Tier II Sampling and Analysis Plan

for the

Sediment Characterization in Support of the Feasibility Study

for

Site 17 - Pettibone Creek

Naval Station Great Lakes

Great Lakes, Illinois

Naval Facilities Engineering Command Midwest

Contract Number N62467-04-D-0055

Contract Task Order 474

March 2012

Title and Approval Page

FINAL
TIER II SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
MARCH 2012

SEDIMENT CHARACTERIZATION IN SUPPORT OF THE FEASIBILITY STUDY FOR

SITE 17 – PETTIBONE CREEK
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

Prepared for:
Naval Facilities Engineering Command Midwest
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Prepared under:
Comprehensive Long-Term Environmental Action Navy
Contract No. N62467-04-D-0055
Contract Task Order 474

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Illinois EPA

Title and Approval Page

(UFP-QAPP Manual Section 2.1)

DRAFT
TIER II SAMPLING AND ANALYSIS PLAN
(Field Sampling Plan and Quality Assurance Project Plan)
March 2012

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EXECUTIVE SUMMARY

This Sampling and Analysis Plan (SAP) describes an investigation designed to collect sediment and benthic samples from the North and South Branches of Site 17 – Pettibone Creek at Naval Station Great Lakes (NSGL) located in Great Lakes, Illinois. The SAP contains all necessary information to complete the project and is a streamlined approach based on the standard worksheets as specified in the Uniform Federal Policy Quality Assurance Project Plan guidance documents (USEPA, 2005). The SAP was prepared by Tetra Tech on behalf of Naval Facilities Engineering Command (NAVFAC) Midwest under Contract Number N62467-04-D-0055, Contract Task Order (CTO) 474. The field investigation described herein will be conducted to collect sediment data that will be used to determine sediment quality and whether implementation of a proposed remedy for sediment contamination is required. If a remedy is required, the data will be used to support the design of a remedy that will cost-effectively reduce risks to acceptable levels.

To answer these questions a benthic invertebrate survey and sediment sampling will be conducted. The benthic invertebrate survey will be used to assess the health of the benthic community. The sediment samples will be analyzed for polynuclear aromatic hydrocarbons (PAHs), select pesticides, select polychlorinated biphenyls (PCBs), and select metals; the results will be compared to remedial goals to characterize sediment quality. In addition, sediment samples will be analyzed for total organic carbon (TOC), grain size, and pH to help describe habitat conditions and assist in understanding spatial distribution and magnitude of the contamination. Toxicity testing will be conducted if the benthic invertebrate survey indicates unacceptable benthic community health and chemical concentrations are greater in the site sediment compared to project screening levels (PSLs) and the maximum concentration from reference locations. In addition, data will be collected to aid in selecting a remedial action designed to be protective of ecological receptors, should remedial action be necessary.

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ACRONYMS AND ABBREVIATIONS

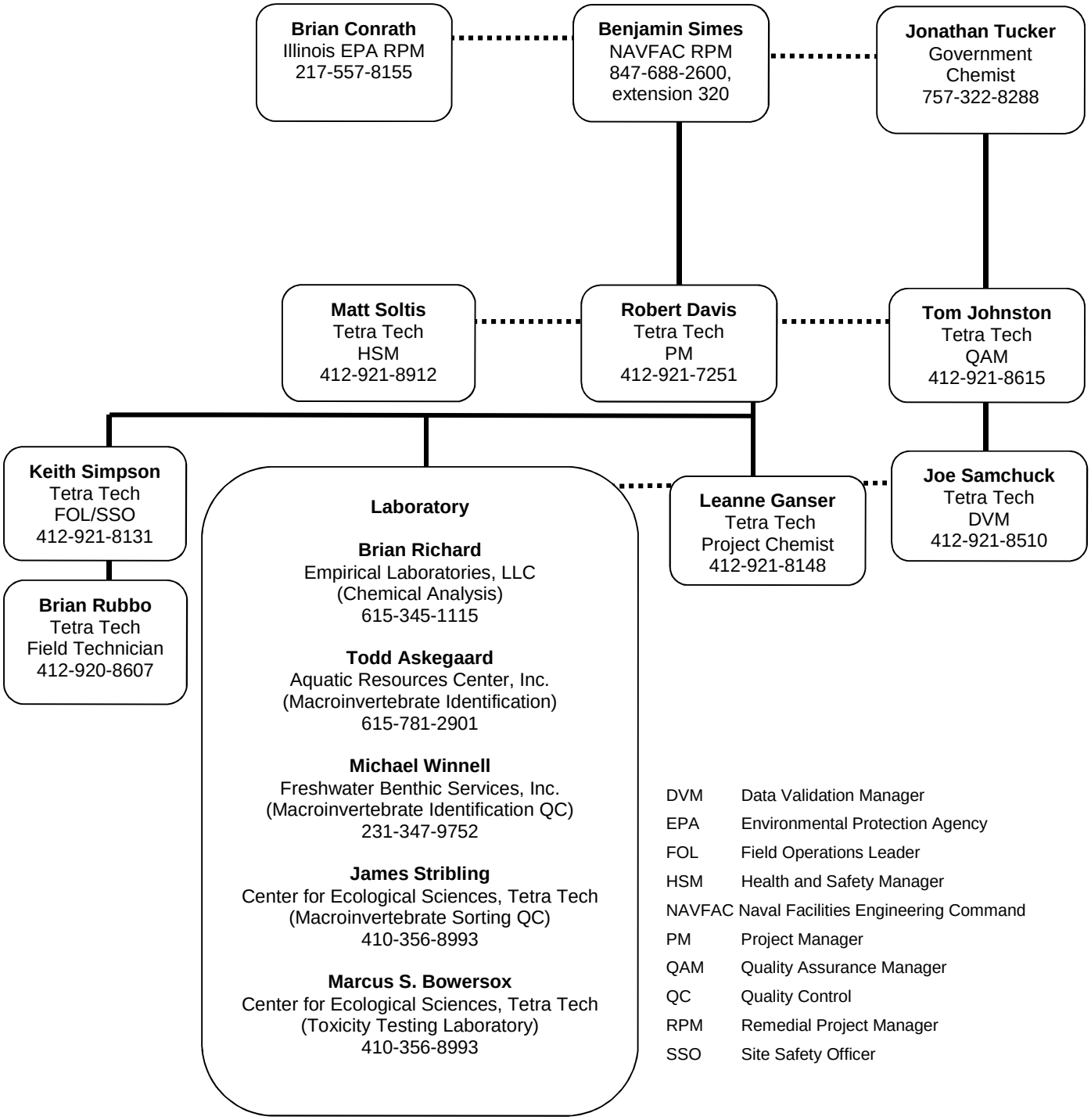
BNA	Base, Neutral, Acid
bss	below sediment surface
CAS	Chemical Abstract Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	cubic feet per second
CLEAN	Comprehensive Long-Term Environmental Action Navy
cm	centimeter
COC	Chemical of Concern
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
CTO	Contract Task Order
DCN	Document Control Number
DL	Detection Limit
DoD	Department of Defense
DOT	Department of Transportation
DQI	Data Quality Indicator
DQO	Data Quality Objective
DVM	Data Validation Manager
ECD	Electron Capture Detector
EDD	Electronic Data Deliverable
ELAP	Environmental Laboratory Approval Program
Empirical	Empirical Laboratories, LLC
EPA	Environmental Protection Agency
ERA	Ecological Risk Assessment
FOL	Field Operations Leader
FS	Feasibility Study
FTMR	Field Task Modification Request
GC	Gas Chromatography
HHRA	Human Health Risk Assessment
HSM	Health and Safety Manager
HMW	high molecular weight
IAS	Initial Assessment Study
ICAL	Initial Calibration
ICP-AES	Inductively Coupled Plasma Atomic Emission Spectroscopy
IDW	Investigation-Derived Waste

LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOD	Limit of Detection
LOQ	Limit of Quantitation
mg/kg	milligram per kilogram
mIBI	Macroinvertebrate Index of Biotic Integrity
MPC	Measurement Performance Criterion
MS	Mass Spectrometry
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MSDS	material safety data sheet
msl	mean sea level
NA	Not Applicable/Not Available
NAVFAC	Naval Facilities Engineering Command
Navy	U. S. Department of the Navy
NCRS	North Chicago Refiners and Smelters
NEDD	NIRIS Electronic Data Deliverable
NFA	No Further Action
NIRIS	Naval Installation Restoration Information Solution
NPDES	National Pollutant Discharge Elimination System
NSGL	Naval Station Great Lakes
OSHA	Occupational Safety and Health Administration
PAH	Polynuclear aromatic hydrocarbon
PAL	Project Action Level
PCB	Polychlorinated biphenyl
PM	Project Manager
PPE	Personal Protective Equipment
PQLG	Project Quantitation Limit Goal
PSL	Project Screening Level
PVC	polyvinyl chloride
QA	Quality Assurance
QAM	Quality Assurance Manager
QC	Quality Control
QHEI	Qualitative Habitat Evaluation Index
QSM	Quality Systems Manual
RA	Risk Assessment
RI	Remedial Investigation
RPD	Relative Percent Difference

RPM	Remedial Project Manager
RSD	Relative Standard Deviations
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SSO	Site Safety Officer
SVOC	Semivolatile Organic Compound
TPH	Total Petroleum Hydrocarbon
TOC	Total Organic Carbon
µg/kg	microgram per kilogram
U.S.	United States
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

1.0 -- Project Organizational Chart

Lines of Authority ——— ..... Lines of Communication



DVM	Data Validation Manager
EPA	Environmental Protection Agency
FOL	Field Operations Leader
HSM	Health and Safety Manager
NAVFAC	Naval Facilities Engineering Command
PM	Project Manager
QAM	Quality Assurance Manager
QC	Quality Control
RPM	Remedial Project Manager
SSO	Site Safety Officer

2.0 -- Communication Pathways

The communication pathways for the SAP are shown below.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Regulatory Agency Interface	Illinois Environmental Protection Agency (EPA) Remedial Project Manager (RPM) Naval Facilities Engineering Command (NAVFAC) RPM	Brian Conrath Benjamin Simes	217-557-8155 847-688-2600, x 320	The NAVFAC RPM will contact the regulatory agency via phone and/or e-mail within 24 hours of recognizing an issue whenever issues arise. The NAVFAC RPM will contact the regulatory agency via phone and/or e-mail at least 48 hours before commencement of field activities and at least 24 hours before a change in schedule so that oversight can be scheduled.
Field Progress Reports	Tetra Tech Field Operations Leader (FOL) Tetra Tech Project Manager (PM)	Keith Simpson Robert Davis	412-921-8131 412-921-7251	The Tetra Tech FOL will contact the Tetra Tech PM on a daily basis via phone, and every 1-2 days summarizing progress via e-mail.
Coordinating field work	Tetra Tech FOL/Site Safety Officer (SSO) Tetra Tech PM NAVFAC RPM	Keith Simpson Robert Davis Benjamin Simes	412-921-8131 412-921-7251 847-688-2600, x 320	See Section 8 for details on mobilization procedure including gaining site access and schedule changes.
Stop Work due to Safety Issues	Tetra Tech FOL/SSO Tetra Tech PM Tetra Tech Health and Safety Manager (HSM) NAVFAC RPM	Keith Simpson Robert Davis Matt Soltis Benjamin Simes	412-921-8131 412-921-7251 412-921-8612 847-688-2600, x 320	See Section 8 for details on health and safety and the procedure for informing onsite personnel, subcontractor(s), the NAVFAC RPM, and the identified Project Team members.

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Sampling and Analyses Plan (SAP) Changes prior to Field/ Laboratory work	Tetra Tech FOL/SSO	Keith Simpson	412-921-8131	See Section 8 for details on procedure for completing a Field Task Modification Request (FTMR).
	Tetra Tech PM	Robert Davis	412-921-7251	
SAP Changes in the Field	NAVFAC RPM	Benjamin Simes	847-688-2600, x 320	
Field Corrective Actions	Tetra Tech PM	Robert Davis	412-921-7251	The Tetra Tech QAM will notify the Tetra Tech PM verbally or by e-mail within 1 business day that the corrective action has been completed. The Tetra Tech PM will then notify the NAVFAC RPM (verbally or by e-mail) within 1 business day.
	Tetra Tech Quality Assurance Manager (QAM)	Tom Johnston	412-921-8615	
	NAVFAC RPM	Benjamin Simes	847-688-2600, x 320	
Sample Receipt Variances	Empirical Laboratories, LLC (Empirical) Laboratory PM	Brian Richard	615-345-1115	See Section 8 for details on sample handling the procedures for the Laboratory PM to notify the Tetra Tech FOL.
	Center for Ecological Sciences- Toxicity Testing PM	Marcus Bowersox	410-356-8993	
	Aquatic Resources Center, Inc. PM	Todd Askegaard	615-781-2901	
	Freshwater Benthic Services, Inc. PM	Michael Winnell	231-347-9752	
	Center for Ecological Sciences- Macroinvertebrate Quality Control (QC) PM	James Stribling	410-356-8993	
	Tetra Tech FOL	Keith Simpson	412-921-8131	
	Tetra Tech PM	Robert Davis	412-921-7251	

Communication Drivers	Responsible Entity	Name	Phone Number	Procedure (Timing, Pathway To/From, etc.)
Reporting Lab Quality Variances	Empirical Laboratory PM	Brian Richard	615-345-1115	Any planned standard operating procedure (SOP) variances from the quality elements specified in the Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories, Version 4.1 (April 2009) are identified in Section 10. See Section 8 for details on analytical tasks and the procedures for addressing concerns regarding laboratory analytical data.
Notification of Non-Usable Data	Center for Ecological Sciences- Toxicity Testing PM	Marcus Bowersox	410-356-8993	
Analytical Corrective Actions	Aquatic Resources Center, Inc. PM	Todd Askegaard	615-781-2901	
Reporting Data Validation Issues	Freshwater Benthic Services, Inc. PM	Michael Winnell	231-347-9752	
Data Validation Corrective Actions	Center for Ecological Sciences- Macroinvertebrate QC PM	James Stribling	410-356-8993	
	Tetra Tech Project Chemist	Leanne Ganser	412-921-8148	
	Tetra Tech PM	Robert Davis	412-921-7251	
	Tetra Tech FOL	Keith Simpson	412-921-8131	
	Empirical Laboratory QAM	Marcia McGinnity	877-345-1113, x 232	
	Tetra Tech Data Validation Manager (DVM)	Joe Samchuck	412-921-8510	
	NAVFAC RPM	Benjamin Simes	847-688-2600, x 320	

3.0 -- Project Planning Session Participants Sheet

Project Name: Sediment Investigation **Projected Date(s) of Sampling**: Spring 2012 **Project Manager**: Robert Davis	**Site Name**: Site 17, Pettibone Creek **Site Location**: Great Lakes, Illinois

Date of Session: December 22, 2011
Scoping Session Purpose: Data Quality Objective (DQO) Scoping Meeting

Name	Title	Affiliation	Phone #	E-Mail Address	Project Role
Robert Davis	PM	Tetra Tech	412-921-7251	Robert.Davis@tetratech.com	Management /Oversight
Leanne Ganser	Project Chemist	Tetra Tech	412-921-8148	Leanne.Ganser@tetratech.com	SAP coordinator
Tom Johnston	DQO Facilitator	Tetra Tech	412-921-8615	Tom.Johnston@tetratech.com	DQO Facilitator
Aaron Bernhardt	Ecological risk assessor	Tetra Tech	412-921-8433	Aaron.Bernhardt@tetratech.com	Risk assessment

Comments/Decisions:

- Site history was discussed. The only remaining risk concern is ecological. Whereas this investigation is concerned only with the North Branch of Pettibone Creek that lies on United States Department of Navy (Navy) property, there is a potential continuing source of contamination located upstream from Navy property where heavy industries used to discharge effluents to the creek.

- Draft DQOs were developed and action items were compiled. Sampling of benthic communities within the creek on Navy property was considered to be essential to this project. The project is on a fast track; however, so the project team wants to sample benthic species earlier in the year than would normally be done in accordance with Illinois Environmental Protection Agency (EPA) methodology for evaluating benthic community health. In addition, a suitable reference area must be identified. The reference area was tentatively identified as the South Branch of Pettibone Creek where there are no unacceptable ecological risks. The South Branch of Pettibone Creek is not affected by industry upstream of Navy property.

Action Items:

- Leanne Ganser will coordinate preparation of the SAP.

- Tom Johnston will prepare a draft DQO summary and distribute them to the team. These will be expanded and included throughout the SAP as appropriate.

- Aaron Bernhardt needs input from Navy and Bob Davis needs input from Illinois EPA regarding acceptance of composite samples for representing stretches of sediment within the creek.

Consensus Decisions:

None.

Project Name: Sediment Investigation **Projected Date(s) of Sampling**: Spring 2012 **Project Manager**: Robert Davis	**Site Name**: Site 17, Pettibone Creek **Site Location**: Great Lakes, Illinois

Date of Session: January 6, 2012
Scoping Session Purpose: DQO Scoping Meeting

Name	Title	Affiliation	Phone #	E-Mail Address	Project Role
Robert Davis	PM	Tetra Tech	412-921-7251	Robert.Davis@tetratech.com	Management /Oversight
Leanne Ganser	Project Chemist	Tetra Tech	412-921-8148	Leanne.Ganser@tetratech.com	SAP coordinator
Tom Johnston	DQO Facilitator	Tetra Tech	412-921-8615	Tom.Johnston@tetratech.com	DQO Facilitator
Aaron Bernhardt	Ecological risk assessor	Tetra Tech	412-921-8433	Aaron.Bernhardt@tetratech.com	Risk assessment
Ken Martin	Technical Advisor	KJM Consulting	412-915-8316	Kjmconsulting@verizon.net	Technical expertise

Comments/Decisions:

- DQOs were developed further.
- The attendees agreed that it might be necessary to build into the decision making process the possibility of not being able to acquire the appropriate benthic community health data

Action Items:

- Aaron Bernhardt will research the benthic sampling guidance and discuss with Illinois EPA whether a spring 2012 sampling time is likely to compromise data interpretation given that it is earlier than recommended in the sampling guidance.

- Ken Martin will draft an example flow chart for the team for consideration as part of the decision rules.

- Bob Davis will distribute photographs of the culverts located at the northern edge of the Navy property to the team.

- Bob Davis will discuss with the NAVFAC RPM the potential for sampling upstream from the culverts because this could provide an estimate of the contamination that could migrate downstream onto Navy property.

- Tom Johnston will revise the DQO text.

- Tom Johnston will send the Tier II SAP template to Ken Martin.

- Bob Davis and Aaron Bernhardt will identify specific sampling locations.

Consensus Decisions:

None.

Project Name: Sediment Investigation **Projected Date(s) of Sampling**: Spring 2012 **Project Manager**: Robert Davis	**Site Name**: Site 17, Pettibone Creek **Site Location**: Great Lakes, Illinois

Date of Session: January 11, 2012
Scoping Session Purpose: Discuss draft SAP for Site 17; obtain additional information and consensus

Name	Title	Affiliation	Phone #	E-Mail Address	Project Role
Robert Davis	PM	Tetra Tech	412-921-7251	Robert.Davis@tetratech.com	Management /Oversight
Leanne Ganser	Project Chemist	Tetra Tech	412-921-8148	Leanne.Ganser@tetratech.com	SAP coordinator
Tom Johnston	DQO Facilitator	Tetra Tech	412-921-8615	Tom.Johnston@tetratech.com	DQO Facilitator
Aaron Bernhardt	Ecological risk assessor	Tetra Tech	412-921-8433	Aaron.Bernhardt@tetratech.com	Risk assessment
Ben Simes	RPM	Navy	847-688-2600, x 320	benjamin.simes@navy.mil	Management
Jon Tucker	Chemist	Navy	757-322-8288	jonathan.tucker@navy.mil	Navy Review
Brian Conrath	RPM	Illinois EPA	217-557-8155	Brian.Conrath@illinois.gov	Management
Les Morrow	Environmental Toxicologist	Illinois EPA	217-785-0878	les.morrow@illinois.gov	Regulatory Review

Comments/Decisions:

- Problems stated in the SAP were reviewed. The project team agreed to delete Problem C (the collection of data to support the selection of a potential remedial action) and data needs for Problem C would be included as supplemental data.

- Discussed the decision to use the South Branch of Pettibone Creek as the reference stream because it may be impacted by runoff from the golf course and also influenced by the North Branch. It was determined that the South Branch of Pettibone Creek was the best choice for a reference stream and the sampling location furthest downstream will be moved to outside possible influence of the North Branch.

- Illinois EPA asked for a habitat assessment of the stream reaches sampled. Information on observed scouring and additional habitat assessment type will be collected and photographs will be taken.

- Sampling concerns, such as the collection of composite versus discrete sediment samples, sediment sampling depth intervals, sampling upstream of Navy property, and collection of surface water were discussed. It was determined that sediment samples will only be collected in the top 4 centimeters (cm) and surface water samples would not provide useful information for this project. It was agreed that composite samples are a better way to characterize large reaches of stream, but sampling design will be finalized internally. Illinois EPA and the Navy said that they should be able to coordinate access to upstream areas if necessary.

- Benthic community sampling was reviewed, including concern that it would occur outside of the standard time frame. Comparison between site and reference samples would be a more applicable comparison than comparison to Illinois EPA scoring system. Benthic community samples will be collected as late as possible in March 2012.

Action Items:

- Aaron Bernhardt will speak with the benthic specialist to obtain more information on quality assurance (QA/QC samples and if the QA/QC samples for the benthic community survey could/should be collected from the same reaches as the site samples or whether there is documentation that this is how Illinois EPA typically collects replicate samples.

- Naval Station Great Lakes (NSGL) will try to acquire information on National Pollutant Discharge Elimination System (NPDES) discharge permit to understand the nature of Navy discharges to the North Branch of Pettibone Creek.

Consensus Decisions:

- The SAP will include SOPs/methodology for the benthic sampling and data interpretation.
- The project team will assume that any dredging that is done to remove contaminated sediment from the North Branch of Pettibone Creek will extend from the sediment surface to the top of the native

blue-gray clay layer. This will obviate the need for sampling between the top 4 cm of sediment and the blue clay.

4.0 -- Conceptual Site Model

The sediment area targeted for this investigation is described below. The description presents the current understanding of the nature and extent of sediment contamination and the basis for additional investigation.

4.1 SITE LOCATION

Site 17 – Pettibone Creek is located at NSGL in Great Lakes, Illinois. Site 17 comprises Pettibone Creek (North and South Branches) and the Boat Basin. The North Branch of Pettibone Creek originates in North Chicago, enters the northwestern corner of NSGL, and flows south and east through the Mainside of the Naval Station until it enters the Boat Basin and discharges into Lake Michigan along the western shoreline. The South Branch of Pettibone Creek originates in a residential area southwest of the Naval Station, flowing northward through a golf course and the Mainside of the Naval Station. The North and South Branch of Pettibone Creek join approximately 1,500 feet west of Lake Michigan. For the investigation described in this SAP, “the Site” is defined as the portion of Site 17 that lies within the NSGL property boundary, exclusive of the Boat Basin as shown on Figure 4-1.

4.2 SITE PHYSICAL DESCRIPTION

The majority of NSGL activities occur on a plateau atop a steep bluff that rises 70 feet above the beach along Lake Michigan. Pettibone Creek and its tributaries flow within a ravine that divides this plateau and discharges to the Boat Basin.

Pettibone Creek ranges between 15 and 30 feet in width, and several inches to 2 feet in depth. Storm sewers that collect stormwater from a large section of the City of North Chicago drain to the creek upstream of Navy property (Illinois EPA, 1995) and 30 NSGL stormwater sewer system outfalls from roadway drainage systems drain to Navy property (Halliburton NUS, Inc., 1993). Because of the industrial and urban nature of this watershed, Pettibone Creek is subject to flash flooding and associated erosive forces during storm events. Sediment present in Pettibone Creek is mobile due to flash floods and, based on layering observed during previous Boat Basin investigations, creek bottom sediment is believed to deposit in layers eroded during storm events.

4.3 SITE HISTORY AND LAND USE

NSGL covers 1,202 acres of Lake County, which is located in northeastern Illinois, north of the City of Chicago along the western shore of Lake Michigan. Lake County extends from the Wisconsin border south to Cook County and west to McHenry County. The Naval Station fronts 1.5 miles of Lake Michigan

shoreline and has provided facilities and support to training activities and a variety of military commands since 1911 and also includes the Navy's only boot camp. A variety of land uses currently surround NSGL, including urbanized and industrial areas to the north, industrial use to the west, and a mixture of public use land and residential neighborhoods to the south.

A dirt path along the North Branch of Pettibone Creek is used by staff, military personnel and their family members, and recreational users who hike, jog, and walk their dogs. The South Branch of Pettibone Creek flows at the base of steep slopes behind buildings and is consequently not frequented by people.

Pettibone Creek is not used as a drinking water source; however, adult humans and children may play in the creek. Fish are present in the creek and fish have been observed migrating upstream in the spring (Illinois EPA, 1995) and fall. No federally listed endangered or threatened species are known to exist in the area. Habitat suitable to threatened or endangered species does not exist in Pettibone Creek, at least in part because of the highly developed nature of the surrounding land (U.S. Navy, 2001). Fish consumption from recreational fishing is not an exposure pathway of concern because the Illinois EPA has instituted fish advisories to limit consumption of fish from Lake Michigan due to polychlorinated biphenyl (PCB) contamination.

Former industries located upstream of NSGL include the North Chicago Refiners and Smelters (NCRS), the Vacant Lot, and Fansteel. Discharges from these industries in combination with several storm sewers collecting water/runoff from a large section of the City of North Chicago, have contributed to elevated concentrations of contaminants in Pettibone Creek and Boat Basin sediments. These facilities were turn-of-the-20th century manufacturing facilities that produced tantalum mill products, non-ferrous metals, and zinc oxide.

The Navy identified potential areas (Navy and non-Navy) where hazardous materials may have been released to the environment at NSGL in the Initial Assessment Study (IAS) (Rogers, Golden, & Halpern and BCM Eastern Inc., 1986). The IAS identified 14 potentially contaminated sites along with potential sources such as surface runoff or fallout from engine exhaust from nearby roadways, historical pesticide usage, and volatile organic compounds (VOCs) detected in the groundwater samples collected from monitoring wells (Tetra Tech, 2005). A Watershed Contaminated Source document was prepared, which summarized activities that may have had an impact on sediments in Pettibone Creek and the Boat Basin (Tetra Tech, 2003a).

4.4 HYDROGEOLOGY

Site 17 is a stream valley with steeply eroded slopes. The topography of Site 17 includes a moderately steep stream gradient and banks and hillsides with 30- to 60-percent slopes that form the ravine through

which Pettibone Creek flows. Site 17 elevations vary from approximately 650 feet above mean sea level (msl) at the tops of the Pettibone Creek hillsides to approximately 577 feet above msl at the Boat Basin, where the Pettibone Creek discharges to Lake Michigan (Tetra Tech, 2003b). The Pettibone Creek watershed drains an area of 4.2 square miles, and the creek consists of North and South Branches, each with minor tributary branches. The creek flows through well-defined ravines within NSGL. In general, flow in Pettibone Creek is eastward, with flow from both the North and South Branches joining within the limits of NSGL Property.

There is very little floodplain area along Pettibone Creek because of the steeply sloped banks. The north branch of the creek has a short time of concentration (i.e., time it takes a unit of water to run the water course) because the source of water is primarily from an urban area with low infiltration rates and fast runoff rates during storms. As a result, Pettibone Creek is susceptible to flash floods characterized by high channel velocities and great erosive potential. The Illinois State Water Survey calculated the average flow rate of Pettibone Creek to be less than 10 cubic feet per second (cfs), which greatly increases during periods of precipitation (Tetra Tech, 2003b).

4.5 PREVIOUS INVESTIGATIONS

The following environmental investigations have been conducted at Site 17:

- Illinois EPA and United States EPA (USEPA) investigations of sediment in 1970s and 1980s
- Initial Assessment Study at Naval Station Great Lakes (Rogers, Golden, & Halpern and BCM Eastern Inc., 1986)
- Site Inspection Report for Pettibone Creek, Boat Basin, and Harbor Area (Halliburton NUS, 1993)
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Expanded Site Inspection Report (Illinois EPA, 1995)
- Remedial Investigation and Risk Assessment Report - Site 17 – Pettibone Creek and Boat Basin (Tetra Tech, 2003b)
- Feasibility Study for Site 17 Pettibone Creek and Boat Basin (Tetra Tech, 2005)

In addition, abandoned industrial facilities in the City of North Chicago, located along the North Branch Pettibone Creek upstream of NSGL, were included in investigations by the USEPA and Illinois EPA.

Details on the previous investigations listed above are provided in the Remedial Investigation/Risk Assessment (RI/RA) (Tetra Tech, 2003b) and Feasibility Study (FS) (Tetra Tech, 2005). An additional field investigation was conducted in December 2008 and included collection of sediment samples. Information obtained through these investigations, including key physical features of Pettibone Creek and the most recent data on sediment conditions are described below.

4.6 KNOWN EXTENT OF SEDIMENT CONTAMINATION

This section summarizes the nature and extent of contamination within Site 17 as documented in the RI/RA (Tetra Tech, 2003b) and FS (Tetra Tech, 2005). Additional detail can be found in these reports. An additional investigation in 2008 was conducted to determine whether contamination detected in sediment extended to the underlying native stream bed soil and to determine the sediment layer thickness. The results of this additional investigation were documented in the draft Remedial Action Plan (Tetra Tech, 2012).

Sediment samples collected during previous investigations were analyzed for VOCs, semi-volatile organic compounds (SVOCs), pesticides/PCBs, and metals. Based upon review of the data, VOCs were not significant site-related contaminants at Site 17. In general, concentrations of polynuclear aromatic hydrocarbons (PAHs) were greatest in surface sediment samples and typically decreased with depth. Average PAH concentrations detected in samples from the North Branch of Pettibone Creek and the Boat Basin (typically less than 5,000 micrograms per kilogram [µg/kg]) generally exceeded average concentrations in the South Branch of Pettibone Creek (typically less than 1,000 µg/kg). PAH concentrations in sediment samples were observed to have increased between the 1991 to 1994 sampling events and the 2001 sampling event, and this is believed to have been caused by the widespread use of petroleum products in modern industrialized society. In general, concentrations of pesticides, PCBs, and metals in the Boat Basin were lower in surface sediment samples and increased with depth. PCBs were detected in less than 50 percent of the sediment samples analyzed. Previous PCB concentration patterns that indicated greater PCB concentrations near the upstream edge of NSGL property suggest that upstream chemical sources may have contributed to the sediment contamination. In addition, PCB contamination of sediments may have occurred due to storage by NSGL of out-of-service transformers (some filled with PCB-containing oil) at various locations within the Naval Station. Predominant inorganic chemicals, such as copper, lead, and zinc found in Site 17 sediments collected during the 2001 sampling event, were identified as significant environmental contaminants in sediment samples collected upstream of Site 17 during past environmental investigations. The RI/RA (Tetra Tech, 2003b) indicated that concentrations of target analytes detected in offsite upstream samples were often two to three times greater than concentrations in Site 17 sediment samples. Elevated concentrations of several chemicals in the most upstream samples indicate that the predominant source of these chemicals appears to be off site of NSGL; therefore, the chemicals may not be site related. Due to the transient

nature of sediment and the amount of time that has passed since the last sediment data collection (nearly 10 years), the current extent of contamination, if any, is unknown. Over time the sediment contaminant concentrations may have decreased and been redistributed along the North Branch of Pettibone Creek. Continued washout of sediments upstream of Navy property is considered to be a potential continuing source of sediment contamination on Navy property.

Previously collected data show that creek bottom sediments are stratified with respect to contaminant levels. A blue-gray clay layer located about 1 foot below the sediment surface (bss) is considered to represent native material that is not contaminated. The 2008 investigation, which analyzed sediment samples for PAHs, pesticides, PCBs, and metals, found that chemical concentrations in the native material were much lower than concentrations in overlying sediment (Tetra Tech, 2012). Benthic organisms generally occupy the top 4 cm of sediment and this is generally observed to be the most contaminated layer. However, the dynamic nature of the creek, however, suggests that the concentration and sediment depth profiles vary along the creek. For example, there are locations within the creek that are well scoured and other locations where increased sediment deposition has occurred and the native blue-gray clay layer may be deeper than 1 foot bss.

Sediments in the South Branch of Pettibone Creek are considered to represent an area unaffected by NSGL operational activities and represent a typical residential area. This branch of the creek is also well scoured in places and has sediment deeper than 1 foot above the native blue-gray layer in other places.

4.7 RISK ASSESSMENTS

Human health and ecological risk assessments were conducted during the RI/RA using data from the 2001 field investigation (Tetra Tech, 2003b) for representative receptors that have the potential to be exposed to site-related contamination.

The human health risk assessment (HHRA) focused on adolescent and adult recreational users exposed to surface water, sediment, and fish in Pettibone Creek. The human health risks associated with exposure to chemicals of potential concern (COPCs) in sediment and surface water from Pettibone Creek for both the adult and adolescent recreational users are either less than or within USEPA target levels. The HHRA assumed that recreational fishing does not occur within Pettibone Creek but it did consider human health risk from ingestion of fish caught in the Boat Basin. This risk evaluation of fish caught in the Boat Basin was performed because although some fish may be present in the North Branch of Pettibone Creek, that portion of the creek does not support a significant fish population. Fish tissue samples were not collected; instead, fish tissue concentrations were estimated from sediment concentrations and sediment bioaccumulation factors. Fish ingestion risks for recreational fishermen (based on the estimated fish tissue contaminant concentrations) exceeded USEPA target levels for PCB

and pesticide contamination; the risks to recreational fishermen were consistent with the Illinois EPA fish advisories for Lake Michigan.

A screening-level ecological risk assessment (ERA) was performed using surface water and sediment data. No chemicals detected in surface water were retained as chemicals of concern (COCs) for potential risks to aquatic organisms. PAHs, several pesticides, and several metals were retained as COCs for potential risks to benthic invertebrates exposed to contaminated sediments. Two pesticides (4,4'-DDE and 4,4'-DDT) were retained as COCs for potential risks to piscivorous birds exposed to contaminated sediments via ingestion of fish and benthic invertebrates. However, wildlife is not expected to be impacted because the limited populations of fish in the creek mean that receptors would only receive a small portion of their diet from the site. Soil erosion in the creek may add physical stressors to the risks to benthic invertebrates.

5.0 -- Project Quality Objectives/Systematic Planning Process Statements

5.1 PROBLEM STATEMENT

The industrial area (no longer active) upstream of the North Branch of Pettibone Creek located on NSGL property, released metals and other contaminants that flowed onto NSGL property, as described in the conceptual site model (CSM, Section 4.0). Some sediment contamination in the North Branch of Pettibone Creek may also have originated on Navy property. Upon completion of the RI, the COCs identified for creek bed sediments on NSGL property were:

- PAHs
- Select Pesticides (DDD, DDT, DDE, alpha- and gamma-chlordane, endosulfan II, and aldrin)
- PCBs as Aroclors
- Select Metals (arsenic, cadmium, chromium, copper, lead, mercury, and zinc)

These contaminants, listed in the RI report, are still considered to be COCs for benthic invertebrates exposed to sediments within Pettibone Creek and potentially downstream in the Boat Basin and in Lake Michigan. A fish advisory is in place to limit consumption of fish from Lake Michigan, including the Boat Basin; therefore, evaluating human health risks from consumption of Lake Michigan (including Boat Basin) fish is outside the scope of this project. A remedial action is being proposed to reduce sediment contaminant levels in the North Branch of Pettibone Creek to acceptable levels for the benthic community. This proposed remedy, which included excavation of Pettibone Creek sediments down to the native blue-gray clay layer, was based on sediment data acquired 10 years ago or more. As described in the CSM; however, industrial discharges into the creek upstream of Navy property, which are considered to have been a major source of Pettibone Creek sediment contamination on Navy property, have been curtailed significantly because these facilities are no longer active and these properties are being redeveloped as commercial retail. Therefore, a reduction in sediment contaminant concentrations on Navy property may have occurred as a result of natural redistribution of sediments. This means that the risks to benthic invertebrates may have decreased and the proposed remedial action may have to be adjusted to render it more cost-effective. Furthermore, in accordance with Navy policy, the Navy will not remediate contaminated sediment if a continuing upstream contaminant source exists that will cause remediated areas to be recontaminated.

Given the potential change in sediment conditions on NSGL property and upstream of this property, the remaining concerns about ecological risks to benthic invertebrates exposed to North Branch Pettibone Creek sediments on Navy property, and the potential effect that changed contaminant concentrations have on the proposed remedy, there are two problems (designated A and B) that need to be resolved.

Each of the two problems is listed below. Remaining DQOs, developed for each problem and the desired additional data collection, are presented in the following sections.

Problem A:

Data on which risks to benthic invertebrates in the North Branch of Pettibone Creek were estimated are a decade old and potentially no longer representative of current risks. The Navy must characterize current risks to benthic invertebrates from exposure to North Branch Pettibone Creek sediment to determine whether remedial action is necessary to reduce risks to acceptable levels.

Problem B:

A continuing source of sediment contamination may persist upstream of Navy property. The Navy needs to determine whether there is a continuing source of contamination to North Branch Pettibone Creek sediments on Navy property, and whether remedial action is appropriate, in accordance with Navy policy that states that contaminated sediments will not be remediated unless continuing sources of sediment contamination are eliminated.

5.2 DECISION INPUTS

The following data are needed to resolve the problems described in Section 5.1.

Problem A Decision Inputs

- Benthic community health data (e.g., macroinvertebrate index of biotic integrity [mIBI]) developed by the state of Illinois EPA. The mIBI rating scales will not be applicable to the samples because the samples will be collected outside of the intended period for application of the mIBI (see Section 7). However, a mIBI will be measured for site and reference areas in compliance with the Illinois EPA mIBI methodology.

- Photographs and field notes that detail the creek and benthic community conditions at the time of sampling are required to help the team interpret the benthic data.

- COC concentrations in sediment (2-week turnaround time) from site and reference areas. These are needed to evaluate benthic contaminant concentrations and, if toxicity testing is necessary, to support the testing. The individual COCs are listed in SAP Section 9.

- COC concentrations in sediment (2-week turnaround time) from site areas not evaluated for benthic community health. These parameters will primarily be used to assist in understanding the spatial distribution and magnitude of contamination.

- Physical sediment data (grain size, total organic carbon (TOC), and pH) from site and reference areas. These parameters will primarily be used to help describe habitat conditions and assist in understanding the spatial distribution and magnitude of contamination.

- Select field water quality parameters such as conductivity, dissolved oxygen, pH, and water temperature from site and reference areas. These parameters will primarily be used to help describe habitat conditions and assist in understanding the spatial distribution and magnitude of contamination.

- Toxicity testing (if needed) for site and reference areas. If the benthic community health is acceptable, this will not be needed; otherwise, it is likely to be needed. A 28-day test was considered but the project Team believes a 10-day test will be sufficient to evaluate significant toxicities for this project.

- Project Screening Levels (PSLs). Screening levels are required to determine if sediment concentrations are ecologically significant. If sediment concentrations are less than PSLs, toxicity testing will not be needed.

- Project Action Levels (PALs). The nature of this project requires non-numeric action levels that are effectively a classification of site conditions such as “acceptable” or “not acceptable” based on standard methodology. The standard methodology is described in Section 7 and rules governing decision making are presented in Section 5.4.

Problem B Decision Inputs

- COC concentrations in suspended sediment (2-week turnaround time) collected from sediment traps positioned at northern entry points (three culverts) representing upstream contamination discharging onto Navy property.

- COC concentrations in sediment from areas upstream of Navy property representing upstream contamination discharging onto Navy property.

The other inputs are the same as those described for Problem A except that benthic studies and toxicity testing do not apply to Problem B and the action levels are as described below:

- **Action Level:** No numerical action level is needed. However, based on data obtained during this investigation the project team will determine whether an upstream source of contamination persists for creek bottom sediments in the North Branch of Pettibone Creek located on NSGL property.

5.3 STUDY BOUNDARIES

Problem A Study Boundaries

The following boundaries and sediment and benthic populations must be investigated for this study.

- For Problem A, sediment within the North Branch (the site) and the South Branch (the reference area) of Pettibone Creek in the 0 to 4 cm depth interval, where the benthic communities live, is of interest. The 0 to 4 cm depth will be considered representative of the full sediment column because the shallow depth of the sediment column will be remediated to the clay layer rather than trying to remediate only to a depth of 4 cm. For the site, this represents sediment potentially contaminated by site-related or upstream chemical releases. For the reference area, this represents sediment similar to site sediment that is not affected by site-related or upstream activities. The native gray sediment clay layer underneath the more mobile sediment in both creek branches is outside the study boundaries.

- Benthic invertebrate populations within the top 4 cm of sediment in the North Branch of Pettibone Creek and reference areas.

- 10-Day bulk sediment toxicity test species that represent sensitive species potentially exposed to North Branch Pettibone Creek sediments. *Hyalella azteca* was selected for this.

- 300-foot segments of the creek branch sediments that are useful for benthic community evaluation. Benthic community samples should be collected in March 2012.

- Composite samples from additional segments of the creek (<300-foot) for additional sediment chemistry analysis.

- The final project report must be submitted by June 15, 2012. To meet this deadline, sediment that could be used for toxicity testing must be collected at the same time as benthic community and chemistry samples.

- No significant change in overall creek COC concentrations or benthic health is expected for the duration of this project. Sediment contaminant concentrations are expected to change over longer time periods but the rate of change is unknown. This means that comparing data from any given sediment sampling point from 10 years ago to current data would not be appropriate for discerning changes in sediment conditions, but treating the creek as a whole would make sense.

- QA/QC samples could/should be collected in accordance with the benthic community evaluation protocol.

Problem B Study Boundaries:

The Project Team assumed, based on knowledge of outfall locations and general operational activities at NSGL, that impact from Navy operations in the northernmost 250 feet of the North Branch of Pettibone Creek is minimal and any sediment contamination there represents contamination from upstream sources.

Sediment collected upstream of the culverts represents contamination from upstream sources.

Temporal boundaries are the same temporal boundaries established for Problem A.

For comparison to the numerical PSLs, the spatial boundaries and populations of interest are Pettibone Creek suspended sediments at the northern entry points (three culverts) and sediment from upstream of Navy property representing upstream contamination discharging onto Navy property in the North Branch of Pettibone Creek.

5.4 ANALYTIC APPROACH

Decision rules for resolving Problems A and B are embodied in Figure 5-1.

The project team noted that it would be useful to examine COC concentration spatial trends in creek sediment, and in suspended sediment throughout the North Branch of Pettibone Creek to identify concentration spatial trends that indicate whether or not an upstream contaminant source exists. Spatial data trends could assume many different patterns; therefore, the project team may consider the existence of spatial trends when interpreting the data but cannot define how those trends would be used at this time.

5.5 PERFORMANCE CRITERIA

Data quality for Problems A and B will be evaluated as part of the verification/validation and the data usability processes described in Section 12. If the planned data are obtained and no data quality deficiencies that compromise the ability to meet project objectives are identified, the data sets will be considered usable for the intended purpose. Failure to meet validation targets or limitations on data use identified during a data usability assessment shall be described in the project report.

5.6 SAMPLING DESIGN

For both problems the sampling design is judgmental. Nevertheless, collection of benthic organisms and sediment composite samples over the length of the North and South Branches of Pettibone Creek is designed to average out variations in sediment COC concentrations and benthic community health to provide as accurate a representation of current creek conditions as possible. Collection of suspended sediments over an extended period of time is also designed to accomplish this goal.

For both problems, collection of composite sediment samples that can be used for toxicity testing and evaluating spatial trends is required. To align with the benthic community study (Problem A), these composites must represent sediment over the same 300-foot long segments of the North (Site) and South (reference area) Branches of Pettibone Creek as the benthic organism data. Although data needs overlap for the two problems, there are sampling design variations that are problem specific described below.

Problem A:

The sampling design incorporates requirements for benthic sampling compliant with the Illinois EPA methodology for evaluating benthic community health (with the exception of sample collection outside of the intended period for application of the mIBI, see Section 7). This methodology requires sampling 300-foot long stream segments for the length of the site and reference areas and comparing the site data to reference area data.

Problem B:

Sediment samples that represent sediment flowing onto Navy property over time must be used to represent average contamination concentrations flowing onto Navy property. Because there is only one opportunity for collecting these samples and a desire to obtain as representative a sample as possible, the sampling period should be as long as possible. This is expected to be a minimum of two months. The best placement for the traps used to collect suspended sediments is the northern edge of Navy property within North Branch Pettibone Creek at the south end of the culverts described in Section 5.2.

Complete details of the sampling and analysis plan are provided in subsequent Sections of this SAP.

6.0 -- Field Quality Control Samples

QC Sample	Analytical Group	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria (MPCs)	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both (S&A)
Equipment Rinsate Blanks[1]	All analytical groups	One per 20 samples.	Bias/Contamination	No target analytes ≥½ limit of quantitation (LOQ), except common laboratory contaminants, which must be < LOQ.	S & A
Field Duplicates	Organics	One per 10 samples.	Precision	Sediments: Relative percent difference (RPD) must be ≤ 50%. Waters: RPD must be ≤ 30%. If sample results are < 2x LOQ, professional judgment is used.	S & A
	Metals	One per 10 samples.	Precision	<u>For values ≥ 5x LOQ</u> Sediments: RPD must be ≤ 50% Waters: RPD must be ≤ 30%. <u>For values < 5x LOQ</u> Sediments: Absolute difference must be ≤ 4x LOQ Waters: Absolute difference must be ≤ 2x LOQ for waters.	S & A
Cooler Temperature Indicator	All analytical groups	One per cooler.	Representativeness	Temperature must be less than or equal to 6 degrees Celsius (≤ 6 ^{o}C).	S

1 Equipment rinsate blanks will be collected if non-dedicated sampling equipment is used. For disposable equipment, one sample per batch of disposable equipment will be collected

7.0 -- Sampling Design and Rationale

Sampling is required in two separate areas representing one environmental site (North Branch of Pettibone Creek) and one reference location (South Branch of Pettibone Creek). The sampling design for this project is judgmental. The sample locations and number of samples were selected to characterize sediment quality.

The following describes the sampling areas, media to be sampled, and analyses to be conducted on the samples. Sampling areas are illustrated on Figure 7-1. A matrix table of samples to be collected for chemical analysis is provided in Table 8-1. Sampling and other field task methodologies are described in Section 8.1.

Benthic Invertebrate Survey

The size and diversity of the project site and contamination pattern will determine the exact number of sample locations required. At this time, 14 reaches are targeted for sampling to adequately characterize Pettibone Creek (see Figure 7-1). Nine of these reaches represent the site and will be located along the preferential pathway of the North Branch of Pettibone Creek, while four are reference areas, located in the South Branch of Pettibone Creek. It is assumed that the South Branch of Pettibone Creek represents site conditions in the absence of upstream or site-related contamination.

Each of the sample locations (NTC17PCSD53, NTC17PCSD54, NTC17PCSD58 through NTC17PCSD69) will consist of samples collected along a 300 foot long creek reach. Because the North Branch of Pettibone Creek is approximately 3,600 feet long, the majority of the creek will be sampled and the reaches will be almost adjacent to each other (see Figure 7-1). Sample locations were selected through mapping exercises and were based on regular distribution of sampling locations throughout the North and South Branches of Pettibone Creek, sufficient width of the wetted stream or tributary, avoidance of bridges or other major habitat alterations (if possible), and avoidance of uncommon habitat features. Although the western fork of the South Branch of Pettibone Creek receives more urban runoff than does the southern fork, one reference sample (NTC17PCSD69) will be collected from this area as the stream is not influenced by potential Navy sources. The portion of the South Branch of Pettibone Creek near its confluence with the North Branch was excluded from sampling because this area may back-up during high stream flows and transport contaminants from the North Branch into the South Branch.

Selection of Number and Location of Sediment Samples for Chemical Analysis and Toxicity Testing

- Sediment samples for chemical analysis and toxicity testing will be collected over the same 300 foot-segments (nine composite samples in the North Branch of Pettibone Creek and five composite samples in the South Branch). These nine composite sediment samples in the North Branch of Pettibone Creek will cover approximate 2700 feet of the creek.

- Three additional composite sediment samples for chemical analysis and toxicity testing will be collected in the North Branch of Pettibone Creek to cover the approximately 900 feet of creek remaining.

- Three additional composite sediment samples for chemical analysis will be collected in the North Branch of Pettibone Creek upstream of Navy property.

- Three sediment samples will be for the collection of suspended sediment as sediment enters the site.

- Two field duplicates will be collected from sediment sample locations NTC17PCSD53 and NTC17PCSD61 (composite samples will be well mixed and divided in the field).

Number of Sediment Samples	Description
9	Composite in the North Branch at location also selected for benthic survey
5	Composite in the South Branch at location also selected for benthic survey
3	Composite in the North Branch at location not selected for benthic survey
3	Composite upstream of Navy property in North Branch
3	Suspended Sediment in the North Branch
2	Field duplicates of composite sediment samples
25	TOTAL

Toxicity Testing

Typically, when conducting toxicity tests to develop concentration gradients, it is standard practice to have between seven and ten samples with a range of chemical concentrations from the lowest to highest observed concentration levels. Up to eight site samples and one reference sample will be selected for toxicity testing, if the results of the benthic invertebrate survey indicate unacceptable benthic community health and chemical concentrations are greater in the site sediment compared to the PSLs and the maximum concentration from reference locations. This decision will be based on a preliminary evaluation

of the benthic community data to keep the holding time as short as possible. Site samples will be selected for toxicity testing by the project ecological risk assessor, based on the results of chemical analyses, such that concentration gradients (from high to low) can be developed for PAHs, select pesticides, select PCBs, and select metals. The sample from the South Branch of Pettibone Creek with the overall lowest chemical concentrations will be selected as the reference locations. The 10-day *Hyalella azteca* toxicity test will be conducted with growth and survival as the endpoints.

