CONCENTRATIONS AND BSAFs -- TREE SWALLOW
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	Tree Swallow Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates[d]	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0.0	30.03	30.03	0.0	30.03	208.3	<1	416.5	<1
Copper	91.4	0.0	14.56	14.56	0.0	14.56	47	<1	62	<1
Selenium	2.0	0.0	0.68	0.68	0.0	0.68	1.6	<1	3.2	<1
Thallium	1.6	0.0	0.68	0.68	0.0	0.68	NA	--	NA	--
Organics										
Total PAHs & VOCs	408.2	0.0	186.5	186.5	0.0	186.5	16.1 / 161	**11.6 / 1.2**	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.012 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (0.02 kg)
IR_s = Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.

--, HQ could not be calculated because TRV was not available or total dose was not adjusted for bioavailability.

d, Assumption: Concentrations of COPCs in aquatic stage invertebrates are equal to COPC concentrations in the adult stage invertebrate.

TABLE I-16
EXPOSURE ESTIMATE BASED ON UCL95 MEDIA CONCENTRATIONS AND BSAFs -- BIG BROWN BAT
BASELINE ECOLOGICAL RISK ASSESSMENT
ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE
ASHLAND, WISCONSIN

Analyte	Exposure Point Concentration	Big Brown Bat Dose (mg/kg bw-day)				TRV (mg/kg bw-day)				
		Diet			Substrate	Unadjusted for Bioavailability				
	UCL_{95} Sediment Concentration (mg/kg, dry weight)	Plant Material	Invertebrates	$Dose_{diet}$	$Dose_{substrate}$	Total $Dose_{Unadjusted}$	TRV_{NOAEL}	HQ	TRV_{LOAEL}	HQ
Metals										
Barium	52.6	0.0	8.3	8.3	0.0	8.3	51.8	<1	259	<1
Copper	91.4	0.0	4.0	4.0	0.0	4.0	11.7	<1	15.1	<1
Selenium	2.0	0.0	0.19	0.19	0.0	0.19	0.35	<1	1.05	<1
Thallium	1.6	0.0	0.19	0.19	0.0	0.19	0.2	<1	1	<1
PAHs										
Total PAHs	364	0.0	50.1	50.1	0.0	50.1	129	<1	NA	--
VOCs										
Benzene	0.5	0.0	0.06	0.06	0.0	0.06	52.80	<1	NA	--
Toluene	1.6	0.0	0.19	0.19	0.0	0.19	156.00	<1	NA	--
Ethylbenzene	2.3	0.0	0.28	0.28	0.0	0.28	97.00	<1	NA	--
Xylenes (total)	4.4	0.0	0.52	0.52	0.0	0.52	357.00	<1	NA	--
m & p-cresols	0.4	0.0	0.04	0.04	0.0	0.04	10.00	<1	NA	--
o-cresol	0.1	0.0	0.008	0.008	0.0	0.008	21	<1	NA	--

Notes:

a, Dietary dose calculated as:

$$ADD_{diet} = \frac{IR_{diet} \times \sum (B[S]AF \times C_{substrate} \times DF_i) \times AUF}{BW}$$

b, Substrate dose calculated as:

$$ADD_{substrate} = \frac{IR_{substrate} \times C_{substrate} \times AUF}{BW}$$

c, Total dose calculated as:

$$ADD_{total} = ADD_{diet} + ADD_{water} + ADD_{substrate}$$

ADD_{diet} = Dose of COPC obtained from the diet (mg COPC/kg receptor body weight-day)
IR_{diet} = Ingestion rate of food (0.00182 kg food ingested per day, dry weight)
B(S)AF = Bioaccumulation factor (BAF) or biota-sediment accumulation factor (BSAF), specific to prey type and COPC (kg substrate/kg food, dry weight) (Table I-2)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)
DF_i = Dietary fraction of food item *i* (100% invertebrates in the diet)
AUF = Area use factor of 1.0 includes seasonal use rates , area use rates, COPC assimilation rate
BW = Body weight of the receptor, wet weight (0.011 kg)
IR_s = Incidental Ingestion Rate of soil (0 kg substrate ingested per day, dry weight)
$C_{substrate}$ = COPC concentration in substrate (mg COPC/kg substrate, dry weight)

NA, Not Available; Not Analyzed; Total dose was not adjusted for bioavailability.
--, HQ not calculated because total dose was not adjusted for bioavailability.