Suspended Sediment Collection

Three sediment traps will be installed at the northern edge of Navy property within the North Branch of Pettibone Creek at the south end of three culverts as identified on Figure 7-1. The sediment samples collected in these traps will be analyzed for the parameters discussed below.

Chemical Analysis

Twenty composite sediment samples, two duplicate composite samples, and three suspended sediment samples will be collected from locations throughout Pettibone Creek and analyzed for PAHs, select pesticides, select PCBs, select metals, TOC, and grain size. Select samples will also be analyzed for pH (see Table 8-1). The twenty composite sediment samples (plus two duplicate composite samples) will be collected at 0 to 4 cm bss to evaluate chemical concentrations in the sediment to which benthic invertebrates will be exposed. Three suspended sediment samples will also be collected using sediment traps to determine if an upstream contamination source exists.

8.0 -- Field Project Implementation (Field Project Instructions)

8.1 Field Project Tasks

Field tasks listed below are summarized with a short description for each task.

- Mobilization/Demobilization
- Site-Specific Health and Safety Training
- Sample Collection Tasks
- Benthic Invertebrate Survey Sampling
- Sediment Sampling
- Suspended Sediment Sampling
- Investigation-Derived Waste (IDW) Management
- Field Decontamination Procedures
- Sample Handling
- QC

The SOPs and field documents referenced below are included in Appendix A.

Any deviations from the protocol outlined in this SAP will be documented. If changes to the SAP are needed prior to field/laboratory work, the Tetra Tech PM will document the proposed changes via an FTMR form within 5 days and send the Navy RPM a concurrence letter within 7 days of identifying the need for change. SAP amendments will be submitted by the Tetra Tech PM to the Navy RPM for review and approval. The Tetra Tech PM will send scope changes to the Project Team via e-mail within 1 business day. If changes to the SAP are needed during field work, The Tetra Tech FOL will verbally inform the Tetra Tech PM on the day that the issue is discovered. The Tetra Tech PM will inform the Navy RPM (verbally or via e-mail) within 1 business day of discovery. The Navy RPM will issue a scope change (verbally or via e-mail), if warranted. The scope change is to be implemented before further work is executed. The Navy RPM will inform the regulatory agency (verbally or via e-mail) before implementing the change. The Tetra Tech PM will document the change via an FTMR form within 2 days of identifying the need for change and will obtain required approvals within 5 days of initiating the form or within the time period of the sampling event (whichever occurs first).

Mobilization/Demobilization

Mobilization will consist of the delivery of equipment, materials, and supplies to the site, complete assembly in satisfactory working order of such equipment at the site, and satisfactory storage at the site of such materials and supplies. The Tetra Tech FOL or designee will coordinate with the Navy RPM to identify appropriate locations for the storage of equipment and supplies. The Tetra Tech FOL or designee will contact the Navy RPM at least 14 days prior to commencement of field work to arrange for access to the site for field personnel and to coordinate field work. The Tetra Tech PM will verbally inform the Navy RPM of any schedule changes on the day that a schedule change is known and document, via a schedule impact letter within 1 business day from when impact is realized. Site-specific health and safety training for Tetra Tech field personnel and subcontractors will be provided as part of site mobilization. The site-specific health and safety plan is attached in Appendix D.

Demobilization will consist of the prompt and timely removal of equipment, materials, and supplies from the site following completion of the work. Demobilization includes the cleanup and removal of waste generated during the performance of the investigation.

Site-Specific Health and Safety Training

There are no specialized/non-routine project-specific training requirements or certifications needed by personnel to successfully complete the project or tasks. Field personnel will have appropriate training to conduct the field activities to which they are assigned. Each site worker will be required to have completed the Occupational Safety and Health Administration (OSHA) 40-hour course (and 8-hour refresher, if applicable) in health and safety training. Safety requirements are addressed in greater detail in the site-specific health and safety plan in Appendix D.

The following procedure will be initiated if work is stopped due to safety concerns. If Tetra Tech is the responsible party for a stop work command, the Tetra Tech FOL will inform onsite personnel, subcontractor(s), the Navy RPM, and the identified Project Team members within 1 hour (verbally or by e-mail).

Sample Collection Tasks

The sampling and analysis program is outlined in Section 7. Samples to be collected for laboratory chemical analysis are identified in Table 8-1. Sample collection will be in accordance with the site-specific SOPs listed in Section 8.2 and provided in Appendix B. The sampling requirements for each type of analysis (i.e., bottleware, preservation, holding time) are listed in Table 8-2. Field and laboratory QC samples will also be collected as outlined in Table 8-3. Samples will be collected in a downstream to

upstream order to avoid any impacts from the disturbance of sediment during sampling. Sampling locations will be identified in the field based on visual observation of landmarks using Figure 7-1. Global Positioning System coordinates will be determined for data reporting purposes after the completion of field tasks using the center of each reach identified on Figure 7-1 as the location of composite sediment samples.

Benthic Invertebrate Survey Sampling

SOPs used by the Illinois EPA will be followed for the field benthic macroinvertebrate sampling (SOP Document Control Number [DCN] 168; Illinois EPA, 2011a; Appendix A). Any deviation from these procedures, with the exception of sampling period, which is addressed in this section, will be explained in the sampling report. Site location and benthic sampling field forms will be completed for each site (Appendix A).

Field sampling methods include using a long handled D-frame net to produce a multi-habitat composite sample (a 20-jab sampling technique) in the field, targeting habitat types in proportion to their occurrence in the reach (SOP DCN 168; Illinois EPA, 2011a; Appendix A). It is assumed that the habitat types in the site and reference areas are comparable and fairly homogenous. Habitats that do not appear comparable and fairly homogenous (i.e., habitat types that make up less than 5 percent of the stream reach or are present only in the reference area and not the impact area) will not be sampled.

In addition to collecting the benthic samples, the field crew will make field observations related to stream habitat conditions and will conduct a visual-based physical habitat assessment and a modified 100-particle Wolman pebble count at each sample location. The modified 100-particle Wolman pebble count will be conducted by dividing the sampling location into 10 transects based upon the percentage of features present within the stream reach (e.g., pools, riffles). Ten particles will be measured in each transect using calipers to determine the size class. The field forms for the habitat assessment and the pebble count that will be completed in the field are presented in Appendix A. Although the habitat assessment form is from Ohio EPA, it is used because it is an attachment in the Illinois EPA Quality Assurance and Field Methods Manual, Section D: Special Stream Surveys (Illinois EPA, 2010). The habitat assessment will include measures of the Qualitative Habitat Evaluation Index (QHEI), as recommended by Illinois EPA and the Wolman pebble count for quantitative measurement of substrate particle size. Select field water quality parameters such as conductivity, dissolved oxygen, pH, and water temperature will be measured in the field with a water quality meter and the results will be recorded in a field log book. Photographs will also be taken, as necessary, to document the sample locations and the field activities.

After the benthic samples are collected, they will be processed in the field, which includes preservation in 95 percent ethanol, and placement in sample jars. The benthic samples should remain in 95 percent ethanol for at least 2-4 hours. Prior to packaging and shipping the samples to the taxonomic laboratory, alcohol preservative will be decanted from the sample jars to comply with Department of Transportation (DOT) requirements. The alcoholic preservative will be discarded after dilution (see Section 8 procedure to dispose of IDW). The sample jars will then be placed into appropriate shipping containers and shipped to the taxonomic laboratory. The taxonomic laboratory will replace the preservative immediately upon receipt.

At the primary taxonomic laboratory (Aquatic Resources Center, Inc), the 13 samples will be randomly subsampled to 300 ± 20 percent organisms, which will then be identified primarily to genus level. For the purposes of indicator calculations, organisms in the following taxonomic groups will only be identified to the stated group levels: Oligochaeta, Turbellaria, Hirudinea, Cambaridae, Sphaeriidae and Unionidae. Identification at genus level will include Chironomidae, including pupae. The laboratory will slide mount specimens where necessary for attaining the hierarchical target levels. Non-target taxa will not be identified beyond very coarse levels. The sample processing (sorting organisms from sediment and detritus) and organism identification will be conducted in accordance with the SOP for Sorting Macroinvertebrate Samples and the SOP for Identification of Benthic Macroinvertebrates (Tetra Tech SOPs in Appendix B). These SOPs were based on requirements of the Illinois EPA SOP for Sample Processing for the Macroinvertebrate Index of Biotic Integrity (mIBI) (Illinois EPA, 2011b; Appendix B).

Laboratory QC will be performed on three randomly-selected samples by a secondary laboratory (Freshwater Benthic Services, Inc). The QC will involve re-identification of the samples that have been sorted to approximately 300 organisms. Re-identification will follow the same SOP as the primary laboratory (Appendix B), except that chironomids will already be mounted. The QC laboratory will follow the same guidelines for taxonomic hierarchical target level, and enumeration. These QC activities generally follow the USEPA SOP for QC activities related to processing benthic macroinvertebrate samples (USEPA, 2009), though the Illinois EPA SOP for Sample Processing for the Macroinvertebrate Index of Biotic Integrity (mIBI) (Illinois EPA, 2011b; Appendix B) takes precedence.

Another laboratory (Center for Ecological Services) will conduct QC of organism sorting by performing a sort-recheck on three randomly-selected samples. This involves examination of the sorted residue under 1.75 times lighted magnification and placing any previously unsorted organisms into a new vial. This is done to determine the percentage of organisms missed by the primary laboratory.

The results of the two QC steps will be used to calculate QC performance measures. They include laboratory sorting and subsampling bias (percent sorting efficiency) and taxonomic precision (percent taxonomic disagreement, difference in enumeration, and completeness).

The Illinois EPA mIBI will be used to assess the biological condition of Pettibone Creek along with qualitative metrics based on taxa that dominate the samples, physical habitat characteristics, water chemistry, etc. Calculation of the mIBI will follow the Illinois EPA SOP for Calculation of the Macroinvertebrate Index of Biotic Integrity (mIBI) (Illinois EPA, 2011c; Appendix B), except that references to the Illinois EPA SOP in that document will refer to the laboratory sorting SOP (SOP for Sorting Macroinvertebrate Samples) and identification SOP (SOP for Identification of Benthic Macroinvertebrates) prepared for this project (Appendix B). Rating scales to be used with the mIBI scores, which relate to general biological condition and aquatic life use standards are presented in Tetra Tech (2007) and Illinois EPA (2010). However, because the samples will be collected outside of the index period intended for application of the mIBI, the rating scales will not apply to the samples. Because samples will not be collected during the recommended index period (between June 1st and October 15th), the assessment results (a multimetric index of condition) of this study will not be directly comparable to assessment thresholds recommended by Illinois EPA. However, results will be comparable within the study area (e.g., site-to-site and test-to-reference comparisons).

Index scores (mIBI) will be related to contaminant identities, concentration information, and habitat observations. Of most interest for this small stream system will be comparisons of those scores from the test site samples (North Branch of Pettibone Creek) to the reference site samples (South Branch of Pettibone Creek). The reference sites are assumed to have only background contamination and will be used as baseline comparison for this assessment. To the extent possible, the level of contamination related to biological impairment will be quantified; however, habitat conditions and other background sources of stress in Pettibone Creek may confound stressor-response signals. In the analysis, the average of mIBI scores of the reference samples will be compared both to the average of scores from the test site samples as well as to the scores in individual test site samples. It is assumed that the magnitude of differences in mIBI scores among test sites will be too small to assign statistical significance (at $\alpha = 0.05$). The variance among reference sites will be used to estimate the confidence limits of the mIBI, and then this information will be used in statistical comparisons. If differences in site scores are not found to be statistically significant, the scores and sample composition will be interpreted based on professional expertise in biological indicators. The statistics will be in accordance with USEPA, 2007.

Sediment Sampling

Sediment will be collected in accordance with Tetra Tech SOP SA-1.2 using a petite ponar grab or Eckman dredge that will be slowly lowered by hand and pressed into the sediment to the necessary

depths (4 cm for surface samples). A small plastic core tube may be used in place of a ponar grab or Eckman dredge if the water is shallow. Enough sediment will be collected in case toxicity testing is required (1 gallon for toxicity testing; see Table 8-2 for volume requirements). The sampler will be closed, raised out of the water, and emptied into a 5 gallon plastic bucket lined with a plastic bag. After the needed volume of sediment is obtained, the sample material will be homogenized by manual mixing and a disposable trowel will be used to place the sediment in the appropriate sample bottles. At least 10 samples (half the locations for benthic sampling using the jab technique) will be collected from each 300 foot reach in order to collect a composite sample for each reach. At least 5 samples will be collected from each <300 foot reach in order to collect a composite sample for each reach.

Suspended Sediment Sampling

Sediment traps will be installed in the culverts that discharge the North Branch of Pettibone Creek onto NSCL and will remain in place for as long as possible (expected to be a minimum of 1 to 2 months). The time frame was selected to obtain a representative sample of sediment flowing onto Navy property over time. The traps will be constructed from 4 inch polyvinyl chloride (PVC) pipe and filter bags and will be designed/installed in such a way as to collect and direct a portion of the stormwater discharge into the 7 inch by 32 inch filter bag. The filter bag will have a pore size of between 1 and 25 microns to trap fine silt/clay size (≤0.003 inches) suspended solids from the stormwater discharge. A screen/diverter will be placed on the inlet end of the trap to minimize trash, leaves, etc. from entering the trap. The installation of the traps will not impede the stormwater discharge from the outfalls and will not cause a back-up in the drainage system. After sufficient fine material has accumulated in each bag, the collected sediment will be placed into a stainless steel bowl and processed, removing rocks, trash, organic material, etc. The jars will be labeled and the sample will be placed in the laboratory-cleaned jars and/or bottles and packed in a cooler with ice. Each cooler will be shipped for next day delivery to the laboratory and accompanied by appropriate chain-of-custody documentation. Once the samples have been collected, the sediment traps will be removed and disposed.

Investigation-Derived Waste Management

IDW includes decontamination fluids, used personal protective equipment (PPE), used sampling equipment, and excess sample material. IDW characterization and disposal will be performed after the IDW has been containerized, and IDW will be managed in accordance with Tetra Tech SOP SA-7.1. Ethanol used for sample preservative will be decanted from the samples and stored in a 5 gallon bucket with a screw on lid. The bucket and material safety data sheet (MSDS) for ethanol will be provided to NSGL for proper disposal.

Field Decontamination Procedures

Decontamination of sampling equipment will not be necessary for dedicated and disposable hand trowels. Decontamination of reusable sampling equipment (e.g., non-disposable hand trowels, ponar grab, Eckman dredge) will be conducted prior to sampling and between samples at each location. Decontamination of equipment will be conducted according to the sequence established in Tetra Tech SOP SA-7.1.

Field documentation will be performed in accordance with Tetra Tech SOP SA-6.3.

Sample Handling

Sample handling and shipping procedures presented in Tetra Tech SOP SA-6.1 will be followed. Sample log sheets will be prepared for each sample collected and will include sample-specific information and other information that documents sampling activities. Sample log sheets will be signed and dated, and the appropriate chain-of-custody procedures will be followed until the samples reach the analytical laboratory. Sample labeling will be in accordance with Tetra Tech SOP CT-04, and the sample numbering scheme will be in accordance with Table 8-1. The selection of sample containers, sample preservation, packaging, and shipping will be in accordance with Table 8-2 and Tetra Tech SOP SA-6.1.

The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech FOL immediately upon receipt of any chain of custody/sample receipt variances for clarification or direction from the Tetra Tech FOL. The Tetra Tech FOL will notify (verbally or via e-mail) the Tetra Tech PM within 1 business day, if corrective action is required. The Tetra Tech PM will notify (verbally or via e-mail) the Laboratory PM and the Tetra Tech FOL within 1 business day of any required corrective action.

Quality Control Tasks

QA/QC samples will be collected at frequencies listed in Section 6.

ADDITIONAL PROJECT-RELATED TASKS

Additional project-related tasks include:

- Analytical tasks
- Data management
- Data review
- Project reports

Analytical Tasks

The Benthic Invertebrate Survey by Aquatic Resources Center, Inc. will identify benthic organisms in accordance with the approach described in Section 7. Freshwater Benthic Services, Inc. will perform QC of taxonomical identification and the Center for Ecological Services, Tetra Tech will perform QC of macroinvertebrate sorting. SOPs for benthic macroinvertebrate analytical tasks are provided in Appendix B.

Toxicity testing, if necessary, will be performed by the Tetra Tech Center for Ecological Services in accordance with the 10-Day Sediment Toxicity Test Using *Hyallela azteca* SOP (See Appendix B).

Chemical analyses will be performed by Empirical, which is a DoD Environmental Laboratory Approval Program (ELAP)-accredited laboratory. A copy of the laboratory accreditation for Empirical is included in Appendix C. Analyses will be performed in accordance with the analytical methods identified in Table 8-2. Empirical will meet the PSLs specified in Section 9 and will perform the chemical analyses following laboratory-specific SOPs (see Table 8-2 and Section 10) developed based on the methods listed in Table 8-2. Empirical Laboratory SOPs are not included in this SAP, but have been reviewed to make sure they are suitable for use on this project.

The sediment results will be reported by the laboratory on an adjusted dry-weight basis. Results of percent moisture will be reported in each analytical data package and associated electronic data files. This information will also be captured in the project database, which will eventually be uploaded to the Naval Installation Restoration Information Solution (NIRIS) database. Percent moisture information will also be captured in the Additional Sampling and Analysis-Site 17 Report.

The analytical data packages provided by Empirical will be in a Contract Laboratory Program-like format and will be fully validatable and contain raw data, summary forms for the sample and laboratory method blank data, and summary forms containing the method-specific QC (results, recoveries, relative percent differences (RPDs), relative standard deviations (RSD), and/or percent differences, etc.).

The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist of any variance from the quality limits identified in this SAP on the day the variance becomes known. The Tetra Tech Project Chemist will notify (verbally or via email) the Tetra Tech PM within 1 business day of the need for corrective action, if the variance is a significant issue. The Tetra Tech PM will notify (verbally or via e-mail) the Laboratory PM and the Tetra Tech FOL and Project Chemist within 1 business day of any required corrective action. The Laboratory QAM will document the quality variances in the Case Narrative of the Analytical Laboratory Report.

The Laboratory PM will notify (verbally or via e-mail) the Tetra Tech Project Chemist within 1 business day of when an issue related to laboratory data is discovered (e.g., non-usable data). The Tetra Tech Project Chemist will notify (verbally or via e-mail) the DVM and the Tetra Tech PM within 1 business day of the need for corrective action (e.g., if the nonusable data is a significant issue, such as critical sample data). Corrective action may include resampling and/or reanalyzing the effected samples.

The Tetra Tech DVM or Project Chemist will notify the Tetra Tech PM verbally or via e-mail within 48 hours of validation completion if a non-routine and significant laboratory quality deficiency has been detected that could affect this and/or other projects. The Tetra Tech PM will verbally advise the Navy RPM within 24 hours of notification from the Tetra Tech Project Chemist or DVM. The Navy RPM will take corrective action appropriate for the identified deficiency. Examples of significant laboratory deficiencies include data reported that has a corresponding failed tune or initial calibration verification. Corrective actions may include a consult with the Navy Chemist.

Data Management

The principal data generated for this project will be from field data and laboratory analytical data. Field sampling log sheets will be organized by date and environmental medium, and filed in the project files. The field logbooks for this project will be used only for this site and will also be categorized and maintained in the project files after the completion of the field program. Project personnel completing concurrent field sampling activities may maintain multiple field logbooks. When possible, logbooks will be segregated by sampling activity. The field logbooks will be titled based on date and activity.

The data handling procedures to be followed by Empirical will meet the requirements of the laboratory technical specifications. Electronic data results will be automatically downloaded into the Tetra Tech database in accordance with proprietary Tetra Tech processes.

The Tetra Tech PM (or designee) is responsible for the overall tracking and control of data generated for the project.

- **Data Tracking**. Data are tracked from generation to archiving in the Tetra Tech project-specific files. The Tetra Tech Project Chemist (or designee) is responsible for tracking the samples collected and shipped to Empirical. Upon receipt of the data packages from Empirical, the Tetra Tech Project Chemist will monitor the data validation effort, which includes verifying that the data packages are complete and results for the samples have been delivered by Empirical.

- **Data Storage, Archiving, and Retrieval**. The data packages received from Empirical are tracked in the data validation logbook. After the data are validated, the data packages are entered into the Tetra Tech Comprehensive Long-Term Environmental Action Navy (CLEAN) file system and archived in secure files. The field records, including field log books, sample logs, chain-of-custody records, and field calibration logs, will be submitted by the Tetra Tech FOL to be entered into the Navy CLEAN file system prior to archiving in secure project files. Project files are audited for accuracy and completeness. At the completion of the Navy contract, the records will be stored by Tetra Tech.

- **Data Security**. Access to Tetra Tech project files is restricted to designated personnel only. Records can only be borrowed temporarily from the project file using a sign-out system. The Tetra Tech Data Manager maintains the electronic data files, and access to the data files is restricted to qualified personnel only. File and data backup procedures are routinely performed.

- **Electronic Data**. The electronic data will be compiled into a NIRIS Electronic Data Deliverable (NEDD) and loaded into NIRIS.

- **Data Review**. This review comprises data verification, validation, and a usability assessment. The data verification and validation processes and requirements are described in Section 6. The data usability assessment will, at a minimum, constitute evaluation of the following characteristics to make sure that the amount, type, and quality of data are sufficient to achieve project objectives. The means of conducting these evaluations will vary depending on the nature of the data. Examples include:

  - Comparing actual to intended sampling locations and verifying that the correct datum was used to delineate contamination
  - Evaluating trends across sample delivery groups or sampling events
  - Identifying potential errant or outlier data points
  - Assessing planning assumption validity
  - Evaluating the potential for contamination of samples by samplers

Data quality indicators to be evaluated during this assessment include:

- **Precision.** A semiquantitative estimate of the uncertainty in contaminant concentrations.

- **Accuracy.** Accuracy of data will be evaluated to make sure that sampling and measurement accuracy is within or exceeds analytical method specifications and may depend in part on the data validation findings.

- **Representativeness.** This evaluation will assess whether the data are adequately representative of intended populations based on the sample collection and data generation requirements specified in this SAP.

- **Completeness.** Failure to obtain critical data from planned locations will be documented. Minor variations in actual versus intended sampling locations (or depths) that do not adversely affect the attainment of project objectives will not be documented.

- **Comparability.** This will be accomplished by comparing overall precision and bias among data sets for each matrix and analytical fraction for each sampled area.

- **Sensitivity.** The Tetra Tech Project Chemist will determine whether project sensitivity goals were achieved by comparing non-detect values to PSLs.

If significant data quality deficiencies are detected that prevent the attainment of project objectives, the limitations on the affected data will be described in the project report. The Tetra Tech PM will bring these deficiencies to the attention of the project team for their evaluation and the team will determine an appropriate corrective action depending on the circumstances.

Project Reports

At the completion of this investigation a draft and final Additional Sampling and Analysis-Site 17 Report will be compiled by Tetra Tech and submitted to the NAVFAC RPM.

8.2 Field SOPs Reference Table

Reference Number	Title, Revision Date, and/or Number	Originating Organization of Sampling SOP	Equipment Type	Modified for Project Work? (Y/N)	Comments
Document Control Number (DCN) 168	Method to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments, 11/16/2011, Rev 0	Illinois EPA	Sampling Procedures, Methods	N	Contained in Appendix A
CT-04	Sample Nomenclature, 01/2012, Rev 3	Tetra Tech	NA	N	Contained in Appendix A
SA-1.1	Groundwater Sample Acquistion and Onsite Water Quality Testing	Tetra Tech	Sampling Procedures, Methods	N	Contained in Appendix A
SA-1.2	Surface Water and Sediment Sampling, 01/2012, Rev 6	Tetra Tech	Sampling Procedures, Methods	N	Contained in Appendix A
SA-6.1	Non-Radiological Sample Handling, 01/2012, Rev 4	Tetra Tech	Sample Bottleware, Packaging Material, Shipping Materials	N	Contained in Appendix A
SA-6.3	Field Documentation, 01/2012, Rev 4	Tetra Tech	Field Logbook, Field Sample Forms, Boring Logs	N	Contained in Appendix A
SA-7.1	Decontamination of Field Equipment, 01/12, Rev 7	Tetra Tech	Decontaminate core barrel and cutting head (scrub brushes, phosphate-free detergent, river water rinse)	N	Contained in Appendix A

Table 8-1 – Sample Details Table

Sampling Location	Sample ID	Analysis	Description
NTC17PCSD50	NTC17PCSD50	Chemistry	Sediment trap at culvert
NTC17PCSD51	NTC17PCSD51	Chemistry	Sediment trap at culvert
NTC17PCSD52	NTC17PCSD52	Chemistry	Sediment trap at culvert
NTC17PCSD53	NTC17PCSD53	Chemistry, Benthic, pH	Site location(1)
NTC17PCSD54	NTC17PCSD54	Chemistry, Benthic	Site location
NTC17PCSD55	NTC17PCSD55	Chemistry	Site location
NTC17PCSD56	NTC17PCSD56	Chemistry	Site location
NTC17PCSD57	NTC17PCSD57	Chemistry	Site location
NTC17PCSD58	NTC17PCSD58	Chemistry, Benthic, pH	Site location
NTC17PCSD59	NTC17PCSD59	Chemistry, Benthic, pH	Site location
NTC17PCSD60	NTC17PCSD60	Chemistry, Benthic	Site location
NTC17PCSD61	NTC17PCSD61	Chemistry, Benthic, pH	Site location(1)
NTC17PCSD62	NTC17PCSD62	Chemistry, Benthic	Site location
NTC17PCSD63	NTC17PCSD63	Chemistry, Benthic, pH	Site location
NTC17PCSD64	NTC17PCSD64	Chemistry, Benthic	Site location
NTC17PCSD65	NTC17PCSD65	Chemistry, Benthic, pH	Reference location
NTC17PCSD66	NTC17PCSD66	Chemistry, Benthic	Reference location
NTC17PCSD67	NTC17PCSD67	Chemistry, Benthic, pH	Reference location
NTC17PCSD68	NTC17PCSD68	Chemistry, Benthic	Reference location
NTC17PCSD69	NTC17PCSD69	Chemistry, Benthic	Reference location
NTC17PCSD70	NTC17PCSD70	Chemistry	Upstream location
NTC17PCSD71	NTC17PCSD71	Chemistry	Upstream location
NTC17PCSD72	NTC17PCSD72	Chemistry	Upstream location

Footnotes:
1 – Location of sediment composite field duplicate.

Notes:
Benthic – Benthic organisms collected for Benthic Macroinvertebrate Survey
Chemistry – PAHs, pesticides, PCBs, select metals, TOC, grain size collected from sediment samples (See Section 9.0 for list of analytes)

Table 8-2 – Analytical SOP Requirements Table

Laboratory point of contact, e-mail address, and phone number: Brian Richard, brichard@empirlabs.com, (615) 345-1115 Ext. 249
Laboratory Name and Address:
Empirical Laboratories, LLC
621 Mainstream Drive,
Suite 270
Nashville, TN 37228
Data Package Turnaround time: 14 days
Tentative Sampling Dates: March 26-30, 2012

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference** [(1)]	**Containers** (number, size, and type)	**Sample Volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time** (preparation/ analysis)
Sediment	PAHs (Low Level scan)	SW-846 3546/ 8270D-Low, Empirical SOP-201/343	One 4-ounce (oz) glass jar with a Teflon-lined lid	15 grams (g)	Cool to 0 to 6 °C	14 days until extraction, 40 days to analysis
Sediment	Pesticides/PCBs	SW-846 3546 /8081B/ 8082A, Empirical SOP-211/343	One 4-oz glass jar with a Teflon-lined lid	15 g	Cool to 0 to 6 °C	14 days until extraction, 40 days to analysis
Sediment	Metals	SW-846 3050B/ 6010C, SW-846 7471A Empirical SOP-100/104/105	One 4-oz glass jar with a Teflon-lined lid	1 to 2 g	Cool to 0 to 6 °C	180 days to analysis except mercury which is 28 days to analysis
Sediment	pH	SW-846 9045D/ Empirical SOP-187	One 4oz glass jar	4 oz.	Cool to 0 to 6°C	Analyze as soon as possible
Sediment	TOC	Lloyd Kahn Empirical SOP-221	One 4oz glass jar	5g	Cool to 0 to 6°C	14 days to analysis

Notes:
Sediment samples will also be analyzed for grain size.

1 See Analytical SOP References table (Section 10) for additional details on SOPs.

Laboratory point of contact, e-mail address, and phone number: Todd Askegaard, aquatres@ix.netcom.com, 615-781-2901

Laboratory Name and Address:
Aquatic Resources Center, Inc.
545 Cathy Jo Circle
Nashville, Tennessee 37211
Data Package Turnaround time: 3 weeks
Tentative Sampling Dates: March 26-30, 2012

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference**	**Containers** (number, size, and type)	**Sample Volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time** (preparation/ analysis)
Benthic Invertebrates	Community Health	Illinois EPA DCN 168; SOP for Sorting Macroinvertebrate Samples; SOP for Identification of Benthic Macroinvertebrates	Leak-proof jar	NA	Store in 95% ethanol	3 weeks

Laboratory point of contact, e-mail address, and phone number: Michael Winnell, freshwater.benthic.services@gmail.com, 231-347-9752

Laboratory Name and Address:
Freshwater Benthic Services, Inc.
3250 Krause Road
Petoskey, Michigan 49770
Data Package Turnaround time: 5 days
Tentative Sampling Dates: March 26-30, 2012

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference**	**Containers** (number, size, and type)	**Sample Volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time** (preparation/ analysis)
Benthic Invertebrates	QC	Will follow requirements listed for Aquatic Resources Center, Inc.				5 days

Laboratory point of contact, e-mail address, and phone number: James Stribling, james.stribling@tetratech.com, 410-356-8993

Laboratory Name and Address:
Center for Ecological Services
Tetra Tech
400 Red Brook Blvd., Suite 200
Owings Mills, MD, 21117
Data Package Turnaround time: 5 days
Tentative Sampling Dates: March 26-30, 2012

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference**	**Containers** (number, size, and type)	**Sample Volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time** (preparation/ analysis)
Benthic Invertebrates	QC	Will follow requirements listed for Aquatic Resources Center, Inc.				

Laboratory point of contact, e-mail address, and phone number: Marcus S. Bowersox, Marcus.Bowersox@tetratech.com, 410-356-8993

Laboratory Name and Address:
Center for Ecological Services
Tetra Tech
400 Red Brook Blvd., Suite 200
Owings Mills, MD, 21117
Data Package Turnaround time: 3 weeks from completion of testing.
Tentative Sampling Dates: March 26-30, 2012

Matrix	**Analytical Group**	**Analytical and Preparation Method/ SOP Reference**	**Containers** (number, size, and type)	**Sample Volume** (units)	**Preservation Requirements** (chemical, temperature, light protected)	**Maximum Holding Time** (preparation/ analysis)
Sediment	Toxicity testing	TT-BRF/TX-SOP-O-017	Polyethylene containers	1 gallon	Cool to 0 to 6 °C	3 weeks[(1)]

1 The recommended storage time ranges from 2 weeks to less than 8 weeks (ASTM, 2005). As the sediments contain relatively stable compounds (high molecular weight [HMW] compounds such as PCBs) which are not expected to vary due to storage duration therefore long term storage (e.g., > 8 weeks) is acceptable (ASTM, 2005). Therefore, a holding time of 4 weeks is acceptable for this project.

Table 8-3 Field Quality Control Sample Summary Table

Matrix	Analytical Group	No. of Samples	No. of Field Duplicates	No. of MS/MSDs(1)	Total No. of Samples to Lab
Sediment	PAHs	23	2	1	25
	Pesticides	23	2	1	25
	PCBs (as Aroclors)	23	2	1	25
	Metals	23	2	1	25
	Total organic carbon	23	2	1	25
	pH	7	1	1	8

1 Although Matrix Spike/Matrix Spike Duplicates (MS/MSDs) are not typically considered field QC samples, they are included here because location determination will be established in the field. The MS/MSDs are not included in the total number of samples sent to the laboratory.

9.0 -- Reference Limits and Evaluation Tables

Matrix: Sediment

Analyte	Chemical Abstract Service (CAS) Number	Project Screening Level (mg/kg)	Project Screening Level Reference[1]	PQLG (mg/kg)	Laboratory		
					Lab LOQ (mg/kg)	Lab LOD (mg/kg)	Lab DL (mg/kg)
Polynuclear Aromatic Hydrocarbons							
2-Methylnaphthalene	91-57-6	0.368	Illinois EPA Tier 1[1]	0.12	0.00667	0.00333	0.00167
Acenaphthene	83-32-9	0.585	Illinois EPA Tier 1	0.20	0.00667	0.00333	0.00167
Acenaphthylene	208-96-8	0.186	Illinois EPA Tier 1	0.062	0.00667	0.00333	0.00167
Anthracene	120-12-7	0.085	Illinois EPA Tier 1	0.028	0.00667	0.00333	0.00167
Benzo(a)anthracene	56-55-3	0.287	Illinois EPA Tier 1	0.096	0.00667	0.00333	0.00167
Benzo(a)pyrene	50-32-8	0.073	Illinois EPA Tier 1	0.024	0.00667	0.00333	0.00167
Benzo(b)fluoranthene	205-99-2	0.886	Illinois EPA Tier 1	0.30	0.00667	0.00333	0.00167
Benzo(g,h,i)perylene	191-24-2	0.17	Region 5	0.057	0.00667	0.00333	0.00167
Benzo(k)fluoranthene	207-08-9	8.86	Illinois EPA Tier 1	3.0	0.00667	0.00333	0.00167
Chrysene	218-01-9	0.4	Illinois EPA Tier 1	0.13	0.00667	0.00333	0.00167
Dibenzo(a,h)anthracene	53-70-3	0.06	Illinois EPA Tier 1	0.020	0.00667	0.00333	0.00167
Fluoranthene	206-44-0	2.79	Illinois EPA Tier 1	0.93	0.00667	0.00333	0.00167
Fluorene	86-73-7	0.035	Illinois EPA Tier 1	0.012	0.00667	0.00333	0.00167
Indeno(1,2,3-cd)pyrene	193-39-5	2.5	Illinois EPA Tier 1	0.83	0.00667	0.00333	0.00167
Naphthalene	91-20-3	0.34	Illinois EPA Tier 1	0.11	0.00667	0.00333	0.00167
Phenanthrene	85-01-8	0.81	Illinois EPA Tier 1	0.27	0.00667	0.00333	0.00167
Pyrene	129-00-0	0.35	Illinois EPA Tier 1	0.12	0.00667	0.00333	0.00167
Pesticides							
4,4' DDD	72-54-8	0.002	Illinois EPA Tier 1[2]	0.00067	0.00067	0.00034	0.00017
4,4'-DDE	72-55-9	0.002	Illinois EPA Tier 1[2]	0.00067	0.00067	0.00034	0.00017
4,4'-DDT	50-29-3	0.001	Illinois EPA Tier 1[2]	0.00033	0.00067	0.00034	0.00017
Aldrin	**309-00-2**	**0.00051**	**Illinois EPA Tier 1[2]**	**0.00017**	**0.00067**	**0.00034**	**0.00011**
alpha-Chlordane	**5103-71-9**	**0.0005**	**Illinois EPA Tier 1[2]**	**0.00017**	**0.00067**	**0.00034**	**0.00011**
Endosulfan II	**33213-65-9**	**0.00015**	**Illinois EPA Tier 1[2]**	**0.000050**	**0.00067**	**0.00034**	**0.00017**
gamma-Chlordane	**5566–34–7**	**0.0005**	**Illinois EPA Tier 1[2]**	**0.00017**	**0.00067**	**0.00034**	**0.00011**

Analyte	Chemical Abstract Service (CAS) Number	Project Screening Level (mg/kg)	Project Screening Level Reference[1]	PQLG (mg/kg)	Laboratory		
					Lab LOQ (mg/kg)	Lab LOD (mg/kg)	Lab DL (mg/kg)
Polychlorinated Biphenyls							
Aroclor-1016	12674-11-2	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1221	11104-28-2	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1232	11141-16-5	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1242	53469-21-9	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1248	12672-29-6	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1254	11097-69-1	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Aroclor-1260	11096-82-5	0.05	Calculated Objective[2]	0.017	0.0167	0.00833	0.00417
Total Aroclor	NA	0.05	Calculated Objective	0.017	0.0167	0.00833	0.00417
Metals							
Arsenic	7440-38-2	9.79	Region 5	3.3	0.5	0.3	0.15
Cadmium	7440-43-9	0.99	Region 5	0.33	0.25	0.1	0.05
Chromium	7440-47-3	43.4	Region 5	14.5	0.5	0.2	0.1
Copper	7440-50-8	31.6	Region 5	10.5	0.5	0.4	0.2
Lead	7439-92-1	35.8	Region 5	11.9	0.25	0.15	0.075
Mercury	7439-97-6	0.174	Region 5	40.3	1	0.5	0.25
Zinc	7440-66-6	121	Region 5	0.058	0.033	0.033	0.0130
Miscellaneous							
Total organic carbon	NA	NA	NA	NA	800	400	200
pH	NA	NA	NA	NA	0.100[3]	0.100[3]	0.100[3]

Notes:
Bolded rows indicate that the PSL is between the LOQ and LOD. **Bolded and shaded** rows indicate that the PSL is less than LOD.

Footnotes:
1 - Values is for total methylnaphthalenes.
2 - Value is for total PCBs.
3 - pH units.

Project Action Limit References:
Illinois EPA Tier 1 – Draft Illinois EPA Tiered Approach for Evaluation and Remediation of Petroleum Product Releases to Sediments (Illinois EPA, September 2000)
Region 5 – USEPA Region 5 Ecological Screening Levels, Sediment (USEPA, 2003)

Calculated Objective – Baseline sediment screening objectives calculated by Illinois EPA using unpublished derived water quality criteria (Brian Conrath, personal communication, February 05, 2002).

Acronyms/Abbreviations:

DL	Detection Limit	mg/kg	milligram per kilogram
LOD	Limit of Detection	NA	Not applicable/Not available.
LOQ	Limit of Quantitation	PQLG	Project Quantitation Limit Goal

10.0 -- Analytical SOP Reference Table

Lab SOP Number	Title, Revision Date, and/or Number	Definitive or Screening Data	Matrix and Analytical Group	Instrument	Organization Performing Analysis	VARIANCE TO QSM? (Y/N)	Modified for Project Work? (Y/N)
Empirical SOP-100	Metals Digestion/ Preparation, Methods 3005A/ USEPA CLP ILMO 4.1 Aqueous, 3010A, 3030C, 3050B, USEPA CLP ILMO 4.1 (Soil/Sediment), 200.7, Standard Methods 3030C (REV22, 11/17/10)	Definitive	Sediment and aqueous QC samples/ Metals Digestion	NA/Preparation	Empirical	NA	N
Empirical SOP-103	Mercury Analysis in Water by Manual Cold Vapor Technique, Methods USEPA SW846 7470A and 245.1, CLP-M 4.1 (REV20, 05/16/11)	Definitive	Aqueous QC samples / Mercury	Flow Injection Mercury Analyzer	Empirical	N	N
Empirical SOP-104	Mercury Analysis in Soil/Sediment by Manual Cold Vapor Technique, Methods SW846 7471A, 7471B, 245.5, and CLP-ILM 4.1 (REV20, 05/16/11)	Definitive	Sediment/Mercury	Flow Injection Mercury Analyzer	Empirical	N	N
Empirical SOP-105	Metals by Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES) Technique, SW-846 Methods 6010B, 6010C, USEPA Method 200.7, Standard Methods 19th Edition 2340B, USEPA CLP ILMO 4.1 (REV17, 05/16/11)	Definitive	Sediment and aqueous QC samples / Metals	Inductively Coupled Plasma – Atomic Emission Spectrometer (ICP-AES)	Empirical	N	N
Empirical SOP-187	Electrometric Determination of pH, Methods 150.1, Standard Method 4500-H+B, and 9040B for Waters, Liquids, and Liquid Wastes, and 9045C for Soils and Solid Wastes (Revision 8, 07/12/10).	Definitive	Sediment / pH	pH meter	Empirical	NA	N

Lab SOP Number	**Title, Revision Date, and/or Number**	**Definitive or Screening Data**	**Matrix and Analytical Group**	**Instrument**	**Organization Performing Analysis**	**VARIANCE TO QSM?** (Y/N)	**Modified for Project Work?** (Y/N)
Empirical SOP-201	Gas Chromatography Mass Spectrometry (GC/MS) semivolatiles and Low-Concentration PAHs using USEPA Method 625 and SW846 Method 8270C and 8270D, Including Appendix IX Compounds (REV21, 05/16/11)	Definitive	Sediment and aqueous QC samples / Low level PAHs	GC/MS	Empirical	N	N
Empirical SOP-208	Gas Chromatography/ Electron Capture Detector (GC/ECD) Chlorinated Acid Herbicides by EPA Method SW-846 8151A (REV16, 11/17/10)	Definitive	Sediment and aqueous QC samples / Pesticides and PCBs	GC/ECD	Empirical	N	N
Empirical SOP-211	GC/ECD Organochlorine Pesticides/ PCBs using USEPA Method 608608.2 or SW846 Method 8081A/8082 or 8081B/8082A (REV24, 05/16/11)	Definitive	Sediment and aqueous QC samples / Pesticides and PCBs	GC/ECD	Empirical	N	N
Empirical SOP-221	Total Organic Carbon (TOC) SM5310C, SW846 Method 9060/9060A and Lloyd Kahn Method (Revision 9, 07/12/10)	Definitive	Sediment / TOC	TOC Analyzer	Empirical	NA	N
Empirical SOP-300	GC/MS- Semivolatile BNA-Aqueous Matrix Extraction using SW-846 Method 3510C for 8270/625 Analysis (REV19, 11/17/10)	Definitive	Aqueous QC samples / Low-level PAH Extraction	NA/Extraction	Empirical	NA	N
Empirical SOP-302	Pesticide/PCBs, Aqueous Matrix Extraction for USEPA 608/608.2 and SW846 Method 8081A/8082 Using SW846 Method 3510C (REV19, 01/12/11)	Definitive	Aqueous QC samples / Pesticide and PCBs Extraction	NA/Extraction	Empirical	NA	N

Lab SOP Number	**Title, Revision Date, and/or Number**	**Definitive or Screening Data**	**Matrix and Analytical Group**	**Instrument**	**Organization Performing Analysis**	**VARIANCE TO QSM?** (Y/N)	**Modified for Project Work?** (Y/N)
Empirical SOP-343	Base, Neutral, Acid (BNA), Pesticides/PCBs, and Total Petroleum Hydrocarbon (TPH) non-Aqueous Matrix (Microwave Extraction) using SW-846 3546 (REV02, 11/17/10)	Definitive	Sediment / low level PAHs/ Pesticide and PCBs Extraction	NA/Extraction	Empirical	NA	N
NA	SOP for Sorting Macroinvertebrate Samples (REV1, 01/12)	Definitive	Macroinvertebrates	NA	Aquatic Resources Center, Inc.	NA	N
NA	SOP for Identification of Benthic Macroinvertebrates (REV1, 01/12)	Definitive	Macroinvertebrates	NA	Aquatic Resources Center, Inc.	NA	N
Illinois EPA DCN 167	Standard Operating Procedure for Sample Processing for the Macroinvertebrate Index of Biotic Integrity (mIBI) (REV 0, 11/16/11)	Definitive	Macroinvertebrates	NA	Aquatic Resources Center, Inc.	NA	N
Illinois EPA DCN 170	Standard Operating Procedure for Calculation of the Macroinvertebrate Index of Biotic Integrity (mIBI) (REV 0, 11/16/11)	Definitive	Macroinvertebrates	NA	Aquatic Resources Center, Inc.	NA	N
TT-BRF/TX-SOP-O-017	10-Day Sediment Toxicity Test Using *Hyallela azteca* (REV 0, 2/3/12(	Definitive	*Hyallela azteca*	NA	Center for Ecological Services, Tetra Tech	NA	N

Notes:

Empirical is a DoD-ELAP-accredited laboratory. A copy of Empirical's accreditation is included in Appendix C.

SOPs that Aquatic Resources Center, Inc. and Center for Ecological Services, Tetra Tech will follow are provided in Appendix B.

11.0 -- Laboratory QC Samples Tables

Matrix	**Sediment and Aqueous QC Samples**
Analytical Group	**Low level PAHs**
Analytical Method / SOP Reference	**SW-846 8270D-Low Empirical SOP-201**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch of 20 or fewer samples of similar matrix.	All target analytes must be ≤ ½ LOQ, except common lab contaminants, which must be < LOQ.	Correct problem. If required, reprepare and reanalyze method blank and the samples processed with the contaminated blank.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits
Laboratory Control Sample (LCS)	One per preparatory batch of 20 or fewer samples of similar matrix.	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G of the DoD QSM.	Correct problem, then reprepare and reanalyze the LCS and the samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Contact Client if samples cannot be reanalyzed within hold time.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix.	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G of the DoD QSM. The RPD between MS and MSD should be ≤ 30%.	CA will not be taken for samples when recoveries are outside limits and surrogate and LCS criteria are met, unless RPDs indicate obvious extraction/ analysis difficulties, then re-prepare and reanalyze MS/MSD.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits

Matrix	**Sediment and Aqueous QC Samples**
Analytical Group	**Low level PAHs**
Analytical Method / SOP Reference	**SW-846 8270D-Low Empirical SOP-201**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Internal Standard	Every field sample, standard, and QC sample - six per sample 1,4-Dichlorobenzene-d_4 Naphthalene-d_8 Acenaphthene-d_{10} Phenanthrene-d_{10} Chrysene-d_{12} Perylene-d_{12}.	RTs must be within ± 30 seconds and the response areas must be within -50% to +100% of the initial calibration midpoint standard for each internal standard.	Re-analyze affected samples.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits
Surrogates	All field and QC samples - six per sample 2-Fluorophenol Phenol-d_6 Nitrobenzene-d_5 2-Fluorobiphenyl 2,4,6-Tribromophenol Terphenyl-d_{14}.	%Rs must meet the DoD QSM Version 4.21 limits as per Appendix G of the DoD QSM	(1) Check chromatogram for interference; if found, then flag data. (2) If not found, then check instrument performance; if problem is found, then correct and reanalyze sample. (3) If still out, then re-extract and reanalyze sample. (4) If reanalysis is out, then flag data.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
Results between DL and LOQ	NA.	Apply "J" qualifier to results detected between DL and LOQ.	NA.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits

Matrix	**Sediment and Aqueous QC Samples**
Analytical Group	**Pesticides/ PCBs**
Analytical Method / SOP Reference	**SW-846 8081B, 8082A/ Empirical SOP-211**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch of 20 or fewer samples of similar matrix.	All target analytes must be ≤ ½ LOQ.	Correct problem. If required, reprepare and reanalyze method blank and the samples processed with the contaminated blank.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits
LCS	One per preparatory batch of 20 or fewer samples of similar matrix. Pesticide: Spike with single component pesticide mix PCB: Spike with Aroclor 1016/1260 mix	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G of the DoD QSM.	Correct problem, then reprepare and reanalyze the LCS and the samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Contact Client if samples cannot be reanalyzed within hold time.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples of similar matrix. (spike same as LCS).	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G of the DoD QSM. The RPD between MS and MSD should be ≤ 30%.	Evaluate the samples and associated QC and if the LCS results are acceptable, then narrate. If both the LCS and MS/MSD are unacceptable, then re-prepare the samples and QC.	Analyst, Supervisor	Accuracy/Bias/ Precision	Same as QC Acceptance Limits

Matrix	**Soil and Aqueous QC Samples**
Analytical Group	**Pesticides/ PCBs**
Analytical Method / SOP Reference	**SW-846 8081B, 8082A/ Empirical SOP-211**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Surrogates	All field and QC samples - two per sample tetrachloro-m-xylene decachlorobiphenyl.	%Rs must meet the DoD QSM Version 4.2 limits as per Appendix G of the DoD QSM.	No corrective will be taken when one surrogate is within criteria. If surrogates recoveries are high and sample is <LOQ, then no CA is taken. If surrogates recoveries are low, then the affected samples are re-extracted and reanalyzed.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
Second Column Confirmation	All positive results must be confirmed.	Results between primary and secondary column must be RPD ≤ 40%. For Method 8082, report the higher of the two concentrations, unless there is interference.	None. Apply "J" flag if RPD >40% and discuss in the case narrative.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits
Results between DL and LOQ	NA.	Apply "J" qualifier to results between DL and LOQ.	NA.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits

Matrix	**Sediment and Aqueous QC Samples**
Analytical Group	**Metals (including Mercury)**
Analytical Method / SOP Reference	**SW-946 6010C, 7470A, 7471B/ Empirical SOP-103, 104, 105**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Method Blank	One per preparatory batch of 20 or fewer samples of similar matrix.	All target analytes must be ≤ ½ LOQ.	Re-analysis to confirm the positive value. Re-prepare and reanalyze samples associated with the blank.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits
LCS	One per preparatory batch of 20 or fewer samples of similar matrix.	%R must be within 80-120% of true value.	Correct problem, then reprepare and reanalyze the LCS and the samples in the associated preparatory batch for failed analytes, if sufficient sample material is available. Contact client if samples cannot be reanalyzed within hold time.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
MS	One per preparatory batch of 20 or fewer samples of similar matrix.	%R should be within 80-120% of true value (if sample is < 4x spike added).	Flag results for affected analytes for the associated samples with “N”.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
Sample Duplicate	One per preparatory batch of 20 or fewer samples of similar matrix.	The RPD should be ≤ 20% for duplicate samples for both water and soils.	Narrate any results that are outside control limits.	Analyst, Supervisor	Precision	Same as QC Acceptance Limits
Serial Dilution (ICP Only)	One per preparatory batch with sample concentration(s) >50x LOD.	The 5-fold dilution result must agree within ±10%D of the original sample result if result is >50x LOD.	Perform post spike addition.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits

Matrix	**Sediment and Aqueous QC Samples**
Analytical Group	**Metals (including Mercury)**
Analytical Method / SOP Reference	**SW-946 6010C, 7470A, 7471B/ Empirical SOP-103, 104, 105**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Post Spike (ICP Only)	One is performed when serial dilution fails or target analyte concentration(s) in the samples are < 50x LOD.	The %R must be within 75-125% of expected value to verify the absence of an interference. Spike addition should produce a concentration of 10-100x LOQ.	Flag results for affected analytes for the associated samples with “J”.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
Results between DL and LOQ	NA.	Apply “J” qualifier to results between DL and LOQ.	NA.	Analyst, Supervisor	Accuracy	Same as QC Acceptance Limits

Matrix	**Sediment**
Analytical Group	**TOC**
Analytical Method / SOP Reference	**Lloyd Kahn Empirical SOP-221**

QC Sample	**Frequency/Number**	**Method / SOP QC Acceptance Limits**	**CA**	**Person(s) Responsible for CA**	**DQI**	**MPC**
Method Blank	One per preparatory batch of 20 or fewer samples.	The target analyte must be ≤ ½ LOQ.	Correct problem, re-prepare and reanalyze along will associated samples.	Analyst, Supervisor	Bias/Contamination	Same as QC Acceptance Limits.
LCS	One per preparatory batch of 20 or fewer samples.	%R must be within 80-120% of true value.	Correct problem, re-prepare, and reanalyze along with associated samples.	Analyst, Supervisor	Accuracy/Bias	Same as QC Acceptance Limits
MS/MSD	One per preparatory batch of 20 or fewer samples per matrix.	%R should be within 75-125% of true value. RPD should be ≤ 50% for sediment.	Contact client for guidance.	Analyst, Supervisor	Accuracy/Bias/ Precision	Same as QC Acceptance Limits

Matrix	**Sediment**
Analytical Group	**pH**
Analytical Method / SOP Reference	**SW-846 9045D/ SOP-187**

QC Sample	Frequency/Number	Method / SOP QC Acceptance Limits	CA	Person(s) Responsible for CA	DQI	MPC
Laboratory Duplicate	One per preparation batch of 10 or fewer samples.	± 0.09 units	Recalibrate and reanalyze samples.	Analyst, Supervisor	Precision	Same as QC Acceptance Limits
LCS	Once per 20 samples.	± 0.25 units	Re-analyze associated samples.	Analyst, Supervisor	Accuracy/bias	Same as QC Acceptance Limits

12.0 -- Data Verification and Validation (Steps I and IIa/IIb) Process Table

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/ External
Chain of Custody Forms	The Tetra Tech FOL or designee will review and sign the chain-of-custody form to verify that the samples listed are included in the shipment to the laboratory and the sample information is accurate. The forms will be signed by the sampler and a copy will be retained for the project file, the Tetra Tech PM, and the Tetra Tech Data Validators. The Tetra Tech FOL or designee will review the chain-of-custody form to verify that the samples listed in the Work Plan have been collected. The deviations should be documented in the report.	Sampler and FOL, Tetra Tech	Internal
Chain of Custody Forms	1 - The Laboratory Sample Custodian will review the sample shipment for completeness and integrity, and sign accepting the shipment. 2- The Tetra Tech Data Validators will check that the chain-of-custody form was signed and dated by the Tetra Tech FOL or designee relinquishing the samples and also by the Laboratory Sample Custodian receiving the samples for analyses.	1 - Laboratory Sample Custodian, Empirical 2 - Data Validators, Tetra Tech	External
Chain of Custody Forms and Work Plan	Make sure that the custody and integrity of the samples was maintained from collection to analysis and the custody records are complete and any deviations are recorded. Review that the samples were shipped and stored at the required temperature and preservation conditions for chemically-preserved samples meet the requirements listed in the Work Plan. Make sure that the analyses were performed within the holding times listed in the Work Plan.	Data Validators, Tetra Tech	External

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/ External
Sample Log Sheets, Chain of Custody Forms, Work Plan, and Laboratory sample login documentation	Verify that information recorded in the log sheets is accurate and complete. Verify that samples were correctly identified, that sampling location coordinates are accurate, and that documentation establishes an unbroken trail of documented chain-of-custody from sample collection to report generation. Verify that the correct sampling and analytical methods/SOPs were applied. Verify that the sampling plan was implemented and carried out as written and that any deviations are documented. Document any discrepancies in the final report.	PM, FOL, or designee, Tetra Tech	Internal
Work Plan, Analytical SOPs, and Analytical Data Packages	Make sure that the laboratory SOPs were followed. Verify that the correct analytical methods/SOPs were applied. Establish that the method QC samples were analyzed and in control as listed in the analytical SOPs. If method QA is not in control, the Laboratory QAM will contact the Tetra Tech PM verbally or via e-mail for guidance prior to report preparation.	Laboratory QAM, Empirical	Internal
Work Plan/Chain-of-Custody Forms	Check that the field QC samples determined necessary were collected as required.	FOL or designee, Tetra Tech	Internal
Analytical Data Package	Verify the analytical data packages for completeness. The Laboratory QAM will sign the case narrative for each data package.	Laboratory QAM, Empirical	Internal
Electronic Data Deliverables (EDDs)/Analytical Data Packages	Check each EDD against the chain-of-custody and hard copy data package for accuracy and completeness. Compare laboratory analytical results to the electronic analytical results to verify accuracy. Evaluate sample results for laboratory contamination and qualify false detections using the laboratory method/preparation blank summaries. Qualify analyte concentrations between the DL and the LOQ as estimated. Remove extraneous laboratory qualifiers from the validation qualifier.	Data Validators, Tetra Tech	External

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/ External
Analytical Data Package	Verify each data package for completeness. Request missing information from the Laboratory PM.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Make sure that the laboratory QC samples were analyzed and that the MPCs listed were met for the field samples and QC analyses. Check that specified field QC samples were collected and analyzed and that the analytical QC criteria set up for this project were met.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Check the field sampling precision by calculating RPDs for field duplicate samples. Check laboratory precision by reviewing the RPD or percent difference values from laboratory duplicate analyses; MS/MSDs; and LCS/laboratory control sample duplicate (LCSD), if available. Make sure compliance with the methods and project MPCs accuracy goals listed in the Work Plan.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Check that the laboratory recorded the temperature at sample receipt and the pH of samples preserved with acid or base to make sure sample integrity from sample collection to analysis.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Review the chain-of-custody forms generated in the field to make sure that the required analytical samples have been collected, appropriate sample identifications have been used, and correct analytical methods have been applied. The Tetra Tech Data Validator will verify that elements of the data package required for validation are present, and if not, the laboratory will be contacted and the missing information will be requested. Check that the data have been transferred correctly and completely to the Tetra Tech SQL database.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/ EDDs	Make sure that the project LOQs listed in Work Plan were achieved.	Data Validators, Tetra Tech	External

Data Review Input	Description	Responsible for Verification (name, organization)	Internal/ External
Work Plan/Laboratory Data Packages/ EDDs	Discuss the impact on DLs that are elevated because of matrix interferences. Be especially cognizant of and evaluate the impact of sample dilutions on low-concentration analytes when the dilution was performed because of the high concentration of one or more other contaminants. Document this usability issue and inform the Tetra Tech PM. Review and add PSLs to the laboratory EDDs. Flag samples and notify the Tetra Tech PM of samples that exceed PSLs listed in Work Plan.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Make sure that the QC samples specified in the Work Plan were collected and analyzed and that the associated results were within prescribed Work Plan acceptance limits. Make sure that QC samples and standards prescribed in analytical SOPs were analyzed and within the prescribed control limits. If any significant QC deviations occur, the Laboratory QAM shall have contacted the Tetra Tech PM.	Data Validators, Tetra Tech	External
Work Plan/Laboratory Data Packages/EDDs	Summarize deviations from methods, procedures, or contracts in the Data Validation Report. Determine the impact of any deviation from sampling or analytical methods and SOPs requirements and matrix interferences effect on the analytical results. Qualify data results based on method or QC deviation and explain the data qualifications. Print a copy of qualified data stored in the project database to depict data qualifiers and data qualifier codes that summarize the reason for data qualifications. Determine if the data met the MPCs and determine the impact of any deviations on the technical usability of the data.	Data Validators, Tetra Tech	External

12.1 VALIDATION SUMMARY

Analytical Group	**Validation Criteria**	**Data Validator** (title and organizational affiliation)
Low Level PAHs, Pesticides and PCBs	25% full (Level IV) data validation and 75% limited data validation[1] will be performed using criteria for SW-846 Methods 8270D, 6 8081B, 8082A, in this SAP and the current DoD QSM. The logic outlined in USEPA "Contract Laboratory Program National Functional Guidelines for Organic Data Review" (USEPA, October 1999) will be used to apply qualifiers to data to the extent possible.	Data Validation Specialist, Tetra Tech
Metals	25% full (Level IV) data validation and 75% limited data validation[1] will be performed using criteria for SW-846 Methods 6010C and 7470A listed in this SAP and the current DoD QSM. The logic outlined in USEPA "Contract Laboratory Program National Functional Guidelines for Inorganic Data Review" (USEPA, October 2004) will be used to apply qualifiers to data to the extent possible.	Data Validation Specialist, Tetra Tech

1 Limited data validation limits the data review to specific review parameters (Data Completeness/Data Verification, Holding Times, Calibrations, Blank Contamination, & Detection Limits) to determine gross deficiencies only. The limited data validation is best expressed as a review to preclude the possibility of not detecting an analyte that is present in a sample and to eliminate false detections. Raw data are not evaluated and sample result verification is not conducted. A formal report, similar to a full data validation report, is prepared but the scope is more limited than a full validation report. The data packages provided by the laboratory will be expansive enough to allow future complete formal data validation, if necessary.

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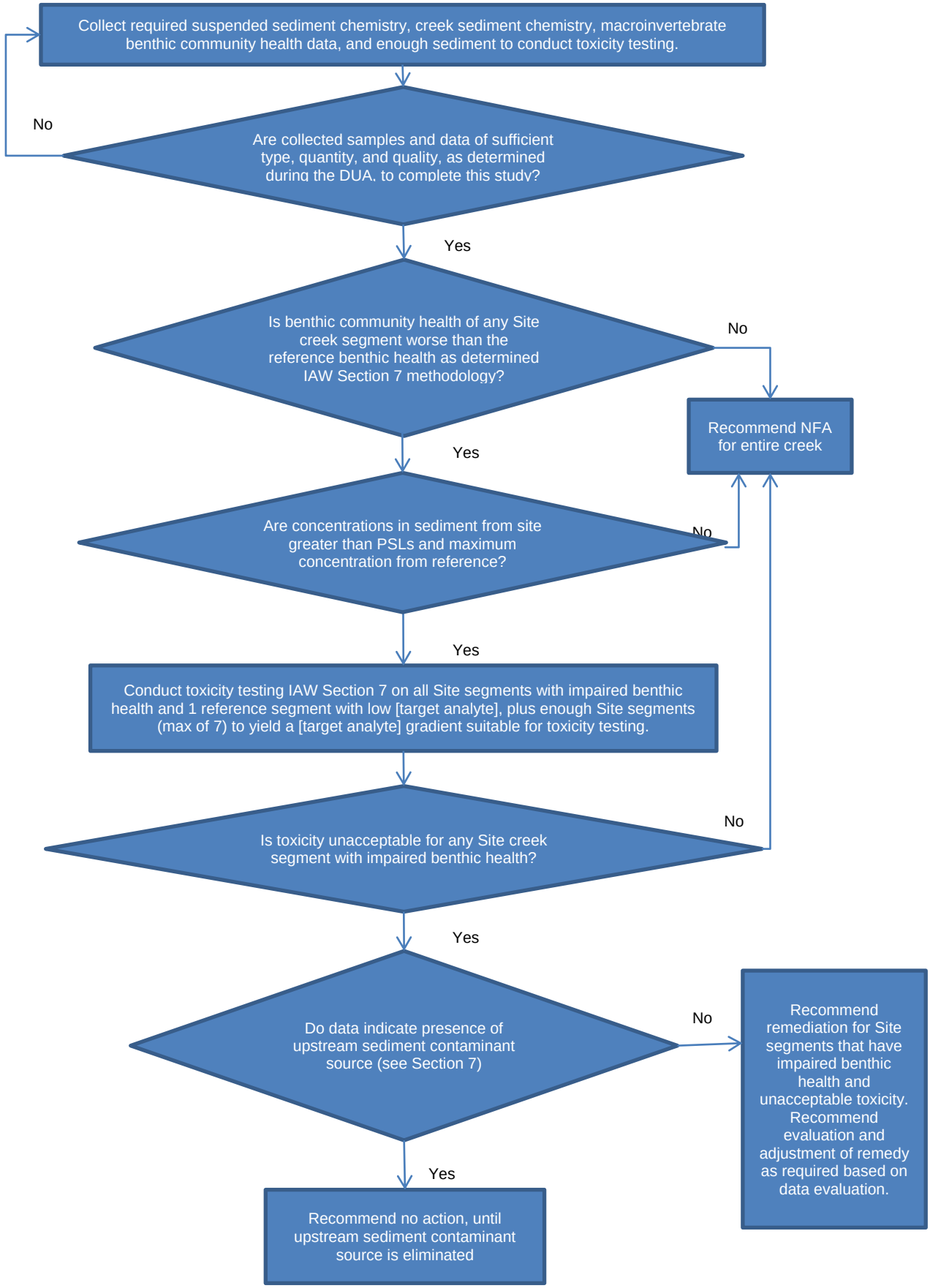
DRAWN BY	DATE
J. ENGLISH	12/19/11
CHECKED BY	DATE
L. GANSER	03/01/12
REVISED BY	DATE
SCALE	
AS NOTED	

NAVFAC

SITE VICINITY MAP
SITE 17 - PETTIBONE CREEK RAP
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

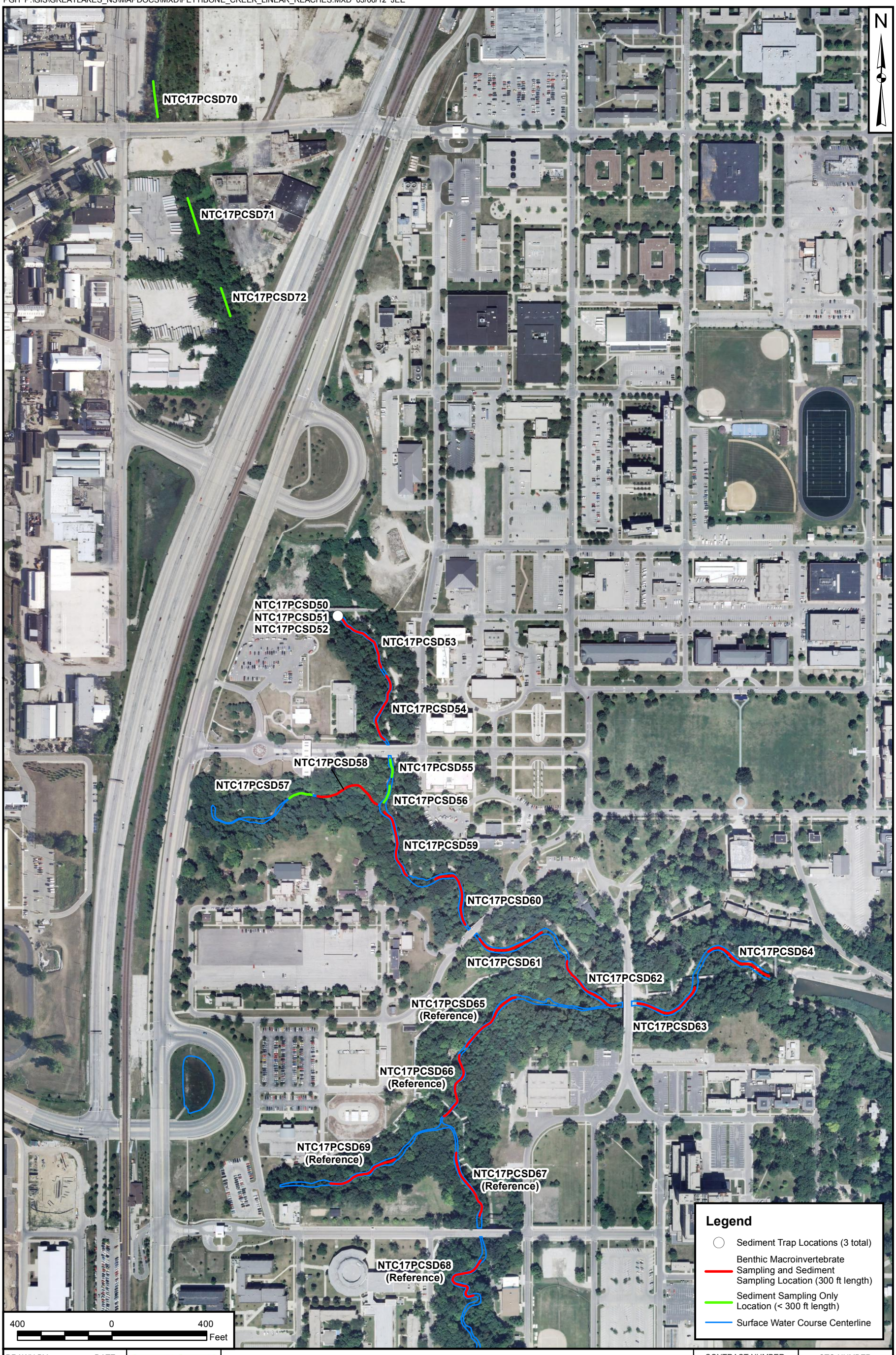
CONTRACT NUMBER	CTO NUMBER
1021	474
APPROVED BY	DATE
APPROVED BY	DATE
FIGURE NO. FIGURE 4-1	REV 0



DUA = Data usability assessment
IAW = in accordance with
NFA = No Further Action
PSL = Project Screening Level

Figure 5-1 Flow Chart of DQO Decision Rules

PGH P:\GIS\GREATLAKES_NS\MAPDOCS\MXD\PETTIBONE_CREEK_LINEAR_REACHES.MXD 03/06/12 JEE



DRAWN BY	DATE
J. ENGLISH	02/01/12
CHECKED BY	DATE
L. GANSER	03/05/12
REVISED BY	DATE
J. ENGLISH	03/06/12
SCALE	
AS NOTED	

NAVFAC

PROPOSED SAMPLING LOCATIONS
PETTIBONE CREEK
NAVAL STATION GREAT LAKES
GREAT LAKES, ILLINOIS

CONTRACT NUMBER	CTO NUMBER
1021	474
APPROVED BY	DATE
—	—
APPROVED BY	DATE
—	—
FIGURE NO.	REV
FIGURE 7-1	0

APPENDIX A

FIELD SAMPLING STANDARD OPERATING PROCEDURES AND DATA SHEETS

FIELD SAMPLING STANDARD OPERATING PROCEDURES

- **ILLINOIS EPA DCN 168: METHOD TO COLLECT AQUATIC MACROINVERTEBRATES FROM WADEABLE STREAMS FOR BIOTIC INTEGRITY ASSESSMENTS**
- **TETRA TECH CT-04: SAMPLE NOMENCLATURE**
- **TETRA TECH SA-1.1: GROUNDWATER SAMPLE ACQUISTION AND ONSITE WATER QUALITY TESTING**
- **TETRA TECH SA-1.2: SURFACE WATER AND SEDIMENT SAMPLING**
- **TETRA TECH SA-6.1: NON-RADIOLOGICAL SAMPLE HANDLING**
- **TETRA TECH SA-6.3: FIELD DOCUMENTATION**
- **TETRA TECH SA-7.1: DECONTAMINATION OF FIELD EQUIPMENT**

Illinois Environmental Protection Agency

Bureau of Water

Document Control Number 168

Standard Operating Procedure for Method to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments

Surface Water Section
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
Contact: Bureau of Water, Quality Assurance Officer 217-782-3362

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1.0 Scope and Application

The instructions outlined in this Standard Operating Procedure (SOP) describe how to collect and preserve aquatic macroinvertebrate samples from perennial streams and rivers using a quantitative multiple-habitat, 20-jab method (see below). Use these samples to calculate an index of biotic integrity (IBI) and assess the physical, chemical and biological condition of the resource. Collect samples between June 1st and October 15th. These protocols apply to perennial streams and wadeable rivers that typically range in size from 2nd through 6th order. In some situations, these protocols may apply to intermittent streams that meet specific base flow criterion (see below in Section 6.1). Use the macroinvertebrate Index of Biotic Integrity (mIBI) to evaluate 20-jab samples.

Aquatic macroinvertebrates are invertebrates that are visible to the unaided eye, retained in a U.S. Standard No. 30 sieve (595-micron mesh size) and live at least a portion of their lives in the water. Refer to Appendix A for the list of IBI-applicable aquatic macroinvertebrates.

The framework outlined in this SOP is a modification of the "*Multihabitat Approach: D-frame dip-net*" collection methodology that was outlined in EPA, (1999). The modifications consist of additional dip allocation criteria, which improve dip allocation consistency when collecting macroinvertebrates. Hereafter, refer to this modified macroinvertebrate collection method as, the "20-jab" approach.

2.0 Summary of Method(s).

- Collect aquatic macroinvertebrate samples from perennial, 2rd through 6th order wadeable streams.
- Collect aquatic macroinvertebrate samples between June 1st and October 15th.
- Collect the sample with 20- dip-net jabs.
- Use a 600-micron mesh, 18x9-inch rectangular-frame, dip-net.
- Clean equipment between each sample.
- Sample an 18x18-inch area of habitat with each dip-net jab.
- Allocate 20 jabs in the sample reach.
- Use the mean water width of the sample reach to determine how to allocate the 20 jabs among the edge-zone and bottom-zone (*e.g., $\bar{x}$ stream width = bank-zone jabs: <10ft=10, 10-29ft=8, 30-59ft=6 and ≥60ft=4*). See Table 1, in Appendix B.
- Establish the relative amounts of each of the pertinent habitat types within the bottom- zone and bank-zone.
- Bottom zone habitats are: *coarse particle substrate, fine particle substrate, vegetation and plant detritus.* See Table 1, in Appendix B.
- Edge zone habitats are: *submerged terrestrial vegetation, submerged tree roots and brush-debris-jams.* See Table 1, in Appendix B.
- Distribute the bank-zone and bottom-zone jab allotments proportionally among the pertinent habitat types within each of the two respective zones (see Equation 1 and Section 6.2.4).
- Summarize the number of jabs allocated to each habitat in the sample reach.
- Perform 20 jabs.
- Use the jab allocation summary and perform the allocated number of jabs in each of the pertinent habitat

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types.

- Take jabs in the more productive areas of each habitat type. More productive areas typically occur where current velocity is relatively high and the substrate is relatively stable.
- Distribute multiple jabs within more productive areas, of a particular habitat type, equally along the entire length of the sample reach when possible.
- Composite the collected materials into a 600-micron sieve bucket or a suitably sized watertight plastic tub after each jab is completed.
- Sieve the collected materials to remove excess water (as needed). As needed, discard excess debris after removing all clinging macroinvertebrates- retain these macroinvertebrates in the sample.
- Preserve the sample with 95% ethanol and return it to the lab for subsequent sub-sampling and identification.

3.0 Interferences and Corrective Action.

- Macroinvertebrate communities vary seasonally. Collect aquatic macroinvertebrate samples between June 1st and October 15th.
- Specimens left on the equipment between samples can give false results. Remove all specimens from the equipment before subsequent samples are collected.
- Improper sample preservation makes specimen identification more difficult. Take care to use large enough containers and adequate amounts of 95% ethanol during the initial preservation of the sample. Safeguard preserved samples that contain a relatively large amount of organic matter by decanting the original, spent, preservative and refilling the container using fresh 95% ethanol - perform this maintenance within 1-week of sample collection. Repeat as needed to maintain the sample preservative.

4.0 Safety.

Follow the general field-safety guidelines in the Illinois EPA, Bureau of Water's Surface Water Section, Field Safety Manual (Document Control Number 151) (Illinois EPA, 1994).

5.0 Equipment and Supplies.

- Nitex bottom kick net with an 18x9-inch rectangular opening and a 600-micron mesh size.
- Sieve bucket with a 600-micron stainless steel mesh bottom.
- Plastic rinse pan
- Forceps
- Sample bottles
- 95% ethanol

6.0 General Guidelines

Collect Macroinvertebrate Samples with the 20-jab Method.

6.1 Select a sampling reach that:

- has instream and riparian habitat conditions typical of the entire assessment reach,
- has flow conditions that approximate typical summer base flow,
- has perennial flow, or if intermittent, has continuous width and depth that extends throughout the sampling reach, which should be at least 300 feet. The length of the sample reach should not exceed

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800 feet.
- has no highly influential tributary streams,
- has at least one riffle/pool sequence or analog (i.e., run/bend meander or alternate point-bar sequence), if present.,

6.1.1 The 20-jab approach is applicable if:
- Conditions allow the sampler to collect macroinvertebrates (i.e., to take jabs with a dip-net) in <u>all</u> pertinent bottom-zone and bank-zone habitat types that occur in the sampling reach.

AND
- Conditions allow the sampler to apply the 11-transect habitat-characterization, as described in Section E of this manual or to estimate the amount of each of several bottom-zone and bank-zone habitat types using the non-transect method (Appendix B).
- In general, the 20-jab approach applies if more than 50% of the stream is accessible and adequately characterized.

- Between each sample, pick equipment clean of macroinvertebrates and debris. Rinse all sampling equipment in ambient water before collecting the sample.

6.2 Jab allotment (sample reach)

6.2.1 Determine jab allotment for the bottom-zone and bank-zone.

- Follow the instructions provided in *Appendix B* to identify bottom-zone and bank-zone jab allotments. Specifically, use Table 1 (Appendix B) and mean water width of the sample reach to determine the number of jabs allocated to the bottom-zone and bank-zone. Essentially, allocate fewer jabs along the edge as stream size increases. Depending on stream size, jab allotment will range from 4-10 jabs in the bank-zone and from 10-16 jabs in the bottom-zone.

6.2.2 Identify the type and amount of bank-zone and bottom-zone habitat.

- Identify the relative amount of pertinent habitat type in each of the respective bank-zone and bottom-zone. Follow the instructions provided in *Appendix B* to identify the presence and relative proportion of pertinent habitat in the sample reach. Specifically, use the appropriate habitat characterization method, 11-transect versus non-transect method, in Appendix B., to determine the relative proportion of pertinent habitat in each collection-zone. Pertinent bottom-zone habitat types are *fine substrate*, *coarse substrate, detritus and vegetation (Table 1, in Appendix B)*. Pertinent bank-zone habitat types are *submerged terrestrial vegetation, submerged tree roots and brush-debris jams (Table 1, in Appendix B)*.

6.2.3 Summarize and record the relative amount of each of the pertinent habitat types in the collection-zones.

6.2.4 Determine jab allotments for each of the various habitat types within the bottom-zone and bank-zone.

- Take the jab allocation assigned to a particular collection-zone (Section 6.2.3) and in turn, redistribute this allotment of jabs proportionally among the various habitat types within the respective zone (Section 6.2.4). Essentially, allocate more jabs to the more frequently encountered habitat types.
- Based on the definition of each bottom-zone habitat type (Table 1 in Appendix B) and Equation 1 (see

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below), translate the relative percentage of the given habitat type (Section 6.2.3) to the number of jabs allocated to *fine substrate, coarse substrate, detritus and vegetation*. Similarly, translate the relative percentage of the given bank-zone habitat type to the number of jabs allocated to *submerged terrestrial vegetation, submerged tree roots* and *brush-debris jams*.

- If rounding results in more than 20 jabs for the total allocation across all habitat types, *decrease* the number of jabs allocated to the most-abundant habitat type to limit the total to 20.

- If rounding results in less than 20 jabs for the total allocation across all habitat types, *increase* the number of jabs allocated to the most-abundant habitat type to expand the total to 20.

Number of jabs to perform in a particular habitat type within a particular bank-zone or bottom-zone =

Percentage or length of pertinent habitat type (Table 1 in Appendix B)	÷	Sum of percentages or lengths of all pertinent habitat types	x	Number of collection zone jabs allocated (Table 1 in Appendix B)

6.2.5 Summarize jab allocation

- Within each of the two collection-zones (bank-zone and bottom-zone), summarize the jabs allocated among each pertinent habitat type. For each zone, if the relative percentage of a habitat type is less than 5%, do not allocate jabs to that type. When transforming relative amounts of habitat types into numbers of jabs, round to the nearest whole number (Equation 1).
- In certain circumstances, rounding to the 20 jab target is allowable (see section 6.2.4).
- Occasionally a stream reach will lack bank-zone habitat. In this instance, allocate all 20 jabs to the bottom-zone habitats.

6.2.6 Record the number of jabs allocated to each bottom-zone and bank-zone habitat type.

6.3 Perform 20 jabs.

6.3.1 General guidelines for jabs:

- Collect macroinvertebrates with 20, dip-net jabs, according to the computed jab allotment summary

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obtained in Section 6.2.6.

- Use an 18x9-inch rectangular dip-net with a Standard #30 (600-micron) mesh size.

- One person performs all jabs taken within both collection zones (bank-zone or bottom-zone).

- For each of the given habitat types, take jabs in the more productive, areas. More productive areas generally occur where current velocity is relatively high. To minimize the potential for sampling bias attributable to uneven spatial distribution of macroinvertebrates throughout an entire sampling reach, distribute multiple jabs in more productive, areas of a particular habitat type as evenly as possible throughout the sampling reach-- providing the particular habitat type and multiple productive areas within the particular habitat type occur throughout the sample reach. In each of the two collection-zones, bank versus bottom, if there is not enough sampling area to allow performing all of the jabs allocated to a particular habitat type in the given zone, then, perform the remaining jabs among the remaining habitat types in the given zone. Allocate these remaining jabs in proportions as close as possible to the original allotments. If the bank-zone lacks bank-zone habitat, re-allocate all 20 jabs proportionally among bottom-zone habitats.

- Between jabs (as needed), composite the dip-net contents into a 600-micron sieve bucket or large plastic tub. These containers facilitate debris removal and provide convenient storage when compositing the materials collected with the 20 jabs prior to sample preservation.

- Debris removal (e.g., coarse-particle substrates) greatly facilitates laboratory sub-sampling and sorting of the preserved sample. To remove large objects from the sample, place the material in a dip net, sieve bucked or watertight tub and vigorously agitate, rinse, brush, or pick the objects (as needed) to remove attached organisms. Discard the debris after all macroinvertebrates are removed. Retain all detached macroinvertebrates and return them to the sieve bucket. To remove ultra-fine particles (e.g., sitl), rinse the sample in a sieve bucked until the unwanted particles are washed away. Be careful to not splash out any organisms. Remove sand by transferring the collected materials from the dip-net into a shallow plastic pan. Add a small amount of water to the pan (e.g., ~1-inch deep) and swirl the contents being careful to not splash out any organisms. Pour the water and dislodged organisms into the sieve bucket while retaining as much of the sand as possible in the rinse pan.
- After rinsing, drain, bottle and preserve the sample.

6.3.2 Specific instructions:

- To perform a jab, place the net immediately downstream from the targeted bottom-zone or bank-zone habitat type and dislodge macroinvertebrates by disturbing an 18x18-inch area of substrate.
At higher water velocities, these activities will flush dislodged substrate and macroinvertebrates directly into the stationary dip-net. At lower velocities, the same activity becomes ineffective and an additional step is required. Immediately after the upper layer of an 18x18-inch patch of substrate is collected, direct several net sweeps through the plume of materials that forms and is momentarily-suspended directly above the just-sampled patch of streambed. If possible, sweep in an upstream direction.

- When large, coarse-particle substrates (e.g., cobble and boulders) are sampled, wash, brush, or pick surface-clinging organisms from each object. Retain all of the dislodged organisms and discard the cleaned object. As needed, use a dip-net, sieve bucket or watertight tub to composite the materials

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collected with each jab(s). Use the sieve bucket or dip-net to remove excess water or fine particle materials from the sample.

- When fine-particle streambed substrates (e.g., silt/mud, sand) are sampled, disturb and collect bottom materials from the upper 1-inch of streambed in an 18x18-inch patch by repeatedly bumping the leading edge of the dip-net along the streambed surface until the entire sample area is disturbed. Immediately after the upper layer of material from the 18x18-inch patch is collected, complete the jab by repeatedly sweeping the net upstream through the plume of materials that becomes dislodged and momentarily-suspended over the disturbed area of streambed. Before preserving the sample, remove excess fines and sediment (see above).

- Large, pieces of wood are sampled if they occupy an 18x18-inch sample area AND if their dimensions allow fitting these objects into the dip-net AND they have microbial conditioning. When sampling large woody-debris, wash, brush, or pick surface-clinging macroinvertebrates from the collected materials and retain these organisms in the dip net. After all macroinvertebrates are retained, discard the woody debris.

7.0 Sample Preservation.

After completing 20-jabs, sieve and transfer the collected materials to an appropriate leak-proof jar(s). Label the container and preserve the sample with 95% ethanol by immersing the sample material. If a sample contains large amounts of organic debris, check for sufficient preservation within five days (or sooner) of initial “fixing”. As needed, decant the spent preservative and add more 95% ethanol to ensure continued sample preservation. Thereafter, periodically check and re-preserve the sample as needed.

DRAFT

8.0 Literature Cited

EPA. 1999. Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers Periphyton, Benthic Macroinvertebrates, and Fish Second Edition. EPA 841-B-99-002. United States Environmental Protection Agency. Office of Water 4503F Washington, DC. 20460.

Illinois EPA, 1994. Quality Assurance Project Plan Integrated Water Monitoring Program Document. Illinois Environmental Protection Agency, 1021 North Grand Avenue East, P.O. Box 19276, Springfield, Illinois. Document Control No.1.

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Appendix A. Illinois Environmental Protection Agency Macroinvertebrate Tolerance List and Functional Feeding Group Classification

January, 2011

Phylogenetic Order

Major Group	Bios ID	Taxon	Tolerance	Functional Feeding Group
Phylum Platyhelminthes	1	Platyhelminthes	99.9	
Class Turbellaria	2	Turbellaria	6	PR
Order Tricladida	3	Tricladida	6	CG
Family Planariidae	4	Planariidae	6	
	5	Dugesia sp.	6	
	6	Dugesia tigrina	6	PR
	7	Planaria sp.	6	
Phylum Nematomorpha	15	Nematomorpha	99.9	PA
Class Gordioida	18	Gordius sp.	99.9	
Phylum Annelida	30	Annelida	99.9	CG
Class Oligochaeta	31	Oligochaeta	10	CG
Order Branchiobdellida	32	Branchiobdellida	10	PA
Family Branchiobdellidae	33	Branchiobdellidae	10	CG
Order Lumbriculida	34	Lumbriculida	10	
Family Lumbriculidae	35	Lumbriculidae	10	CG
Order Haplotaxida	36	Haplotaxida	10	
Family Aeolosomatidae	37	Aeolosomatidae	10	CF
Family Enchytraeidae	38	Enchytraeidae	10	CG
Family Lumbricidae	39	Lumbricidae	10	CG
Order Tubificida	212	Tubificida	10	
Family Naididae	40	Naididae	10	CG
	41	Allonais sp.	10	CG
	42	Allonais pectinata	10	
	43	Amphichaeta sp.	10	CG
	44	Amphichaeta leydigi	10	
	45	Arcteonais sp.	10	
	46	Arcteonais lomondi	10	CG
	47	Bratislavia sp.	10	CG
	48	Bratislavia unidentata	10	CG
	49	Chaetogaster sp.	10	SH
	50	Chaetogaster diaphanus	10	PR
	51	Chaetogaster diastrophus	10	PR
	52	Chaetogaster limnaei	10	PR
	53	Dero sp.	10	CG
	54	Dero digitata	10	CG
	55	Dero furcata	10	CG
	56	Dero lodeni	10	CG
	57	Dero nivea	10	CG
	109	Dero pectinata	10	CG
	58	Nais sp.	10	CG

Functional Feeding Group (ffg)
SC=scraper, PA=parasite, PR=predator, OM=omnivore, GC=gatherer/collector, FC=filter/collector, SH=shredder, PI=piercer
99.9=Taxon excluded from mIBI computation

	59	Nais barbata	10	CG
	60	Nais behningi	10	CG
	61	Nais bretscheri	10	CG
	62	Nais communis	10	CG
	63	Nais elinguis	10	CG
	64	Nais pardalis	10	CG
	65	Nais simplex	10	CG
	66	Nais variabilis	10	CG
	110	Paranais sp.	10	
	67	Paranais frici	10	
	68	Ophidonais sp.	10	
	69	Ophidonais serpentina	10	CG
	70	Pristina sp.	10	CG
	71	Pristina aequiseta	10	CG
	72	Pristina leidyi	10	CG
	73	Pristina breviseta	10	CG
	74	Pristina longiseta	10	
	75	Pristina osborni	10	CG
	76	Pristina synclites	10	CG
	77	Slavina sp.	10	CG
	78	Slavina appendiculata	10	CG
	79	Specaria sp.	10	CG
	80	Specaria josinae	10	CG
	81	Stephensoniana sp.	10	
	82	Stephensoniana trivandrana	10	CG
	83	Stylaria sp.	10	
	84	Stylaria fossularis	10	CG
	85	Stylaria lacustris	10	CG
	86	Uncinais sp.	10	
	87	Uncinais uncinata	10	
	88	Vejdovskyella sp.	10	CG
	89	Vejdovskyella intermedia	10	CG
	90	Wapsa sp.	10	
	91	Wapsa mobilis	10	
Family Tubificidae	92	Tubificidae	10	CG
	93	Aulodrilus pigueti	10	CG
	94	Branchiura sp.	10	CG
	95	Branchiura sowerbyi	10	CG
	96	Ilyodrilus sp.	10	
	97	Ilyodrilus templetoni	10	CG
	98	Limnodrilus sp.	10	CG
	99	Limnodrilus cervix	10	CG
	100	Limnodrilus claparedianus	10	CG

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99.9=Taxon excluded from mIBI computation

	101	Limnodrilus hoffmeisteri	10	CG
	102	Limnodrilus udekemianus	10	CG
	103	Tubifex sp.	10	CG
	104	Tubifex tubifex	10	CG
	105	Potamothrix vejdovskyi	10	
	108	Quistradrilus multisetosus	10	CG
Class Hirudinea	249	Hirudinea	8	PR
Order Rhynchobdellida	151	Rhynchobdellida	8	
Family Glossiphoniidae	152	Glossiphoniidae	8	PR
	153	Actinobdella sp.	8	
	154	Actinobdella inequiannulata	8	
	155	Alboglossiphonia sp.	8	
	156	Alboglossiphonia heteroclita	8	PR
	157	Batracobdella sp.	8	PR
	158	Batracobdella phalera	8	
	159	Batracobdella picta	8	
Order Pharyngobdellidae	209	Pharyngobdellidae	8	
Family Erpobdellidae	208	Desserobdella phalera	8	
	210	Gloiobdella elongata	8	
Family Glossiphoniidae	160	Glossiphonia sp.	8	PR
	161	Glossiphonia complanata	8	PR
	162	Helobdella sp.	8	PA
	163	Helobdella elongata	8	PR
	164	Helobdella fusca	8	PA
	165	Helobdella papillata	8	PR
	166	Helobdella stagnalis	8	PR
	167	Helobdella triserialis	8	PA
	168	Placobdella montifera	8	PR
	169	Placobdella sp.	8	PR
	170	Placobdella multilineata	8	PR
	171	Placobdella ornata	8	PR
	172	Placobdella papillifera	8	PA
	173	Placobdella parasitica	8	PA
	174	Placobdella pediculata	8	
	175	Theromyzon sp.	8	PR
	176	Theromyzon biannulatum	8	
Family Piscicolidae	177	Piscicolidae	7	
	178	Cystobranchus verrilli	7	
	179	Cystobranchus sp.	7	
	180	Myzobdella sp.	7	
	181	Myzobdella lugubris	7	PR
	182	Piscicola sp.	7	PR
	183	Piscicola milneri	7	PR

Functional Feeding Group (ffg)
SC=scraper, PA=parasite, PR=predator, OM=omnivore, GC=gatherer/collector, FC=filter/collector, SH=shredder, PI=piercer
99.9=Taxon excluded from mIBI computation

	184	Piscicola punctata	7	PR
	185	Piscicolaria sp.	7	
	186	Piscicolaria reducta	7	
Order Gnathobdellida	211	Gnathobdellida	7	
Family Hirudinidae	188	Hirudinidae	8	PR
	189	Haemopis sp.	7	PR
	190	Haemopis marmorata	7	
	191	Haemopis terrestris	7	
	192	Macrobdella sp.	7	
	193	Macrobdella decora	7	
	194	Philobdella sp.	7	
	195	Philobdella gracilis	7	PR
Family Erpobdellidae	197	Erpobdellidae	8	PR
	198	Dina sp.	8	PR
	199	Dina dubia	8	
	200	Dina parva	8	
	201	Erpobdella sp.	8	
	202	Erpobdella punctata	8	PR
	203	Mooreobdella sp.	8	PR
	204	Mooreobdella fervida	8	
	205	Mooreobdella microstoma	8	PR
	206	Nephelopsis sp.	8	
	207	Nephelopsis obscura	8	PR
Phylum Arthropoda	250	Arthropoda	99.9	
Class Crustacea	251	Crustacea	99.9	CG
Order Isopoda	252	Isopoda	99.9	CG
Family Asellidae	253	Asellidae	6	CG
	254	Caecidotea sp.	6	CG
	256	Caecidotea brevicaudus	6	
	347	Caecidotea communis	6	CG
	257	Caecidotea forbesi	6	
	258	Caecidotea intermedia	6	
	259	Caecidotea kendeighi	6	
	263	Caecidotea tridentata	6	
	268	Caecidotea packardi	6	
	269	Caecidotea spatulata	6	
	270	Caecidotea stygia	6	
	255	Asellus sp.	6	
	272	Lirceus sp.	4	CG
	273	Lirceus fontinalis	4	CG
	274	Lirceus garmani	4	CG
	275	Lirceus lineatus	4	CG
	276	Lirceus louisianae	4	

Functional Feeding Group (ffg)
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Order Amphipoda	325	Amphipoda	4	CG
Family Talitridae	326	Hyalellidae	4	
	327	Hyalella sp.	4	CG
	328	Hyalella azteca	5	CG
Family Gammaridae	329	Gammaridae	4	CG
	341	Gammarus sp.	3	
	344	Gammarus pseudolimnaeus	3	CG
	345	Gammarus troglophilus	3	
	346	Gammarus fasciatus	3	CG
	330	Stygobromus sp.	4	PR
	331	Stygobromus subtilis	4	
	332	Bactrurus sp.	1	
Family Crongonyctidae	348	Crongonyctidae	4	
	335	Crangonyx sp.	4	CG
	336	Crangonyx forbesi	4	CG
	337	Crangonyx gracilis	4	CG
	338	Crangonyx minor	4	
	339	Crangonyx packardi	4	
	340	Crangonyx pseudogracilis	4	
Order Decapoda	400	Decapoda	99.9	SH
Family Cambaridae	401	Cambaridae	5	CG
	402	Cambarellus sp.	5	SH
	403	Cambarellus puer	5	CG
	404	Cambarellus shufeldtii	5	CG
	405	Cambarus sp.	5	CG
	406	Cambarus diogenes	5	
	407	Cambarus rusticiformis	5	
	408	Cambarus tenebrosus	5	
	409	Fallicambarus sp.	5	
	410	Fallicambarus fodiens	5	
	411	Orconectes sp.	5	
	412	Orconectes illinoiensis	5	
	413	Orconectes immunis	5	
	414	Orconectes indianensis	5	
	415	Orconectes kentuckiensis	5	
	416	Orconectes lancifer	5	
	417	Orconectes placidus	5	
	418	Orconectes propinquus	5	
	419	Orconectes rusticus	5	
	420	Orconectes stannardi	5	
	421	Orconectes virilis	5	
	430	Orconectes bisectus	5	
	422	Procambarus sp.	5	SH

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	423	Procambarus acutus	5	SH
	424	Procambarus clarki	5	
	425	Procambarus gracilis	5	
	426	Procambarus viaeviridis	5	
Family Palaemonidae	427	Palaemonidae	4	
	428	Palaemonetes sp.	4	
	429	Palaemonetes kadiakensis	4	
Class Insecta	475	Insecta	99.9	
Order Ephemeroptera	476	Ephemeroptera	3	CG
Family Acanthametropodidae	2605	Acanthametropodidae		
	478	Acanthametropus sp.	3	PR
	479	Acanthametropus pecatonica	3	
Family Ameletidae	2604	Ameletidae		
	480	Ameletus sp.	0	CG
	481	Ameletus lineatus	0	
Family Siphlonuridae	477	Siphlonuridae	3	CG
	482	Siphlonurus sp.	2	CG
	483	Siphlonurus alternatus	2	
	484	Siphlonurus quebecensis	2	
	485	Siphlonurus rapidus	2	
Family Oligoneuriidae	486	Oligoneuriidae	3	CF
Family Isonychiidae	487	Isonychia sp.	3	CF
	488	Isonychia arida	3	
	489	Isonychia bicolor	3	CG
	490	Isonychia rufa	3	
	491	Isonychia sayi	3	
	492	Isonychia sicca	3	
Family Metretopodidae	493	Metretopodidae	3	
	494	Siphloplecton sp.	2	CG
	495	Siphloplecton basale	2	
	496	Siphloplecton interlineatum	2	
Family Baetidae	497	Baetidae	4	CG
	652	Acentrella sp.	4	
	2203	Acerpenna sp.	4	SH
	506	Acerpenna macdunnoughi	4	CG
	498	Baetis sp.	4	CG
	645	Baetis amplus	4	CG
	653	Baetis armillatus	4	
	499	Baetis brunneicolor	4	CG
	500	Baetis ephippiatus	4	
	501	Baetis flavistriga	4	CG
	502	Baetis frondalis	4	
	503	Baetis hageni	4	CG

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	504	Baetis intercalaris	7	
	646	Baetis levitans	4	
	505	Baetis longipalpus	6	
	507	Baetis propinquus gr.	4	
	508	Acerpenna pygmaeus	4	
	509	Baetis quilleri	4	
	510	Baetis tricaudatus	1	CG
	650	Barbaetis cestus	4	
	647	Baetis vagans	4	
	511	Callibaetis sp.	4	CG
	512	Callibaetis ferrugineus	4	
	513	Callibaetis fluctuans	4	
	514	Callibaetis skokianus	4	
	515	Centroptilum sp.	2	CG
	661	Diphetor hageni	4	
	643	Procloeon sp.	4	
	516	Cloeon sp.	3	
	517	Cloeon alamance	3	
	518	Cloeon rubropictum	3	
	519	Heterocloeon sp.	4	SC
	520	Heterocloeon curiosum	4	SC
	651	Plauditus sp.	3	
	660	Plauditus armillatus	4	
	657	Plauditus punctiventris	3	
	521	Pseudocloeon sp.	4	SC
	522	Pseudocloeon carolina	4	
	523	Pseudocloeon dubium	4	SC
	524	Pseudocloeon myrsum	4	
	525	Pseudocloeon parvulum	4	
	656	Pseudocloeon propinquus gr.	4	
	526	Pseudocloeon punctiventris	4	
	527	Paracloeodes sp.	4	SC
	2233	Paracloeodes minutus	5	
Family Arthropleidae	2603	Arthropleidae		
	531	Arthroplea sp.	3	CF
	532	Arthroplea bipunctata	3	
Family Heptageniidae	528	Heptageniidae	3.5	SC
	529	Anepeorus sp.	3.5	PR
	530	Anepeorus simplex	3.5	
	533	Epeorus sp.	1	SC
	534	Epeorus vitreus	0	
	535	Heptagenia diabasia	4	
	644	Nixe sp.	4	SC

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	655	Nixe perfida	4	
	536	Heptagenia sp.	3	SC
	537	Heptagenia flavescens	2	
	538	Heptagenia hebe	3	
	539	Heptagenia lucidipennis	3	
	540	Heptagenia maculipennis	3	SC
	541	Heptagenia marginalis	1	SC
	542	Heptagenia perfida	1	
	543	Heptagenia pulla	0	SC
	544	Rhithrogena sp.	0	SC
	545	Rhithrogena pellucida	0	SC
	550	Stenacron sp.	4	SC
	548	Stenacron interpunctatum	4	
	648	Leucrocuta sp.	3	SC
	654	Leucrocuta hebe	3	
	649	Leucrocuta maculipennis	3	
	551	Maccaffertium sp.	4	SC
	565	Maccaffertium ares	3	
	552	Maccaffertium exiguum	5	
	553	Maccaffertium quinquespinum	5	
	556	Maccaffertium integrum	4	
	557	Maccaffertium luteum	1	SC
	559	Maccaffertium mediopunctatum	2	SC
	558	Maccaffertium nepotellum	5	
	560	Maccaffertium modestum	3	SC
	561	Maccaffertium annexum	4	
	563	Maccaffertium pulchellum	3	SC
	562	Maccaffertium rubromaculatum	2	
	564	Maccaffertium terminatum	4	SC
	566	Maccaffertium vicarium	3	SC
	659	Stenonema sp.	4	SC
	554	Stenonema femoratum	7	SC
Family Ephemerellidae	567	Ephemerellidae	3.5	CG
	568	Attenella sp.	2	CG
	569	Attenella attenuata	2	CG
	570	Dannella sp.	2	
	571	Dannella lita	2	CG
	572	Dannella simplex	2	CG
	573	Drunella sp.	1	PR
	574	Ephemerella cornuta	1	
	575	Drunella cornutella	1	SC
	576	Ephemerella lata	1	
	577	Ephemerella walkeri	1	

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	578	Ephemerella sp.	2	CG
	579	Ephemerella aurivillii	2	CG
	580	Ephemerella catawba	2	CG
	581	Ephemerella dorothea	2	CG
	582	Ephemerella excrucians	2	CG
	583	Ephemerella invaria	2	CG
	584	Ephemerella needhami	2	CG
	585	Ephemerella rotunda	2	
	586	Ephemerella subvaria	2	CG
	587	Eurylophella sp.	4	SC
	588	Eurylophella aestiva	4	
	589	Eurylophella bicolor	4	CG
	590	Ephemerella coxalis	4	
	591	Eurylophella funeralis	4	
	592	Eurylophella lutulenta	4	CG
	593	Eurylophella temporalis	4	CG
	594	Serratella sp.	1	CG
	595	Serratella deficiens	1	CG
	596	Ephemerella frisoni	1	
	597	Serratella sordida	1	CG
Family Leptohyphidae	598	Leptohyphidae	5.5	CG
	662	Leptohyphe sp.	5.5	CG
	599	Tricorythodes sp.	5	CG
Family Caenidae	600	Caenidae	5.5	CG
	601	Brachycercus sp.	3	CG
	602	Caenis sp.	6	CG
Family Baetiscidae	603	Baetiscidae	3	CG
	604	Baetisca bajkovi	3	
	605	Baetisca sp.	3	CG
	606	Baetisca lacustris	3	
	607	Baetisca laurentina	3	
	608	Baetisca obesa	3	
Family Leptophlebiidae	609	Leptophlebiidae	3	CG
	610	Choroterpes sp.	2	CG
	611	Choroterpes basalis	2	CG
	612	Habrophlebiodes sp.	2	SC
	613	Habrophlebiodes americana	2	
	614	Leptophlebia sp.	3	CG
	615	Paraleptophlebia sp.	2	CG
	616	Paraleptophlebia moerens	2	
	617	Paraleptophlebia ontario	2	
	618	Paraleptophlebia praepedita	2	
	619	Paraleptophlebia sticta	2	

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Family Potamanthidae	620	Potamanthidae	5	CF
	621	Anthopotamus sp.	4	
	623	Anthopotamus myops	4	
Family Ephemeridae	625	Ephemeridae	5	CG
	626	Ephemera sp.	3	CG
	627	Ephemera simulans	3	CG
	628	Hexagenia sp.	6	CG
	629	Hexagenia atrocaudata	6	CG
	630	Hexagenia bilineata	6	CG
	631	Hexagenia limbata	5	CG
	632	Hexagenia munda	5	
	633	Hexagenia rigida	6	CG
Family Palingeniidae	635	Pentagenia sp.	4	CF
	636	Pentagenia vittigera	4	CG
Family Polymitarcyidae	637	Polymitarcyidae	3	CG
	638	Ephoron sp.	2	CG
	639	Ephoron album	2	CG
	640	Ephoron leukon	2	CG
	641	Tortopus sp.	4	CG
Order Odonata	700	Odonata	99.9	PR
Family Cordulegastridae	702	Cordulegastridae	4.5	PR
	703	Cordulegaster sp.	2	PR
	704	Cordulegaster maculata	2	PR
	705	Cordulegaster obliqua	2	PR
Family Gomphidae	706	Gomphidae	4.5	PR
	2602	Erpetogomphus sp.	2	
	2229	Erpetogomphus designatus	2	
	713	Dromogomphus sp.	4	PR
	714	Dromogomphus spinosus	4	PR
	707	Arigomphus sp.	7	PR
	722	Gomphus sp.	7	PR
	738	Gomphus amnicola	7	
	716	Gomphus crassus	7	
	723	Gomphus exilis	7	
	717	Gomphus externus	7	PR
	724	Gomphus graslinellus	7	
	710	Gomphus lentulus	7	
	719	Gomphus lineatifrons	7	
	725	Gomphus lividus	7	PR
	739	Gomphus notatus	7	
	740	Gomphus plagiatus	7	
	726	Gomphus quadricolor	7	
	711	Gomphus submedianus	7	

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	741	Gomphus spiniceps	7	
	720	Gomphus vastus	7	PR
	712	Gomphus villosipes	7	
	879	Gomphurus sp.	7	
	737	Stylurus sp.	7	PR
	728	Hagenius sp.	3	PR
	729	Hagenius brevistylus	3	PR
	735	Lanthus sp.	6	PR
	730	Ophiogomphus sp.	2	PR
	731	Ophiogomphus rupinsulensis	2	
	732	Progomphus sp.	5	PR
	733	Progomphus obscurus	5	PR
	734	Stylogomphus sp.	4.5	PR
	736	Stylogomphus albistylus	4.5	PR
Family Aeshnidae	742	Aeshnidae	4.5	PR
	743	Aeshna sp.	4	PR
	744	Aeshna canadensis	4	
	746	Aeshna constricta	4	PR
	747	Aeshna umbrosa	4	
	748	Aeshna verticalis	4	
	749	Anax sp.	5	PR
	750	Anax junius	5	PR
	751	Basiaeschna sp.	2	PR
	752	Basiaeschna janata	2	PR
	753	Boyeria sp.	3	PR
	754	Boyeria vinosa	3	PR
	755	Epiaeschna sp.	1	PR
	756	Epiaeschna heros	1	PR
	758	Nasiaeschna sp.	2	PR
	757	Nasiaeschna pentacantha	2	PR
Family Macromiidae	759	Macromiidae	4.5	PR
	760	Didymops sp.	4	PR
	761	Didymops transversa	4	PR
	762	Macromia sp.	3	PR
	764	Macromia georgina	3	PR
	765	Macromia illinoiensis	3	PR
	766	Macromia pacifica	3	
	767	Macromia taeniolata	3	PR
Family Corduliidae	768	Corduliidae	4.5	PR
	769	Cordulia sp.	2	PR
	770	Cordulia shurtleffi	2	
	771	Epitheca sp.	4	PR
	772	Epicordulia sp.	4.5	PR

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	773	Epicordulia princeps	4.5	PR
	774	Helocordulia sp.	2	PR
	775	Neurocordulia sp.	3	PR
	776	Neurocordulia molesta	3	PR
	777	Neurocordulia obsoleta	3	PR
	778	Neurocordulia yamaskanensis	3	
	779	Somatochlora sp.	1	PR
	781	Somatochlora filosa	1	
	782	Somatochlora linearis	1	PR
	783	Somatochlora tenebrosa	1	
	784	Tetragoneuria sp.	4.5	PR
	785	Tetragoneuria cynosura	4.5	PR
Family Libellulidae	787	Libellulidae	4.5	PR
	788	Celithemis sp.	2	PR
	789	Celithemis elisa	2	
	790	Celithemis eponina	2	
	791	Celithemis monomelaena	2	
	792	Erythemis sp.	5	PR
	793	Erythemis simplicicollis	5	PR
	794	Erythrodiplax sp.	5	PR
	795	Ladona sp.	4.5	PR
	796	Ladona julia	4.5	
	797	Leucorrhinia sp.	4.5	PR
	799	Leucorrhinia intacta	4.5	
	800	Libellula sp.	8	PR
	801	Libellula cyanea	8	
	802	Libellula incesta	8	PR
	803	Libellula luctuosa	8	
	804	Libellula pulchella	8	
	805	Libellula quadrimaculata	8	
	806	Libellula semifasciata	8	PR
	807	Libellula vibrans	8	PR
	809	Pachydiplax sp.	8	PR
	810	Pachydiplax longipennis	8	PR
	811	Pantala sp.	7	PR
	812	Pantala flavescens	7	
	813	Pantala hymenaea	7	
	814	Perithemis sp.	4	PR
	815	Perithemis tenera	4	PR
	816	Plathemis sp.	3	PR
	817	Plathemis lydia	3	PR
	818	Sympetrum sp.	4	PR
	819	Sympetrum ambiguum	4	PR

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	820	Sympetrum corruptum	4	
	821	Sympetrum obstrusum	4	
	822	Sympetrum rubicundulum	4	
	823	Sympetrum semicinctum	4	
	824	Sympetrum vicinum	4	
	825	Tramea sp.	4	PR
	826	Tramea carolina	4	PR
	827	Tramea lacerata	4	
	828	Tramea onusta	4	
	829	Zygoptera	99.9	PR
Family Calopterygidae	830	Calopterygidae	3.5	PR
	831	Calopteryx sp.	4	PR
	832	Calopteryx aequabilis	4	
	833	Calopteryx maculata	4	PR
	834	Hetaerina sp.	3	PR
	835	Hetaerina americana	3	PR
	836	Hetaerina titia	3	PR
Family Lestidae	837	Lestidae	99.9	PR
	838	Archilestes sp.	1	PR
	839	Archilestes grandis	1	
	840	Lestes sp.	6	PR
	841	Lestes disjunctus	6	
	842	Lestes eurinus	6	
	843	Lestes forcipatus	6	
	844	Lestes inaequalis	6	
	845	Lestes rectangularis	6	
	846	Lestes vigilax	6	
Family Coenagrionidae	847	Coenagrionidae	5.5	PR
	848	Amphiagrion sp.	5	PR
	849	Amphiagrion saucium	5	
	850	Anomalagrion sp.	5.5	PR
	851	Anomalagrion hastatum	5.5	PR
	852	Argia sp.	5	PR
	853	Argia apicalis	5	PR
	854	Argia bipunctulata	5	
	997	Argia fumipennis	5	PR
	855	Argia moesta	5	PR
	856	Argia sedula	5	PR
	857	Argia tibialis	5	PR
	858	Argia translata	5	
	859	Argia violacea	5	PR
	860	Chromagrion sp.	5.5	PR
	861	Chromagrion conditum	5.5	

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	862	Coenagrion sp.	5.5	PR
	863	Enallagma sp.	6	PR
	864	Enallagma aspersum	6	
	865	Enallagma civile	6	
	866	Enallagma divagans	6	PR
	867	Enallagma exsulans	6	
	868	Enallagma geminatum	6	
	869	Enallagma hageni	6	
	870	Enallagma signatum	6	PR
	871	Enallagma traviatum	6	
	872	Enallagma vesperum	6	PR
	873	Ischnura sp.	6	PR
	874	Ischnura posita	6	PR
	875	Ischnura verticalis	6	
	876	Nehalennia sp.	7	PR
	877	Nehalennia gracilis	7	
	878	Nehalennia irene	7	
Order Plecoptera	925	Plecoptera	1.5	PR
Family Pteronarcyidae	927	Pteronarcys sp.	2	SH
Family Taeniopterygidae	928	Taeniopterygidae	1.5	SH
	929	Oemopteryx sp.	1.5	SH
	930	Oemopteryx glacialis	1.5	
	931	Strophopteryx sp.	1.5	
	932	Strophopteryx fasciata	1.5	SH
	933	Taeniopteryx sp.	2	SH
	934	Taeniopteryx nivalis	2	SH
	935	Taeniopteryx parvula	2	SH
Family Nemouridae	936	Nemouridae	1.5	SH
	937	Amphinemura sp.	1.5	SH
	938	Nemoura sp.	1	SH
	939	Nemoura venosa	1	
	940	Prostoia sp.	1.5	SH
	941	Soyedina sp.	1.5	SH
Family Leuctridae	942	Leuctridae	1.5	SH
	943	Leuctra sp.	1	SH
Family Capniidae	944	Capniidae	1.5	SH
	945	Allocapnia sp.	2	SH
	946	Allocapnia mystica	1.5	
	947	Allocapnia recta	1.5	
	948	Allocapnia vivipara	1.5	SH
	949	Capnia sp.	1	SH
	950	Capnia vernalis	1	
	951	Paracapnia sp.	1.5	SH

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	952	Paracapnia angulata	1.5	
	953	Paracapnia opis	1.5	
Family Perlidae	954	Perlidae	1.5	PR
	955	Acroneuria sp.	1	PR
	956	Acroneuria abnormis	1	PR
	957	Acroneuria arida	1	PR
	958	Acroneuria carolinensis	1	PR
	959	Acroneuria evoluta	1	PR
	960	Acroneuria internata	1	PR
	961	Acroneuria lycorias	1	PR
	962	Attaneuria sp.	1.5	
	963	Attaneuria ruralis	1.5	PR
	964	Neoperla sp.	1	PR
	965	Neoperla clymene	1	PR
	966	Paragnetina sp.	1.5	PR
	967	Paragnetina media	1.5	PR
	968	Perlesta sp.	4	PR
	971	Atoperla sp.	1	
	969	Perlesta placida	4	
	970	Perlinella sp.	2	PR
	972	Perlinella drymo	2	PR
	973	Perlinella ephyre	2	PR
	974	Phasganophora sp.	1.5	PR
	975	Phasganophora capitata	1.5	
Family Perlodidae	976	Perlodidae	1.5	PR
	977	Hydroperla sp.	1	PR
	978	Hydroperla crosbyi	1	
	979	Isogenoides sp.	1.5	PR
	980	Isoperla sp.	2	PR
	981	Isoperla bilineata	2	
	982	Isoperla clio	2	
	996	Isoperla confusa	2	
	983	Isoperla cotta	2	
	984	Isoperla dicala	2	
	985	Isoperla lata	2	
	986	Isoperla marlynia	2	
	987	Isoperla nana	2	
	988	Isoperla richardsoni	2	
Family Chloroperlidae	989	Chloroperlidae	1.5	PR
	990	Chloroperla sp.	3	
	991	Alloperla sp.	1.5	PR
	992	Hastaperla sp.	1.5	SC
	993	Hastaperla brevis	1.5	

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	994	Rasvena sp.	1.5	
	995	Rasvena terna	1.5	CG
Order Hemiptera	1050	Hemiptera	99.9	PR
Family Hebridae	1051	Hebridae	99.9	PR
	1052	Hebrus sp.	99.9	PR
	1053	Merragata sp.	99.9	PR
Family Mesoveliidae	1054	Mesoveliidae	99.9	PR
	1055	Mesovelia sp.	99.9	PR
	1056	Mesovelia mulsanti	99.9	PR
Family Gerridae	1057	Gerridae	99.9	PR
	1058	Gerris sp.	99.9	PR
	1059	Limnogonus sp.	99.9	PR
	1060	Limnogonus hesione	99.9	
	1061	Metrobates sp.	99.9	PR
	1062	Rheumatobates sp.	99.9	PR
	1063	Trepobates sp.	99.9	PR
Family Veliidae	1064	Veliidae	99.9	PR
	1065	Microvelia sp.	99.9	PR
	1066	Rhagovelia sp.	99.9	PR
Family Notonectidae	1067	Notonectidae	99.9	PR
	1068	Buenoa sp.	99.9	PR
	1069	Notonecta sp.	99.9	PR
Family Pleidae	1070	Pleidae	99.9	PR
	1071	Neoplea sp.	99.9	PR
	1072	Neoplea striola	99.9	
Family Naucoridae	1073	Naucoridae	99.9	PR
	1074	Pelocoris sp.	99.9	PR
	1075	Pelocoris femoratus	99.9	PR
Family Nepidae	1076	Nepidae	99.9	PR
	1077	Nepa sp.	99.9	PR
	1078	Nepa apiculata	99.9	
	1079	Ranatra fusca	99.9	PR
	1080	Ranatra sp.	99.9	PR
	1081	Ranatra kirkaldyi	99.9	PR
	1082	Ranatra nigra	99.9	PR
Family Belostomatidae	1083	Belostomatidae	99.9	PR
	1084	Belostoma sp.	99.9	PR
	1085	Belostoma flumineum	99.9	PR
	1086	Lethocerus sp.	99.9	PR
	1087	Lethocerus americans	99.9	
	1088	Lethocerus griseus	99.9	
	1089	Lethocerus uhleri	99.9	
Family Corixidae	1090	Corixidae	99.9	PR

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	1091	Hesperocorixa sp.	99.9	PR
	1092	Hesperocorixa interrupta	99.9	
	1094	Hesperocorixa laevigata	99.9	
	1096	Hesperocorixa lucida	99.9	
	1097	Hesperocorixa nitida	99.9	
	1098	Hesperocorixa obliqua	99.9	
	1100	Hesperocorixa vulgaris	99.9	
	1101	Palmacorixa sp.	99.9	PR
	1102	Palmacorixa buenoi	99.9	
	1103	Palmacorixa gilletteii	99.9	
	1104	Palmacorixa nana	99.9	
	1105	Ramphocorixa sp.	99.9	PR
	1106	Ramphocorixa acuminata	99.9	
	1107	Sigara sp.	99.9	PR
	1108	Sigara alternata	99.9	
	1109	Sigara compressoidea	99.9	
	1111	Sigara hubbelli	99.9	
	1113	Sigara modesta	99.9	
	1115	Sigara signata	99.9	
	1117	Trichocorixa sp.	99.9	PR
	1118	Trichocorixa calva	99.9	
	1119	Trichocorixa kanza	99.9	
	1120	Trichocorixa macroceps	99.9	
Order Megaloptera	1175	Megaloptera	3.5	
Family Sialidae	1176	Sialidae	3.5	PR
	1177	Sialis sp.	4	PR
	1180	Sialis infumata	4	
	1181	Sialis itasca	4	
	1183	Sialis mohri	4	PR
	1184	Sialis vagans	4	
	1185	Sialis velata	4	
Family Corydalidae	1186	Corydalidae	3	PR
	1187	Chauliodes sp.	4	PR
	1188	Chauliodes pectinicornis	4	PR
	1189	Chauliodes rastricornis	4	PR
	1190	Corydalus sp.	3	PR
	1191	Corydalus cornutus	3	PR
	1192	Nigronia sp.	2	PR
	1193	Nigronia fasciatus	2	PR
	1194	Nigronia serricornis	2	PR
Order Neuroptera	1250	Neuroptera	99.9	PR
Family Sisyridae	1251	Sisyridae	1	PR
	1252	Climacea sp.	1	

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	1253	Climacea areolaris	1	
	1254	Sisyra sp.	1	PR
	1255	Sisyra vicaria	1	
Order Trichoptera	1300	Trichoptera	3.5	
Family Hydropsychidae	1301	Hydropsychidae	5.5	CF
	1302	Cheumatopsyche sp.	6	CF
	1304	Diplectrona sp.	2	CF
	1303	Diplectrona metaqui	2	
	1305	Diplectrona modesta	2	CF
	1306	Hydropsyche sp.	5	CF
	1307	Hydropsyche aerata	5	CF
	1308	Hydropsyche arinale	5	
	1309	Hydropsyche betteni	5	CF
	1310	Hydropsyche bidens	5	
	1333	Ceratopsyche cheilonis	4	
	1332	Ceratopsyche bronta	4	CF
	1311	Hydropsyche cuanis	5	
	1312	Hydropsyche dicantha	5	CF
	1313	Hydropsyche frisoni	5	CF
	1314	Hydropsyche hageni	5	
	1316	Hydropsyche incommoda	5	
	1493	Ceratopsyche morosa	4	
	1317	Hydropsyche orris	4	CF
	1318	Hydropsyche phalerata	2	CF
	1319	Hydropsyche placoda	4	
	1320	Hydropsyche scalaris	5	CF
	1492	Ceratopsyche alternans	5	CF
	1321	Hydropsyche simulans	5	CF
	1322	Hydropsyche valanis	5	CF
	1323	Hydropsyche venularis	5	CF
	1324	Macronema sp.	2	CF
	2217	Macrostemum sp.	2	CF
	1325	Macronema zebratum	2	CF
	1326	Parapsyche sp.	5.5	PR
	1327	Parapsyche apicalis	5.5	
	1328	Potamyia sp.	4	CF
	1329	Potamyia flava	4	CF
	1330	Ceratopsyche sp.	4	CF
	1496	Ceratopsyche alhedra	4	
	1499	Ceratopsyche slossonae	4	
	1337	Ceratopsyche sparna	4	
Family Philopotamidae	1338	Philopotamidae	3.5	CF
	1339	Chimarra sp.	3	CF

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	1340	Chimarra aterrima	3	CF
	1341	Chimarra feria	3	CF
	1342	Chimarra obscura	3	CF
	1343	Chimarra socia	3	CF
	1344	Dolophilodes sp.	0	CG
	1345	Dolophilodes distinctus	0	
	1346	Wormaldia sp.	3.5	CF
	1348	Wormaldia shawnee	3.5	
Family Polycentropodidae	1349	Polycentropodidae	3.5	CF
	1350	Cyrnellus sp.	5	CF
	1351	Cyrnellus fraternus	5	CF
	1352	Neureclipsis sp.	3	CF
	1353	Neureclipsis crepuscularis	3	CF
	1354	Neureclipsis bimaculata	3	CF
	1355	Nyctiophylax sp.	1	CF
	1356	Phylocentropus sp.	3.5	CF
	1357	Phylocentropus placidus	3.5	
	1358	Polycentropus sp.	3	PR
	1359	Polycentropus centralis	3	PR
	1360	Polycentropus cinereus	3	PR
	1361	Polycentropus flavus	3	PR
	1362	Polycentropus glacialis	3	PR
	1363	Polycentropus interruptus	3	PR
	1364	Polycentropus remotus	3	PR
Family Psychomyiidae	1365	Psychomyiidae	3.5	CG
	1366	Lype sp.	3.5	SC
	1367	Lype diversa	3.5	SC
	1368	Psychomyia sp.	2	SC
	1369	Psychomyia flavida	2	CG
Family Glossosomatidae	1370	Glossosomatidae	3.5	SC
	1372	Agapetus sp.	2	SC
	1371	Agapetus illini	2	
	1373	Glossosoma sp.	3.5	SC
	1374	Glossosoma intermedium	3.5	SC
	1375	Protoptila sp.	1	SC
Family Hydroptilidae	1376	Hydroptilidae	3.5	PH
	1377	Agraylea sp.	2	PH
	1378	Agraylea multipunctata	2	
	1379	Hydroptila sp.	2	SC
	1500	Hydroptila waubesiana	2	
	1380	Ithytrichia sp.	1	SC
	1381	Leucotrichia sp.	3	SC
	1382	Leucotrichia pictipes	3	

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	1384	Mayatrichia sp.	1	SC
	1383	Mayatrichia ayama	1	SC
	1385	Neotrichia sp.	4	SC
	1386	Ochrotrichia sp.	4	CG
	1387	Orthotrichia sp.	1	SC
	1388	Oxyethira sp.	2	MH
	1389	Stactobiella sp.	3.5	SH
	1390	Stactobiella palmata	3.5	
Family Rhyacophilidae	1391	Rhyacophilidae	3.5	PR
	1392	Rhyacophila sp.	1	PR
	1393	Rhyacophila fenestra	1	
	1394	Rhyacophila fuscula	1	PR
	1395	Rhyacophila lobifera	1	
	1396	Rhyacophila vibox	1	
Family Brachycentridae	1397	Brachycentridae	3.5	CF
	1398	Brachycentrus sp.	1	CF
	1399	Brachycentrus americanus	1	CF
	1400	Brachycentrus lateralis	1	CF
	1401	Brachycentrus numerosus	1	CF
	1402	Brachycentrus occidentalis	1	CF
	1403	Micrasema sp.	3.5	MH
	1404	Micrasema rusticum	3.5	
Family Lepidostomatidae	1405	Lepidostomatidae	3.5	SH
	1406	Lepidostoma sp.	3	SH
	1407	Lepidostoma liba	3	
Family Limnephilidae	1408	Limnephilidae	3.5	SH
	1409	Anabolia sp.	3.5	SH
	1410	Frenesia sp.	3.5	SH
	1411	Frenesia missa	3.5	
	1412	Goera sp.	3.5	SC
	1413	Hesperophylax sp.	3.5	SH
	1414	Hesperophylax designatus	3.5	SH
	1415	Hydatophylax sp.	2	SH
	1416	Hydatophylax argus	2	SH
	1417	Ironoquia sp.	3.5	SH
	1418	Leptophylax sp.	3.5	SH
	1420	Limnephilus sp.	3	SH
	1421	Neophylax sp.	3	SC
	1422	Neophylax concinnus	3	
	1423	Platycentropus sp.	3	SH
	1424	Platycentropus radiatus	3	
	1425	Pseudostenophylax sp.	3.5	SH
	1426	Pseudostenophylax uniformis	3.5	

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	1427	Pycnopsyche sp.	3	SH
	1428	Pycnopsyche guttifer	3	SH
	1429	Pycnopsyche lepida	3	
	1430	Pycnopsyche luculenta	3	
	1431	Pycnopsyche scabripennis	3	SH
	1432	Pycnopsyche subfasciata	3	SH
Family Molannidae	1433	Molannidae	3.5	CG
	1434	Molanna sp.	3.5	SC
	1435	Molanna blenda	3.5	
	1436	Molanna tryphena	3.5	
	1437	Molanna uniophila	3.5	
Family Phryganeidae	1438	Phryganeidae	3.5	SH
	1439	Agrypnia sp.	3	SH
	1441	Agrypnia vestita	3	
	1442	Banksiola sp.	2	SH
	1443	Banksiola crotchi	2	
	1444	Fabria sp.	3.5	SH
	1445	Fabria inornata	3.5	
	1446	Oligostomis sp.	3.5	PR
	1447	Oligostomis ocelligera	3.5	PR
	1448	Phryganea sp.	3	
	1449	Ptilostomis sp.	3	SH
Family Helicopsychidae	1450	Helicopsychidae	3.5	SC
	1451	Helicopsyche sp.	2	SC
	1452	Helicopsyche borealis	2	SC
Family Leptoceridae	1453	Leptoceridae	3.5	CG
	1454	Ceraclea sp.	3	CG
	1456	Ceraclea ancylus	3	
	1457	Ceraclea cancellata	3	
	1458	Ceraclea diluta	3	
	1459	Ceraclea flava	3	
	1460	Ceraclea maculata	3	
	1462	Ceraclea nepha	3	
	2510	Ceraclea transversa	3	
	1463	Ceraclea resurgens	3	
	1466	Leptocerus sp.	3	SH
	1467	Leptocerus americanus	3	
	1468	Mystacides sp.	2	CG
	1470	Mystacides sepulchralis	2	
	1471	Nectopsyche sp.	3	SH
	1472	Nectopsyche albida	3	
	1473	Nectopsyche candida	3	
	1474	Nectopsyche diarina	3	

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	1475	Nectopsyche exquisita	3	
	1476	Nectopsyche pavida	3	
	1477	Oecetis sp.	5	PR
	1478	Oecetis avara	5	PR
	1479	Oecetis cinerascens	5	PR
	1480	Oecetis eddlestoni	5	PR
	1481	Oecetis inconspicua	5	PR
	2521	Oecetis nocturna	5	
	1482	Oecetis ochracea	5	
	1483	Setodes sp.	3.5	
	1484	Triaenodes sp.	3	MH
	1486	Triaenodes injustus	3	
	1487	Triaenodes marginatus	3	sh
	1488	Triaenodes tardus	3	SH
Family Sericostomatidae	1489	Sericostomatidae	3.5	SH
	1490	Agarodes distincta	3.5	
Order Lepidoptera	1550	Lepidoptera	99.9	SH
	1501	Crambidae	99.9	SH
Family Pyralidae	1551	Pyralidae	99.9	SH
	1552	Munroessa sp.	99.9	SH
	1554	Nymphula sp.	99.9	SH
	1555	Paraponyx sp.	99.9	SH
	1556	Petrophila sp.	5	SC
	1557	Synclita sp.	99.9	SH
Order Coleoptera	1600	Coleoptera	99.9	PR
Family Gyrinidae	1601	Gyrinidae	99.9	PR
	1602	Dineutus sp. (larvae only)	4	PR
	1603	Dineutus assimilis (larvae only)	4	PR
	1604	Dineutus discolor (larvae only)	4	PR
	1607	Gyrinus sp. (larvae only)	4	PR
	1608	Gyrinus aeneolus (larvae only)	4	PR
	1609	Gyrinus analis (larvae only)	4	
Family Psephenidae	1614	Psephenidae	4	SC
	1616	Psephenus sp.	4	SC
	1615	Psephenus herricki	4	SC
Family Scirtidae	1617	Helodidae	7	SC
	1618	Cyphon sp.	7	SC
	1619	Cyphon americanus	7	
	1620	Cyphon collaris	7	
	1621	Cyphon modestus	7	
	1622	Cyphon nebulosus	7	
	1623	Cyphon obscurus	7	
	1624	Cyphon punctatus	7	

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	1625	Cyphon perplexus	7	
	1626	Scirtes sp.	7	SH
	1627	Scirtes orbiculatus	7	
	1628	Scirtes tibialis	7	
Family Haliplidae	1629	Haliplidae	99.9	SH
	1630	Haliplus sp.	99.9	MH
	1631	Haliplus fasciatus	99.9	SH
	1632	Haliplus immaculicollis	99.9	
	1633	Haliplus leopardus	99.9	
	1634	Haliplus pantherinus	99.9	
	1635	Haliplus triopsis	99.9	
	1636	Peltodytes sp.	99.9	SH
	1637	Peltodytes duodecimpunctatus	99.9	
	1638	Peltodytes dunavani	99.9	
	1639	Peltodytes lengi	99.9	
	1640	Peltodytes sexmaculatus	99.9	
Family Hydrophilidae	1641	Hydrophilidae	99.9	PR
	1642	Anacaena sp.	99.9	
	1643	Anacaena limbata	99.9	
	1644	Berosus sp.	99.9	PR
	1646	Berosus fraternus	99.9	
	1647	Berosus infuscatus	99.9	
	1649	Berosus peregrinus	99.9	
	1650	Berosus pugnax	99.9	
	1651	Berosus striatus	99.9	CG
	1652	Crenitis sp.	99.9	PR
	1653	Cymbiodyta sp.	99.9	CG
	1655	Cymbiodyta chamberlaini	99.9	
	1656	Cymbiodyta semistriata	99.9	
	1657	Cymbiodyta vindicata	99.9	
	1658	Enochrus sp.	99.9	CG
	1660	Enochrus cinctus	99.9	
	1662	Enochrus consortus	99.9	
	1663	Enochrus hamiltoni	99.9	
	1664	Enochrus ochraceus	99.9	
	1665	Enochrus perplexus	99.9	
	1666	Enochrus pygmaeus	99.9	
	1667	Enochrus sayi	99.9	
	1803	Helocombus sp.	99.9	
	1668	Helophorus sp.	99.9	SH
	1669	Hydrobius sp.	99.9	PR
	1670	Hydrobius fuscipes	99.9	
	1673	Hydrochara sp.	99.9	CG

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	1674	Hydrochus sp.	99.9	SH
	1675	Hydrophilus sp.	99.9	PR
	1676	Laccobius sp.	99.9	PR
	1677	Laccobius agilis	99.9	
	1678	Laccobius minutoides	99.9	
	1679	Paracymus sp.	99.9	PR
	1680	Paracymus subcupreus	99.9	
	1681	Tropisternus sp.	99.9	PR
	1682	Tropisternus blatchleyi	99.9	
	1684	Tropisternus lateralis	99.9	CG
	1685	Tropisternus mixtus	99.9	
	1686	Tropisternus natator	99.9	
Family Dytiscidae	1687	Dytiscidae	99.9	PR
	1688	Acilius sp.	99.9	PR
	1689	Acilius fraternus	99.9	
	1691	Acilius semisulcatus	99.9	
	1692	Agabetes sp.	99.9	PR
	1694	Agabus sp.	99.9	PR
	1696	Agabus ambiguus	99.9	
	1698	Agabus disintegratus	99.9	
	1703	Bidessonotus sp.	99.9	PR
	1704	Bidessonotus inconspicuus	99.9	
	1705	Celina sp.	99.9	PR
	1706	Celina hubbelli	99.9	
	1707	Copelatus sp.	99.9	PR
	1708	Copelatus chevrolati	99.9	
	1709	Copelatus glyphicus	99.9	
	1710	Coptotomus sp.	99.9	PR
	1713	Cybister sp.	99.9	PR
	1714	Cybister fimbriolatus	99.9	
	1715	Deronectes sp.	99.9	PR
	1717	Dytiscus sp.	99.9	PR
	1719	Dytiscus hybridus	99.9	
	1720	Hydaticus sp.	99.9	PR
	1721	Hydaticus modestus	99.9	
	1722	Hydroporus sp.	99.9	PR
	1725	Hydroporus clypealis	99.9	
	1726	Hydroporus consimilus	99.9	
	1728	Hydroporus niger	99.9	
	1729	Hydroporus rufilabris	99.9	
	1733	Hydroporus vittatipennis	99.9	
	1734	Hydrovatus sp.	99.9	PR
	1735	Hydrovatus pustalatus	99.9	PR

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	1736	Hygrotus sp.	99.9	PR
	1737	Ilybius sp.	99.9	PR
	1738	Ilybius biguttulus	99.9	
	1739	Laccophilus sp.	99.9	PR
	1740	Laccophilus fasciatus	99.9	PR
	1741	Laccophilus maculosus	99.9	
	1742	Laccophilus proximus	99.9	PR
	1744	Laccornis sp.	99.9	PR
	1745	Liodessus sp.	99.9	PR
	1748	Matus sp.	99.9	PR
	1749	Matus bicarinatus	99.9	
	1751	Rhantus sp.	99.9	PR
	1752	Rhantus binotatus	99.9	
	1753	Thermonectus sp.	99.9	PR
	1754	Thermonectus basillaris	99.9	PR
	1755	Thermonectus ornaticollis	99.9	
	1756	Uvarus sp.	99.9	PR
Family Psephenidae	1760	Dicranopselaphus	4	SC
	1761	Ectopria sp.	4	SC
	1762	Ectopria nervosa	4	SC
	1763	Ectopria thoracica	4	
Family Dryopidae	1764	Dryopidae	4	SH
	1765	Helichus sp.	4	SH
	1766	Helichus fastigiatus	4	
	1767	Helichus lithophilus	4	
	1768	Helichus striatus	4	
	1769	Pelonomus sp.	4	CG
	1770	Pelonomus obscurus	4	
Family Elmidae	1771	Elmidae	5	CG
	1772	Ancyronyx sp.	2	
	1773	Ancyronyx variegatus	2	CG
	1774	Dubiraphia sp.	5	CG
	1775	Dubiraphia bivittata	2	
	1776	Dubiraphia minima	5	
	1777	Dubiraphia quadrinotata	7	
	1778	Dubiraphia vittata	7	
	1779	Macronychus sp.	2	
	1780	Macronychus glabratus	2	
	1781	Microcylloepus sp.	2	CG
	1782	Microcylloepus pusillus	2	CG
	1783	Optioservus sp.	4	SC
	1784	Optioservus fastiditus	4	SC
	1785	Optioservus ovalis	4	SC

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	1786	Optioservus trivittatus	4	SC
	1787	Promoresia sp.	5	SC
	1788	Stenelmis sp.	7	SC
	1789	Stenelmis bicarinata	7	SC
	1790	Stenelmis crenata	7	
	1791	Stenelmis decorata	7	SC
	1792	Stenelmis lateralis	7	SC
	1793	Stenelmis markeli	7	SC
	1794	Stenelmis mera	7	SC
	1795	Stenelmis musgravei	7	SC
	1796	Stenelmis sexlineata	7	SC
	1797	Stenelmis vittipennis	6	
Family Curculionidae	1799	Curculionidae	99.9	SH
	1800	Listronotus sp.	99.9	CF
Family Scirtidae	1801	Elodes sp.	7	
	1802	Prionocyphon sp.	7	SC
Order Diptera	1850	Diptera	10	
Family Blephariceridae	1851	Blephariceridae	0	SC
	1852	Blepharicera sp.	0	SC
Family Tipulidae	1853	Tipulidae	4	SH
	1854	Tipula sp.	4	SH
	1855	Antocha sp.	5	CG
	1856	Dicranota sp.	4	PR
	1857	Eriocera sp.	7	PR
	1858	Erioptera sp.	4	CG
	2221	Gonomyia sp.	4	CG
	1859	Helius sp.	5	CG
	1860	Hesperoconopa sp.	2	CG
	1861	Hexatoma sp.	4	PR
	1862	Limnophila sp.	4	PR
	1863	Limonia sp.	3	SH
	1864	Ormosia sp.	4	CG
	1865	Pedicia sp.	4	PR
	1866	Pilaria sp.	4	PR
	1867	Prionocera sp.	4	SH
	1868	Pseudolimnophila sp.	2	PR
Family Chaoboridae	1869	Chaoboridae	8	PR
	1870	Chaoborus sp.	8	PR
	1871	Corethrella sp.	8	PR
Family Culicidae	1873	Culicidae	8	CG
	1875	Aedes sp.	8	CF
	1876	Aedes atropalpus	8	
	1879	Aedes canadensis	8	

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	1880	Aedes cinereus	8	
	1881	Aedes communis	8	
	1882	Aedes dorsalis	8	
	1885	Aedes flavescens	8	
	1888	Aedes sollicitans	8	
	1889	Aedes sticticus	8	
	1890	Aedes stimulans	8	
	1894	Aedes triseriatus	8	
	1895	Aedes trivittatus	8	
	1896	Aedes vexans	8	
	1897	Anopheles sp.	6	CF
	1898	Anopheles barberi	6	
	1899	Anopheles crucians	6	
	1900	Anopheles earlei	6	
	1901	Anopheles punctipennis	6	
	1902	Anopheles quadrimaculatus	6	
	1903	Anopheles walkeri	6	
	1904	Culex sp.	8	CF
	1905	Culex erraticus	8	
	1906	Culex peccator	8	
	1907	Culex pipiens	8	CF
	1908	Culex quinquefasciatus	8	
	1909	Culex restuans	8	
	1910	Culex salinarius	8	
	1911	Culex tarsalis	8	
	1912	Culiseta sp.	8	CG
	1913	Culiseta inornata	8	
	1914	Culiseta melanura	8	
	1917	Mansonia sp.	8	CG
	1918	Mansonia perturbans	8	
	1919	Psorophora sp.	8	PR
	1920	Psorophora ciliata	8	
	1921	Psorophora confinnis	8	PR
	1922	Psorophora cyanescens	8	
	1923	Psorophora discolor	8	
	1924	Psorophora ferox	8	
	1925	Psorophora horrida	8	
	1926	Psorophora howardi	8	
	1927	Psorophora varipes	8	
	1928	Uranotaenia sp.	8	CF
	1929	Uranotaenia sapphirina	8	
Family Dixidae	1930	Dixidae	10	CG
	1931	Dixa sp.	10	CG

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	2238	Dixella sp.	10	
Family Psychodidae	1933	Psychodidae	11	CG
	2165	Telmatoscopus sp.	11	CG
	1934	Pericoma sp.	11	CG
	1935	Psychoda sp.	11	CG
Family Ceratopogonidae	1936	Ceratopogonidae	5	PR
	1937	Atrichopogon sp.	2	PR
	1938	Bezzia sp.	5	CG
	2166	Ceratopogon sp.	5	PR
	1939	Culicoides sp.	5	PR
	1940	Dasyhelea sp.	5	CG
	1941	Forcipomyia sp.	5	SC
	2167	Monohelea sp.	5	PR
	2223	Nilobezzia sp.	5	PR
	1942	Palpomyia sp.	6	PR
	2596	Serromyia sp.	5	
	1943	Probezzia sp.	5	PR
	2224	Sphaeromias sp.	5	
	1945	Stilobezzia sp.	5	
Family Simuliidae	1946	Simuliidae	6	CF
	1947	Cnephia sp.	4	CF
	1948	Cnephia pecuarum	4	
	1949	Prosimulium sp.	2	CF
	1950	Prosimulium magnum	2	
	1951	Prosimulium mixtum	2	
	1952	Simulium sp.	6	CF
	1953	Simulium clarkei	4	
	1954	Simulium corbis	0	
	1955	Simulium decorum	4	CF
	1956	Simulium jenningsi	4	CF
	1957	Simulium luggeri	2	
	1958	Simulium meridionale	1	CF
	1959	Simulium tuberosum	4	CF
	1960	Simulium venustum	6	CF
	1961	Simulium verecundum	6	
	1962	Simulium vittatum	8	CF
Family Chironomidae	1963	Chironomidae	6	CG
Tribe Tanypodinae	2206	Tanypodinae	6	PR
	1965	Ablabesmyia sp.	6	CG
	2168	Ablabesmyia annulata	6	
	2169	Ablabesmyia hauberi	6	
	2501	Ablabesmyia janta	6	
	2502	Ablabesmyia janta var II	6	

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	1966	Ablabesmyia mallochi	6	
	1967	Ablabesmyia monilis	6	PR
	1968	Ablabesmyia parajanta	6	
	1969	Ablabesmyia peleensis	6	
	2170	Ablabesmyia tarella	6	
	1970	Clinotanypus sp.	6	PR
	1971	Clinotanypus pinguis	6	PR
	1973	Coelotanypus sp.	4	PR
	1972	Coelotanypus concinnus	6	PR
	2171	Conchapelopia sp.	6	PR
	1974	Djalmabatista sp.	6	PR
	2239	Djalmabatista pulchra	6	
	1975	Guttipelopia sp.	6	PR
	2214	Hayesomyia sp.	5	
	2215	Helopelopia sp.	4	PR
	2509	Hudsonimyia sp.	6	
	1976	Labrundinia sp.	4	PR
	2512	Labrundinia neopilosella	4	
	2241	Labrundinia pilosella	4	
	2172	Labrundinia virescens	6	PR
	1977	Larsia sp.	6	PR
	1978	Macropelopia sp.	7	PR
	2211	Meropelopia sp.	3	
	1979	Natarsia sp.	6	PR
	1980	Nilotanypus sp.	6	PR
	2174	Nilotanypus fimbriatus	6	PR
	2173	Paramerina sp.	6	PR
	1981	Pentaneura sp.	3	PR
	1982	Procladius sp.	8	PR
	1983	Psectrotanypus sp.	8	PR
	2225	Rheopelopia sp.	3	PR
	1984	Tanypus sp.	8	PR
	2516	Tanypus carinatus	8	
	2175	Tanypus neopunctipennis	8	
	2508	Tanypus punctipennis	8	
	2515	Tanypus stellatus	8	
	1985	Thienemannimyia sp.	6	PR
	2176	Thienemannimyia senata	6	
	1986	Zavrelimyia sp.	8	
	2235	Zavrelimyia sinuosa com	8	
Tribe Diamesinae	2210	Diamesinae	6	
	1988	Diamesa sp.	4	CG
	1989	Odontomesa sp.	6	CG

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	1990	Potthastia sp.	6	
	1991	Prodiamesa sp.	3	CG
	1992	Pseudodiamesa sp.	1	CG
	1993	Sympotthastia sp.	6	CG
	1994	Syndiamesa sp.	6	CG
Tribe Orthocladiinae	1995	Orthocladiinae	6	CG
	2202	Orthocladius sp./Cricotopus sp.	6	
	1996	Brillia sp.	6	SH
	1997	Cardiocladius sp.	6	PR
	1998	Chaetocladius sp.	6	CG
	1999	Corynoneura sp.	2	CG
	2177	Corynoneura taris	2	CG
	2000	Cricotopus sp.	8	SH
	2001	Cricotopus bicinctus	10	
	2002	Cricotopus intersectus	8	SH
	2003	Cricotopus sylvestris	8	
	2004	Cricotopus trifascia	6	
	2209	Epoicocladius sp.	6	CG
	2005	Eukiefferiella sp.	4	CG
	2006	Heterotrissocladius sp.	6	CG
	2007	Hydrobaenus sp.	2	SC
	2250	Gymnometriocnemus sp.	6	
	2578	Lopescladius sp.	4	
	2008	Metriocnemus sp.	6	CG
	2009	Nanocladius sp.	3	CG
	2178	Nanocladius distinctus	3	CG
	2010	Orthocladius sp.	4	CG
	2216	Parakiefferiella sp.	5	
	2011	Parametriocnemus sp.	4	CG
	2179	Paraphaenocladius sp.	6	CG
	2012	Psectrocladius sp.	5	CG
	2597	Psilometriocnemus sp.	6	
	2013	Pseudorthocladius sp.	6	CG
	2014	Rheocricotopus sp.	6	CG
	2180	Rheocricotopus fuscipes	6	
	2246	Rheocricotopus robacki	6	
	2015	Smittia sp.	6	CG
	2220	Stilocladius sp.	6	
	2213	Tvetenia sp.	5	
	2016	Thienemanniella sp.	2	CG
	2017	Thienemanniella xena	2	CG
	2200	Zalutschia sp.	6	SH
Tribe Chironomini	2205	Chironomini	6	CG

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2201	Axarus sp.	6	CG
2019	Chironomus sp.	11	CG
2020	Chironomus anthracinus	11	
2021	Chironomus attenuatus	10	
2022	Chironomus decorus	11	
2023	Chironomus plumosus	11	
2024	Chironomus riparius	11	
2186	Chironomus staegeri	11	
2025	Cladopelma sp.	6	CG
2026	Cryptochironomus sp.	8	PR
2027	Cryptochironomus digitatus	8	
2028	Cryptochironomus fulvus	8	PR
2029	Cryptotendipes sp.	6	CG
2030	Demicryptochironomus sp.	6	CG
2031	Dicrotendipes sp.	6	CG
2523	Dicrotendipes lucifer	6	
2032	Dicrotendipes modestus	6	CG
2033	Dicrotendipes neomodestus	6	CG
2034	Dicrotendipes nervosus	6	
2517	Dicrotendipes simpsoni	6	
2524	Dicrotendipes tritomus	6	
2035	Einfeldia sp.	10	CG
2189	Einfeldia austeni	10	
2240	Einfeldia pagana	10	
2036	Endochironomus sp.	6	SH
2037	Endochironomus nigricans	6	SH
2038	Endochironomus subtendens	6	SH
2039	Glyptotendipes sp.	10	CF
2533	Glyptotendipes amplus	10	
2040	Glyptotendipes lobiferus	10	SH
2041	Glyptotendipes paripes	10	
2042	Harnischia sp.	6	CG
2255	Hyporhygma quadripunctatum	4	
2043	Kiefferulus sp.	7	CG
2518	Lipiniella sp.	6	
2044	Microchironomus sp.	6	CG
2045	Microtendipes sp.	6	CF
2046	Microtendipes caducus	6	
2047	Microtendipes pedellus	6	CF
2208	Nilothauma sp.	3	
2048	Parachironomus sp.	8	PR
2194	Parachironomus carinatus	8	PR
2195	Parachironomus directus	8	

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2242	Parachironomus frequens	8	
2049	Parachironomus monochromus	8	
2525	Parachironomus pectinatella	4	
2520	Parachironomus tenuicaudatus	8	
2050	Paracladopelma sp.	4	CG
2537	Paracladopelma nereis	4	CG
2052	Paralauterborniella sp.	6	CG
2243	Paralauterborniella nigrohalteralis	6	
2053	Paratendipes sp.	3	CG
2251	Pagastiella sp.	6	
2244	Paratendipes albimanus	3	
2054	Phaenopsectra sp.	4	SC
2055	Phaenopsectra flavipes	4	SC
2507	Phaenopsectra obediens gr.	4	
2245	Phaenopsectra punctipes gr.	4	
2057	Polypedilum sp.	6	SH
2540	Polypedilum aviceps	6	
2058	Polypedilum convictum gr.	6	SH
2065	Polypedilum digitifer	6	SH
2060	Polypedilum fallax	6	SH
2541	Polypedilum flavum	6	
2061	Polypedilum halterale	4	SH
2062	Polypedilum illinoense	5	SH
2059	Polypedilum obtusum	6	SH
2063	Polypedilum scalaenum	6	SH
2064	Polypedilum simulans	6	SH
2066	Pseudochironomus sp.	5	CG
2198	Pseudochironomus fulviventris	5	
2199	Pseudochironomus prasinatus	5	
2218	Robackia sp.	3	CG
2067	Saetheria sp.	6	CG
2514	Seatheria tylus	4	
2068	Stenochironomus sp.	3	SH
2069	Stenochironomus hilaris	3	CG
2219	Stelechomyia	6	CG
2247	Stelechomyia pulpulchra	99.9	CG
2070	Stictochironomus sp.	5	
2519	Stictochironomus caffrarius	5	
2248	Stictochironomus devinctus	5	
2071	Tribelos sp.	5	CG
2197	Tribelos fuscicorne	4	CG
2232	Tribelos jucundus	5	
2072	Xenochironomus sp.	4	PR

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	2513	Xenochironomus xenolabis	6	
	2227	Xestochironomus sp.	6	
	2249	Xylotopus par.	6	
	3433	Zavreliella sp.	2	PR
	2254	Zavreliella marmorata	2	
Tribe Tanytarsini	2207	Tanytarsini	6	CF
	2074	Cladotanytarsus sp.	7	CG
	2503	Cladotanytarsus daviese	7	
	2504	Cladotanytarsus species a	7	
	2236	Cladotanytarsus species b	7	
	2505	Cladotanytarsus species c	7	
	2237	Cladotanytarsus species f	7	
	2506	Cladotanytarsus species h	7	
	2075	Micropsectra sp.	4	CG
	2076	Paratanytarsus sp.	6	CG
	2077	Rheotanytarsus sp.	6	CF
	2226	Stempellina sp.	2	CG
	2212	Stempellinella sp.	2	CG
	2228	Sublettea sp.	6	CF
	2078	Tanytarsus sp.	7	CF
	2230	Tanytarsus guerlus	7	
	2231	Tanytarsus glabrescan	7	
Family Ptychopteridae	2079	Ptychopteridae	8	CG
	2080	Bittacomorpha sp.	8	CG
	2081	Ptychoptera sp.	8	CG
Family Stratiomyidae	2082	Stratiomyidae	10	CG
	2092	Allognosta sp.	10	CG
	2083	Odostomia sp.	10	CG
	2084	Odostomia cincta	10	
	2085	Oxycera sp.	10	SC
	2086	Stratiomys sp.	10	CF
	2087	Stratiomys discalis	10	
	2088	Stratiomys meigeni	10	
Family Tabanidae	2089	Tabanidae	7	PR
	2090	Atylotus sp.	7	PR
	2091	Atylotus bicolor	7	
	2143	Chlorotabanus sp.	7	
	2093	Chrysops sp.	7	CG
	2094	Chrysops aberrans	7	
	2097	Chrysops brunneus	7	
	2098	Chrysops callidus	7	
	2100	Chrysops cincticornis	7	
	2101	Chrysops dimmocki	7	

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	2103	Chrysops flavidus	7	
	2105	Chrysops geminatus	7	
	2106	Chrysops macquarti	7	
	2108	Chrysops moechus	7	
	2109	Chrysops montanus	7	
	2110	Chrysops niger	7	
	2115	Chrysops striatus	7	
	2116	Chrysops univittatus	7	
	2118	Chrysops vittatus	7	
	2119	Hybomitra sp.	7	PR
	2125	Tabanus sp.	7	PR
	2126	Tabanus atratus	7	
	2127	Tabanus cymatophorus	7	
	2128	Tabanus fairchildi	7	
	2130	Tabanus lineola	7	
	2131	Tabanus marginalis	7	
	2132	Tabanus nigrescens	7	
	2133	Tabanus pumilus	7	
	2134	Tabanus quinquevittatus	7	
	2135	Tabanus reinwardtii	7	
	2136	Tabanus sparus	7	
	2137	Tabanus stygius	7	
	2139	Tabanus subsimilis	7	
	2140	Tabanus sulcifrons	7	
	2141	Tabanus superjumentarius	7	
	2142	Tabanus trimaculatus	7	
Family Dolichopodidae	2144	Dolichopodidae	5	PR
	2145	Hydrophorus sp.	99.9	PR
	2594	Raphium sp.	99.9	
Family Empididae	2146	Empididae	6	PR
	2147	Hemerodromia sp.	6	PR
	2595	Rhamphomyia sp.	1.0	
Family Syrphidae	2148	Syrphidae	11	CG
	2149	Chrysogaster sp.	11	CG
	2150	Eristalis sp.	11	CG
Family Ephydridae	2151	Ephydridae	8	CG
	2152	Ephydra sp.	8	CG
Family Sciomyzidae	2153	Sciomyzidae	10	PR
	2154	Dictya sp.	10	PR
	2155	Dictya pictipes	10	
Family Muscidae	2156	Muscidae	8	PR
	2157	Limnophora sp.	8	PR
Family Athericidae	2158	Athericidae	10	

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	2159	Atherix sp.	10	PR
	2160	Atherix variegata	4	PR
Phylum Mollusca	2300	Mollusca	99.9	
Class Gastropoda	2301	Gastropoda	99.9	SC
Order Mesogastropoda	2599	Mesogastropoda	99.9	
Family Viviparidae	2302	Viviparidae	6	SC
	2303	Campeloma sp.	7	SC
	2304	Lioplax sp.	7	SC
	2305	Viviparus sp.	1	SC
	2306	Valvatidae	6	SC
	2307	Valvata sp.	2	SC
Family Bithyniidae	2308	Bithyniidae	6	
	2309	Bithynia sp.	6	
Family Hydrobiidae	2310	Hydrobiidae	6	SC
	2312	Amnicola sp.	4	SC
	2313	Amnicola walkeri	4	
	2314	Cincinnatia sp.	6	SC
	2315	Marstonia sp.	6	
	2316	Probythinella sp.	6	
	2317	Pyrgulopsis sp.	6	SC
	2318	Somatogyrus sp.	6	
Family Pleuroceridae	2319	Pleuroceridae	6	
	2320	Elimia sp.	6	SC
	2321	Goniobasis sp.	5	SC
	2322	Leptoxis sp.	6	
	2323	Lithasia sp.	6	
	2324	Pleurocera sp.	7	SC
	2325	Pleurocera acuta	7	SC
Family Pomatiopsidae	2326	Pomatiopsidae	6	
	2327	Pomatiopsis sp.	6	
Family Physidae	2328	Physidae	9	SC
	2329	Aplexa sp.	7	
	2330	Physa sp.	9	SC
	2351	Physa acuta	9	
	2361	Physa integra	9	CG
	2331	Physella sp.	9	SC
	2352	Physella sayi	9	
Family Lymnaeidae	2332	Lymnaeidae	7	SC
	2333	Acella sp.	7	
Order Basommatophora	2598	Basommatophora	7	
	2334	Fossaria sp.	7	SC
	2362	Fossaria obrussa	7	
	2335	Lymnaea sp.	7	SC

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	2336	Pseudosuccinea sp.	7	SC
	2355	Pseudosuccinea columella	7	SC
	2337	Stagnicola sp.	7	SC
	2338	Stagnicola emarginatus	7	
Family Planorbidae	2339	Planorbidae	6.5	SC
	2340	Gyraulus sp.	6	SC
	2341	Helisoma sp.	7	SC
	2342	Menetus sp.	6.5	SC
	2343	Planorbella sp.	6.5	SC
	2357	Planorbella truncata	6.5	
	2344	Planorbula sp.	7	SC
	2345	Promenetus sp.	6.5	CG
Family Ancylidae	2346	Ancylidae	7	SC
	2347	Ferrissia sp.	7	SC
	2358	Ferrissia rivularis	7	SC
	2348	Laevapex sp.	6	SC
	2359	Laevapex fuscus	6	SC
	2360	Laevapex diaphanus	6	SC
Class Pelecypoda	2400	Pelecypoda	99.9	CF
Order Unionoida	2600	Unionoida	99.9	
Family Unionidae	2401	Unionidae	1.5	CF
	2402	Actinonaias sp.	1.5	
	2403	Actinonaias carinata	1	
	2404	Actinonaias ellipsiformis	1.5	
	2405	Actinonaias ligamentina	1.5	
	2406	Alasmidonta sp.	1.5	CF
	2407	Alasmidonta calceolus	1.5	
	2408	Alasmidonta marginata	1	
	2409	Alasmidonta triangulata	1.5	
	2410	Amblema sp.	1.5	
	2411	Amblema plicata	1.5	
	2412	Anodonta sp.	3	CF
	2413	Anodonta grandis	3	
	2415	Anodonta imbecilis	3	
	2416	Anodonta suborbiculata	3	
	2417	Anodontoides sp.	1.5	CF
	2418	Anodontoides ferussacianus	1.5	
	2419	Arcidens sp.	1.5	CF
	2420	Arcidens confragosus	1.5	
	2421	Carunculina sp.	7	CF
	2500	Toxolasma paruvus	7	
	2423	Carunculina parva	7	
	2424	Toxolasma texasensis	7	

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2425	Cyclonaias sp.	1.5	
2426	Cyclonaias tuberculata	1.5	
2427	Cyprogenia sp.	1.5	
2428	Cyprogenia irrorata	1.5	
2429	Dysnomia sp.	1.5	
2431	Dysnomia triquetra	1.5	
2432	Elliptio sp.	2	CF
2433	Elliptio crassidens	2	
2434	Elliptio dilatata	2	
2435	Fusconaia sp.	1	
2436	Fusconaia ebena	1	
2437	Fusconaia flava	1	
2438	Lampsilis sp.	1	CF
2439	Lampsilis teres	1	CF
2498	Lampsilis fasciola	1	
2441	Lampsilis radiata	1	
2442	Lampsilis ventricosa	1	
2443	Lampsilis orbiculata	1	
2444	Lampsilis higginsi	1	
2445	Lasmigona sp.	1.5	
2446	Lasmigona complanata	1.5	
2447	Lasmigona compressa	1.5	
2448	Lasmigona costata	1.5	
2449	Leptodea sp.	1.5	CF
2450	Leptodea fragilis	1.5	
2451	Ligumia sp.	1	CF
2452	Ligumia recta	1	
2453	Ligumia subrostrata	1	
2454	Megalonaias sp.	1.5	
2455	Megalonaias nervosa	1.5	
2456	Obliquaria sp.	1	
2457	Obliquaria reflexa	1	
2458	Obovaria sp.	1.5	
2459	Obovaria olivaria	1.5	
2460	Obovaria subrotunda	1.5	
2462	Plagiola lineolata	1.5	
2463	Plethobasus sp.	1.5	
2464	Plethobasus cyphyus	1.5	
2465	Pleurobema sp.	1.5	
2466	Pleurobema cordatum	1.5	
2467	Proptera sp.	1	
2468	Proptera alata	1	
2469	Proptera capax	1	

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	2470	Proptera laevissimus	1	
	2471	Ptychobranchus sp.	1.5	
	2472	Ptychobranchus fasciolaris	1.5	
	2473	Quadrula sp.	1.5	
	2474	Quadrula cyclindrica	1.5	
	2475	Quadrula metanerva	1.5	
	2476	Quadrula nodulata	1.5	
	2477	Quadrula pustulosa	1.5	
	2478	Quadrula quadrula	1.5	
	2479	Strophitus sp.	4	
	2480	Strophitus undulatus	4	
	2481	Tritogonia sp.	1	
	2482	Tritogonia verrucosa	1	
	2483	Truncilla sp.	1	
	2484	Truncilla donaciformis	1	
	2485	Truncilla truncata	1	
	2486	Uniomerus sp.	1.5	
	2487	Uniomerus tetralasmus	1.5	
	2488	Villosa sp.	1	
	2489	Villosa iris	1	
	2490	Villosa lienosa	1	
Order Venerioda	2601	Veneroida	5	
Family Pisidiidae	2499	Pisidiidae	5	
Family Sphaeriidae	2491	Sphaeriidae	5	
	2492	Musculium sp.	5	CF
	2493	Musculium transversum	5	CF
	2494	Pisidium sp.	5	CF
	2495	Sphaerium sp.	5	CG
Family Corbiculidae	2497	Corbicula sp.	4	CF
Family Dreissenidae	2234	Dreissena polymorpha	99.9	

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Appendix A. Illinois Environmental Protection Agency Macroinvertebrate Tolerance List and Functional Feeding Group Classification

January, 2011

Alphabetic Order

Bios ID	Taxon	Tolerance	Functional Feeding Group
2168	Ablabesmyia annulata	6	
2169	Ablabesmyia hauberi	6	
2501	Ablabesmyia janta	6	
2502	Ablabesmyia janta var II	6	
1966	Ablabesmyia mallochi	6	
1967	Ablabesmyia monilis	6	PR
1968	Ablabesmyia parajanta	6	
1969	Ablabesmyia peleensis	6	
1965	Ablabesmyia sp.	6	CG
2170	Ablabesmyia tarella	6	
2605	Acanthametropodidae		
479	Acanthametropus pecatonica	3	
478	Acanthametropus sp.	3	PR
2333	Acella sp.	7	
652	Acentrella sp.	4	
506	Acerpenna macdunnoughi	4	CG
508	Acerpenna pygmaeus	4	
2203	Acerpenna sp.	4	SH
1689	Acilius fraternus	99.9	
1691	Acilius semisulcatus	99.9	
1688	Acilius sp.	99.9	PR
956	Acroneuria abnormis	1	PR
957	Acroneuria arida	1	PR
958	Acroneuria carolinensis	1	PR
959	Acroneuria evoluta	1	PR
960	Acroneuria internata	1	PR
961	Acroneuria lycorias	1	PR
955	Acroneuria sp.	1	PR
154	Actinobdella inequiannulata	8	
153	Actinobdella sp.	8	
2403	Actinonaias carinata	1	
2404	Actinonaias ellipsiformis	1.5	
2405	Actinonaias ligamentina	1.5	
2402	Actinonaias sp.	1.5	
1876	Aedes atropalpus	8	
1879	Aedes canadensis	8	
1880	Aedes cinereus	8	
1881	Aedes communis	8	
1882	Aedes dorsalis	8	
1885	Aedes flavescens	8	
1888	Aedes sollicitans	8	

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1875	Aedes sp.	8	CF
1889	Aedes sticticus	8	
1890	Aedes stimulans	8	
1894	Aedes triseriatus	8	
1895	Aedes trivittatus	8	
1896	Aedes vexans	8	
37	Aeolosomatidae	10	CF
744	Aeshna canadensis	4	
746	Aeshna constricta	4	PR
743	Aeshna sp.	4	PR
747	Aeshna umbrosa	4	
748	Aeshna verticalis	4	
742	Aeshnidae	4.5	PR
1692	Agabetes sp.	99.9	PR
1696	Agabus ambiguus	99.9	
1698	Agabus disintegratus	99.9	
1694	Agabus sp.	99.9	PR
1371	Agapetus illini	2	
1372	Agapetus sp.	2	SC
1490	Agarodes distincta	3.5	
1378	Agraylea multipunctata	2	
1377	Agraylea sp.	2	PH
1439	Agrypnia sp.	3	SH
1441	Agrypnia vestita	3	
2407	Alasmidonta calceolus	1.5	
2408	Alasmidonta marginata	1	
2406	Alasmidonta sp.	1.5	CF
2409	Alasmidonta triangulata	1.5	
156	Alboglossiphonia heteroclita	8	PR
155	Alboglossiphonia sp.	8	
946	Allocapnia mystica	1.5	
947	Allocapnia recta	1.5	
945	Allocapnia sp.	2	SH
948	Allocapnia vivipara	1.5	SH
2092	Allognosta sp.	10	CG
42	Allonais pectinata	10	
41	Allonais sp.	10	CG
991	Alloperla sp.	1.5	PR
2411	Amblema plicata	1.5	
2410	Amblema sp.	1.5	
2604	Ameletidae		
481	Ameletus lineatus	0	
480	Ameletus sp.	0	CG

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2312	Amnicola sp.	4	SC
2313	Amnicola walkeri	4	
849	Amphiagrion saucium	5	
848	Amphiagrion sp.	5	PR
44	Amphichaeta leydigi	10	
43	Amphichaeta sp.	10	CG
937	Amphinemura sp.	1.5	SH
325	Amphipoda	4	CG
1409	Anabolia sp.	3.5	SH
1643	Anacaena limbata	99.9	
1642	Anacaena sp.	99.9	
750	Anax junius	5	PR
749	Anax sp.	5	PR
2346	Ancylidae	7	SC
1772	Ancyronyx sp.	2	
1773	Ancyronyx variegatus	2	CG
530	Anepeorus simplex	3.5	
529	Anepeorus sp.	3.5	PR
30	Annelida	99.9	CG
2413	Anodonta grandis	3	
2415	Anodonta imbecilis	3	
2412	Anodonta sp.	3	CF
2416	Anodonta suborbiculata	3	
2418	Anodontoides ferussacianus	1.5	
2417	Anodontoides sp.	1.5	CF
851	Anomalagrion hastatum	5.5	PR
850	Anomalagrion sp.	5.5	PR
1898	Anopheles barberi	6	
1899	Anopheles crucians	6	
1900	Anopheles earlei	6	
1901	Anopheles punctipennis	6	
1902	Anopheles quadrimaculatus	6	
1897	Anopheles sp.	6	CF
1903	Anopheles walkeri	6	
623	Anthopotamus myops	4	
621	Anthopotamus sp.	4	
1855	Antocha sp.	5	CG
2329	Aplexa sp.	7	
839	Archilestes grandis	1	
838	Archilestes sp.	1	PR
2420	Arcidens confragosus	1.5	
2419	Arcidens sp.	1.5	CF
46	Arcteonais lomondi	10	CG

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45	Arcteonais sp.	10	
853	Argia apicalis	5	PR
854	Argia bipunctulata	5	
997	Argia fumipennis	5	PR
855	Argia moesta	5	PR
856	Argia sedula	5	PR
852	Argia sp.	5	PR
857	Argia tibialis	5	PR
858	Argia translata	5	
859	Argia violacea	5	PR
707	Arigomphus sp.	7	PR
532	Arthroplea bipunctata	3	
531	Arthroplea sp.	3	CF
2603	Arthropleidae		
250	Arthropoda	99.9	
253	Asellidae	6	CG
255	Asellus sp.	6	
2158	Athericidae	10	
2159	Atherix sp.	10	PR
2160	Atherix variegata	4	PR
971	Atoperla sp.	1	
1937	Atrichopogon sp.	2	PR
963	Attaneuria ruralis	1.5	PR
962	Attaneuria sp.	1.5	
569	Attenella attenuata	2	CG
568	Attenella sp.	2	CG
2091	Atylotus bicolor	7	
2090	Atylotus sp.	7	PR
93	Aulodrilus pigueti	10	CG
2201	Axarus sp.	6	CG
332	Bactrurus sp.	1	
497	Baetidae	4	CG
645	Baetis amplus	4	CG
653	Baetis armillatus	4	
499	Baetis brunneicolor	4	CG
500	Baetis ephippiatus	4	
501	Baetis flavistriga	4	CG
502	Baetis frondalis	4	
503	Baetis hageni	4	CG
504	Baetis intercalaris	7	
646	Baetis levitans	4	
505	Baetis longipalpus	6	
507	Baetis propinquus gr.	4	

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509	Baetis quilleri	4	
498	Baetis sp.	4	CG
510	Baetis tricaudatus	1	CG
647	Baetis vagans	4	
604	Baetisca bajkovi	3	
606	Baetisca lacustris	3	
607	Baetisca laurentina	3	
608	Baetisca obesa	3	
605	Baetisca sp.	3	CG
603	Baetiscidae	3	CG
1443	Banksiola crotchi	2	
1442	Banksiola sp.	2	SH
650	Barbaetis cestus	4	
752	Basiaeschna janata	2	PR
751	Basiaeschna sp.	2	PR
2598	Basommatophora	7	
158	Batracobdella phalera	8	
159	Batracobdella picta	8	
157	Batracobdella sp.	8	PR
1085	Belostoma flumineum	99.9	PR
1084	Belostoma sp.	99.9	PR
1083	Belostomatidae	99.9	PR
1646	Berosus fraternus	99.9	
1647	Berosus infuscatus	99.9	
1649	Berosus peregrinus	99.9	
1650	Berosus pugnax	99.9	
1644	Berosus sp.	99.9	PR
1651	Berosus striatus	99.9	CG
1938	Bezzia sp.	5	CG
1704	Bidessonotus inconspicuus	99.9	
1703	Bidessonotus sp.	99.9	PR
2309	Bithynia sp.	6	
2308	Bithyniidae	6	
2080	Bittacomorpha sp.	8	CG
1852	Blepharicera sp.	0	SC
1851	Blephariceridae	0	SC
753	Boyeria sp.	3	PR
754	Boyeria vinosa	3	PR
1397	Brachycentridae	3.5	CF
1399	Brachycentrus americanus	1	CF
1400	Brachycentrus lateralis	1	CF
1401	Brachycentrus numerosus	1	CF
1402	Brachycentrus occidentalis	1	CF

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1398	Brachycentrus sp.	1	CF
601	Brachycercus sp.	3	CG
32	Branchiobdellida	10	PA
33	Branchiobdellidae	10	CG
95	Branchiura sowerbyi	10	CG
94	Branchiura sp.	10	CG
47	Bratislavia sp.	10	CG
48	Bratislavia unidentata	10	CG
1996	Brillia sp.	6	SH
1068	Buenoa sp.	99.9	PR
256	Caecidotea brevicaudus	6	
347	Caecidotea communis	6	CG
257	Caecidotea forbesi	6	
258	Caecidotea intermedia	6	
259	Caecidotea kendeighi	6	
268	Caecidotea packardi	6	
254	Caecidotea sp.	6	CG
269	Caecidotea spatulata	6	
270	Caecidotea stygia	6	
263	Caecidotea tridentata	6	
600	Caenidae	5.5	CG
602	Caenis sp.	6	CG
512	Callibaetis ferrugineus	4	
513	Callibaetis fluctuans	4	
514	Callibaetis skokianus	4	
511	Callibaetis sp.	4	CG
830	Calopterygidae	3.5	PR
832	Calopteryx aequabilis	4	
833	Calopteryx maculata	4	PR
831	Calopteryx sp.	4	PR
403	Cambarellus puer	5	CG
404	Cambarellus shufeldtii	5	CG
402	Cambarellus sp.	5	SH
401	Cambaridae	5	CG
406	Cambarus diogenes	5	
407	Cambarus rusticiformis	5	
405	Cambarus sp.	5	CG
408	Cambarus tenebrosus	5	
2303	Campeloma sp.	7	SC
949	Capnia sp.	1	SH
950	Capnia vernalis	1	
944	Capniidae	1.5	SH
1997	Cardiocladius sp.	6	PR

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2423	Carunculina parva	7	
2421	Carunculina sp.	7	CF
1706	Celina hubbelli	99.9	
1705	Celina sp.	99.9	PR
789	Celithemis elisa	2	
790	Celithemis eponina	2	
791	Celithemis monomelaena	2	
788	Celithemis sp.	2	PR
515	Centroptilum sp.	2	CG
1456	Ceraclea ancylus	3	
1457	Ceraclea cancellata	3	
1458	Ceraclea diluta	3	
1459	Ceraclea flava	3	
1460	Ceraclea maculata	3	
1462	Ceraclea nepha	3	
1463	Ceraclea resurgens	3	
1454	Ceraclea sp.	3	CG
2510	Ceraclea transversa	3	
2166	Ceratopogon sp.	5	PR
1936	Ceratopogonidae	5	PR
1496	Ceratopsyche alhedra	4	
1492	Ceratopsyche alternans	5	CF
1332	Ceratopsyche bronta	4	CF
1333	Ceratopsyche cheilonis	4	
1493	Ceratopsyche morosa	4	
1499	Ceratopsyche slossonae	4	
1330	Ceratopsyche sp.	4	CF
1337	Ceratopsyche sparna	4	
1998	Chaetocladius sp.	6	CG
50	Chaetogaster diaphanus	10	PR
51	Chaetogaster diastrophus	10	PR
52	Chaetogaster limnaei	10	PR
49	Chaetogaster sp.	10	SH
1869	Chaoboridae	8	PR
1870	Chaoborus sp.	8	PR
1188	Chauliodes pectinicornis	4	PR
1189	Chauliodes rastricornis	4	PR
1187	Chauliodes sp.	4	PR
1302	Cheumatopsyche sp.	6	CF
1340	Chimarra aterrima	3	CF
1341	Chimarra feria	3	CF
1342	Chimarra obscura	3	CF
1343	Chimarra socia	3	CF

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1339	Chimarra sp.	3	CF
1963	Chironomidae	6	CG
2205	Chironomini	6	CG
2020	Chironomus anthracinus	11	
2021	Chironomus attenuatus	10	
2022	Chironomus decorus	11	
2023	Chironomus plumosus	11	
2024	Chironomus riparius	11	
2019	Chironomus sp.	11	CG
2186	Chironomus staegeri	11	
990	Chloroperla sp.	3	
989	Chloroperlidae	1.5	PR
2143	Chlorotabanus sp.	7	
611	Choroterpes basalis	2	CG
610	Choroterpes sp.	2	CG
861	Chromagrion conditum	5.5	
860	Chromagrion sp.	5.5	PR
2149	Chrysogaster sp.	11	CG
2094	Chrysops aberrans	7	
2097	Chrysops brunneus	7	
2098	Chrysops callidus	7	
2100	Chrysops cincticornis	7	
2101	Chrysops dimmocki	7	
2103	Chrysops flavidus	7	
2105	Chrysops geminatus	7	
2106	Chrysops macquarti	7	
2108	Chrysops moechus	7	
2109	Chrysops montanus	7	
2110	Chrysops niger	7	
2093	Chrysops sp.	7	CG
2115	Chrysops striatus	7	
2116	Chrysops univittatus	7	
2118	Chrysops vittatus	7	
2314	Cincinnatia sp.	6	SC
2025	Cladopelma sp.	6	CG
2503	Cladotanytarsus daviese	7	
2074	Cladotanytarsus sp.	7	CG
2504	Cladotanytarsus species a	7	
2236	Cladotanytarsus species b	7	
2505	Cladotanytarsus species c	7	
2237	Cladotanytarsus species f	7	
2506	Cladotanytarsus species h	7	
1253	Climacea areolaris	1	

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1252	Climacea sp.	1	
1971	Clinotanypus pinguis	6	PR
1970	Clinotanypus sp.	6	PR
517	Cloeon alamance	3	
518	Cloeon rubropictum	3	
516	Cloeon sp.	3	
1948	Cnephia pecuarum	4	
1947	Cnephia sp.	4	CF
1972	Coelotanypus concinnus	6	PR
1973	Coelotanypus sp.	4	PR
862	Coenagrion sp.	5.5	PR
847	Coenagrionidae	5.5	PR
1600	Coleoptera	99.9	PR
2171	Conchapelopia sp.	6	PR
1708	Copelatus chevrolati	99.9	
1709	Copelatus glyphicus	99.9	
1707	Copelatus sp.	99.9	PR
1710	Coptotomus sp.	99.9	PR
2497	Corbicula sp.	4	CF
704	Cordulegaster maculata	2	PR
705	Cordulegaster obliqua	2	PR
703	Cordulegaster sp.	2	PR
702	Cordulegastridae	4.5	PR
770	Cordulia shurtleffi	2	
769	Cordulia sp.	2	PR
768	Corduliidae	4.5	PR
1871	Corethrella sp.	8	PR
1090	Corixidae	99.9	PR
1186	Corydalidae	3	PR
1191	Corydalus cornutus	3	PR
1190	Corydalus sp.	3	PR
1999	Corynoneura sp.	2	CG
2177	Corynoneura taris	2	CG
1501	Crambidae	99.9	SH
336	Crangonyx forbesi	4	CG
337	Crangonyx gracilis	4	CG
338	Crangonyx minor	4	
339	Crangonyx packardi	4	
340	Crangonyx pseudogracilis	4	
335	Crangonyx sp.	4	CG
1652	Crenitis sp.	99.9	PR
2001	Cricotopus bicinctus	10	
2002	Cricotopus intersectus	8	SH

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2000	Cricotopus sp.	8	SH
2003	Cricotopus sylvestris	8	
2004	Cricotopus trifascia	6	
348	Crongonyctidae	4	
251	Crustacea	99.9	CG
2027	Cryptochironomus digitatus	8	
2028	Cryptochironomus fulvus	8	PR
2026	Cryptochironomus sp.	8	PR
2029	Cryptotendipes sp.	6	CG
1905	Culex erraticus	8	
1906	Culex peccator	8	
1907	Culex pipiens	8	CF
1908	Culex quinquefasciatus	8	
1909	Culex restuans	8	
1910	Culex salinarius	8	
1904	Culex sp.	8	CF
1911	Culex tarsalis	8	
1873	Culicidae	8	CG
1939	Culicoides sp.	5	PR
1913	Culiseta inornata	8	
1914	Culiseta melanura	8	
1912	Culiseta sp.	8	CG
1799	Curculionidae	99.9	SH
1714	Cybister fimbriolatus	99.9	
1713	Cybister sp.	99.9	PR
2425	Cyclonaias sp.	1.5	
2426	Cyclonaias tuberculata	1.5	
1655	Cymbiodyta chamberlaini	99.9	
1656	Cymbiodyta semistriata	99.9	
1653	Cymbiodyta sp.	99.9	CG
1657	Cymbiodyta vindicata	99.9	
1619	Cyphon americanus	7	
1620	Cyphon collaris	7	
1621	Cyphon modestus	7	
1622	Cyphon nebulosus	7	
1623	Cyphon obscurus	7	
1625	Cyphon perplexus	7	
1624	Cyphon punctatus	7	
1618	Cyphon sp.	7	SC
2428	Cyprogenia irrorata	1.5	
2427	Cyprogenia sp.	1.5	
1351	Cyrnellus fraternus	5	CF
1350	Cyrnellus sp.	5	CF

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179	Cystobranchus sp.	7	
178	Cystobranchus verrilli	7	
571	Dannella lita	2	CG
572	Dannella simplex	2	CG
570	Dannella sp.	2	
1940	Dasyhelea sp.	5	CG
400	Decapoda	99.9	SH
2030	Demicryptochironomus sp.	6	CG
54	Dero digitata	10	CG
55	Dero furcata	10	CG
56	Dero lodeni	10	CG
57	Dero nivea	10	CG
109	Dero pectinata	10	CG
53	Dero sp.	10	CG
1715	Deronectes sp.	99.9	PR
208	Desserobdella phalera	8	
1988	Diamesa sp.	4	CG
2210	Diamesinae	6	
1760	Dicranopselaphus	4	SC
1856	Dicranota sp.	4	PR
2523	Dicrotendipes lucifer	6	
2032	Dicrotendipes modestus	6	CG
2033	Dicrotendipes neomodestus	6	CG
2034	Dicrotendipes nervosus	6	
2517	Dicrotendipes simpsoni	6	
2031	Dicrotendipes sp.	6	CG
2524	Dicrotendipes tritomus	6	
2155	Dictya pictipes	10	
2154	Dictya sp.	10	PR
760	Didymops sp.	4	PR
761	Didymops transversa	4	PR
199	Dina dubia	8	
200	Dina parva	8	
198	Dina sp.	8	PR
1603	Dineutus assimilis (larvae only)	4	PR
1604	Dineutus discolor (larvae only)	4	PR
1602	Dineutus sp. (larvae only)	4	PR
661	Diphetor hageni	4	
1303	Diplectrona metaqui	2	
1305	Diplectrona modesta	2	CF
1304	Diplectrona sp.	2	CF
1850	Diptera	10	
1931	Dixa sp.	10	CG

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2238	Dixella sp.	10	
1930	Dixidae	10	CG
2239	Djalmabatista pulchra	6	
1974	Djalmabatista sp.	6	PR
2144	Dolichopodidae	5	PR
1345	Dolophilodes distinctus	0	
1344	Dolophilodes sp.	0	CG
2234	Dreissena polymorpha	99.9	
713	Dromogomphus sp.	4	PR
714	Dromogomphus spinosus	4	PR
575	Drunella cornutella	1	SC
573	Drunella sp.	1	PR
1764	Dryopidae	4	SH
1775	Dubiraphia bivittata	2	
1776	Dubiraphia minima	5	
1777	Dubiraphia quadrinotata	7	
1774	Dubiraphia sp.	5	CG
1778	Dubiraphia vittata	7	
5	Dugesia sp.	6	
6	Dugesia tigrina	6	PR
2429	Dysnomia sp.	1.5	
2431	Dysnomia triquetra	1.5	
1687	Dytiscidae	99.9	PR
1719	Dytiscus hybridus	99.9	
1717	Dytiscus sp.	99.9	PR
1762	Ectopria nervosa	4	SC
1761	Ectopria sp.	4	SC
1763	Ectopria thoracica	4	
2189	Einfeldia austeni	10	
2240	Einfeldia pagana	10	
2035	Einfeldia sp.	10	CG
2320	Elimia sp.	6	SC
2433	Elliptio crassidens	2	
2434	Elliptio dilatata	2	
2432	Elliptio sp.	2	CF
1771	Elmidae	5	CG
1801	Elodes sp.	7	
2146	Empididae	6	PR
864	Enallagma aspersum	6	
865	Enallagma civile	6	
866	Enallagma divagans	6	PR
867	Enallagma exsulans	6	
868	Enallagma geminatum	6	

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869	Enallagma hageni	6	
870	Enallagma signatum	6	PR
863	Enallagma sp.	6	PR
871	Enallagma traviatum	6	
872	Enallagma vesperum	6	PR
38	Enchytraeidae	10	CG
2037	Endochironomus nigricans	6	SH
2036	Endochironomus sp.	6	SH
2038	Endochironomus subtendens	6	SH
1660	Enochrus cinctus	99.9	
1662	Enochrus consortus	99.9	
1663	Enochrus hamiltoni	99.9	
1664	Enochrus ochraceus	99.9	
1665	Enochrus perplexus	99.9	
1666	Enochrus pygmaeus	99.9	
1667	Enochrus sayi	99.9	
1658	Enochrus sp.	99.9	CG
533	Epeorus sp.	1	SC
534	Epeorus vitreus	0	
627	Ephemera simulans	3	CG
626	Ephemera sp.	3	CG
579	Ephemerella aurivillii	2	CG
580	Ephemerella catawba	2	CG
574	Ephemerella cornuta	1	
590	Ephemerella coxalis	4	
581	Ephemerella dorothea	2	CG
582	Ephemerella excrucians	2	CG
596	Ephemerella frisoni	1	
583	Ephemerella invaria	2	CG
576	Ephemerella lata	1	
584	Ephemerella needhami	2	CG
585	Ephemerella rotunda	2	
578	Ephemerella sp.	2	CG
586	Ephemerella subvaria	2	CG
577	Ephemerella walkeri	1	
567	Ephemerellidae	3.5	CG
625	Ephemeridae	5	CG
476	Ephemeroptera	3	CG
639	Ephoron album	2	CG
640	Ephoron leukon	2	CG
638	Ephoron sp.	2	CG
2152	Ephydra sp.	8	CG
2151	Ephydridae	8	CG

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756	Epiaeschna heros	1	PR
755	Epiaeschna sp.	1	PR
773	Epicordulia princeps	4.5	PR
772	Epicordulia sp.	4.5	PR
771	Epitheca sp.	4	PR
2209	Epoicocladius sp.	6	CG
1857	Eriocera sp.	7	PR
1858	Erioptera sp.	4	CG
2150	Eristalis sp.	11	CG
2229	Erpetogomphus designatus	2	
2602	Erpetogomphus sp.	2	
202	Erpobdella punctata	8	PR
201	Erpobdella sp.	8	
197	Erpobdellidae	8	PR
793	Erythemis simplicicollis	5	PR
792	Erythemis sp.	5	PR
794	Erythrodiplax sp.	5	PR
2005	Eukiefferiella sp.	4	CG
588	Eurylophella aestiva	4	
589	Eurylophella bicolor	4	CG
591	Eurylophella funeralis	4	
592	Eurylophella lutulenta	4	CG
587	Eurylophella sp.	4	SC
593	Eurylophella temporalis	4	CG
1445	Fabria inornata	3.5	
1444	Fabria sp.	3.5	SH
410	Fallicambarus fodiens	5	
409	Fallicambarus sp.	5	
2358	Ferrissia rivularis	7	SC
2347	Ferrissia sp.	7	SC
1941	Forcipomyia sp.	5	SC
2362	Fossaria obrussa	7	
2334	Fossaria sp.	7	SC
1411	Frenesia missa	3.5	
1410	Frenesia sp.	3.5	SH
2436	Fusconaia ebena	1	
2437	Fusconaia flava	1	
2435	Fusconaia sp.	1	
329	Gammaridae	4	CG
346	Gammarus fasciatus	3	CG
344	Gammarus pseudolimnaeus	3	CG
341	Gammarus sp.	3	
345	Gammarus troglophilus	3	

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2301	Gastropoda	99.9	SC
1057	Gerridae	99.9	PR
1058	Gerris sp.	99.9	PR
210	Gloiobdella elongata	8	
161	Glossiphonia complanata	8	PR
160	Glossiphonia sp.	8	PR
152	Glossiphoniidae	8	PR
1374	Glossosoma intermedium	3.5	SC
1373	Glossosoma sp.	3.5	SC
1370	Glossosomatidae	3.5	SC
2533	Glyptotendipes amplus	10	
2040	Glyptotendipes lobiferus	10	SH
2041	Glyptotendipes paripes	10	
2039	Glyptotendipes sp.	10	CF
211	Gnathobdellida	7	
1412	Goera sp.	3.5	SC
706	Gomphidae	4.5	PR
738	Gomphus amnicola	7	
716	Gomphus crassus	7	
723	Gomphus exilis	7	
717	Gomphus externus	7	PR
724	Gomphus graslinellus	7	
710	Gomphus lentulus	7	
719	Gomphus lineatifrons	7	
725	Gomphus lividus	7	PR
739	Gomphus notatus	7	
740	Gomphus plagiatus	7	
726	Gomphus quadricolor	7	
722	Gomphus sp.	7	PR
741	Gomphus spiniceps	7	
711	Gomphus submedianus	7	
720	Gomphus vastus	7	PR
879	Gomphurus sp.	7	
712	Gomphus villosipes	7	
2321	Goniobasis sp.	5	SC
2221	Gonomyia sp.	4	CG
18	Gordius sp.	99.9	
1975	Guttipelopia sp.	6	PR
2250	Gymnometriocnemus sp.	6	
2340	Gyraulus sp.	6	SC
1601	Gyrinidae	99.9	PR
1608	Gyrinus aeneolus (larvae only)	4	PR
1609	Gyrinus analis (larvae only)	4	

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1607	Gyrinus sp. (larvae only)	4	PR
613	Habrophlebiodes americana	2	
612	Habrophlebiodes sp.	2	SC
190	Haemopis marmorata	7	
189	Haemopis sp.	7	PR
191	Haemopis terrestris	7	
729	Hagenius brevistylus	3	PR
728	Hagenius sp.	3	PR
1629	Haliplidae	99.9	SH
1631	Haliplus fasciatus	99.9	SH
1632	Haliplus immaculicollis	99.9	
1633	Haliplus leopardus	99.9	
1634	Haliplus pantherinus	99.9	
1630	Haliplus sp.	99.9	MH
1635	Haliplus triopsis	99.9	
36	Haplotaxida	10	
2042	Harnischia sp.	6	CG
993	Hastaperla brevis	1.5	
992	Hastaperla sp.	1.5	SC
2214	Hayesomyia sp.	5	
1051	Hebridae	99.9	PR
1052	Hebrus sp.	99.9	PR
1766	Helichus fastigiatus	4	
1767	Helichus lithophilus	4	
1765	Helichus sp.	4	SH
1768	Helichus striatus	4	
1452	Helicopsyche borealis	2	SC
1451	Helicopsyche sp.	2	SC
1450	Helicopsychidae	3.5	SC
2341	Helisoma sp.	7	SC
1859	Helius sp.	5	CG
163	Helobdella elongata	8	PR
164	Helobdella fusca	8	PA
165	Helobdella papillata	8	PR
162	Helobdella sp.	8	PA
166	Helobdella stagnalis	8	PR
167	Helobdella triserialis	8	PA
1803	Helocombus sp.	99.9	
774	Helocordulia sp.	2	PR
1617	Helodidae	7	SC
2215	Helopelopia sp.	4	PR
1668	Helophorus sp.	99.9	SH
2147	Hemerodromia sp.	6	PR

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1050	Hemiptera	99.9	PR
535	Heptagenia diabasia	4	
537	Heptagenia flavescens	2	
538	Heptagenia hebe	3	
539	Heptagenia lucidipennis	3	
540	Heptagenia maculipennis	3	SC
541	Heptagenia marginalis	1	SC
542	Heptagenia perfida	1	
543	Heptagenia pulla	0	SC
536	Heptagenia sp.	3	SC
528	Heptageniidae	3.5	SC
1860	Hesperoconopa sp.	2	CG
1092	Hesperocorixa interrupta	99.9	
1094	Hesperocorixa laevigata	99.9	
1096	Hesperocorixa lucida	99.9	
1097	Hesperocorixa nitida	99.9	
1098	Hesperocorixa obliqua	99.9	
1091	Hesperocorixa sp.	99.9	PR
1100	Hesperocorixa vulgaris	99.9	
1414	Hesperophylax designatus	3.5	SH
1413	Hesperophylax sp.	3.5	SH
835	Hetaerina americana	3	PR
834	Hetaerina sp.	3	PR
836	Hetaerina titia	3	PR
520	Heterocloeon curiosum	4	SC
519	Heterocloeon sp.	4	SC
2006	Heterotrissocladius sp.	6	CG
629	Hexagenia atrocaudata	6	CG
630	Hexagenia bilineata	6	CG
631	Hexagenia limbata	5	CG
632	Hexagenia munda	5	
633	Hexagenia rigida	6	CG
628	Hexagenia sp.	6	CG
1861	Hexatoma sp.	4	PR
249	Hirudinea	8	PR
188	Hirudinidae	8	PR
2509	Hudsonimyia sp.	6	
328	Hyalella azteca	5	CG
327	Hyalella sp.	4	CG
326	Hyalellidae	4	
2119	Hybomitra sp.	7	PR
1721	Hydaticus modestus	99.9	
1720	Hydaticus sp.	99.9	PR

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1416	Hydatophylax argus	2	SH
1415	Hydatophylax sp.	2	SH
2007	Hydrobaenus sp.	2	SC
2310	Hydrobiidae	6	SC
1670	Hydrobius fuscipes	99.9	
1669	Hydrobius sp.	99.9	PR
1673	Hydrochara sp.	99.9	CG
1674	Hydrochus sp.	99.9	SH
978	Hydroperla crosbyi	1	
977	Hydroperla sp.	1	PR
1641	Hydrophilidae	99.9	PR
1675	Hydrophilus sp.	99.9	PR
2145	Hydrophorus sp.	99.9	PR
1725	Hydroporus clypealis	99.9	
1726	Hydroporus consimilus	99.9	
1728	Hydroporus niger	99.9	
1729	Hydroporus rufilabris	99.9	
1722	Hydroporus sp.	99.9	PR
1733	Hydroporus vittatipennis	99.9	
1307	Hydropsyche aerata	5	CF
1308	Hydropsyche arinale	5	
1309	Hydropsyche betteni	5	CF
1310	Hydropsyche bidens	5	
1311	Hydropsyche cuanis	5	
1312	Hydropsyche dicantha	5	CF
1313	Hydropsyche frisoni	5	CF
1314	Hydropsyche hageni	5	
1316	Hydropsyche incommoda	5	
1317	Hydropsyche orris	4	CF
1318	Hydropsyche phalerata	2	CF
1319	Hydropsyche placoda	4	
1320	Hydropsyche scalaris	5	CF
1321	Hydropsyche simulans	5	CF
1306	Hydropsyche sp.	5	CF
1322	Hydropsyche valanis	5	CF
1323	Hydropsyche venularis	5	CF
1301	Hydropsychidae	5.5	CF
1379	Hydroptila sp.	2	SC
1500	Hydroptila waubesiana	2	
1376	Hydroptilidae	3.5	PH
1735	Hydrovatus pustalatus	99.9	PR
1734	Hydrovatus sp.	99.9	PR
1736	Hygrotus sp.	99.9	PR

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2255	Hyporhygma quadripunctatum	4	
1738	Ilybius biguttulus	99.9	
1737	Ilybius sp.	99.9	PR
96	Ilyodrilus sp.	10	
97	Ilyodrilus templetoni	10	CG
475	Insecta	99.9	
1417	Ironoquia sp.	3.5	SH
874	Ischnura posita	6	PR
873	Ischnura sp.	6	PR
875	Ischnura verticalis	6	
979	Isogenoides sp.	1.5	PR
488	Isonychia arida	3	
489	Isonychia bicolor	3	CG
490	Isonychia rufa	3	
491	Isonychia sayi	3	
492	Isonychia sicca	3	
487	Isonychia sp.	3	CF
981	Isoperla bilineata	2	
982	Isoperla clio	2	
996	Isoperla confusa	2	
983	Isoperla cotta	2	
984	Isoperla dicala	2	
985	Isoperla lata	2	
986	Isoperla marlynia	2	
987	Isoperla nana	2	
988	Isoperla richardsoni	2	
980	Isoperla sp.	2	PR
252	Isopoda	99.9	CG
1380	Ithytrichia sp.	1	SC
2043	Kiefferulus sp.	7	CG
2512	Labrundinia neopilosella	4	
2241	Labrundinia pilosella	4	
1976	Labrundinia sp.	4	PR
2172	Labrundinia virescens	6	PR
1677	Laccobius agilis	99.9	
1678	Laccobius minutoides	99.9	
1676	Laccobius sp.	99.9	PR
1740	Laccophilus fasciatus	99.9	PR
1741	Laccophilus maculosus	99.9	
1742	Laccophilus proximus	99.9	PR
1739	Laccophilus sp.	99.9	PR
1744	Laccornis sp.	99.9	PR
796	Ladona julia	4.5	

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795	Ladona sp.	4.5	PR
2360	Laevapex diaphanus	6	SC
2359	Laevapex fuscus	6	SC
2348	Laevapex sp.	6	SC
2498	Lampsilis fasciola	1	
2444	Lampsilis higginsi	1	
2443	Lampsilis orbiculata	1	
2441	Lampsilis radiata	1	
2438	Lampsilis sp.	1	CF
2439	Lampsilis teres	1	CF
2442	Lampsilis ventricosa	1	
735	Lanthus sp.	6	PR
1977	Larsia sp.	6	PR
2446	Lasmigona complanata	1.5	
2447	Lasmigona compressa	1.5	
2448	Lasmigona costata	1.5	
2445	Lasmigona sp.	1.5	
1550	Lepidoptera	99.9	SH
1407	Lepidostoma liba	3	
1406	Lepidostoma sp.	3	SH
1405	Lepidostomatidae	3.5	SH
1453	Leptoceridae	3.5	CG
1467	Leptocerus americanus	3	
1466	Leptocerus sp.	3	SH
2450	Leptodea fragilis	1.5	
2449	Leptodea sp.	1.5	CF
662	Leptohyphe sp.	5.5	CG
598	Leptohyphidae	5.5	CG
614	Leptophlebia sp.	3	CG
609	Leptophlebiidae	3	CG
1418	Leptophylax sp.	3.5	SH
2322	Leptoxis sp.	6	
841	Lestes disjunctus	6	
842	Lestes eurinus	6	
843	Lestes forcipatus	6	
844	Lestes inaequalis	6	
845	Lestes rectangularis	6	
840	Lestes sp.	6	PR
846	Lestes vigilax	6	
837	Lestidae	99.9	PR
1087	Lethocerus americans	99.9	
1088	Lethocerus griseus	99.9	
1086	Lethocerus sp.	99.9	PR

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1089	Lethocerus uhleri	99.9	
799	Leucorrhinia intacta	4.5	
797	Leucorrhinia sp.	4.5	PR
1382	Leucotrichia pictipes	3	
1381	Leucotrichia sp.	3	SC
654	Leucrocuta hebe	3	
649	Leucrocuta maculipennis	3	
648	Leucrocuta sp.	3	SC
943	Leuctra sp.	1	SH
942	Leuctridae	1.5	SH
801	Libellula cyanea	8	
802	Libellula incesta	8	PR
803	Libellula luctuosa	8	
804	Libellula pulchella	8	
805	Libellula quadrimaculata	8	
806	Libellula semifasciata	8	PR
800	Libellula sp.	8	PR
807	Libellula vibrans	8	PR
787	Libellulidae	4.5	PR
2452	Ligumia recta	1	
2451	Ligumia sp.	1	CF
2453	Ligumia subrostrata	1	
1408	Limnephilidae	3.5	SH
1420	Limnephilus sp.	3	SH
99	Limnodrilus cervix	10	CG
100	Limnodrilus claparedianus	10	CG
101	Limnodrilus hoffmeisteri	10	CG
98	Limnodrilus sp.	10	CG
102	Limnodrilus udekemianus	10	CG
1060	Limnogonus hesione	99.9	
1059	Limnogonus sp.	99.9	PR
1862	Limnophila sp.	4	PR
2157	Limnophora sp.	8	PR
1863	Limonia sp.	3	SH
1745	Liodessus sp.	99.9	PR
2304	Lioplax sp.	7	SC
2518	Lipiniella sp.	6	
273	Lirceus fontinalis	4	CG
274	Lirceus garmani	4	CG
275	Lirceus lineatus	4	CG
276	Lirceus louisianae	4	
272	Lirceus sp.	4	CG
1800	Listronotus sp.	99.9	CF

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2323	Lithasia sp.	6	
2578	Lopescladius sp.	4	
39	Lumbricidae	10	CG
34	Lumbriculida	10	
35	Lumbriculidae	10	CG
2335	Lymnaea sp.	7	SC
2332	Lymnaeidae	7	SC
1367	Lype diversa	3.5	SC
1366	Lype sp.	3.5	SC
561	Maccaffertium annexum	4	
565	Maccaffertium ares	3	
552	Maccaffertium exiguum	5	
556	Maccaffertium integrum	4	
557	Maccaffertium luteum	1	SC
559	Maccaffertium mediopunctatum	2	SC
560	Maccaffertium modestum	3	SC
558	Maccaffertium nepotellum	5	
563	Maccaffertium pulchellum	3	SC
553	Maccaffertium quinquespinum	5	
562	Maccaffertium rubromaculatum	2	
551	Maccaffertium sp.	4	SC
564	Maccaffertium terminatum	4	SC
566	Maccaffertium vicarium	3	SC
193	Macrobdella decora	7	
192	Macrobdella sp.	7	
764	Macromia georgina	3	PR
765	Macromia illinoiensis	3	PR
766	Macromia pacifica	3	
762	Macromia sp.	3	PR
767	Macromia taeniolata	3	PR
759	Macromiidae	4.5	PR
1324	Macronema sp.	2	CF
1325	Macronema zebratum	2	CF
1780	Macronychus glabratus	2	
1779	Macronychus sp.	2	
1978	Macropelopia sp.	7	PR
2217	Macrostemum sp.	2	CF
1918	Mansonia perturbans	8	
1917	Mansonia sp.	8	CG
2315	Marstonia sp.	6	
1749	Matus bicarinatus	99.9	
1748	Matus sp.	99.9	PR
1383	Mayatrichia ayama	1	SC

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1384	Mayatrichia sp.	1	SC
2455	Megalonaias nervosa	1.5	
2454	Megalonaias sp.	1.5	
1175	Megaloptera	3.5	
2342	Menetus sp.	6.5	SC
2211	Meropelopia sp.	3	
1053	Merragata sp.	99.9	PR
2599	Mesogastropoda	99.9	
1056	Mesovelia mulsanti	99.9	PR
1055	Mesovelia sp.	99.9	PR
1054	Mesoveliidae	99.9	PR
493	Metretopodidae	3	
2008	Metriocnemus sp.	6	CG
1061	Metrobates sp.	99.9	PR
1404	Micrasema rusticum	3.5	
1403	Micrasema sp.	3.5	MH
2044	Microchironomus sp.	6	CG
1782	Microcylloepus pusillus	2	CG
1781	Microcylloepus sp.	2	CG
2075	Micropsectra sp.	4	CG
2046	Microtendipes caducus	6	
2047	Microtendipes pedellus	6	CF
2045	Microtendipes sp.	6	CF
1065	Microvelia sp.	99.9	PR
1435	Molanna blenda	3.5	
1434	Molanna sp.	3.5	SC
1436	Molanna tryphena	3.5	
1437	Molanna uniophila	3.5	
1433	Molannidae	3.5	CG
2300	Mollusca	99.9	
2167	Monohelea sp.	5	PR
204	Mooreobdella fervida	8	
205	Mooreobdella microstoma	8	PR
203	Mooreobdella sp.	8	PR
1552	Munroessa sp.	99.9	SH
2156	Muscidae	8	PR
2492	Musculium sp.	5	CF
2493	Musculium transversum	5	CF
1470	Mystacides sepulchralis	2	
1468	Mystacides sp.	2	CG
181	Myzobdella lugubris	7	PR
180	Myzobdella sp.	7	
40	Naididae	10	CG

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59	Nais barbata	10	CG
60	Nais behningi	10	CG
61	Nais bretscheri	10	CG
62	Nais communis	10	CG
63	Nais elinguis	10	CG
64	Nais pardalis	10	CG
65	Nais simplex	10	CG
58	Nais sp.	10	CG
66	Nais variabilis	10	CG
2178	Nanocladius distinctus	3	CG
2009	Nanocladius sp.	3	CG
757	Nasiaeschna pentacantha	2	PR
758	Nasiaeschna sp.	2	PR
1979	Natarsia sp.	6	PR
1073	Naucoridae	99.9	PR
1472	Nectopsyche albida	3	
1473	Nectopsyche candida	3	
1474	Nectopsyche diarina	3	
1475	Nectopsyche exquisita	3	
1476	Nectopsyche pavida	3	
1471	Nectopsyche sp.	3	SH
877	Nehalennia gracilis	7	
878	Nehalennia irene	7	
876	Nehalennia sp.	7	PR
15	Nematomorpha	99.9	PA
938	Nemoura sp.	1	SH
939	Nemoura venosa	1	
936	Nemouridae	1.5	SH
965	Neoperla clymene	1	PR
964	Neoperla sp.	1	PR
1422	Neophylax concinnus	3	
1421	Neophylax sp.	3	SC
1071	Neoplea sp.	99.9	PR
1072	Neoplea striola	99.9	
1385	Neotrichia sp.	4	SC
1078	Nepa apiculata	99.9	
1077	Nepa sp.	99.9	PR
207	Nephelopsis obscura	8	PR
206	Nephelopsis sp.	8	
1076	Nepidae	99.9	PR
1354	Neureclipsis bimaculata	3	CF
1353	Neureclipsis crepuscularis	3	CF
1352	Neureclipsis sp.	3	CF

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776	Neurocordulia molesta	3	PR
777	Neurocordulia obsoleta	3	PR
775	Neurocordulia sp.	3	PR
778	Neurocordulia yamaskanensis	3	
1250	Neuroptera	99.9	PR
1193	Nigronia fasciatus	2	PR
1194	Nigronia serricornis	2	PR
1192	Nigronia sp.	2	PR
2223	Nilobezzia sp.	5	PR
2174	Nilotanypus fimbriatus	6	PR
1980	Nilotanypus sp.	6	PR
2208	Nilothauma sp.	3	
655	Nixe perfida	4	
644	Nixe sp.	4	SC
1069	Notonecta sp.	99.9	PR
1067	Notonectidae	99.9	PR
1355	Nyctiophylax sp.	1	CF
1554	Nymphula sp.	99.9	SH
2457	Obliquaria reflexa	1	
2456	Obliquaria sp.	1	
2459	Obovaria olivaria	1.5	
2458	Obovaria sp.	1.5	
2460	Obovaria subrotunda	1.5	
1386	Ochrotrichia sp.	4	CG
700	Odonata	99.9	PR
1989	Odontomesa sp.	6	CG
2084	Odostomia cincta	10	
2083	Odostomia sp.	10	CG
1478	Oecetis avara	5	PR
1479	Oecetis cinerascens	5	PR
1480	Oecetis eddlestoni	5	PR
1481	Oecetis inconspicua	5	PR
2521	Oecetis nocturna	5	
1482	Oecetis ochracea	5	
1477	Oecetis sp.	5	PR
930	Oemopteryx glacialis	1.5	
929	Oemopteryx sp.	1.5	SH
31	Oligochaeta	10	CG
486	Oligoneuriidae	3	CF
1447	Oligostomis ocelligera	3.5	PR
1446	Oligostomis sp.	3.5	PR
69	Ophidonais serpentina	10	CG
68	Ophidonais sp.	10	

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731	Ophiogomphus rupinsulensis	2	
730	Ophiogomphus sp.	2	PR
1784	Optioservus fastiditus	4	SC
1785	Optioservus ovalis	4	SC
1783	Optioservus sp.	4	SC
1786	Optioservus trivittatus	4	SC
430	Orconectes bisectus	5	
412	Orconectes illinoiensis	5	
413	Orconectes immunis	5	
414	Orconectes indianensis	5	
415	Orconectes kentuckiensis	5	
416	Orconectes lancifer	5	
417	Orconectes placidus	5	
418	Orconectes propinquus	5	
419	Orconectes rusticus	5	
411	Orconectes sp.	5	
420	Orconectes stannardi	5	
421	Orconectes virilis	5	
1864	Ormosia sp.	4	CG
1995	Orthocladiinae	6	CG
2010	Orthocladius sp.	4	CG
2202	Orthocladius sp./Cricotopus sp.	6	
1387	Orthotrichia sp.	1	SC
2085	Oxycera sp.	10	SC
1388	Oxyethira sp.	2	MH
810	Pachydiplax longipennis	8	PR
809	Pachydiplax sp.	8	PR
2251	Pagastiella sp.	6	
429	Palaemonetes kadiakensis	4	
428	Palaemonetes sp.	4	
427	Palaemonidae	4	
1102	Palmacorixa buenoi	99.9	
1103	Palmacorixa gilletteii	99.9	
1104	Palmacorixa nana	99.9	
1101	Palmacorixa sp.	99.9	PR
1942	Palpomyia sp.	6	PR
812	Pantala flavescens	7	
813	Pantala hymenaea	7	
811	Pantala sp.	7	PR
952	Paracapnia angulata	1.5	
953	Paracapnia opis	1.5	
951	Paracapnia sp.	1.5	SH
2194	Parachironomus carinatus	8	PR

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2195	Parachironomus directus	8	
2242	Parachironomus frequens	8	
2049	Parachironomus monochromus	8	
2525	Parachironomus pectinatella	4	
2048	Parachironomus sp.	8	PR
2520	Parachironomus tenuicaudatus	8	
2537	Paracladopelma nereis	4	CG
2050	Paracladopelma sp.	4	CG
2233	Paracloeodes minutus	5	
527	Paracloeodes sp.	4	SC
1679	Paracymus sp.	99.9	PR
1680	Paracymus subcupreus	99.9	
967	Paragnetina media	1.5	PR
966	Paragnetina sp.	1.5	PR
2216	Parakiefferiella sp.	5	
2243	Paralauterborniella nigrohalteralis	6	
2052	Paralauterborniella sp.	6	CG
616	Paraleptophlebia moerens	2	
617	Paraleptophlebia ontario	2	
618	Paraleptophlebia praepedita	2	
615	Paraleptophlebia sp.	2	CG
619	Paraleptophlebia sticta	2	
2173	Paramerina sp.	6	PR
2011	Parametriocnemus sp.	4	CG
67	Paranais frici	10	
110	Paranais sp.	10	
2179	Paraphaenocladius sp.	6	CG
1555	Paraponyx sp.	99.9	SH
1327	Parapsyche apicalis	5.5	
1326	Parapsyche sp.	5.5	PR
2076	Paratanytarsus sp.	6	CG
2244	Paratendipes albimanus	3	
2053	Paratendipes sp.	3	CG
1865	Pedicia sp.	4	PR
2400	Pelecypoda	99.9	CF
1075	Pelocoris femoratus	99.9	PR
1074	Pelocoris sp.	99.9	PR
1770	Pelonomus obscurus	4	
1769	Pelonomus sp.	4	CG
1638	Peltodytes dunavani	99.9	
1637	Peltodytes duodecimpunctatus	99.9	
1639	Peltodytes lengi	99.9	
1640	Peltodytes sexmaculatus	99.9	

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1636	Peltodytes sp.	99.9	SH
635	Pentagenia sp.	4	CF
636	Pentagenia vittigera	4	CG
1981	Pentaneura sp.	3	PR
1934	Pericoma sp.	11	CG
814	Perithemis sp.	4	PR
815	Perithemis tenera	4	PR
969	Perlesta placida	4	
968	Perlesta sp.	4	PR
954	Perlidae	1.5	PR
972	Perlinella drymo	2	PR
973	Perlinella ephyre	2	PR
970	Perlinella sp.	2	PR
976	Perlodidae	1.5	PR
1556	Petrophila sp.	5	SC
2055	Phaenopsectra flavipes	4	SC
2507	Phaenopsectra obediens gr.	4	
2245	Phaenopsectra punctipes gr.	4	
2054	Phaenopsectra sp.	4	SC
209	Pharyngobdellidae	8	
975	Phasganophora capitata	1.5	
974	Phasganophora sp.	1.5	PR
195	Philobdella gracilis	7	PR
194	Philobdella sp.	7	
1338	Philopotamidae	3.5	CF
1448	Phryganea sp.	3	
1438	Phryganeidae	3.5	SH
1357	Phylocentropus placidus	3.5	
1356	Phylocentropus sp.	3.5	CF
2351	Physa acuta	9	
2361	Physa integra	9	CG
2330	Physa sp.	9	SC
2352	Physella sayi	9	
2331	Physella sp.	9	SC
2328	Physidae	9	SC
1866	Pilaria sp.	4	PR
183	Piscicola milneri	7	PR
184	Piscicola punctata	7	PR
182	Piscicola sp.	7	PR
186	Piscicolaria reducta	7	
185	Piscicolaria sp.	7	
177	Piscicolidae	7	
2499	Pisidiidae	5	

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2494	Pisidium sp.	5	CF
168	Placobdella montifera	8	PR
170	Placobdella multilineata	8	PR
171	Placobdella ornata	8	PR
172	Placobdella papillifera	8	PA
173	Placobdella parasitica	8	PA
174	Placobdella pediculata	8	
169	Placobdella sp.	8	PR
2462	Plagiola lineolata	1.5	
7	Planaria sp.	6	
4	Planariidae	6	
2343	Planorbella sp.	6.5	SC
2357	Planorbella truncata	6.5	
2339	Planorbidae	6.5	SC
2344	Planorbula sp.	7	SC
817	Plathemis lydia	3	PR
816	Plathemis sp.	3	PR
1424	Platycentropus radiatus	3	
1423	Platycentropus sp.	3	SH
1	Platyhelminthes	99.9	
660	Plauditus armillatus	4	
657	Plauditus punctiventris	3	
651	Plauditus sp.	3	
925	Plecoptera	1.5	PR
1070	Pleidae	99.9	PR
2464	Plethobasus cyphyus	1.5	
2463	Plethobasus sp.	1.5	
2466	Pleurobema cordatum	1.5	
2465	Pleurobema sp.	1.5	
2325	Pleurocera acuta	7	SC
2324	Pleurocera sp.	7	SC
2319	Pleuroceridae	6	
1349	Polycentropodidae	3.5	CF
1359	Polycentropus centralis	3	PR
1360	Polycentropus cinereus	3	PR
1361	Polycentropus flavus	3	PR
1362	Polycentropus glacialis	3	PR
1363	Polycentropus interruptus	3	PR
1364	Polycentropus remotus	3	PR
1358	Polycentropus sp.	3	PR
637	Polymitarcyidae	3	CG
2540	Polypedilum aviceps	6	
2058	Polypedilum convictum gr.	6	SH

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2065	Polypedilum digitifer	6	SH
2060	Polypedilum fallax	6	SH
2541	Polypedilum flavum	6	
2061	Polypedilum halterale	4	SH
2062	Polypedilum illinoense	5	SH
2059	Polypedilum obtusum	6	SH
2063	Polypedilum scalaenum	6	SH
2064	Polypedilum simulans	6	SH
2057	Polypedilum sp.	6	SH
2326	Pomatiopsidae	6	
2327	Pomatiopsis sp.	6	
620	Potamanthidae	5	CF
105	Potamothrix vejdovskyi	10	
1329	Potamyia flava	4	CF
1328	Potamyia sp.	4	CF
1990	Potthastia sp.	6	
1867	Prionocera sp.	4	SH
1802	Prionocyphon sp.	7	SC
71	Pristina aequiseta	10	CG
73	Pristina breviseta	10	CG
72	Pristina leidyi	10	CG
74	Pristina longiseta	10	
75	Pristina osborni	10	CG
70	Pristina sp.	10	CG
76	Pristina synclites	10	CG
1943	Probezzia sp.	5	PR
2316	Probythinella sp.	6	
423	Procambarus acutus	5	SH
424	Procambarus clarki	5	
425	Procambarus gracilis	5	
422	Procambarus sp.	5	SH
426	Procambarus viaeviridis	5	
1982	Procladius sp.	8	PR
643	Procloeon sp.	4	
1991	Prodiamesa sp.	3	CG
733	Progomphus obscurus	5	PR
732	Progomphus sp.	5	PR
2345	Promenetus sp.	6.5	CG
1787	Promoresia sp.	5	SC
2468	Proptera alata	1	
2469	Proptera capax	1	
2470	Proptera laevissimus	1	
2467	Proptera sp.	1	

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1950	Prosimulium magnum	2	
1951	Prosimulium mixtum	2	
1949	Prosimulium sp.	2	CF
940	Prostoia sp.	1.5	SH
1375	Protoptila sp.	1	SC
2012	Psectrocladius sp.	5	CG
1983	Psectrotanypus sp.	8	PR
1614	Psephenidae	4	SC
1615	Psephenus herricki	4	SC
1616	Psephenus sp.	4	SC
2198	Pseudochironomus fulviventris	5	
2199	Pseudochironomus prasinatus	5	
2066	Pseudochironomus sp.	5	CG
522	Pseudocloeon carolina	4	
523	Pseudocloeon dubium	4	SC
524	Pseudocloeon myrsum	4	
525	Pseudocloeon parvulum	4	
656	Pseudocloeon propinquus gr.	4	
526	Pseudocloeon punctiventris	4	
521	Pseudocloeon sp.	4	SC
1992	Pseudodiamesa sp.	1	CG
1868	Pseudolimnophila sp.	2	PR
2013	Pseudorthocladius sp.	6	CG
1425	Pseudostenophylax sp.	3.5	SH
1426	Pseudostenophylax uniformis	3.5	
2355	Pseudosuccinea columella	7	SC
2336	Pseudosuccinea sp.	7	SC
2597	Psilometriocnemus sp.	6	
1920	Psorophora ciliata	8	
1921	Psorophora confinnis	8	PR
1922	Psorophora cyanescens	8	
1923	Psorophora discolor	8	
1924	Psorophora ferox	8	
1925	Psorophora horrida	8	
1926	Psorophora howardi	8	
1919	Psorophora sp.	8	PR
1927	Psorophora varipes	8	
1935	Psychoda sp.	11	CG
1933	Psychodidae	11	CG
1369	Psychomyia flavida	2	CG
1368	Psychomyia sp.	2	SC
1365	Psychomyiidae	3.5	CG
927	Pteronarcys sp.	2	SH

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1449	Ptilostomis sp.	3	SH
2472	Ptychobranchus fasciolaris	1.5	
2471	Ptychobranchus sp.	1.5	
2081	Ptychoptera sp.	8	CG
2079	Ptychopteridae	8	CG
1428	Pycnopsyche guttifer	3	SH
1429	Pycnopsyche lepida	3	
1430	Pycnopsyche luculenta	3	
1431	Pycnopsyche scabripennis	3	SH
1427	Pycnopsyche sp.	3	SH
1432	Pycnopsyche subfasciata	3	SH
1551	Pyralidae	99.9	SH
2317	Pyrgulopsis sp.	6	SC
2474	Quadrula cyclindrica	1.5	
2475	Quadrula metanerva	1.5	
2476	Quadrula nodulata	1.5	
2477	Quadrula pustulosa	1.5	
2478	Quadrula quadrula	1.5	
2473	Quadrula sp.	1.5	
108	Quistradrilus multisetosus	10	CG
1106	Ramphocorixa acuminata	99.9	
1105	Ramphocorixa sp.	99.9	PR
1079	Ranatra fusca	99.9	PR
1081	Ranatra kirkaldyi	99.9	PR
1082	Ranatra nigra	99.9	PR
1080	Ranatra sp.	99.9	PR
2594	Raphium sp.	99.9	
994	Rasvena sp.	1.5	
995	Rasvena terna	1.5	CG
1066	Rhagovelia sp.	99.9	PR
2595	Rhamphomyia sp.	1	
1752	Rhantus binotatus	99.9	
1751	Rhantus sp.	99.9	PR
2180	Rheocricotopus fuscipes	6	
2246	Rheocricotopus robacki	6	
2014	Rheocricotopus sp.	6	CG
2225	Rheopelopia sp.	3	PR
2077	Rheotanytarsus sp.	6	CF
1062	Rheumatobates sp.	99.9	PR
545	Rhithrogena pellucida	0	SC
544	Rhithrogena sp.	0	SC
1393	Rhyacophila fenestra	1	
1394	Rhyacophila fuscula	1	PR

Functional Feeding Group (ffg)
SC=scraper, PA=parasite, PR=predator, OM=omnivore, GC=gatherer/collector, FC=filter/collector, SH=shredder, PI=piercer
99.9=Taxon excluded from mIBI computation

1395	Rhyacophila lobifera	1	
1392	Rhyacophila sp.	1	PR
1396	Rhyacophila vibox	1	
1391	Rhyacophilidae	3.5	PR
151	Rhynchobdellida	8	
2218	Robackia sp.	3	CG
2067	Saetheria sp.	6	CG
2153	Sciomyzidae	10	PR
1627	Scirtes orbiculatus	7	
1626	Scirtes sp.	7	SH
1628	Scirtes tibialis	7	
2514	Seatheria tylus	4	
1489	Sericostomatidae	3.5	SH
595	Serratella deficiens	1	CG
597	Serratella sordida	1	CG
594	Serratella sp.	1	CG
2596	Serromyia sp.	5	
1483	Setodes sp.	3.5	
1176	Sialidae	3.5	PR
1180	Sialis infumata	4	
1181	Sialis itasca	4	
1183	Sialis mohri	4	PR
1177	Sialis sp.	4	PR
1184	Sialis vagans	4	
1185	Sialis velata	4	
1108	Sigara alternata	99.9	
1109	Sigara compressoidea	99.9	
1111	Sigara hubbelli	99.9	
1113	Sigara modesta	99.9	
1115	Sigara signata	99.9	
1107	Sigara sp.	99.9	PR
1946	Simuliidae	6	CF
1953	Simulium clarkei	4	
1954	Simulium corbis	0	
1955	Simulium decorum	4	CF
1956	Simulium jenningsi	4	CF
1957	Simulium luggeri	2	
1958	Simulium meridionale	1	CF
1952	Simulium sp.	6	CF
1959	Simulium tuberosum	4	CF
1960	Simulium venustum	6	CF
1961	Simulium verecundum	6	
1962	Simulium vittatum	8	CF

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99.9=Taxon excluded from mIBI computation

477	Siphlonuridae	3	CG
483	Siphlonurus alternatus	2	
484	Siphlonurus quebecensis	2	
485	Siphlonurus rapidus	2	
482	Siphlonurus sp.	2	CG
495	Siphloplecton basale	2	
496	Siphloplecton interlineatum	2	
494	Siphloplecton sp.	2	CG
1254	Sisyra sp.	1	PR
1255	Sisyra vicaria	1	
1251	Sisyridae	1	PR
78	Slavina appendiculata	10	CG
77	Slavina sp.	10	CG
2015	Smittia sp.	6	CG
781	Somatochlora filosa	1	
782	Somatochlora linearis	1	PR
779	Somatochlora sp.	1	PR
783	Somatochlora tenebrosa	1	
2318	Somatogyrus sp.	6	
941	Soyedina sp.	1.5	SH
80	Specaria josinae	10	CG
79	Specaria sp.	10	CG
2491	Sphaeriidae	5	
2495	Sphaerium sp.	5	CG
2224	Sphaeromias sp.	5	
1390	Stactobiella palmata	3.5	
1389	Stactobiella sp.	3.5	SH
2338	Stagnicola emarginatus	7	
2337	Stagnicola sp.	7	SC
2219	Stelechomyia	6	CG
2247	Stelechomyia pulpulchra	99.9	CG
2226	Stempellina sp.	2	CG
2212	Stempellinella sp.	2	CG
548	Stenacron interpunctatum	4	
550	Stenacron sp.	4	SC
1789	Stenelmis bicarinata	7	SC
1790	Stenelmis crenata	7	
1791	Stenelmis decorata	7	SC
1792	Stenelmis lateralis	7	SC
1793	Stenelmis markeli	7	SC
1794	Stenelmis mera	7	SC
1795	Stenelmis musgravei	7	SC
1796	Stenelmis sexlineata	7	SC

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99.9=Taxon excluded from mIBI computation

1788	Stenelmis sp.	7	SC
1797	Stenelmis vittipennis	6	
2069	Stenochironomus hilaris	3	CG
2068	Stenochironomus sp.	3	SH
554	Stenonema femoratum	7	SC
659	Stenonema sp.	4	SC
81	Stephensoniana sp.	10	
82	Stephensoniana trivandrana	10	CG
2519	Stictochironomus caffrarius	5	
2248	Stictochironomus devinctus	5	
2070	Stictochironomus sp.	5	
1945	Stilobezzia sp.	5	
2220	Stilocladius sp.	6	
2082	Stratiomyidae	10	CG
2087	Stratiomys discalis	10	
2088	Stratiomys meigeni	10	
2086	Stratiomys sp.	10	CF
2479	Strophitus sp.	4	
2480	Strophitus undulatus	4	
932	Strophopteryx fasciata	1.5	SH
931	Strophopteryx sp.	1.5	
330	Stygobromus sp.	4	PR
331	Stygobromus subtilis	4	
84	Stylaria fossularis	10	CG
85	Stylaria lacustris	10	CG
83	Stylaria sp.	10	
736	Stylogomphus albistylus	4.5	PR
734	Stylogomphus sp.	4.5	PR
737	Stylurus sp.	7	PR
2228	Sublettea sp.	6	CF
819	Sympetrum ambiguum	4	PR
820	Sympetrum corruptum	4	
821	Sympetrum obstrusum	4	
822	Sympetrum rubicundulum	4	
823	Sympetrum semicinctum	4	
818	Sympetrum sp.	4	PR
824	Sympetrum vicinum	4	
1993	Sympotthastia sp.	6	CG
1557	Synclita sp.	99.9	SH
1994	Syndiamesa sp.	6	CG
2148	Syrphidae	11	CG
2089	Tabanidae	7	PR
2126	Tabanus atratus	7	

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2127	Tabanus cymatophorus	7	
2128	Tabanus fairchildi	7	
2130	Tabanus lineola	7	
2131	Tabanus marginalis	7	
2132	Tabanus nigrescens	7	
2133	Tabanus pumilus	7	
2134	Tabanus quinquevittatus	7	
2135	Tabanus reinwardtii	7	
2125	Tabanus sp.	7	PR
2136	Tabanus sparus	7	
2137	Tabanus stygius	7	
2139	Tabanus subsimilis	7	
2140	Tabanus sulcifrons	7	
2141	Tabanus superjumentarius	7	
2142	Tabanus trimaculatus	7	
928	Taeniopterygidae	1.5	SH
934	Taeniopteryx nivalis	2	SH
935	Taeniopteryx parvula	2	SH
933	Taeniopteryx sp.	2	SH
2206	Tanypodinae	6	PR
2516	Tanypus carinatus	8	
2175	Tanypus neopunctipennis	8	
2508	Tanypus punctipennis	8	
1984	Tanypus sp.	8	PR
2515	Tanypus stellatus	8	
2207	Tanytarsini	6	CF
2231	Tanytarsus glabrescan	7	
2230	Tanytarsus guerlus	7	
2078	Tanytarsus sp.	7	CF
2165	Telmatoscopus sp.	11	CG
785	Tetragoneuria cynosura	4.5	PR
784	Tetragoneuria sp.	4.5	PR
1754	Thermonectus basillaris	99.9	PR
1755	Thermonectus ornaticollis	99.9	
1753	Thermonectus sp.	99.9	PR
176	Theromyzon biannulatum	8	
175	Theromyzon sp.	8	PR
2016	Thienemanniella sp.	2	CG
2017	Thienemanniella xena	2	CG
2176	Thienemannimyia senata	6	
1985	Thienemannimyia sp.	6	PR
1854	Tipula sp.	4	SH
1853	Tipulidae	4	SH

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99.9=Taxon excluded from mIBI computation

641	Tortopus sp.	4	CG
2500	Toxolasma paruvus	7	
2424	Toxolasma texasensis	7	
826	Tramea carolina	4	PR
827	Tramea lacerata	4	
828	Tramea onusta	4	
825	Tramea sp.	4	PR
1063	Trepobates sp.	99.9	PR
1486	Triaenodes injustus	3	
1487	Triaenodes marginatus	3	sh
1484	Triaenodes sp.	3	MH
1488	Triaenodes tardus	3	SH
2197	Tribelos fuscicorne	4	CG
2232	Tribelos jucundus	5	
2071	Tribelos sp.	5	CG
1118	Trichocorixa calva	99.9	
1119	Trichocorixa kanza	99.9	
1120	Trichocorixa macroceps	99.9	
1117	Trichocorixa sp.	99.9	PR
1300	Trichoptera	3.5	
3	Tricladida	6	CG
599	Tricorythodes sp.	5	CG
2481	Tritogonia sp.	1	
2482	Tritogonia verrucosa	1	
1682	Tropisternus blatchleyi	99.9	
1684	Tropisternus lateralis	99.9	CG
1685	Tropisternus mixtus	99.9	
1686	Tropisternus natator	99.9	
1681	Tropisternus sp.	99.9	PR
2484	Truncilla donaciformis	1	
2483	Truncilla sp.	1	
2485	Truncilla truncata	1	
103	Tubifex sp.	10	CG
104	Tubifex tubifex	10	CG
212	Tubificida	10	
92	Tubificidae	10	CG
2	Turbellaria	6	PR
2213	Tvetenia sp.	5	
86	Uncinais sp.	10	
87	Uncinais uncinata	10	
2486	Uniomerus sp.	1.5	
2487	Uniomerus tetralasmus	1.5	
2401	Unionidae	1.5	CF

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99.9=Taxon excluded from mIBI computation

2600	Unionoida	99.9	
1929	Uranotaenia sapphirina	8	
1928	Uranotaenia sp.	8	CF
1756	Uvarus sp.	99.9	PR
2307	Valvata sp.	2	SC
2306	Valvatidae	6	SC
89	Vejdovskyella intermedia	10	CG
88	Vejdovskyella sp.	10	CG
1064	Veliidae	99.9	PR
2601	Veneroida	5	
2489	Villosa iris	1	
2490	Villosa lienosa	1	
2488	Villosa sp.	1	
2302	Viviparidae	6	SC
2305	Viviparus sp.	1	SC
91	Wapsa mobilis	10	
90	Wapsa sp.	10	
1348	Wormaldia shawnee	3.5	
1346	Wormaldia sp.	3.5	CF
2072	Xenochironomus sp.	4	PR
2513	Xenochironomus xenolabis	6	
2227	Xestochironomus sp.	6	
2249	Xylotopus par.	6	
2200	Zalutschia sp.	6	SH
3433	Zavreliella sp.	2	
2254	Zavreliella marmorata	2	
2235	Zavrelimyia sinuosa com	8	
1986	Zavrelimyia sp.	8	PR
829	Zygoptera	99.9	PR

Functional Feeding Group (ffg)
SC=scraper, PA=parasite, PR=predator, OM=omnivore, GC=gatherer/collector, FC=filter/collector, SH=shredder, PI=piercer
99.9=Taxon excluded from mIBI computation

Appendix B. Methods utilized to determine the types and amounts of pertinent macroinvertebrate habitats in perennial wadeable streams for 20-jab allocation.

Use the average stream width in the sampling reach to allocate jabs between bank-zone and bottom-zone habitats. Use Table 1 (see below) to identify all pertinent, macroinvertebrate habitats. Note that Table 1 definitions were developed exclusively for 20-jab collections and may not fulfill the requirements of other sampling methods.

Table 1 (Appendix B). 20-jab macroinvertebrate collection-zone criteria and categories plus habitat types.

Mean water width (to nearest foot)	Assumed width of bank-zone	Bank-zone jabs	Bottom-zone jabs
< 10 ft	25% of water width per bank	10	10
10-29 ft	20% of water width per bank	8	12
30-59 ft	15% of water width per bank	6	14
≥60	10% of water width per bank	4	16

Bottom-zone habitat type	Definition
- *Fine substrate*:	Streambed surface predominantly comprising silt/mud to fine gravel (i.e., particles < 8mm in diameter of intermediate dimension).
- *Coarse substrate*:	Streambed surface predominantly comprising medium gravel to boulder (i.e., particles ≥ 8 mm in diameter of intermediate dimension).
- *Plant detritus*:	Streambed surface predominantly comprising nonliving plant material (e.g., leaves, twigs).
- *Vegetation*:	Streambed surface predominantly comprising living plant material (e.g., aquatic macrophytes, filamentous algae, submerged terrestrial plants).

Bank-zone habitat type	Definition
- *Submerged terrestrial vegetation:*	Living, terrestrial plants (along stream banks) of which submerged portions provide cover or attachment sites for macroinvertebrates.
- *Submerged tree roots*:	Living tree roots (along stream banks) of which submerge portions provide cover or attachment sites for macroinvertebrates.
- *Brush-debris jams*:	Non-living, submerged, woody material (e.g., branches, twigs, smaller logs) that occurs above the streambed surface and that appears to have microbial conditioning. Exclude recent deadfall that lacks microbial conditioning.

When using the definitions in Table 1, (see above) base all classifications on conditions that exist within the sample reach at the time of the macroinvertebrate collection. If water turbidity or excessive depth prevents seeing the entire wetted stream channel throughout the sampling reach, the sampler may use tactile cues to obtain a reasonably accurate estimate of the amount of each habitat type. However, in most cases, if more than half of the wetted stream channel cannot be seen, touched, or otherwise appropriately-characterized, it is unknown that the 20-jab method will apply.

Habitat characterization methods

Two approved habitat characterization methods exist for use with the 20-jab sample approach. Review the criteria (see below) included with the 11-transect and the non-transect methods and decide which of the two habitat characterizations apply. Based on this decision, use the pre-defined habitat types (Table 1 above) and the chosen characterization method to determine the amount of pertinent macroinvertebrate habitat present in the sample reach. It is important to note the difference between 11-transect and non-transect methods. The 11-transect method establishes 11- equally spaced transects, which results in a relatively consistent number of observation points based on stream width. It should also be pointed out that observations taken along the transect do not always represent the predominant substrate at a given point. In many situations there is an intermixture of substrates types along a transect (e.g. silt, sand and fine gravel). In these circumstances an equal number of points in a transect are assigned to each of the substrate types in the intermixture (e.g. 3-silt, 3-sand, 3-fine gravel). More importantly, it is unknown how well the substrate types observed at the established points along a transect represent the relative amounts of substrate types that occur between the transects. These unknowns may be significant since the area between the transects is the majority of the sample reach. Conversely, the non-transect approach provides an estimate of the relative amounts of each substrate type throughout the sample reach. Both the 11-transect and non-transect methods rely on visual and tactile cues and both methods provide estimates that account for the intermixture of substrates as described above.

1.0 11-transect habitat characterization method

Use the 11-transect method if: the type or amount of habitat encountered during the last appraisal differs obviously from the present appraisal OR; the 11-transect habitat method has never been applied in the sample reach OR; the habitat appraisal would be made by qualified, trained personnel with fewer than two years of experience in measuring and characterizing instream physical habitat (including stream-bottom composition) for purposes of natural-resource management.

Table 2 (Appendix B). 11-transect "point-increment" habitat categories.

Substrates Types:

Name	Particle-Size Range
[1]*Silt/mud*	*< 0.062 mm*
[1]*Sand*	*0.062 – 2 mm*
[1]*Fine gravel*	*2 – 8 mm*
[2]*Medium gravel*	*8 – 16 mm*
[2]*Coarse gravel*	*16 – 64 mm*
[2]*Small cobble*	*64 – 128 mm*
[2]*Large cobble*	*128 – 256 mm*
[2]*Boulder*	*256 – 4000 mm*
Bedrock	*> 4000 mm*

Bottom Types:

Claypan/Compacted soil
[3]*Plant detritus*

[4]*Vegetation*
[5]*Submerged log*
Other (please specify)

Instream Cover Types:

[6]*Submerged terrestrial vegetation*
[7]*Submerged tree roots*
[5]*Brush-debris jam*
Boulder (not embedded)
Undercut bank
Rock/clay ledge
[5]*Log*
[4]*Aquatic vegetation*
Other (please specify)

Point-increment observation to collection-zone translation
[1]*Fine substrate* (Bottom-zone habitat type)
[2]*Coarse substrate* (Bottom-zone habitat type)
[3]*Plant detritus* (Bottom-zone habitat type)
[4]Vegetation (Bottom-zone OR Bank-zone) (macrophytes, filamentous algae and submerged terrestrial vegetation)
[5]*Brush-debris jams* (Bank-zone habitat type)
[6]*Submerged terrestrial vegetation* (Bank-zone habitat type)
[7]*Submerged tree roots* (Bank-zone habitat type)

- When applicable, coarsely measure and estimate habitat conditions by applying the appropriate parts of the 11-transect method as described in *Section E:* of this manual. Specifically, use the point-transect approach to identify the predominant "substrate type" or "bottom type" (Table 2 in Appendix B) at each of many points distributed regularly on the wetted stream bed throughout the entire sampling reach. Also, per each of ten segments in the sampling reach, coarsely measure the area occupied by each of the nine "instream cover type"(s) (Table 2 in Appendix B). Often there is an intermixture of substrate types. In these situations an equal number of points in a transect are assigned to each of the substrate types in the intermixture (e.g. 3-silt, 3-sand, 3-fine gravel). Instream cover is measured in square feet for the 11-transect method.

Bottom-zone habitat classification based on 11-transect methodology

Refer to the assumed width of bank-zone criteria provided in Table 1 to determine the width of the bottom-zone.

Based on 11-transect habitat information, translate each of the pertinent point-increment transect observations of "*substrate*" and "*bottom type*" (Table 2) into an observation point that is classified as one of the four corresponding 20-jab "*bottom-zone"* habitat types (Table 1). Note that claypan and bedrock are not considered as a bottom-zone habitat type for applying the 20-jab method and the area of wetted stream bottom that consists of claypan should be ignored (in the denominator in Equation 1) when considering the relative percentage of relevant bottom-zone habitat types. Explicit translation instructions are included in the Table 2 footnotes.

Per each of the four 20-jab bottom-zone habitat types, calculate the number of times a specified types occur among all of the 11-transect point-increment observations.

Use Equation 1 (see below) to calculate the relative percentage of each of the four, 20-jab, bottom-zone habitat types in the sampling reach as:

Equation 1. *Relative percentage of each bottom-zone habitat type =*

$$\frac{\text{Sum of the points (from all transects) at which the bottom-zone habitat type occurred}}{\text{Sum of the points (from all transects) at which any of the four bottom-zone habitat types occurred}} \times 100$$

Record the relative percentage result for each, 20-jab, bottom-zone habitat type. Note: claypan and bedrock are not included in bottom zone allocations (Table 2).

Bank-zone habitat classification based on 11-transect methodology

Refer to the assumed width of bank-zone criteria provided in Table 1 to determine the width of the bank-zone collection area.

Submerged terrestrial vegetation

- With the 11-transect habitat characterization method, the spatial coverage of submerged terrestrial vegetation is determined for both banks within each of the ten stream segments delineated by the eleven transects. In each of the ten segments, use a known distance such as the length of a wading rod or the distance between transects, to coarsely measure the total length (ft) of *submerged terrestrial vegetation* present (Table 2). Sum the ten segment totals and record this grand total as the amount of *submerged terrestrial vegetation* that occurs along the banks of the sample reach. The linear amount (ft) of submerged terrestrial vegetation that occurs along the banks of the sample reach- as determined by the 11-transect method- is considered equivalent to the amount of submerged terrestrial vegetation that occurs in the assumed bank-zone of the 20-jab collection area.

Submerged tree roots

- With the 11-transect habitat characterization method, the spatial coverage of submerged tree roots is determined for both banks within each of the ten stream segments delineated by the eleven transects. In each of the ten segments, use known distance such as the length of a wading rod or the distance between transects, to coarsely measure the total length (ft) of *submerged tree roots* present (Table 2). Sum the ten segment totals and record this grand total as the amount of *submerged tree roots* that occurs along the banks of the sample reach. The linear amount (ft) of submerged tree roots that occurs along the banks of the sample reach- as determined by the 11-transect method- is considered equivalent to the amount of submerged tree roots that occurs in the assumed bank-zone of the 20-jab collection area.

Brush-debris jams

- The amount of *log* plus *brush-debris jam* habitat is calculated in a slightly different manner than the previous two bank-zone habitats. Here, consider each *log* plus *brush-debris jams* as bank-zone habitat, regardless of where the woody materials are located in the sample reach— provided that the woody material occurs at a depth and water velocity that allow safe and sufficient sampling of macroinvertebrates with a dip net. Coarsely measure the single longest dimension covered by each log and brush-debris jam. Sum these lengths to yield the total length of *logs* plus *brush-debris jams* within each of the ten stream segments. In turn, sum the ten segment totals and record the grand total length of *log* plus *brush-debris jams* that occurs in the sample reach.

Use Equation 2 (see below) to calculate the relative percentage of each bank-zone habitat type in the sampling reach as

Equation 2. Relative percentage of each bank-zone habitat type =

$$\frac{\textit{Total length that a given bank-zone habitat type occurred in the sample reach}}{\textit{Sum of total length for each of the three bank-zone habitat types that occur in the sample reach}} \times 100$$

Record the relative percentage of each bank-zone habitat type.

2.0 Non-Transect habitat characterization method

For qualified, trained personnel having two or more years of experience in measuring and characterizing instream physical habitat (including stream-bottom composition) for purposes of natural-resource management, use either the 11-transect (see above) or the non-transect approach to characterize macroinvertebrate habitat within the sample reach.

Bottom-zone habitat classification based on non-transect estimations

- Estimate and record the percent surface area of the relevant portion of wetted stream bottom that consists of each of the four bottom-zone habitat types (Table 1). Note that claypan and bedrock are not considered as a bottom-zone habitat type for applying the 20-jab method and the area of wetted stream bottom that consists of claypan should be ignored (in the denominator in Equation 1) when considering the relative percentage of relevant bottom-zone habitat types.

Bank-zone habitat classification based on non-transect estimations

- Estimate and record the percentage of bank length occupied by each of the three bank-zone habitat types. Estimate and record *logs* plus *submerged terrestrial vegetation* (Table 1 in Appendix B) and *submerged tree roots* (Table 1 in Appendix B) as the length of bank-zone covered by each habitat type in the sampling reach. When estimating the amount of *logs* plus *brush-debris jams (*Table 1*)* in the sampling reach, consider all logs and brush-debris jams as bank-zone habitat, regardless of where the snag occurs in the sample reach—provided that the log and brush-debris jam occurs at a depth and water velocity that allow safe and sufficient sampling of macroinvertebrates with a dip-net. Estimate the single longest dimension covered by each log and brush-debris jam and then sum these lengths to yield the total length of *logs* plus *Brush-debris jams* in the sample reach. The percentage of bank length is from IEPA STREAM ASSESSMENT FORM-Non-Transect Habitat Information.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to specify a consistent sample nomenclature system that will facilitate subsequent data management in a cost-effective manner. The sample nomenclature system has been devised such that the following objectives can be attained:

- Sorting of data by matrix
- Sorting of data by depth
- Maintenance of consistency (field, laboratory, and database sample numbers)
- Accommodation of all project-specific requirements
- Accommodation of laboratory sample number length constraints (maximum of 20 characters)

2.0 SCOPE

The methods described in this SOP shall be used consistently for all projects requiring electronic data. Other contract- or project-specific sample nomenclature requirements may also be applicable.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Program Manager - It shall be the responsibility of the Project Manager (or designee) to inform contract-specific Project Managers (PMs) of the existence and requirements of this SOP.

Project Manager - It shall be the responsibility of the PM to determine the applicability of this SOP based on: (1) program-specific requirements and (2) project size and objectives. It shall be the responsibility of the PM (or designee) to ensure that sample nomenclature requirements are thoroughly specified in the relevant project planning document (e.g., sampling and analysis plan) and are consistent with this SOP if relevant. It shall be the responsibility of the PM to ensure that the FOL is familiar with the sample nomenclature system.

Field Operations Leader (FOL) - It shall be the responsibility of the FOL to ensure that all field technicians or sampling personnel are thoroughly familiar with this SOP and the project-specific sample nomenclature system. It shall be the responsibility of the FOL to ensure that the sample nomenclature system is used during all project-specific sampling efforts.

General personnel qualifications for sample nomenclature activities in the field include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for field documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 INTRODUCTION

The sample identification (ID) system can consist of as few as eight but not more than 20 distinct alpha-numeric characters. The sample ID will be provided to the laboratory on the sample labels and chain-of-custody forms. The basic sample ID provided to the laboratory has three segments and shall be as follows, where "A" indicates "alpha," and "N" indicates "numeric":

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**
Site Identifier	Sample Type	Sample Location

Additional segments may be added as needed. For example:

(1) Soil and sediment sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NNNN 4 Characters**
Site identifier	Sample type	Sample location	Sample depth

(2) Aqueous (groundwater or surface water) sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**NN 2 Characters**	**-A 1 Character**
Site identifier	Sample type	Sample location	Round number	Filtered sample only

(3) Biota sample ID

A or N 3 or 4 Characters	**AAA 2 or 3 Characters**	**A or N 3 to 6 Characters**	**AA 2 Characters**	**NNN 3 Characters**
Site identifier	Sample type	Sample location	Species identifier	Sample group number

5.2 SAMPLE IDENTIFICATION FIELD REQUIREMENTS

The various fields in the sample ID include but are not limited to the following:

- Site identifier
- Sample type
- Sample location
- Sample depth
- Sampling round number
- Filtered
- Species identifier
- Sample group number

The site identifier must be a three- or four-character field (numeric characters, alpha characters, or a mixture of alpha and numeric characters may be used). A site number is necessary because many

facilities/sites have multiple individual sites, Solid Waste Management Units (SWMUs), Operable Units (OUs), etc. Several examples are presented in Section 5.3 of this SOP.

The sample type must be a two- or three-character alpha field. Suggested codes are provided in Section 5.3 of this SOP.

The sample location must be at least a three-character field but may have up to six characters (alpha, numeric, or a mixture). The six characters may be useful in identifying a monitoring well to be sampled or describing a grid location.

The sample depth field is used to note the depth below ground surface (bgs) at which a soil or sediment sample is collected. The first two numbers of the four-number code specify the top interval, and the third and fourth specify the bottom interval in feet bgs of the sample. If the sample depth is equal to or greater than 100, then only the top interval would be represented and the sampling depth would be truncated to three characters. The depths will be noted in whole numbers only; further detail, if needed, will be recorded on the sample log sheet or boring log, in the logbook, etc.

A two-digit round number will be used to track the number of aqueous samples collected from a particular aqueous sample location. The first sample collected from a location will be assigned the round identifier 01, the second 02, etc. This applies to both existing and proposed monitoring wells and surface water locations.

Aqueous samples that are field filtered (dissolved analysis) will be identified with an "-F" in the last field segment. No entry in this segment signifies an unfiltered (total) sample.

The species identifier must be a two-character alpha field. Several suggested codes are provided in Section 5.3 of this SOP.

The three-digit sample group number will be used to track the number of biota sample groups (a particular group size may be determined by sample technique, media type, the number of individual caught, weight issues, time, etc.) by species and location. The first sample group of a particular species collected from a given location will be assigned the sample group number 001, and the second sample group of the same species collected from the same location will be assigned the sample group number 002.

5.3 EXAMPLE SAMPLE FIELD DESIGNATIONS

Examples of each of the fields are as follows:

Site identifier - Examples of site numbers/designations are as follows:

A01 - Area of Concern (AOC) 1
125 - SWMU 125
000 - Base- or facility-wide sample (e.g., upgradient well)
BBG - Base background

The examples cited are only suggestions. Each PM (or designee) must designate appropriate (and consistent) site designations for their individual project.

Sample type - Examples of sample types are as follows:

AH - Ash Sample
AS - Air Sample
BM - Building Material Sample

BSB - Biota Sample Full Body
BSF - Biota Sample Fillet
CP - Composite Sample
CS - Chip Sample
DS - Drum Sample
DU - Dust Sample
FP - Free Product
IDW - Investigation-Derived Waste Sample
LT - Leachate Sample
MW - Monitoring Well Groundwater Sample
OF - Outfall Sample
RW - Residential Well Sample
SB - Soil Boring Sample
SD - Sediment Sample
SC - Scrape Sample
SG - Soil Gas Sample
SL - Sludge Sample
SP - Seep Sample
SS - Surface Soil Sample
ST - Storm Sewer Water Sample
SW - Surface Water Sample
TP - Test Pit Sample
TW - Temporary Well Sample
WC - Well Construction Material Sample
WP - Wipe Sample
WS - Waste/Solid Sample
WW - Wastewater Sample

Sample location - Examples of the location field are as follows:

001 - Monitoring well 1
N32E92 - Grid location 32 North and 92 East
D096 - Investigation-derived waste drum number 96

Species identifier - Examples of species identifier are as follows:

BC - Blue Crab
GB - Blue Gill
CO - Corn
SB - Soybean

5.4 EXAMPLES OF SAMPLE NOMENCLATURE

The first round monitoring well groundwater sample collected from existing monitoring well 001 at SWMU 16 for a filtered sample would be designated as 016MW00101-F.

The second round monitoring well groundwater sample collected from existing monitoring well C20P2 at Site 23 for an unfiltered sample would be designated as 023MWC20P202.

The second surface water sample collected from point 01 at SWMU 130 for an unfiltered sample would be designated as 130SW00102.

A surface soil sample collected from grid location 32 North and 92 East at Site 32 at the 0- to 2-foot

interval would be designated as 032SSN32E920002.

A subsurface soil sample from soil boring 03 at SWMU 32 at an interval of 4 to 5 feet bgs would be designated as 032SB0030405.

A sediment sample collected at SWMU 19 from 0 to 6 inches at location 14 would be designated as 019SD0140001. The sample data sheet would reflect the precise depth at which this sample was collected.

During biota sampling for full-body analysis, the first time a minnow trap was checked at grid location A25 of SWMU 1415, three small blue gills were captured, collected, and designated with the sample ID of 1415BSBA25BG001. The second time blue gill were collected at the same location (grid location A25 at SWMU 1415), the sample ID would be 1415BSBA25BG002.

Note: No dash (-) or spacing is used between the segments with the exception of the filtered segment. The "F" used for a filtered aqueous sample is preceded by a dash (-F).

5.5 FIELD QA/QC SAMPLE NOMENCLATURE

Field Quality Assurance (QA)/Quality Control (QC) samples are designated using a different coding system. The QC code will consist of a three- to four-segment alpha-numeric code that identifies the sample QC type, the date the sample was collected, and the number of this type of QC sample collected on that date.

AA	NNNNNN	NN	-F
QC type	Date	Sequence number (per day)	Filtered (aqueous only, if needed)

The QC types are identified as:

TB = Trip Blank
RB = Rinsate Blank (Equipment Blank)
FD = Field Duplicate
AB = Ambient Conditions Blank
WB = Source Water Blank

The sampling time recorded on the chain-of-custody form, labels, and tags for duplicate samples will be 0000 so that the samples are "blind" to the laboratory. Notes detailing the sample number, time, date, and type will be recorded on the routine sample log sheets and will document the location of the duplicate sample (sample log sheets are not provided to the laboratory). Documentation for all other QC types (TB, RB, AB, and WB) will be recorded on the QC Sample Log Sheet (see SOP SA-6.3, Field Documentation).

5.6 EXAMPLES OF FIELD QA/QC SAMPLE NOMENCLATURE

The first duplicate of the day for a filtered groundwater sample collected on June 3, 2000, would be designated as FD06030001-F.

The third duplicate of the day taken of a subsurface soil sample collected on November 17, 2003, would be designated as FD11170303.

The first trip blank associated with samples collected on October 12, 2000, would be designated as TB10120001.

The only rinsate blank collected on November 17, 2001, would be designated as RB11170101.

6.0 DEVIATIONS

Any deviation from this SOP must be addressed in detail in the site-specific planning documents.

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		Applicability Tetra Tech, Inc.	
		Prepared Earth Sciences Department	
Subject GROUNDWATER SAMPLE ACQUISITION AND ONSITE WATER QUALITY TESTING		Approved J. Zimmerly	

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes the process to be used for purging groundwater monitoring wells prior to sampling, for collecting groundwater samples, and for measuring groundwater quality parameters.

2.0 SCOPE

This document provides information on proper sampling equipment, onsite water quality testing, safety measures to ensure the safety of the field technician(s), and techniques for groundwater sampling. All personnel are encouraged to review the information contained herein to facilitate planning of the field sampling effort. The techniques described shall be followed whenever applicable, noting that site-specific conditions or project-specific plans may require modifications to methodology.

3.0 GLOSSARY

Conductivity – Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions and their total concentration, mobility, valence, and relative concentrations and on temperature. Conductivity is highly dependent on temperature and should be reported at a particular temperature, i.e., 20.2 microSiemens per centimeter (mS/cm) at 14°C.

Dissolved Oxygen (DO) – DO levels in natural and wastewater depend on the physical, chemical, and biochemical activities in the water sample.

Groundwater Sample – A quantity of water removed from the ground, usually via a monitoring well that may or may not be lined with a well casing.

Oxidation-Reduction Potential (ORP) - A measure of the activity ratio of oxidizing and reducing species as determined by the electromotive force developed by a noble metal electrode immersed in water, as referenced against a reference electrode. A reference electrode commonly used in the field is the silver/silver chloride electrode, which has a voltage offset of about 210 mV from the standard hydrogen electrode (SHE). To convert field ORP measurements to equivalent SHE values, approximately 210 mV must be added to the ORP values obtained using the silver/silver chloride electrode. The actual offset depends on the concentration of the potassium chloride (KCl) in the field reference electrode and the temperature. Offsets typically range from 199 (saturated KCl) to 205 (3.5 Molar KCl) to 222 mV (1 Molar KCl) at 25°C and are greater at lower temperatures.

pH - The negative logarithm (base 10) of the hydrogen ion activity. The hydrogen ion activity is related to the hydrogen ion concentration, and, in a relatively weak solution, the two are nearly equal. Thus, for all practical purposes, pH is a measure of the hydrogen ion concentration.

pH Paper - Indicator paper that turns different colors depending on the pH of the solution to which it is exposed. Comparison with color standards supplied by the manufacturer will then give an indication of the solution's pH.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

Salinity – The measurement of dissolved salts in a given mass of solution. Note: most field meters determined salinity automatically from conductivity and temperature. The value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent). The parts per thousand symbol ($^0/_{00}$) is not the same as the percent symbol (%).

Turbidity – Turbidity in water is caused by suspended matter such as clay, silt, and fine organic and inorganic matter. Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of groundwater samples. Additionally, in consultation with other project personnel (geologist, hydrogeologist, etc.), the Project Manager identifies sampling locations.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling, boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP or other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, boring logs, container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

Project Hydrogeologist – This individual is responsible for selecting and detailing the specific groundwater sampling techniques, onsite water quality testing (type, frequency, and location), equipment to be used, and providing detailed input in this regard to the project planning documents. The project hydrogeologist is also responsible for properly briefing and overseeing the performance of site sampling personnel.

Field Operations Leader (FOL) – This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field technicians) where credentials and time permit. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.
General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.

- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Specific safety and health precautions are identified throughout this SOP. In addition to those precautions, the following general hazards may be incurred during sampling activities:

- Knee injuries from kneeling on hard surfaces
- Slips, trips, and falls
- Cuts and lacerations
- Traffic hazards associated with sampling in parking areas and roadways and along highways.

Methods of avoiding these hazards are provided below.

Knee injuries – Many monitoring wells are installed as flush mounts. Personnel are required to kneel to open these wells and to take groundwater level measurements, etc. This could result in knee injuries from kneeling on stones/foreign objects and general damage due to stress on the joints. To combat this hazard:

- Clear any foreign objects from the work area.
- Wear hard-sided knee pads.

Slips, Trips, and Falls – These hazards exist while traversing varying terrains carrying equipment to sample wells. To minimize these hazards:

- Pre-survey well locations. Eliminate, barricade, or otherwise mark physical hazards leading to the locations.
- Carry small loads that do not restrict the field of vision.
- Travel the safest and clearest route (not necessarily the shortest).

Cuts and Lacerations – To prevent cuts and lacerations associated with groundwater sampling, the following provisions are required:

- Always cut away from yourself and others when cutting tubing or rope. This will prevent injury to yourself and others if the knife slips.
- Do not place items to be cut in your hand or on your knee.
- Change blades as necessary to maintain a sharp cutting edge. Many accidents result from struggling with dull cutting attachments.
- Whenever practical, wear cut-resistant gloves (e.g., leather or heavy cotton work gloves) at least on the hand not using the knife.
- Keep cutting surfaces clean and smooth.

- Secure items to be cut -- do not hold them against the opposing hand, a leg, or other body part.
- When transporting glassware, keep it in a hard-sided container such as a cooler so that if there is a fall, you will be less likely to get cut by broken glass.
- DO NOT throw broken glass or glass ampoules into garbage bags. Place broken glass and glass ampoules in hard-sided containers such as a cardboard box or directly into a dumpster. DO NOT reach into garbage bags to retrieve any item accidentally thrown away. Empty the contents onto a flat surface to avoid punctures and lacerations from reaching where you cannot see.

Vehicular and Foot Traffic Hazards – When sampling along the roadway or near traffic patterns, follow the following precautions:

- Motorists may be distracted by onsite activities – ASSUME THEY DO NOT SEE YOU OR MEMBERS OF YOUR FIELD CREW.
- DO NOT place obstructions (such as vehicles) along the sides of the road that may cause site personnel to move into the flow of traffic to avoid your activities or equipment or that will create a blind spot.
- **Provide a required free space of travel**. Maintain at least 6 feet of space between you and moving traffic. Where this is not possible, use flaggers and/or signs to warn oncoming traffic of activities near or within the travel lanes.
- Face Traffic. Whenever feasible, if you must move within the 6 feet of the required free space or into traffic, attempt to face moving traffic at all times. Always leave yourself an escape route.
- Wear high-visibility vests to increase visual recognition by motorists.
- Do not rely on the vehicle operator's visibility, judgment, or ability. Make eye contact with the driver. Carefully and deliberately use hand signals so they will not startle or confuse motorists or be mistaken for a flagger's direction before moving into traffic.
- Your movements may startle a motorist and cause an accident, so move deliberately. Do not make sudden movements that might confuse a motorist.

6.0 PROCEDURES

6.1 General

For information derived from a groundwater sample to be useful and accurate, the sample must be representative of the particular zone being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from the time of sampling to the time of analysis to keep any changes in water quality parameters to a minimum.

CAUTION

A closed well may generate and accumulate gases due to biological degradation, evolution of volatile chemicals from groundwater into the air, or other chemical actions. These gases may also be artificially generated, such as in the case of air sparging or

extraction wells, which may take several days to depressurize. See Section 6.6.2 for safety measures to be employed to protect sampling personnel.

Methods for withdrawing samples from completed wells include the use of pumps, compressed air or nitrogen, bailers, and various types of samplers. The primary considerations in obtaining a representative sample of groundwater are to avoid collection of stagnant (standing) water in the well and to avoid physical or chemical alteration of the water sample due to external influences of the sampling technique(s). In a non-pumping well, there will be little or no vertical mixing of water in the well pipe or casing, and stratification will occur. The well water in the screened section will mix with groundwater due to normal flow patterns, but the well water above the screened section will remain isolated and become stagnant. Concentration gradients resulting from mixing and dispersion processes, layers of variable geologic permeability, and the presence of separate-phase product (e.g., floating hydrocarbons) may cause stratification. Excessive pumping or improper sampling methods can dilute or increase contaminant concentrations in the collected sample compared to what is representative of the integrated water column as it naturally occurs at that point, resulting in the collection of a non-representative sample. To safeguard against collecting non-representative samples, the following approach shall be followed prior to sample acquisition:

CAUTION

Mechanical agitation of well water may cause off-gas generation of volatile contaminants, creating an inhalation exposure to the sampler(s). Where avoiding an inhalation exposure is not possible and mechanical agitation is possible, pump into closed-top containers to control potential air emissions.

1. If possible, position yourself (and the sampling equipment) upwind of the well head.

2. Purge the monitoring well to be sampled prior to obtaining any samples from it. Evacuation of three to five well volumes is recommended prior to sampling, unless low-flow purging and sampling methods are utilized as described in Section 6.7 (Consult the site-specific SAP for exact purging parameters). In a high-yielding groundwater formation and where there is no stagnant water in the well above the screened section, extensive evacuation prior to sample withdrawal is not as critical as it is in a low-yielding well or in wells containing stagnant water.

3. For wells with low yields that are purged dry during sampling, evacuate the well and allow it to recover to 75 percent of full capacity prior to sample acquisition. If the recovery rate is fairly rapid (generally 300 mL per minute or greater), attempt to continue evacuation until the number of well volumes specified in the SAP is achieved. If this cannot be accomplished, allow recovery to 75 percent of capacity and begin sampling.

CAUTION

For moderate to high-yielding monitoring wells, an evacuation rate that does not cause excessive turbulence in the well should be selected. There is no absolute safeguard against contaminating the sample with stagnant water; hence, special techniques are required for purging to minimize the potential for sample contamination (see below).

4. For moderate to high-yielding monitoring wells, use one of the following purge techniques:

   - Place a submersible pump or the intake line of a surface pump or bailer just below the water surface when removing the stagnant water.

- While purging and as the water level decreases, lower the pump or intake line as the water level drops in the well. Three to five volumes of water shall be removed to provide reasonable assurance that all stagnant water has been evacuated. After this is accomplished, a bailer or other approved device may be used to collect the sample for analysis.

- Unless otherwise directed, place the intake line of the sampling pump (or the submersible pump itself) near the center of the screened section, and pump approximately one casing volume of water from the well at a low purge rate equal to the well's recovery rate (low-flow sampling).

6.2 Sampling, Monitoring, and Evacuation Equipment

Sample containers shall conform to the guidelines in SOP SA-6.1.

The following equipment shall be on hand when sampling groundwater wells (reference SOPs SA-6.1 and SA-7.1):

- Sample packaging and shipping equipment – Coolers for sample shipping and cooling, chemical preservatives, appropriate sampling containers and filler materials, ice, labels, and chain-of-custody documents.

- Field tools and instrumentation

  - Multi-parameter water quality meter with an in-line sample chamber capable of measuring ORP, pH, temperature, DO, specific conductance, turbidity, and salinity, or individual meters (as applicable)

  - pH Paper

  - Camera and film (if appropriate)

  - Appropriate keys (for locked wells)

  - Water level indicator and/or oil-water interface probe if separate-phase product is expected

- Pumps

  - Shallow-well pumps: Centrifugal, bladder, suction, or peristaltic pumps with drop lines and air-lift apparatus (compressor and tubing) where applicable.

  - Deep-well pumps: Submersible pump and electrical power-generating unit, or bladder pumps where applicable.

- Other sampling equipment – Bailers, graduated cylinder, stopwatch, and inert line with tripod-pulley assembly (if necessary).

- Pails – Plastic, graduated.

- Clean paper or cotton towels for cleaning equipment.

- Buckets with lids for collecting purge water.

- Decontamination solutions – Deionized water, potable water, phosphate-free laboratory-grade detergent, and analytical-grade solvent (e.g., pesticide-grade isopropanol), as required.

Ideally, sample withdrawal equipment shall be completely inert, economical, easily cleaned, cleaned prior to use, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for well purging and sample collection.

6.3 Calculations of Well Volume

To ensure that the proper volume of water has been removed from the well prior to sampling, it is first necessary to know the volume of standing water in the well pipe (including well screen where applicable). This volume can be easily calculated by the following method. Calculations shall be entered in the site logbook or field notebook or on a sample log sheet form or equivalent electronic form(s) (see SOP SA-6.3):

1. Obtain all available information on well construction (location, casing, screen, etc.).

2. Determine well or inner casing diameter.

3. Measure and record static water level (depth below ground level or top of casing reference point).

4. Determine depth of well by sounding using a clean, decontaminated, weighted tape measure or water level indicator.

5. Calculate number of linear feet of static water (total depth or length of well pipe minus the depth to static water level).

6. Calculate one static well volume in gallons $V = (0.163)(T)(r^2)$

   where: V = Static volume of well in gallons.
   T = Linear feet of water in the well.
   r = Inside radius of well casing in inches.
   0.163 = Conversion factor (compensates for conversion of casing radius from inches to feet and cubic feet to gallons and pi.

7. Per evacuation volumes discussed above, determine the minimum amount to be evacuated before sampling.

Measuring devices may become contaminated when gathering the above information if they are submerged in contaminated water. Decontamination of the tape or water level indicator must be conducted between measurements in different wells as follows:

1. Saturate a paper towel or clean cotton towel with deionized water.

2. As the measuring device is extracted, wipe the tape, changing the cleaning surface frequently.

3. After it is extracted, rinse the probe or tape using a spray bottle of deionized water over a bucket or similar collection container.

Based on the contaminant (oily, etc), it may be necessary to use a soap and water wash and rinse to remove contaminants. Isopropanol can be used on the probe/tape. However, it is recommended that the use of solvents on the tape be minimized because they could degrade the protective covering or possibly

remove the scale designations. If isopropanol (or some other solvent) is used, assure that the manufacturer/supplier Material Safety Data Sheet (MSDS) is obtained, kept on site at a readily available location with other MSDSs, and reviewed by personnel prior to the first usage of the solvent. Also, add the substance to the site-specific Hazardous Chemical Inventory list (see Section 5 of the TtNUS Health and Safety Guidance Manual [HSGM], Hazard Communication Program and OSHA Standard 29 CFR 1910.1200).

6.4 Evacuation of Static Water – Purging

6.4.1 General

The amount to be purged from each well will be determined prior to sample collection. This amount will depend on the intent of the monitoring program and the hydrogeologic conditions. Programs to determine overall quality of water resources may require long pumping periods to obtain a sample that is representative of a large volume of the aquifer. The pumped volume may be specified prior to sampling so that the sample can be a composite of a known volume of the aquifer. Alternately, the well can be pumped until parameters such as temperature, specific conductance, pH, and turbidity (as applicable) have stabilized. Onsite measurements of these parameters shall be recorded in the site logbook or field notebook or on standardized data sheets or an equivalent electronic form(s).

6.4.2 Evacuation Devices

The following discussion is limited to those devices commonly used at hazardous waste sites. Attachment A provides guidance on the proper evacuation device to use for given sampling situations. All of these techniques involve equipment that is portable and readily available.

Bailers

Bailers are the simplest evacuation devices used and have many advantages. They generally consist of a length of tubing equipped with a base plate and ball check-valve at the bottom. Bailers are comprised of stainless steel and plastic. They come in a variety of sizes, but the two most often used are 2 inches and 4 inches in diameter. An inert non-absorbent line such as polyethylene rope is used to lower and then raise the bailer to retrieve the sample. As the bailer is lowered into the water column, the ball is pushed up allowing the tube to be filled. When the bailer is pulled upward, the ball seats in the base plate preventing water from escaping.

Advantages of bailers include the following:

- There are few limitations on size and materials used.
- No external power source is needed.
- Bailers are inexpensive and can be dedicated and hung in a well to reduce the chances of cross-contamination.
- Bailers are relatively easy to decontaminate.

Limitations on the use of bailers include the following:

- It is time consuming to remove stagnant water using a bailer.

- Splashing the bailer into the water or transfer of sample may cause aeration.
- The use of a bailer does not permit constant in-line monitoring of groundwater parameters.
- Use of bailers is physically demanding, especially in warm temperatures at personal protection equipment (PPE) levels above Level D.

Safety concerns using a bailer include the following:

- Muscle stress and strain, especially when using 4-inch bailers and when pulling from excessively deep wells.
- Entanglement, possible hand/finger injuries, and rope burns during a sudden release of the bailer back down the well.
- Direct contact with contaminants of concern and sample preservatives when discharging the bailer contents because there is not a high level of control during a direct pour, and splashing and indirect contact with contaminants/preservatives could occur.

Control measures for these hazards are provided in Section 6.6.2.

Suction Pumps

There are many different types of inexpensive suction pumps including centrifugal, diaphragm, and peristaltic pumps. Centrifugal and diaphragm pumps can be used for well evacuation at a fast pumping rate and for sampling at a low pumping rate. The peristaltic pump is a low-volume pump that uses rollers to squeeze flexible tubing to create suction. This tubing can be dedicated to a well to prevent cross-contamination from well to well. Suction pumps are all portable, inexpensive, and readily available. However, because they are based on suction, their use is restricted to areas with water levels within 20 to 25 feet of the ground surface. A significant limitation is that the vacuum created by these pumps can cause loss of dissolved gases and volatile organics. Another limitation of these pumps is that they require a secondary energy source to drive them. Electrically driven pumps may require portable generators as energy sources. Air diaphragm pumps require air compressors and/or compressed gas cylinders to drive them. The advantage of the peristaltic pump is that it will operate from a portable battery source. Safety measures associated with these pumps are provided below.

Air-Lift and Gas-Lift Samplers

This group of pump samplers uses gas pressure either in the annulus of the well or in a venturi to force groundwater up a sampling tube. These pumps are also relatively inexpensive. Air- or gas-lift samplers are more suitable for well development than for sampling because the samples may be aerated as a result of pump action. Aeration can cause pH changes and subsequent trace metal precipitation or loss of volatile organics.

Submersible Pumps

Submersible pumps take in water and push the sample up a sample tube to the surface. The power sources for these samplers may be compressed gas or electricity. Operation principles vary, and displacement of the sample can be by an inflatable bladder, sliding piston, gas bubble, or impeller. Pumps are available for 2-inch-diameter wells and larger. These pumps can lift water from considerable depths (several hundred feet).

Limitations of this class of pumps include the following:

- They may have low delivery rates.
- Many models are expensive.
- Compressed gas or electric power is needed.
- Sediment in water may cause clogging of the valves or eroding of the impellers with some of these pumps.
- Decontamination of internal components can be difficult and time consuming.

Compressed Gases

Safety concerns using compressed gases as an energy source in these pumps are numerous. The nitrogen gas or compressed air is provided in a compressed gas cylinder at a pressure of approximately 2,000 psi. If damaged, these cylinders can become dangerous projectiles. Additionally, a sudden release of a cylinder's contents can involve considerable force that could cause significant damage to the eyes and/or skin. Protective measures include the following:

- Always wear safety impact glasses when handling compressed gases.
- Always administer compressed gases through an appropriate pressure-reducing regulator.
- When clearing the cylinder connection port, open the cylinder valve only enough to clear foreign debris. During this process, always position the cylinder valve so that it faces away from you and others.
- If the cylinder is designed to accept a valve protection cap, always keep that protection cap in place, except the cylinder is connected for use.
- When using the cylinder, lay the cylinder on its side to avoid the potential of it falling and knocking the valve off (and becoming a missile).
- DO NOT use the compressed nitrogen or air to clean clothing or to spray off the skin. Small cuts in the protective layer of the skin may permit the gas to enter into the bloodstream, presenting the potential danger of an embolism.

See the project-specific HASP for additional direction concerning cylinder safe handling procedures pertaining to the safe handling, transportation, and storage of compressed gas cylinders.

Electrical Shock

Even in situations where portable batteries are used, the potential for electrical shock exists. This potential risk is increased in groundwater sampling activities because of the presence of groundwater near the batteries. This potential is also increased in (prohibited) situations where jury-rigging of electrical connections is performed. Other potential hazards occur when field samplers open the hood of a running car to access the battery as a power source. To control these hazards:

- If you are unfamiliar with electrical devices, do not experiment, get help, and get the proper equipment necessary to power your device.
- Use the proper portable power inverters for cigarette lighter connections to minimize the need to access the battery under the hood of your vehicle.
- Use of electrical generators may pose a number of hazards including noise, those associated with fueling, and indirect sample influence.

To minimize or eliminate electrical generator hazards:

- Inspect the generator before use. Ensure that the generator and any extension cords are rated for the intended operation and have a Ground Fault Circuit Interrupter (GFCI) in line to control potential electrical shock.
- Fuel the generator before purging and sampling to avoid loss of power during sampling.
- Fuel engines only when they are turned OFF and have cooled sufficiently to prevent a fire hazard.
- Place the generator and any fuel source at least 50 feet from the well to be sampled to avoid indirect influence to the sample from fuel vapors or emission gases.

Lifting Hazards

This hazard may be experienced when moving containers of purge water, equipment, cylinders, etc. To control these potential hazards:

- Do not fill purge buckets to more than 80 percent of their capacity.
- Obtain a gas cylinder of sufficient size to complete the designated task but not too large to handle. K-size cylinders weigh approximately 135 pounds and are difficult to handle. M-size cylinders weigh approximately 50 pounds and are easier to handle and move.
- When necessary, get help lifting and moving gas cylinders and other heavy objects. Minimize twisting and turning while lifting. If it is necessary to move these cylinders or generators over significant distance, use mechanical means (carts, etc.).
- Use proper lifting techniques as described in Section 4.4 of the HSGM.

6.5 Onsite Water Quality Testing

This section describes the procedures and equipment required to measure the following parameters of an aqueous sample in the field:

- pH
- Specific conductance
- Temperature
- DO
- ~~ORP~~
- ~~Turbidity~~
- ~~Salinity~~

This section is applicable for use in an onsite groundwater quality monitoring program to be conducted at a hazardous or nonhazardous waste site. The procedures and equipment described are applicable to groundwater samples and are not, in general, subject to solution interferences from color, turbidity, or colloidal material or other suspended matter.

This section provides general information for measuring the parameters listed above with instruments and techniques in common use. Because instruments from different manufacturers may vary, review of the manufacturer's literature pertaining to the use of a specific instrument is required before use. Most meters used to measure field parameters require calibration on a daily basis. Refer to SOP SA-6.3 for an example equipment calibration log.

6.5.1 Measurement of pH

6.5.1.1 General

Measurement of pH is one of the most important and frequently used tests in water chemistry. Practically every phase of water supply and wastewater treatment such as acid-base neutralization, water softening, and corrosion control is pH dependent. Likewise, the pH of leachate can be correlated with other chemical analyses to determine the probable source of contamination. It is therefore important that reasonably accurate pH measurements be taken and recorded on the groundwater sample log sheet (Attachment B) or equivalent electronic form.

Two methods are given for pH measurement: the pH meter and pH indicator paper. Indicator paper is used when only an approximation of the pH is required or when pH meter readings need to be verified, and the pH meter is used when a more accurate measurement is needed. The response of a pH meter can be affected by high levels of colloidal or suspended solids, but the effect is generally of little significance. Consequently, specific methods to overcome this interference are not described. The response of pH paper is unaffected by solution interferences from color, turbidity, or colloidal or suspended materials unless extremely high levels capable of coating or masking the paper are encountered. In such cases, use of a pH meter is recommended.

6.5.1.2 Principles of Equipment Operation

Use of pH papers for pH measurement relies on a chemical reaction caused by the acidity or alkalinity of the solution created by the addition of the water sample reacting with the indicator compound on the paper. Various types of pH papers are available, including litmus (for general acidity or alkalinity determination) and specific, or narrower range, pH range paper.

Use of a pH meter relies on the same principle as other ion-specific electrodes. Measurement relies on establishment of a potential difference across a glass or other type of membrane in response to (in this instance, hydrogen) ion activity (which is usually similar to concentration) across that membrane. The membrane is conductive to ionic species and, in combination with a standard or reference electrode, a potential difference proportional to the ion concentration is generated and measured.

6.5.1.3 Equipment

The following equipment is to be used for obtaining pH measurements:

- A stand-alone portable pH meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).

- Combination electrode with polymer body to fit the above meter. Alternately, a pH electrode and a reference electrode can be used if the pH meter is equipped with suitable electrode inputs.

- Buffer solutions, as specified by the manufacturer. If the buffer solutions are considered hazardous per 29 Code of Federal Regulations (CFR) 1910.1200 (Hazard Communication) or the volumes used are greater than consumer commodity levels, the SSO shall obtain MSDSs from the manufacturer for the specific buffer solutions (see Section 4 of the HSGM regarding the Hazard Communication Program)

- pH indicator paper to cover the pH range 2 through 12.

- Manufacturer's operation manual. All personnel must be familiar with the equipment operation to ensure that the integrity of samples is preserved and that the equipment is operated safely.

6.5.1.4 Measurement Techniques for Field Determination of pH

pH Meter

The following procedure shall be used for measuring pH with a pH meter (meter standardization is according to manufacturer's instructions):

1. Inspect the instrument and batteries prior to initiation of the field effort.

2. Check the integrity of the buffer solutions used for field calibration. Buffer solutions need to be changed often as a result of degradation upon exposure to the atmosphere.

3. If applicable, make sure all electrolyte solutions within the electrode(s) are at their proper levels and that no air bubbles are present within the electrode(s).

4. Calibrate the meter and electrode(s) on a daily use basis (or as recommended by manufacturer) following manufacturer's instructions. Record calibration data on a water quality meter calibration log sheet (Attachment C) or equivalent electronic form.

5. Immerse the electrode(s) in the sample. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a physical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. The failure of the measurements to stabilize must be clearly noted in the logbook or equivalent electronic form.

6. Read and record the pH of the sample. pH shall be recorded to the nearest 0.01 pH standard unit. Also record the sample temperature (unless otherwise specified in the SAP, record temperatures to the nearest whole degree Fahrenheit or 0.5 degree Celsius).

7. Rinse the electrode(s) with deionized water.

8. Store the electrode(s) in an accordance with manufacturer's instructions when not in use.

Any visual observation of conditions that may interfere with pH measurement, such as oily materials or turbidity, shall be noted and avoided as much as possible.

pH Paper

Use of pH paper is very simple and requires no sample preparation, standardization, etc. pH paper is available in several ranges, including wide-range (indicating approximately pH 1 to 12), mid-range (approximately pH 0 to 6, 6 to 9, 8 to 14) and narrow-range (many available, with ranges as narrow as 1.5 pH units). The appropriate range of pH paper shall be selected. If the pH is unknown the investigation shall start with wide-range paper and proceed with successively narrower range paper until the sample pH is determined. To measure the pH with pH paper:

1. Collect a small portion of sample into a clean container.
2. Dip the pH paper into this small portion of sample.
3. Compare the color of the paper to the color chart that is provided with the pH paper and read the corresponding pH from the chart.
4. Record the pH value from the chart on the sampling log sheet.
5. Discard the used pH paper as trash.
6. Discard the small volume of sample that was used for the pH measurement with the other investigative derived waste.

6.5.2 Measurement of Specific Conductance

6.5.2.1 General

Conductance provides a measure of dissolved ionic species in water and can be used to identify the direction and extent of migration of contaminants in groundwater or surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. The mobility of each of the various dissolved ions, their valences, and their actual and relative concentrations affect conductivity.

It is important to obtain a specific conductance measurement soon after taking a sample because temperature changes, precipitation reactions, and absorption of carbon dioxide from the air all affect specific conductance. Most conductivity meters in use today display specific conductance in units of mS/cm, which is the conductivity normalized to a temperature of 25°C. These are the required units to be recorded on the groundwater sample log field form or equivalent electronic form.

6.5.2.2 Principles of Equipment Operation

An aqueous system containing ions will conduct an electric current. In a direct-current field, the positive ions migrate toward the negative electrode, and the negatively charged ions migrate toward the positive electrode. Most inorganic acids, bases, and salts such as hydrochloric acid, sodium carbonate, and sodium chloride, respectively, are relatively good conductors. Conversely, organic compounds such as sucrose or benzene, which do not dissociate in aqueous solution, conduct a current very poorly if at all.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also

be used as a measure of conductance. The core element of the apparatus is the conductivity cell containing the solution of interest. Depending on the ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell, which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

6.5.2.3 Equipment

The following equipment is needed for taking specific conductance measurements:

- Stand-alone portable conductivity meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution, as specified by the manufacturer.
- Manufacturer's operation manual.

A variety of conductivity meters are available that may also be used to monitor salinity and temperature. Probe types and cable lengths vary, so equipment must be obtained to meet the specific requirements of the sampling program.

6.5.2.4 Measurement Techniques for Specific Conductance

The steps involved in taking specific conductance measurements are as follows (calibration shall be conducted according to manufacturer's instructions):

1. Check batteries and calibrate instrument before going into the field.
2. Calibrate on a daily use basis (or as recommended by manufacturer), according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form. Potassium chloride solutions with a specific conductance closest to the values expected in the field shall be used for calibration.
3. Rinse the cell with one or more portions of the sample to be tested or with deionized water and shake excess water from the cell.
4. Immerse the electrode in the sample and measure the conductivity.
5. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.
6. Rinse the electrode with deionized water.

If the specific conductance measurements become erratic, recalibrate the instrument and see the manufacturer's instructions for troubleshooting assistance.

6.5.3 Measurement of Temperature

6.5.3.1 General

In combination with other parameters, temperature can be a useful indicator of the likelihood of biological action in a water sample. It can also be used to trace the flow direction of contaminated groundwater. Temperature measurements shall be taken in situ, or as quickly as possible in the field because collected water samples may rapidly equilibrate with the temperature of their surroundings.

6.5.3.2 Equipment

Temperature measurements may be taken with alcohol-toluene, mercury-filled, dial-type thermometers or combination meters equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22). In addition, various meters such as specific conductance or DO meters that have temperature measurement capabilities may also be used. Using such instrumentation along with suitable probes and cables, in-situ measurements of temperature at great depths can be performed.

6.5.3.3 Measurement Techniques for Water Temperature

If a thermometer is used to determine the temperature for a water sample, use the following procedure:

1. Immerse the thermometer in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the thermometer shall not be inserted into samples that will undergo subsequent chemical analysis.

2. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

If a temperature meter or probe is used:

1. Calibrate the instrument according to manufacturer's recommendations prior to use.

2. Immerse the meter/probe in the sample until temperature equilibrium is obtained (1 to 3 minutes). To avoid the possibility of cross-contamination, the meter/probe shall not be inserted into samples that will undergo subsequent chemical analysis.

3. Record values in a field logbook or on a sample log sheet or equivalent electronic form.

6.5.4 Measurement of Dissolved Oxygen

6.5.4.1 General

DO levels in natural water and wastewater depend on the physical, chemical and biochemical activities in the water body. In addition, the growth of many aquatic organisms and the rate of corrosivity are dependent on DO concentrations. Thus, analysis for DO is a key test in water pollution and waste treatment process control. If at all possible, DO measurements shall be taken in situ because concentrations may show a large change in a short time if the sample is not adequately preserved.

The monitoring method discussed herein is limited to the use of DO meters. Chemical methods of analysis (i.e., Winkler methods) are available but require more equipment and greater sample manipulation. Furthermore, DO meters using a membrane electrode are suitable for highly polluted waters because the probe is completely submersible and is not susceptible to interference caused by color, turbidity, or colloidal material or suspended matter.

6.5.4.2 Principles of Equipment Operation

DO probes are normally electrochemical cells that have two solid metal electrodes of different nobility immersed in an electrolyte. The electrolyte is retained by an oxygen-permeable membrane. The metal of highest nobility (the cathode) is positioned at the membrane. When a suitable potential exists between the two metals, reduction of oxygen to hydroxide ion (OH^-) occurs at the cathode surface. An electrical

current is developed that is directly proportional to the rate of arrival of oxygen molecules at the cathode. This rate is proportional to the oxygen concentration in the water being measured.

Because the current produced in the probe is directly proportional to the rate of arrival of oxygen at the cathode, it is important that a fresh supply of sample always be in contact with the membrane. Otherwise, the oxygen in the aqueous layer along the membrane is quickly depleted and false low readings are obtained. It is therefore necessary to stir the sample (or the probe) constantly to maintain fresh solution near the membrane interface. Stirring, however, shall not be so vigorous that additional oxygen is introduced through the air-water interface at the sample surface. To avoid this possibility, some probes are equipped with stirrers to agitate the solution near the probe, leaving the surface of the solution undisturbed.

DO probes are relatively unaffected by interferences. Interferences that can occur are reactions with oxidizing gases such as chlorine or with gases such as hydrogen sulfide that are not easily depolarized from the indicating electrode. If a gaseous interference is suspected, it shall be noted in the field logbook and checked if possible. Temperature variations can also cause interference because probes exhibit temperature sensitivity. Automatic temperature compensation is normally provided by the manufacturer. This compensation can counteract some of the temperature effects but not all of them.

6.5.4.3 Equipment

The following equipment is needed to measure DO concentrations:

- A stand-alone portable DO meter or combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Sufficient cable to allow the probe to contact the sample.
- Manufacturer's operation manual.

6.5.4.4 Measurement Techniques for Dissolved Oxygen Determination

DO probes differ as to instructions for use. Follow the manufacturer's instructions to obtain an accurate reading. The following general steps shall be used to measure DO concentrations:

1. Check the DO meter batteries before going to the field.
2. Condition the probe in a water sample for as long a period as practical before use in the field. Long periods of dry storage followed by short periods of use in the field may result in inaccurate readings.
3. Calibrate the instrument in the field according to manufacturer's recommendations or in a freshly air-saturated water sample of known temperature.
4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.
5. Rinse the probe with deionized water.
6. Immerse the probe in the sample. Be sure to provide for sufficient flow past the membrane by stirring the sample. Probes without stirrers placed in wells may be moved up and down to achieve the required mixing.

7. Record the DO content and temperature of the sample in a field logbook or on a sample log sheet or equivalent electronic form.

8. Rinse the probe with deionized water.

9. Recalibrate the probe when the membrane is replaced, or as needed. Follow the manufacturer's instructions.

Note that in-situ placement of the probe is preferable because sample handling is not involved. This however may not always be practical.

Special care shall be taken during sample collection to avoid turbulence that can lead to increased oxygen solubilization and positive test interferences.

6.5.5 Measurement of Oxidation-Reduction Potential

6.5.5.1 General

ORP provides a measure of the tendency of organic or inorganic chemicals to exist in an oxidized state. The ORP parameter therefore provides evidence of the likelihood of anaerobic degradation of biodegradable organics or the ratio of activities of reduced to oxidized species in the sample.

6.5.5.2 Principles of Equipment Operation

When an inert metal electrode, such as platinum, is immersed in a solution, a potential is developed at that electrode depending on the ions present in the solution. If a reference electrode is placed in the same solution, an ORP electrode pair is established. This electrode pair allows the potential difference between the two electrodes to be measured and is dependent on the concentration of the ions in solution. By this measurement, the ability to oxidize or reduce species in solution may be determined. Supplemental measurements, such as DO, may be correlated with ORP to provide knowledge of the quality of the solution, water, or wastewater.

6.5.5.3 Equipment

The following equipment is needed for measuring the ORP of a solution:

- A combination meter with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Reference solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.5.4 Measurement Techniques for Oxidation-Reduction Potential

The following procedure is used for measuring ORP:

1. Check the equipment using the manufacturer's recommended reference solution and check its batteries before going to the field.

2. Thoroughly rinse the electrode with deionized water.

3. If the probe does not respond properly to the recommended reference solution, verify the sensitivity of the electrodes by noting the change in millivolts when the pH of a test solution is altered. The ORP will increase when the pH of a test solution decreases, and the ORP will decrease when the test solution pH is increased. Place the sample in a clean container and agitate the sample. Insert the electrodes and note that the ORP drops sharply when the caustic is added (i.e., pH increases) thus indicating that the electrodes are sensitive and operating properly. If the ORP increases sharply when the caustic is added, the polarity is reversed and must be corrected in accordance with the manufacturer's instructions or the probe should be replaced.

4. Record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

6.5.6 Measurement of Salinity

6.5.6.1 General

Salinity is a unitless property of industrial and natural waters. It is the measurement of dissolved salts in a given mass of solution. Most field meters determine salinity automatically from conductivity and temperature. The displayed value will be displayed in either parts per thousand (ppt) or percent (e.g., 35 ppt equals 3.5 percent).

6.5.6.2 Principles of Equipment Operation

Salinity is determined automatically from the meter's conductivity and temperature readings according to algorithms (such as are found in Standard Methods for the Examination of Water and Wastewater). Depending on the meter, the results are displayed in either ppt or percent. The salinity measurements are carried out in reference to the conductivity of standard seawater (corrected to salinity = 35 ppt).

6.5.6.3 Equipment

The following equipment is needed for salinity measurements:

- A multi-parameter water quality meter capable of measuring conductivity and temperature and converting them to salinity (e.g., Horiba U-22 or YSI 600 series).
- Calibration solution as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.6.4 Measurement Techniques for Salinity

The steps involved in taking salinity measurements are as follows (standardization shall be conducted according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.
2. Check batteries and calibrate the meter before going into the field.

3. Calibrate on a daily use basis, according to the manufacturer's instructions and record all pertinent information on a water quality meter calibration log sheet or equivalent electronic form.

4. Rinse the cell with the sample to be tested. This is typically accomplished as the probe is placed in line during the collection of the purge water up to the time of sample acquisition.

5. Immerse the multi-probe in the sample and measure the salinity. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form.

6. Rinse the probes with deionized water.

6.5.7 Measurement of Turbidity

6.5.7.1 General

Turbidity is an expression of the optical property that causes light to be scattered and absorbed rather than transmitted in a straight line through the sample. Turbidity in water is caused by suspended matter such as clay, silt, or other finely divided organic and inorganic matter and microscopic organisms including plankton.

It is important to obtain a turbidity reading immediately after taking a sample because irreversible changes in turbidity may occur if the sample is stored too long.

6.5.7.2 Principles of Equipment Operation

Turbidity is measured by the Nephelometric Method, which is based on a comparison of the intensity of light scattered by the sample under defined conditions with the intensity of light scattered by a standard reference suspension under the same conditions. The higher the scattered light intensity, the higher the turbidity.

Formazin polymer is used as the reference turbidity standard suspension because of its ease of preparation combined with a higher reproducibility of its light-scattering properties than clay or turbid natural water. The turbidity of a specified concentration of formazin suspension is defined as 40 nephelometric units. This same suspension has an approximate turbidity of 40 Jackson units when measured on the candle turbidimeter. Therefore, nephelometric turbidity units (NTUs) based on the formazin preparation will approximate units derived from the candle turbidimeter but will not be identical to them.

6.5.7.3 Equipment

The following equipment is needed for turbidity measurements:

- A turbidity meter (e.g., LaMotte 2020) that calibrates easily using test cells with standards of 0.0, 1.0, and 10 NTUs, or a combination meter equipped with an in-line sample chamber (e.g., YSI 600 series and Horiba U-22).
- Calibration solution and sample tubes, as specified by the manufacturer.
- Manufacturer's operation manual.

6.5.7.4 Measurement Techniques for Turbidity

The steps involved in taking turbidity measurements utilizing an electrode (e) or light meter (l) are listed below (standardization shall be done according to manufacturer's instructions):

1. Check the expiration date of the solutions used for field calibration and replace them if they are expired.

2. Check batteries and calibrate the instrument before going into the field.

3. Calibrate on a daily basis according to the manufacturer's instructions, and record all pertinent information on a turbidity meter calibration log sheet (Attachment C) or equivalent electronic form.

4. When using the YSI and/or Horiba U-22, rinse the electrode with one or more portions of the sample to be tested or with deionized water.

5. When using the Lamotte 2020, fill the light meter's glass test cell with approximately 5 mL of sample, screw on the cap, wipe off glass to remove all residue that could intercept the instrument's light beam, place the test cell in the light meter and close the lid.

6. Immerse the electrode in the sample and measure the turbidity.

7. The reading must be taken immediately because suspended solids will settle over time resulting in a lower, inaccurate turbidity reading.

8. Read and record the results in a field logbook or on a sample log sheet or equivalent electronic form. Include a physical description of the sample, including color, qualitative estimate of turbidity, etc.

9. Rinse the electrode or test cell with deionized water.

6.6 Sampling

6.6.1 Sampling Plan

The sampling approach consisting of the following shall be developed as part of the project planning documents approved prior to beginning work in the field:

- Background and objectives of sampling.

- Brief description of area and waste characterization.

- Identification of sampling locations, with map or sketch, and applicable well construction data (well size, depth, screened interval, reference elevation).

- Intended number, sequence, volumes, and types of samples. If the relative degree of contamination between wells is insignificant, a sampling sequence that facilitates sampling logistics may be followed. Where some wells are known or strongly suspected of being highly contaminated, these shall be sampled last to reduce the risk of cross-contamination between wells. In situations where the well is not well-characterized and the nature or extent of airborne contamination is unknown, it is recommended that head space analysis using a photoionization detector (PID) or flame ionization detector (FID) is performed to rate the wells, sampling from least contaminated to most contaminated.

Refer to the project-specific HASP for appropriate information and direction on air monitoring requirements.

- Sample preservation requirements.
- Work schedule.
- List of team members.
- List of observers and contacts.
- Other information, such as the necessity for a warrant or permission of entry, requirements for split samples, access problems, location of keys, etc.
- The FOL shall ensure that the sampling method(s) to be employed is accurately represented in the HASP, indicating the types of sampling to be employed and the hazards. If the methods are not accurately represented, the FOL should rectify this with the HASP author.
- The FOL shall ensure that sampling teams understand the sampling approach that they are to follow. Where sampling teams are made up of personnel from multiple locations, personal sampling experiences may vary. Therefore the FOL shall review project-specific requirements, SOPs, and protocol to be followed. The FOL will conduct periodic surveys to ensure that these methods are being completed per his/her direction.

6.6.2 Sampling Methods as Related to Low-Flow Sampling

The collection of a groundwater sample consists of the following steps:

1. Ensure the safety of the sample location. Take a few minutes to evaluate the area for physical hazards (trip hazards, uneven ground, overhanging branches, etc.) and natural hazards (snakes, bees, spiders, etc.) that may exist in the area or that may have constructed nests in the well head. Snakes often like to sun themselves on concrete well pads. Follow provisions in the project-specific HASP and/or HSGM for addressing natural hazards.

2. As indicated earlier, some monitoring wells have the potential to contain pressurized headspace (e.g., through the generation of gases form contaminated groundwater, due to biological processes, degradation of contaminants, or simply based on location such as near a landfill or in areas that intersect lithological abnormalities) or through intentional artificial means such as those associated with air sparging systems. Injection or extraction wells may be artificially pressurized and may remain so for several days after the system has been turned off. This presents a hazard to people opening these wells. The Field Sampling Technician shall employ the following practices to minimize these hazards:

   - Wear safety glasses to protect the eyes. If site-specific observations and conditions indicate that the wells may be pressurized, wear a full-face shield over the safety impact eye protection.
   - DO NOT place your face or any other part of your body over the well when opening because this may place you in a strike zone.
   - Open the well cover at arms length, then step away and allow the well to off gas and stabilize.

   Follow directions provided in the project-specific HASP, Work Plan and/or Sampling Plan pertaining to the use of volatile chemical detection equipment (PID or FID) within the breathing zone of the

sampler during sampling to determine the need to retreat from the work area and/or for the use of respiratory protection (as specified in the HASP).

3. When proper respiratory protection has been donned, sound the well for total depth and water level (using clean equipment) and record these data on a groundwater sampling log sheet or equivalent electronic form; then calculate the fluid volume in the well pipe (as previously described in this SOP). It is imperative that downhole equipment be adequately decontaminated between wells to prevent cross-contamination. Just as sampling occurs from the least contaminated to the most contaminated, it is also recommended that groundwater level measurements be taken in this manner.

4. Calculate volume of well water to be removed as described in Section 6.3.

5. Select the appropriate purging equipment (see Attachment A to this SOP) or as designated within your Work Plan/Sampling Plan. If an electric submersible pump with packer is chosen, go to Step 10.

6. Lower the purging equipment or intake into the well to a short distance below the water level or mid-screen as indicated in project-specific documentation and begin water removal. Remember that some contaminants are "bottom dwellers," and in these cases, project-specific direction may specify placing the intake just above (1 to 2 feet) the well bottom. Secure the pump intake at the well and secure the effluent at the collection container and begin pumping. The pumping rate will be determined based on the decrease in the water level (see Section 6.7) or as directed in your project-specific documents or this SOP. Purge water is generally collected in a 5-gallon bucket or similar open- or closed-top container. To minimize the potential for spills and back injuries, do not fill 5-gallon buckets beyond approximately 80 percent of their capacity. Dispose of purge water was as indicated in the planning document(s). Where necessary, slow the pumping rate or lower the pump intake as required to maintain submergence.

7. Estimate the approximate rate of discharge frequently and record it on the Low Flow Purge Data Sheet (see Attachment D). Estimate flow rate by noting the amount of discharge in a bucket or graduated cylinder per unit time using a watch with a second hand or a stopwatch.

8. Observe the peristaltic pump tubing intake for degassing "bubbles." If bubbles are abundant and the intake is fully submerged, this pump is not suitable for collecting samples for volatile organics.

9. Purge a minimum of three to five casing volumes before sampling (or as directed by the site-specific SAP). In low-permeability strata (i.e., if the well is pumped to dryness), one volume will suffice. Allow the well to recover to 75 percent of initial water level before sampling. Do not overfill purge containers because this increases the potential for spills and lifting injuries.

10. If sampling using a submersible pump, lower the pump intake to mid-screen (or the middle of the open section in unscreased wells) and collect the sample. If sampling with a bailer, lower the bailer to just below the water surface.

11. For pump and packer assemblies only: Lower the assembly into the well so that the packer is positioned just above the screen or open section. Inflate the packer. Purge a volume equal to at least twice the screened interval (or unscreened open section volume below the packer) before sampling. Packers shall always be tested in a casing section above ground to determine proper inflation pressures for good sealing.

12. If the recovery time of the well is very slow (e.g., 24 hours or greater), sample collection can be delayed until the following day. If the well has been purged early in the morning, sufficient water may be standing in the well by the day's end to permit sample collection. If the well is incapable of producing a sufficient volume of sample at any time, take the largest quantity available and record

this occurrence in the site logbook or equivalent electronic form. When this occurs, contact the analytical laboratory to alert them that a reduced sample volume(s) will be submitted for analysis.

13. Fill sample containers and preserve and label them as described in SOP SA-6.1. Many sample bottles will contain preservative when they are shipped to the field. In those cases, do not add preservative.

14. Replace the well cap and lock it as appropriate. Make sure the well is readily identifiable as the source of the sample.

15. Process sample containers as described in SOP SA-6.1.

16. Decontaminate equipment as described in SOP SA-7.1.

6.7 Low-Flow Purging and Sampling

6.7.1 Scope and Application

Low-flow purging and sampling techniques may be required for groundwater sampling activities. The purpose of low-flow purging and sampling is to collect groundwater samples that contain "representative" amounts of mobile organic and inorganic constituents in the vicinity of the selected open well interval, at or near natural flow conditions. This minimum-stress procedure emphasizes negligible water level drawdown and low pumping rates to collect samples with minimal alterations in water chemistry. This procedure is designed primarily to be used in wells with a casing diameter of 1 inch or more and a saturated screen length, or open interval, of 10 feet or less. Samples obtained are suitable for analyses of common types of groundwater contaminants (volatile and semivolatile organic compounds, pesticides, polychlorinated biphenyls [PCBs], metals and other inorganic ions [cyanide, chloride, sulfate, etc.]). This low-flow procedure is not designed for collection of non-aqueous phase liquid samples from wells containing light or dense non-aqueous phase liquids (LNAPLs or DNAPLs).

This procedure is flexible for various well construction types and groundwater yields. The goal of the procedure is to obtain a turbidity level of less than 10 NTUs and to achieve a water level drawdown of less than 0.3 foot during purging and sampling. If these goals cannot be achieved, sample collection can take place provided that the remaining criteria in this procedure are met.

6.7.2 Equipment

The following equipment is required (as applicable) for low-flow purging and sampling:

- Adjustable rate submersible pump (e.g., centrifugal or bladder pump constructed of stainless steel or Teflon).

- Disposable clear plastic bottom-filling bailers to be used to check for and obtain samples of LNAPLs or DNAPLs.

- Tubing – Teflon, Teflon-lined polyethylene, polyethylene, polyvinyl chloride (PVC), Tygon, or stainless steel tubing can be used to collect samples for analysis, depending on the analyses to be performed and regulatory requirements.

- Water level measuring device with 0.01-foot accuracy (electronic devices are preferred for tracking water level drawdown during all pumping operations).

Interface probe.

- Flow measurement supplies.
- Power source (generator, nitrogen tank, etc.). If a gasoline generator is used, it must be located downwind and at a safe distance from the well so that the exhaust fumes do not contaminate the samples.
- Indicator parameter monitoring instruments – pH, turbidity, specific conductance, and temperature. Use of a flow-through cell is recommended. Optional indicators - ORP, salinity, and DO. A flow-through cell (also referred to as an in-line sample chamber) is required.
- Standards to perform field calibration of instruments.
- Decontamination supplies.
- Logbook(s) and other forms (see Attachments B through D) or equivalent electronic form(s).
- Sample bottles.
- Sample preservation supplies (as required by the analytical methods).
- Sample tags and/or labels.
- Well construction data, location map, field data from last sampling event (if available).
- Field Sampling Plan.
- PID or FID instrument for measuring volatile organic compounds (VOCs) per the HASP.

6.7.3 Purging and Sampling Procedure

1. Open the monitoring well as stated earlier and step away. Prepare sampling equipment while allowing 3 to 5 minutes to allow the water level to reach equilibrium. In situations where VOCs are the primary contaminants of concern, air monitoring of the samplers' breathing zone areas may be required by the HASP (typically with a PID or FID).

2 Measure the water level immediately prior to placing the pump in the well and record the water level on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well.

3. Lower the measuring device further into the well to collect the total depth measurement. Again wait 3 to 5 minutes to allow the well to equilibrate to the initial water level prior to placing the pump or pump intake in the well.

4. Record the total well depth on the Low-Flow Purge Data Form or equivalent electronic form immediately prior to placing the pump or tubing into the well

5. Lower the pump or tubing slowly into the well so that the pump intake is located at the center of the saturated screen length of the well. If possible, keep the pump intake at least 2 feet above the bottom of the well to minimize mobilization of sediment that may be present in the bottom of the well. Collection of turbidity-free water samples may be difficult if there is 3 feet or less of standing water in the well.

6. Start with the initial pump rate set at approximately 0.1 liter per minute. Use a graduated cylinder and stopwatch to measure the pumping rate. Adjust the pumping rates as necessary to prevent drawdown from exceeding 0.3 foot during purging. If no drawdown is noted, the pump rate may be increased (to a maximum of 0.4 liter per minute) to expedite the purging and sampling event. The pump rate will be reduced if turbidity is greater than 10 NTUs after all other field parameters have stabilized. If groundwater is drawn down below the top of the well screen, purging shall cease or the well shall be pumped to dryness and then allowed to recover before purging continues. Well recovery to 75 percent is necessary prior to sampling. Slow-recovering wells should be identified and purged at the beginning of the workday to maximize field work efficiency. If possible, samples should be collected from these wells within the same workday and no later than 24 hours after the end of purging.

7. Measure the water level in the well every 5 to 10 minutes using the water level meter. Record the well water level on the Low Flow Purge Data Form (Attachment D) or equivalent electronic form.
8. Record on the Low Flow Purge Data Form every 5 to 10 minutes the water quality parameters (pH, specific conductance, temperature, turbidity, ORP, DO, and salinity or as specified by the approved site-specific planning document) measured by the water quality meter and turbidity meter. If the cell needs to be cleaned during purging operations, continue pumping (allow the pump to discharge into a container) and disconnect the cell. Rinse the cell with distilled/deionized water. After cleaning is completed, reconnect the flow-through cell and continue purging. Document the cell cleaning on the Low-Flow Purge Data Form or equivalent electronic form.

9. Estimate the flow rate by noting the amount of discharge in a graduated cylinder per unit time using a watch with a second hand. Remeasure the flow rate any time the pump rate is adjusted and periodically during purging. This will determine if a reduction in rate has occurred due to possible battery depletion.

10. During purging, check for the presence of bubbles in the flow-through cell. The presence of bubbles is an indication that connections are not tight. If bubbles are observed, check for loose connections and tighten, repair, or replace them as necessary to achieve a tight connection.

11. Wait until stabilization is achieved, or a minimum of two saturated screen volumes have been removed and three consecutive readings, taken at 5 to 10 minute intervals, are within the following limits, then begin sampling:

    - pH ±0.2 standard units
    - Specific conductance ±10%
    - Temperature ±10%
    - Turbidity less than 10 NTUs
    - DO ±10%

12. If the above conditions have not been met after the well has been purged for 4 hours, purging will be considered complete and sampling can begin. Record the final well stabilization parameters from the Low-Flow Purge Data Form onto the Groundwater Sample Log Form or equivalent electronic form.

NOTE: VOC samples are preferably collected first, directly into pre-preserved sample containers. Fill all sample containers by allowing the pump discharge to flow gently down the inside of the container with minimal turbulence.

13. If the water column in the pump tubing collapses (water does not completely fill the tubing) before exiting the tubing, use one of the following procedures to collect VOC samples:

- Collect samples for non-VOC analyses first, then increase the flow rate incrementally until the water column completely fills the tubing, collect the sample for VOCs, and record the new flow rate.

- Reduce the diameter of the existing tubing until the water column fills the tubing either by adding a connector (Teflon or stainless steel) or clamp, which should reduce the flow rate by constricting the end of the tubing. Proceed with sample collection.

- Insert a narrow-diameter Teflon tube into the pump's tubing so that the end of the tubing is in the water column and the other end of the tubing protrudes beyond the pump's tubing, then collect the sample from the narrow diameter tubing.

- Prepare samples for shipping as per SOP SA-6.1.

7.0 REFERENCES

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ATTACHMENT A

PURGING EQUIPMENT SELECTION

Diameter Casing		Bailer	Peristaltic Pump	Vacuum Pump	Air-lift	Diaphragm "Trash" Pump	Submersible Diaphragm Pump	Submersible Electric Pump	Submersible Electric Pump w/Packer
1.25-Inch	Water level <25 feet	X	X	X	X	X			
	Water Level >25 feet	X			X				
2-Inch	Water level <25 feet	X	X	X	X	X	X		
	Water Level >25 feet	X			X		X		
4-Inch	Water level <25 feet	X	X	X	X	X	X	X	X
	Water Level >25 feet	X			X		X	X	X
6-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X
8-Inch	Water level <25 feet				X	X		X	X
	Water Level >25 feet				X			X	X

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 2

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
BarCad Systems, Inc.	BarCad Sampler	Dedicated; gas drive (positive displacement)	1.5/16	PE, brass, nylon, aluminum oxide	0-150 with std. tubing	1 liter for each 10-15 feet of submergence	$220-350	Requires compressed gas; custom sizes and materials available; acts as piezometer.
Cole-Parmer Inst. Co.	Master Flex 7570 Portable Sampling Pump	Portable; peristaltic (suction)	<1.0/NA	(not submersible) Tygon®, silicone Viton®	0-30	670 mL/min with 7015 20 pump head	$500-600	AC/DC; variable speed control available; other models may have different flow rates.
ECO Pump Corp.	SAMPLifier	Portable; venturi	<1.5 or <2.0/NA	PP, PE, PVC, SS, Teflon®, Tefzel®	0-100	0-500 mL/min depending on lift	$400-700	AC, DC, or gasoline-driven motors available; must be primed.
Geltek Corp.	Bailer 219-4	Portable; grab (positive displacement)	1.66/38	Teflon®	No limit	1,075 mL	$120-135	Other sizes available.
GeoEngineering, Inc.	GEO-MONITOR	Dedicated; gas drive (positive displacement)	1.5/16	PE, PP, PVC, Viton®	Probably 0-150	Approximately 1 liter for each 10 feet of submergence	$185	Acts as piezometer; requires compressed gas.
Industrial and Environmental Analysts, Inc. (IEA)	Aquarius	Portable; bladder (positive displacement)	1.75/43	SS, Teflon®, Viton®	0-250	0-2,800 mL/min	$1,500-3,000	Requires compressed gas; other models available; AC, DC, manual operation possible.
IEA	Syringe Sampler	Portable; grab (positive displacement)	1.75/43	SS, Teflon®	No limit	850 mL sample volume	$1,100	Requires vacuum and/or pressure from hand pump.
Instrument Specialties Co. (ISCO)	Model 2600 Well Sampler	Portable; bladder (positive displacement)	1.75/50	PC, silicone, Teflon®, PP, PE, Detrin®, acetal	0-150	0-7,500 mL/min	$990	Requires compressed gas (40 psi minimum).
Keck Geophysical Instruments, Inc.	SP-81 Submersible Sampling Pump	Portable; helical rotor (positive displacement)	1.75/25	SS, Teflon®, PP, EPDM, Viton®	0-160	0-4,500 mL/min	$3,500	DC operated.
Leonard Mold and Die Works, Inc.	GeoFilter Small Diameter Well Pump (#0500)	Portable; bladder (positive displacement)	1.75/38	SS, Teflon®, PC, Neoprene®	0-400	0-3,500 mL/min	$1,400-1,500	Requires compressed gas (55 psi minimum); pneumatic or AC/DC control module.
Oil Recovery Systems, Inc.	Surface Sampler	Portable; grab (positive displacement)	1.75/12	acrylic, Detrin®	No limit	Approximately 250 mL	$125-160	Other materials and models available; for measuring thickness of "floating" contaminants.
Q.E.D. Environmental Systems, Inc.	Well Wizard® Monitoring System (P-100)	Dedicated; bladder (positive displacement)	1.66/36	PVC	0-230	0-2,000 mL/min	$300-400	Requires compressed gas; piezometric level indicator; other materials available.

ATTACHMENT A

PURGING EQUIPMENT SELECTION

PAGE 3

Manufacturer	Model Name/Number	Principle of Operation	Maximum Outside Diameter/Length (Inches)	Construction Materials (w/Lines and Tubing)	Lift Range (ft)	Delivery Rates or Volumes	1982 Price (Dollars)	Comments
Randolph Austin Co.	Model 500 Vari-Flow Pump	Portable; peristaltic (suction)	<0.5/NA	(Not submersible) Rubber, Tygon®, or Neoprene®	0-30	See comments	$[illegible]200-1,300	Flow rate dependent on motor and tubing selected; AC operated; other models available.
Robert Bennett Co.	Model 180	Portable; piston (positive displacement)	1.8/22	SS, Teflon®, Delrin® PP, Viton®, acrylic, PE	0-500	0-1,800 mL/min	$2,600-2,700	Requires compressed gas; water level indicator and flow meter; custom models available.
Slope Indicator Co. (SINCO)	Model 514124 Pneumatic Water Sampler	Portable; gas drive (positive displacement)	1.9/[illegible]	PVC, nylon	0-1,100	[illegible]00 mL/flushing cycle	$250-350	Requires compressed gas; SS available; piezometer model available; dedicated model available.
Solinst Canada Ltd.	5W Water Sampler	Portable; grab (positive displacement)	1.9/27	PVC, brass, nylon, Neoprene®	[illegible]330	500 mL	$1,300-1,800	Requires compressed gas; custom models available.
TIMCO Mfg. Co., Inc.	Std. Bailer	Portable; grab (positive displacement)	1.66/Custom	PVC, PP	No limit	250 mL/ft of bailer	$20-60	Other sizes, materials, models available; optional bottom-emptying device available; no solvents used.
TIMCO	Air or Gas Lift Sampler	Portable; gas drive (positive displacement)	1.66/30	PVC, Tygon®, Teflon®	0-150	350 mL/flushing cycle	$100-200	Requires compressed gas; other sizes, materials, models available; no solvents used.
Tole Devices Co.	Sampling Pump	Portable; bladder (positive displacement)	1.38/48	SS, silicone, Delrin®, Tygon®	0-125	0-4,000 mL/min	$800-1,000	Compressed gas required; DC control module; custom built.

Construction Material Abbreviations:

PE Polyethylene
PP Polypropylene
PVC Polyvinyl chloride
SS Stainless steel
PC Polycarbonate
EPDM Ethylene-propylene diene (synthetic rubber)

Other Abbreviations:

NA Not applicable
AC Alternating current
DC Direct current

NOTE: Other manufacturers market pumping devices which could be used for groundwater sampling, though not expressly designed for this purpose. The list is not meant to be all-inclusive and listing does not constitute endorsement for use. Information in the table is from sales literature and/or personal communication. No skimmer, scavenger-type, or high-capacity pumps are included.

Source: Barcelona et al., 1983.

ATTACHMENT B
GROUNDWATER SAMPLE LOG SHEET

Tetra Tech

GROUNDWATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No: _____

[ ] Domestic Well Data
[x] Monitoring Well Data
[ ] Other Well Type: _____
[ ] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____
Type of Sample:
[X] Low Concentration
[ ] High Concentration

SAMPLING DATA:

Date:	Color	pH	S.C.	Temp.	Turbidity	DO	ORP	Other
Time:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	mV	NA
Method:								

PURGE DATA:

Date:	Volume	pH	S.C.	Temp. (C)	Turbidity	DO	ORP	Other
Method:								
Monitor Reading (ppm):			SEE LOW FLOW PURGE DATA SHEET					
Well Casing Diameter & Material								
Type:								
Total Well Depth (TD):								
Static Water Level (WL):								
One Casing Volume(gal/L):								
Start Purge (hrs):								
End Purge (hrs):								
Total Purge Time (min):								
Total Vol. Purged (gal/L):								

SAMPLE COLLECTION INFORMATION:

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS/NOTES:

Circle if Applicable:		Signature(s):
MS/MSD	Duplicate ID No.:	

ATTACHMENT C
EQUIPMENT CALIBRATION LOG

Tetra Tech

EQUIPMENT CALIBRATION LOG

PROJECT NAME : _____ INSTRUMENT NAME/MODEL: _____

SITE NAME: _____ MANUFACTURER: _____

PROJECT No.: _____ SERIAL NUMBER: _____

Date of Calibration	Instrument I.D. Number	Person Performing Calibration	Instrument Settings		Instrument Readings		Calibration Standard (Lot No.)	Remarks and Comments
			Pre-calibration	Post-calibration	Pre-calibration	Post-calibration		

ATTACHMENT D
LOW FLOW PURGE DATA SHEET

LOW FLOW PURGE DATA SHEET

PROJECT SITE NAME: _____
PROJECT NUMBER: _____

WELL ID.: _____
DATE: _____

Time (Hrs.)	Water Level (Ft. below TOC)	Flow (mL/Min.)	pH (S.U.)	S. Cond. (mS/cm)	Turb. (NTU)	DO (mg/L)	Temp. (Celcius)	ORP mV	Salinity % or ppt	Comments

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SIGNATURE(S): _____

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1.0 PURPOSE

This Standard Operating Procedure (SOP) describes procedures and equipment commonly used for collecting environmental samples of surface water and aquatic sediment for either onsite examination and chemical testing or for offsite laboratory analysis.

2.0 SCOPE

The information presented in this document is applicable to all environmental sampling of surface waters (Section 5.3) and aquatic sediments (Section 5.5), except where the analyte(s) may interact with the sampling equipment. The collection of concentrated sludges or hazardous waste samples from disposal or process lagoons often requires methods, precautions, and equipment different from those described herein.

3.0 GLOSSARY

Analyte – Chemical or radiochemical material whose concentration, activity, or mass is measured.

Composite Sample – A sample representing a physical average of grab samples.

Environmental Sample – A quantity of material collected in support of an environmental investigation that does not require special handling or transport considerations as detailed in SOP SA-6.1.

Grab Sample – A portion of material collected to represent material or conditions present at a single unit of space and time.

Hazardous Waste Sample – A sample containing (or suspected to contain) concentrations of contaminants that are high enough to require special handling and/or transport considerations per SOP SA-6.1.

Representativeness – A qualitative description of the degree to which an individual sample accurately reflects population characteristics or parameter variations at a sampling point. It is therefore an important characteristic not only of assessment and quantification of environmental threats posed by the site, but also for providing information for engineering design and construction. Proper sample location selection and proper sample collection methods are important to ensure that a truly representative sample has been collected.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - The Project Manager is responsible for determining the sampling objectives, initial sampling locations, and field procedures used in the collection of soil samples. The Project Manager also has the overall responsibility for seeing that all surface water and sediment sampling activities are properly conducted by appropriately trained personnel in accordance with applicable planning documents.

Field Operations Leader - This individual is primarily responsible for the execution of the planning document containing the Sampling and Analysis Plan (SAP). This is accomplished through management of a field sampling team for the proper acquisition of samples. He or she is responsible for the supervision of onsite analyses; ensuring proper instrument calibration, care, and maintenance; sample collection and handling; the completion and accuracy of all field documentation; and making sure that custody of all samples obtained is maintained according to proper procedures. When appropriate and as directed by the FOL, such responsibilities may be performed by other qualified personnel (e.g., field

technicians) where credentials and time permit. The FOL is responsible for finalizing the locations for collection of surface water and sediment samples. The FOL is ultimately responsible for adherence to Occupational Safety and Health Administration (OSHA) regulations during these operations through self acquisition or through the management of a field team of samplers.

Site Safety Officer (SSO) - The SSO (or a qualified designee) is responsible for providing the technical support necessary to implement the project Health and Safety Plan (HASP). This includes but is not be limited to performing air quality monitoring during sampling and boring and excavation activities, and ensuring that workers and offsite (downwind) individuals are not exposed to hazardous levels of airborne contaminants. The SSO or SSO designee may also be required to advise the FOL on other safety-related matters regarding boring and sampling, such as mitigative measures to address potential hazards from hazardous objects or conditions.

Project Geologist/Sampler - The project geologist/sampler is responsible for the proper acquisition of samples in accordance with this SOP and other project-specific documents. In addition, this individual is responsible for the completion of all required paperwork (e.g., sample log sheets, field notebook, , container labels, custody seals, and chain-of-custody forms) associated with the collection of those samples.

General personnel qualifications for groundwater sample collection and onsite water quality testing include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for sample documentation, handling, packaging, and shipping.

5.0 HEALTH AND SAFETY

Precautions to preserve the health and safety of field personnel implementing this SOP are distributed throughout. The following general hazards may also exist during field activities, and the means of avoiding them must be used to preserve the health and safety of field personnel:

Bridge/Boat Sampling – Potential hazards associated with this activity include:

- Traffic – one of the primary concerns as samplers move across a bridge because free space of travel is not often provided. Control measures should include:
  - When sampling from a bridge, if the samplers do not have at least 6 feet of free travel space or physical barriers separating them and the traffic patterns, the HASP will include a Traffic Control Plan.
  - The use of warning signs and high-visibility vests are required to warn oncoming traffic and to increase the visibility of sample personnel.
- Slips, trips, and falls from elevated surfaces are a primary concern. Fall protection shall be worn when or if samplers must lean over a rail to obtain sample material. A Fall Protection Competent Person (in accordance with Occupational safety and Health Administration [OSHA] fall protection standards) must be assigned to ensure that fall protection is appropriately and effectively employed

- Water hazards/drowning – if someone enters the water from an elevated surface (such as a bridge or dock) and when sampling from a boat. To minimize this potential, personnel shall wear United states Coast Guard (USCG)-approved floatation devices, and the sampling crew must also have on hand a Type IV Throwable Personal Floatation Device with at least 90 feet of 3/8-inch rope. See Section 5.5.2 of this SOP.

- Within the HASP, provisions will also be provided concerning the requirement of a Safe Vessel Certification or the necessity to conduct a boat inspection prior to use. In addition, the HASP shall also specify requirements as to whether the operator must be certified as a commercial boat operator and whether members of the sampling team must have a state-specific safe boating certification.

Entering Water to Collect Samples – Several hazards are associated with this activity and can be mitigated as follows:

- Personnel must wear a USCG-approved Floatation Device (selected and identified in the HASP). The SSO shall ensure that the device selected is in acceptable condition and suitable for the individual using it. This includes consideration of the weight of the individual.

- Lifelines shall be employed from a point on the shore. This activity will always be conducted with a Buddy. See Section 6.5.2.

- Personnel shall carry a probe to monitor the bottom ahead of them for drop offs or other associated hazards.

- The person in the water shall exercise caution concerning the path traveled so that the lifeline does not become entangled in underwater obstructions such as logs, branches, stumps, etc., thereby restricting its effectiveness in extracting the person from the water.

- Personnel shall not enter waters on foot in situations where natural hazards including alligators, snakes, as well as sharks, gars, and other predators within inland waterways may exist.

- In all cases, working along and/or entering the water during high currents or flood conditions shall be prohibited.

- Personnel shall not enter bodies of water where known debris exists that could result in injuries from cuts and lacerations.

Sampling in marshes or tidal areas in some instances can be accomplished using an all-terrain vehicle (ATV). This is not the primary recommended approach because the vehicle may become disabled, or weather conditions or tidal changes could result in environmental damage as well as loss of the vehicle. The primary approach is recommended to be on foot where minimal disturbance would occur. The same precautions specified above with regard to sediment disturbance apply as well as the previously described safety concerns associated with natural hazards. The natural hazards include alligators, bees (nests in dead falls and tree trunks), snakes, etc. In addition, moving through and over this terrain is difficult and could result in muscle strain and slips, trips, and falls. Common sense dictates that the sampler selects the most open accessible route over moderate terrain. Move slowly and deliberately through challenging terrain to minimize falls. Mud boots or other supportive PPE should be considered and specified in the HASP to permit samplers to move over soft terrain with the least amount of effort. In these situations, it is also recommended, as the terrain allows, that supplies be loaded and transported in a sled over the soft ground.

Working in these areas, also recognize the following hazards and means of protection against them:

Insects are also a primary concern. These include mosquitoes, ticks, spiders, bees, ants, etc. The HASP will identify those particular to your area. Typical preventative measures include:

- Use insect repellant. Approval of various repellants should be approved by the Project Chemist or Project Manager.
- Wearing light-colored clothing to control heat load due to excessive temperatures. In addition, it makes it easier to detect crawling insects on your clothing.
- Taping pants to boots to deny access. Again, this is recommended to control access to the skin by crawling insects. Consultation with the Project Health and Safety Officer SSO/Health and Safety Manager is recommended under extreme heat loads because this will create conditions of heat stress.
- Performing a body check to remove insects. The quicker you remove ticks, the less likely they will become attached and transfer bacteria to your bloodstream. Have your Buddy check areas inaccessible to yourself. This includes areas such as the upper back and between shoulder blades where it is difficult for you to examine and even more difficult for you to remove.

Safety Reminder

If you are allergic to bee or ant stings, it is especially critical that you carry your doctor-recommended antidote with you in these remote sampling locations due to the extended time required to extract incapacitated individuals as well as the effort required to extract them. In these scenarios, instruct your Buddy in the proper administration of the antidote. In all cases, if you have received a sting, administer the antidote regardless of the immediate reaction, evacuate, and seek medical attention as necessary. The FOL and/or SSO will determine when and if you may return to the field based on the extent of the immune response and hazards or potential hazards identified in these locations. To the FOL and SSO, this is a serious decision you have to make as to whether to take someone vulnerable to these hazards into a remote location where you may not be able to carry them out. Consider it wisely.

Poisonous Plants – To minimize the potential of encountering poisonous plants in the field, at least one member of the field team needs to have basic knowledge of what these plants look like so that they can be recognized, pointed out to other field personnel, and avoided if at all possible. If the field team cannot avoid contact and must move through an area where these plants exist, the level of personal protective equipment (PPE) shall include Tyvek coveralls and enhanced decontamination procedures for the removal of oils from the tooling and/or equipment.

Temperature-Related Stress – Excessively cold temperatures may result in cold stress, especially when entering the water either intentionally or by accident. Provisions for combating this hazard should be maintained at the sample location during this activity. Excessively hot temperatures may result in heat stress especially in scenarios where equipment is packed through the marsh.

Because all of these activities are conducted outside, electrical storms are a significant concern. The following measures will be incorporated to minimize this hazard:

- Where possible, utilize commercial warning systems and weather alerts to detect storms moving into the area.

- If on or in the water, get out of the water. Move to vehicles or preferably into enclosed buildings with plumbing and wiring.

- Where warning systems are not available, follow the 30/30 Rule (*if there are less than 30 seconds between thunder and lightning, go inside for at least 30 minutes after the last thunder).*

See Section 4.0 of the Health and Safety Guidance Manual (HSGM) for additional protective measures.

6.0 PROCEDURES

6.1 Introduction

Collecting a representative sample of surface water or sediment may be difficult because of water movement, stratification, or heterogeneous distribution of the targeted analytes. To collect representative samples, one must standardize sampling methods related to site selection, sampling frequency, sample collection, sampling devices, and sample handling, preservation, and identification. Regardless of quality control applied during laboratory analyses and subsequent scrutiny of analytical data packages, reported data are no better than the confidence that can be placed in the representativeness of the samples. Consult Appendix C for guidance on sampling that should be considered during project planning and that may be helpful to field personnel.

6.1.1 Surface Water Sampling Equipment

The selection of sampling equipment depends on the site conditions and sample type to be acquired. In general, the most representative samples are obtained from mid-channel at a stream depth of 0.5 foot in a well-mixed stream; however, project-specific planning documents will address site-specific sampling requirements including sample collection points and sampling equipment. The most frequently used samplers include the following:

- Peristaltic pump
- Bailer
- Dip sampler
- Weighted bottle
- Hand pump
- Kemmerer
- Depth-integrating sampler

The dip sampler and weighted bottle sampler are used most often, and detailed discussions for these devices and the Kemmerer sampler are addressed subsequently in this section.

The criteria for selecting a sampler include:

1. Disposability and/or easy decontamination.

2. Inexpensive cost (if the item is to be disposed).

3. Ease of operation.

4. Non-reactive/non-contaminating properties - Teflon-coated, glass, stainless-steel or polyvinyl chloride (PVC) sample chambers are preferred (in that order).

Measurements collected for each sample (grab or each aliquot collected for compositing) shall include but not be limited to:

- Specific conductance
- Temperature
- pH
- Dissolved oxygen

Sample measurements shall be conducted as soon as the sample is acquired. Measurement techniques described in SOP SA-1.1 shall be followed. All pertinent data and results shall be recorded in a field notebook or on sample log sheets (see Attachment A) or an equivalent electronic form(s). These analyses may be selected to provide information on water mixing/stratification and potential contamination. Various types of water bodies have differing potentials for mixing and stratification.

In general, the following equipment if necessary for obtaining surface water samples:

- Required sampling equipment, which may include a remote sampling pole, weighted bottle sampler, Kemmerer sampler, or other device.

- Real-time air monitoring instrument (e.g., PID, FID) as directed in the project-specific planning document.

- Required PPE as directed in the project-specific planning document, which may include:

  - Nitrile surgeon's or latex gloves (layered as necessary).

  - Safety glasses.

  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

Safety Reminder

The use of latex products may elicit an allergic reaction in some people. Should this occur, remove the latex gloves, treat for an allergic reaction, and seek medical attention as necessary.

  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

  - Required decontamination equipment.

  - Required sample containers.

  - Sealable polyethylene bags (e.g., Ziploc® baggies).

  - Heavy-duty cooler.

  - Ice.

  - Paper towels and garbage bags.

  - Chain-of-custody records and custody seals.

Dip Sampling

Specific procedures for collecting a dip or grab sample of surface water can vary based on site-specific conditions (e.g., conditions near the shore and how closely a sampler can safely get to the shore). The general procedure for collecting a sample using a pole or directly from the water body is as follows:

1. If using a remote sampling pole, securely attach the appropriate sample container to a pole of sufficient length to reach the water to be sampled. Samples for volatile analysis should be collected first. Use PPE as described in the HASP. When sample containers are provided pre-preserved or if the pole cannot accommodate a particular sample container, use a dedicated, clean, unpreserved bottle/container for sampling and transfer to an appropriately preserved container.

2. Remove the cap. Do not place the cap on the ground or elsewhere where it might become contaminated.

3. Carefully dip the container into the water just below the surface (or as directed by project-specific planning documents), and allow the bottle to fill. Sample bottles for volatile analysis must be filled with no headspace. Avoid contacting the bottom of the water body because this will disturb sediment that may interfere with the surface water sample.

4. Retrieve the container and carefully replace the cap securely. If using a container other than the sample bottle, pour the water from that container into the sample bottle and replace the cap securely.

5. Use a clean paper towel to clean and dry the outside of the container.

6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Constituents measured in grab samples collected near the water surface are only indicative of conditions near the surface of the water and may not be a true representation of the total concentration distributed throughout the water column and in the cross section. Therefore, as possible based on site conditions, the sampler may be required to augment dip samples with samples that represent both dissolved and suspended constituents and both vertical and horizontal distributions.

CAUTION

In areas prone to natural hazards such as alligators and snakes, etc., always use a buddy as a watch. Always have and use a lifeline or throwable device to extract persons who could potentially fall into the water. Be attentive to the signs, possible mounds indicating nests, and possible slides into the water. Remember that although snakes are typically encountered on the ground, it is not unheard of to see them on low-hanging branches. Be attentive to your surroundings because these may indicate that hazards are nearby.

Weighted Bottle Sampling

A grab sample can also be collected using a weighted holder that allows a bottle to be lowered to any desired depth, opened for filling, closed, and returned to the surface. This allows discrete sampling with depth. Several of these samples can be combined to provide a vertical composite. Alternatively, an open

bottle can be lowered to the bottom and raised to the surface at a uniform rate so that the bottle collects sample throughout the total depth and is just filled on reaching the surface. The resulting sample using either method will roughly approach what is known as a depth-integrated sample.

A closed weighted bottle sampler consists of glass or plastic bottle with a stopper, a weight and/or holding device, and lines to open the stopper and lower or raise the bottle. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth so as not to remove the stopper prematurely (watch for bubbles).
2. When the desired depth is reached, pull out the stopper with a sharp jerk of the stopper line.
3. Allow the bottle to fill completely, as evidenced by the absence of air bubbles.
4. Raise the sampler and cap the bottle.
5. Use a paper towel to clean and dry the outside of the container. This bottle can be used as the sample container as long as the bottle is an approved container type.
6. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
7. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

Kemmerer Sampler

If samples are desired at a specific depth, and the parameters to be measured do not require a Teflon-coated sampler, a standard Kemmerer sampler may be used. The Kemmerer sampler is a brass, stainless steel or acrylic cylinder with rubber stoppers that leave the ends open while it is lowered in a vertical position (thus allowing free passage of water through the cylinder). A "messenger" is sent down the line when the sampler is at the designated depth to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample bottles. The general procedure for sampling with this device is as follows:

1. Gently lower the sampler to the desired depth.
2. When the desired depth is reached, send down the messenger to close the cylinder and then raise the sampler.
3. Open the sampler valve to fill each sample bottle (filling bottles for volatile analysis first).
4. Use a paper towel to clean and dry the outside of the container.
5. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.
6. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

6.1.2 Surface Water Sampling Techniques

Samples collected during site investigations may be grab samples or composite samples. The following general procedures apply to various types of surface water collection techniques:

- If a clean, pre-preserved sample container is not used, rinse the sample container least once with the water to be sampled before the sample is collected. This is not applicable when sample containers are provided pre-preserved because doing so will wash some or all of the preservative out of the bottle.

- For sampling moving water, collect the farthest downstream sample first, and continue sample collection in an upstream direction. In general, work from zones suspected of low contamination to zones of high contamination.

- Take care to avoid excessive agitation of the water because loss of volatile constituents could result.

- When obtaining samples in 40 mL vials with septum-lined lids for volatile organics analysis, fill the container completely (with a meniscus) to exclude any air space in the top of the bottle and to be sure that the Teflon liner of the septum faces in after the vial is filled and capped. Turn the vial upside down and tap gently on your wrist to check for air bubbles. If air bubbles rise in the bottle, add additional sample volume to the container.

- Do not sample at the surface, unless sampling specifically for a known constituent that is immiscible and on top of the water. Instead, invert the sample container, lower it to the approximate depth, and hold it at about a 45-degree angle with the mouth of the bottle facing upstream.

6.2 Onsite Water Quality Testing

Onsite water quality testing shall be conducted as described in SOP SA-1.1.

6.3 Sediment Sampling

6.3.1 General

If composite surface water samples are collected, sediment samples are usually collected at the same locations as the associated surface water samples. If only one sediment sample is to be collected, the sampling location shall be approximately at the center of the water body, in a depositional area if possible based on sample location restraints (see below), unless the SAP states otherwise.

Generally, coarser-grained sediments are deposited near the headwaters of reservoirs. Bed sediments near the center of a water body will be composed of fine-grained materials that may, because of their lower porosity and greater surface area available for adsorption, contain greater concentrations of contaminants. The shape, flow pattern, bathymetry (i.e., depth distribution), and water circulation patterns must all be considered when selecting sediment sampling sites. In streams, areas likely to have sediment accumulation (e.g., bends, behind islands or boulders, quiet shallow areas or very deep, low-velocity areas) shall be sampled, in general, and areas likely to show net erosion (i.e., high-velocity, turbulent areas) and suspension of fine solid materials shall be generally avoided. Follow instructions in the SAP, as applicable.

Chemical constituents associated with bottom material may reflect an integration of chemical and biological processes. Bottom samples reflect the historical input to streams, lakes, and estuaries with respect to time, application of chemicals, and land use. Bottom sediments (especially fine-grained material) may act as a sink or reservoir for adsorbed heavy metals and organic contaminants (even if water column concentrations are less than detection limits). Therefore, it is important to minimize the loss of low-density "fines" during any sampling process.

Samples collected for volatile organic compound (VOC) analysis must be collected prior to any sample homogenization. Regardless of the method used for collection, the aliquot for VOC analysis must be collected directly from the sampling device (hand auger bucket, scoop, trowel), to the extent practical. If a device such as a dredge is used, the aliquot should be collected after the sample is placed in the mixing container prior to mixing.

In some cases, the sediment may be soft and not lend itself to collection by plunging Encore™ or syringe samplers into the sample matrix. In these cases, it is appropriate to open the sampling device, (Encore™ barrel or syringe) prior to sample collection, and carefully place the sediment in the device, filling it fully with the required volume of sample.

On active or former military sites, ordnance items may be encountered in some work areas. Care should be exercised when handling site media (such as if unloading a dredge as these materials may be scooped up). If suspected ordnance items are encountered, stop work immediately, move to shore and notify the Project Manager and Health and Safety Manager.

All relevant information pertaining to sediment sampling shall be documented as applicably described in SOP SA-6.3 and Attachment B or an equivalent electronic form.

6.3.2 Sampling Equipment and Techniques for Bottom Materials

A bottom-material sample may consist of a single scoop or core, or may be a composite of several individual samples in the cross section. Sediment samples may be obtained using onshore or offshore techniques.

SAFETY REMINDER

The following health and safety provisions apply when working on/over/near water:

- At least two people are required to be present at the sampling location in situations where the water depth and/or movement deem it necessary, each wearing a USCG-approved Personal Flotation Devices
- A minimum of three people are required if *any* of the following conditions are anticipated or observed:
  - Work in a waterway that is turbulent *or* swift that could sweep a sampler down stream should he or she fall in accidentally.
  - The underwater walking surface (e.g., stream/river bed) is suspected or observed to involve conditions that increase the potential for a worker to fall into the water. Examples include large/uneven rocks or boulders, dense mud or sediment that could entrap worker's feet, etc.
  - Waterway is tidal, and conditions such as those listed above could rapidly change.

The third person in the above condition must be equipped and prepared to render emergency support [e.g., lifeline, tethered Personal Flotation Device (Throwable Type IV, life saver), skiff, means to contact external emergency response support, etc.]

The following samplers may be used to collect sediment samples:

- Scoop sampler
- Dredge samplers
- Coring samplers

Each type of sampler is discussed below.

In general, the following equipment if necessary for obtaining sediment samples:

- Required sampling equipment, which may include a scoop sampler, dredge sampler, coring sampler, or stainless steel or pre-cleaned disposable trowel.

- Stainless bowl or pre-cleaned disposable bowl to homogenize sample.

- ~~Real-time air monitoring instrument (e.g., PID, FID) as directed in the project specific planning document.~~

- Required PPE as directed in the project-specific planning document, which may include:

  - Nitrile surgeon's or latex gloves (layered as necessary).

  - Safety glasses.

  - Other items identified on the Safe Work Permit that may be required based on location-specific requirements (e.g., hearing protection, steel-toed work boots, hard hat). These provisions will be listed in the HASP or addressed by the FOL and/or SSO.

  - Required paperwork (see SOP SA-6.3 and Attachments A and B to this SOP).

  - Required decontamination equipment.

  - Required sample containers.

  - Sealable polyethylene bags (e.g., Ziploc® baggies).

  - Heavy-duty cooler.

  - Ice.

  - Paper towels and garbage bags.

  - Chain-of-custody records and custody seals.

Scoop Sampler

A scoop sampler consists of a pole to which a jar or scoop is attached. The pole may be made of bamboo, wood, PVC, or aluminum and be either telescoping or of fixed length. The scoop or jar at the end of the pole is usually attached using a clamp.

If the water body can be sampled from the shore or if the sampler can safely wade to the required location, the easiest and best way to collect a sediment sample is to use a scoop sampler. Scoop sampling also reduces the potential for cross-contamination. The general scoop sampling procedure is as follows:

1. Reach over or wade into the water body.

2. While facing upstream (into the current), scoop the sampler along the bottom in an upstream direction. Although it is very difficult not to disturb fine-grained materials at the sediment-water interface when using this method, try to keep disturbances to a minimum.

Dredge Samplers

Dredges are generally used to sample sediments that cannot easily be obtained using coring devices (e.g., coarse-grained or partially cemented materials) or when large quantities of sample are required. Dredges generally consist of a clam shell arrangement of two buckets. The buckets may either close upon impact or be activated by use of a "messenger." Some dredges are heavy and may require use of a winch and crane assembly for sample retrieval. The three major types of dredges are Peterson, Eckman and Ponar.

The Peterson dredge is used when the bottom is rocky, in very deep water, or when the flow velocity is high. The Peterson dredge shall be lowered very slowly as it approaches bottom, because it can force out and miss lighter materials if allowed to drop freely.

The Eckman dredge has only limited usefulness. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms and is too light for use in streams with high flow velocities.

The Ponar dredge is a Peterson dredge modified by the addition of side plates and a screen on the top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends, thus reducing the "shock wave." The Ponar dredge is easily operated by one person in the same fashion as the Peterson dredge. The Ponar dredge is one of the most effective samplers for general use on all types of substrates.

The general procedure for using dredge samplers is as follows:

1. Gently lower the dredge to the desired depth.

2. When the desired depth is reached, send the messenger down to cable to close the cylinder and then carefully raise the sampler.

3. Open the sampler to retrieve the sediment.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis *prior to* homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

SAFETY REMINDER
Safety concerns using these dredges include lifting hazards, pinches, and compressions (several pinch points exist within the jaws and levers). In all cases, handle the dredge by the rope to avoid capturing fingers/hands.

Coring Samplers

Coring samplers are used to sample vertical columns of sediment. Many types of coring devices have been developed depending on the depth of water from which the sample is to be obtained, the nature of the bottom material, and the length of core to be collected. They vary from hand-push tubes to electronic vibrational core tube drivers.

Coring devices are particularly useful in pollutant monitoring because turbulence created by descent through the water is minimal, thus the fines at the sediment-water interface are only minimally disturbed. The sample is withdrawn intact, permitting the removal of only those layers of interest.

In shallow, wadeable waters, the use of a core liner or tube manufactured of Teflon or plastic is recommended for the collection of sediment samples. Caution should be exercised not to disturb the bottom sediments when the sample is obtained by wading in shallow water. The general procedure to collecting a sediment sample with a core tube is as follows:

1. Push the tube into the substrate until 4 inches or less of the tube is above the sediment-water interface. When sampling hard or coarse substrates, a gentle rotation of the tube while it is being pushed will facilitate greater penetration and decrease core compaction.

2. Cop the top of the tube to provide suction and reduce the chance of losing the sample.

3. Slowly extract the tube so as not to lose sediment from the bottom of the tube. Cap the bottom of the tube before removing it from the water. This will also help to minimize loss of sample.

4. Transfer the sediment to the bowl in which it will be homogenized. Fill the sample bottle(s) for volatile analysis prior to homogenization. Homogenize the remainder of the sediment collected.

5. Fill the containers for all analyses other and VOCs.

6. Use a paper towel to clean and dry the outside of each container.

7. Affix a sample label to each container, ensuring that each label is completely carefully, clearly, and completely, addressing all of the categories described in SOP SA-6.3.

8. Proceed with the handling and processing of each sample container as described in SOP SA-6.2.

In deeper, non-wadeable water bodies, sediment cores may be collected from a bridge or boat using different coring devices such as Ogeechee Sand Pounders, gravity cores, and vibrating coring devices. All three devices utilize a core barrel with a core liner tube system. The core liners can be removed from the core barrel and replaced with a clean core liner after each sample. Before extracting the sediment from the coring tubes, the clear supernatant above the sediment-water interface in the core should be decanted from the tube. This is accomplished by turning the core tube to its side and gently pouring the liquid out until fine sediment particles appear in the waste liquid. Post-retrieval processing of samples is the same as above.

7.0 REFERENCES

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ATTACHMENT A
SURFACE WATER SAMPLE LOG SHEET

Tetra Tech

SURFACE WATER SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Stream
[] Spring
[] Pond
[] Lake
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

SAMPLING DATA

	Color	pH	S.C.	Temp.	Turbidity	DO	Salinity	Other
Date:	Visual	Standard	mS/cm	Degrees C	NTU	mg/l	%	NA
Time:								
Depth:								
Method:								

SAMPLE COLLECTION INFORMATION

Analysis	Preservative	Container Requirements	Collected

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

ATTACHMENT B
SOIL & SEDIMENT SAMPLE LOG SHEET

Tetra Tech

SOIL & SEDIMENT SAMPLE LOG SHEET

Page___ of ___

Project Site Name: _____
Project No.: _____

[] Surface Soil
[] Subsurface Soil
[] Sediment
[] Other: _____
[] QA Sample Type: _____

Sample ID No.: _____
Sample Location: _____
Sampled By: _____
C.O.C. No.: _____

Type of Sample:
[] Low Concentration
[] High Concentration

GRAB SAMPLE DATA:

Date:	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Time:			
Method:			
Monitor Reading (ppm):			

COMPOSITE SAMPLE DATA:

Date:	Time	Depth	Color	Description (Sand, Silt, Clay, Moisture, etc.)
Method:				
Monitor Readings (Range in ppm):				

SAMPLE COLLECTION INFORMATION:

Analysis	Container Requirements	Collected	Other

OBSERVATIONS / NOTES:

MAP:

Circle if Applicable:

MS/MSD	Duplicate ID No.:

Signature(s):

APPENDIX C
GUIDANCE ON SAMPLING DESIGN AND SAMPLE COLLECTION

C.1 Defining the Sampling Program

Many factors are considered in developing a sampling program for surface water and/or sediment, including study objectives, accessibility, site topography, physical characteristics of the water body (e.g., flow and mixing), point and diffuse sources of contamination, and personnel and equipment available to conduct the study. For waterborne constituents, dispersion depends on vertical and lateral mixing within the body of water. For sediment, dispersion depends on bottom current or flow characteristics, sediment characteristics (e.g., density, size), and geochemical properties (that affect adsorption/desorption). The hydrogeologist developing the sampling plan must therefore know not only the mixing characteristics of streams and lakes but must also understand the role of fluvial-sediment transport, deposition, and chemical sorption.

C.1.1 Sampling Program Objectives

The scope of the sampling program must consider the sources and potential pathways for transport of contamination to or within a surface water body. Sources may include point sources (leaky tanks, outfalls, etc.) or nonpoint sources (e.g., contaminated runoff). The major pathways for surface water contamination (not including airborne deposition) are overland runoff, leachate influx to the water body, direct waste disposal (solid or liquid) into the water body, and groundwater flow influx from upgradient. The relative importance of these pathways, and therefore the design of the sampling program, is controlled by the physiographic and hydrologic features of the site, the drainage basin(s) that encompasses the site, and the history of site activities.

Physiographic and hydrologic features to be considered include slopes and runoff direction, areas of temporary flooding or pooling, tidal effects, artificial surface runoff controls such as berms or drainage ditches (and when they were constructed relative to site operation), and locations of springs, seeps, marshes, etc. In addition, the obvious considerations such as the locations of man-made discharge points to the nearest stream (intermittent or flowing), pond, lake, estuary, etc. shall be considered.

A more subtle consideration in designing the sampling program is the potential for dispersion of dissolved or sediment-associated contaminants away from the source. The dispersion could lead to a more homogeneous distribution of contamination at low or possibly non-detectable concentrations. Such dispersion does not, however, always readily occur. For example, obtaining a representative sample of contamination from a main stream immediately below an outfall or a tributary is difficult because the inflow frequently follows a stream bank with little lateral mixing for some distance. Sampling alternatives to overcome this situation include: (1) moving the sampling location far enough downstream to allow for adequate mixing, or (2) collecting integrated samples in a cross section. Also, non-homogeneous distribution is a particular problem with regard to sediment-associated contaminants, which may accumulate in low-energy environments (coves, river bends, deep spots, or even behind boulders) near or distant from the source while higher-energy areas (main stream channels) near the source may show no contaminant accumulation.

The distribution of particulates within a sample itself is an important consideration. Many organic compounds are only slightly water soluble and tend to adsorb onto particulate matter. Nitrogen, phosphorus, and heavy metals may also be transported by particulates. Samples must be collected with a representative amount of suspended material; transfer from the sampling device shall include transferring a proportionate amount of the suspended material.

C.1.2 Location of Sampling Stations

Accessibility is the primary factor affecting sampling costs. The desirability and utility of a sample for analysis and consideration of site conditions must be balanced against the costs of collection as controlled by accessibility. Bridges or piers are the first choice for locating a sampling station on a stream because bridges provide ready access and also permit the sampling technician to sample any point across the stream. A boat or pontoon (with an associated increase in cost) may be needed to sample locations on lakes, reservoirs, or larger rivers. Frequently, however, a boat will take longer to cross a water body and will hinder manipulation of the sampling equipment. Wading for samples is not recommended unless it is known that contaminant levels are low so that skin contact will not produce adverse health effects. This provides a built in margin of safety in the event that wading boots or other protective equipment should fail to function properly. If it is necessary to wade into the water body to obtain a sample, the sampler shall be careful to minimize disturbance of bottom sediments and must enter the water body downstream of the sampling location. If necessary, the sampling technician shall wait for the sediments to settle before taking a sample.

Under ideal and uniform contaminant dispersion conditions in a flowing stream, the same concentrations of each contaminant would occur at all points along the cross section. This situation is most likely downstream of areas of high turbulence. Careful site selection is needed to ensure, as nearly as possible, that samples are taken where uniform flow or deposition and good mixing conditions exist.

The availability of stream flow and sediment discharge records can be an important consideration in choosing sampling sites in streams. Stream flow data in association with contaminant concentration data are essential for estimating the total contaminant loads carried by the stream. If a gaging station is not conveniently located on a selected stream, the project hydrogeologist shall explore the possibility of obtaining stream flow data by direct or indirect methods. Remember these locations are also where you may encounter natural hazards as these are areas where they hunt. Always exercise extreme caution.

C.1.3 Frequency of Sampling

The sampling frequency and objectives of the sampling event will be defined by the project planning documents. For single-event site or area characterization sampling, both bottom material and overlying water samples shall be collected at the specified sampling stations. If valid data are available on the distribution of a contaminant between the solid and aqueous phases, it may be appropriate to sample only one phase, although this is not often recommended. If samples are collected primarily for monitoring purposes (i.e., consisting of repetitive, continuing measurements to define variations and trends at a given location), water samples should be collected at a pre-established and constant interval as specified in the project plans (often monthly or quarterly and during droughts and floods). Samples of bottom material should generally be collected from fresh deposits at least yearly, and preferably seasonally, during both spring and fall.

The variability in available water quality data shall be evaluated before determining the number and collection frequency of samples required to maintain an effective monitoring program.

~~C.2~~ Surface Water Sample Collection

C.2.1 Streams, Rivers, Outfalls and Drainage Features

Methods for sampling streams, rivers, outfalls, and drainage features (ditches, culverts) at a single point vary from the simplest of hand-sampling procedures to the more sophisticated multi-point sampling techniques known as the equal-width-increment (EWI) method or the equal-discharge-increment (EDI) methods (see below).

Samples from different depths or cross-sectional locations in the watercourse taken during the same sampling episode shall be composited. However, samples collected along the length of the watercourse or at different times may reflect differing inputs or dilutions and therefore shall not be composited. Generally, the number and type of samples to be taken depend on the river's width, depth, and discharge and on the suspended sediment the stream or river transports. The greater the number of individual points that are sampled, the more likely that the composite sample will truly represent the overall characteristics of the water.

In small streams less than about 20 feet wide, a sampling site can generally be found where the water is well mixed. In such cases, a single grab sample taken at mid-depth in the center of the channel is adequate to represent the entire cross section.

For larger streams, at least one vertical composite shall be taken with one sample each from just below the surface, at mid-depth, and just above the bottom. The measurement of dissolved oxygen (DO), pH, temperature, conductivity, etc., shall be made on each aliquot of the vertical composite and on the composite itself. For rivers, several vertical composites shall be collected, as directed in the project planning documents.

C.2.2 Lakes, Ponds and Reservoirs

Lakes, ponds, and reservoirs have a much greater tendency to stratify than rivers and streams. The relative lack of mixing requires that more samples be obtained. The number of water sampling sites on a lake, pond, or impoundment will vary with the size and shape of the basin. In ponds and small lakes, a single vertical composite at the deepest point may be sufficient. Similarly, measurement of DO, pH, temperature, etc. is to be conducted on each aliquot of the vertical composite and on the composite itself. In naturally formed ponds, the deepest point may have to be determined empirically; in impoundments, the deepest point is usually near the dam.

In lakes and larger reservoirs, several vertical composites shall be composited to form a single sample if a sample representative of the water column is required. These vertical composites are often collected along a transect or grid. In some cases, it may be of interest to form separate composites of epilimnetic and hypolimnetic zones. In a stratified lake, the epilimnion is the thermocline that is exposed to the atmosphere. The hypolimnion is the lower, "confined" layer that is only mixed with the epilimnion and vented to the atmosphere during seasonal "overturn" (when density stratification disappears). These two zones may thus have very different concentrations of contaminants if input is only to one zone, if the contaminants are volatile (and therefore vented from the epilimnion but not the hypolimnion), or if the epilimnion only is involved in short-term flushing (i.e., inflow from or outflow to shallow streams). Normally, however, a composite consists of several vertical composites with samples collected at various depths.

In lakes with irregular shape and with bays and coves that are protected from the wind, separate composite samples may be needed to adequately represent water quality because it is likely that only poor mixing will occur. Similarly, additional samples are recommended where discharges, tributaries, land use characteristics, and other such factors are suspected of influencing water quality.

Many lake measurements are now made in situ using sensors and automatic readout or recording devices. Single and multi-parameter instruments are available for measuring temperature, depth, pH, oxidation-reduction potential (ORP), specific conductance, DO, some cations and anions, and light penetration.

C.2.3 Estuaries

Estuarine areas are, by definition, zones where inland freshwaters (both surface and ground) mix with oceanic saline waters. Knowledge of the estuary type may be necessary to determine sampling locations. Estuaries are generally categorized into one of the following three types dependent on freshwater inflow and mixing properties:

- Mixed Estuary - characterized by the absence of a vertical halocline (gradual or no marked increase in salinity in the water column) and a gradual increase in salinity seaward. Typically, this type of estuary is shallow and is found in major freshwater sheet flow areas. Because this type of estuary is well mixed, sampling locations are not critical.

- Salt Wedge Estuary - characterized by a sharp vertical increase in salinity and stratified freshwater flow along the surface. In these estuaries, the vertical mixing forces cannot override the density differential between fresh and saline waters. In effect, a salt wedge tapering inland moves horizontally back and forth with the tidal phase. If contamination is being introduced into the estuary from upstream, water sampling from the salt wedge may miss it entirely.

- Oceanic Estuary - characterized by salinities approaching full-strength oceanic waters. Seasonally, freshwater inflow is small, with the preponderance of the fresh-saline water mixing occurring near or at the shore line.

Sampling in estuarine areas is normally based on the tidal phase, with samples collected on successive slack tides (i.e., when the tide turns). Estuarine sampling programs shall include vertical salinity measurements at 1- to 5-foot increments, coupled with vertical DO and temperature profiles.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to provide information on sample preservation, packaging, and shipping procedures to be used in handling environmental samples submitted for chemical constituent, biological, or geotechnical analysis. Sample chain-of-custody procedures and other aspects of field documentation are addressed in SOP SA-6.3. Sample identification is addressed in SOP CT-04.

2.0 SCOPE

This procedure describes the appropriate containers to be used for samples depending on the analyses to be performed, and the steps necessary to preserve the samples when shipped off site for chemical analysis.

3.0 GLOSSARY

Hazardous Material - A substance or material which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety, and property when transported in commerce, and which has been so designated. Under 49 CFR, the term includes hazardous substances, hazardous wastes, marine pollutants, and elevated temperature materials, as well as materials designated as hazardous under the provisions of ∋172.101 and ∋172.102 and materials that meet the defining criteria for hazard classes and divisions in Part 173. With slight modifications, IATA has adopted DOT "hazardous materials" as IATA "Dangerous Goods."

Hazardous Waste - Any substance listed in 40 CFR, Subpart D (ɣ261.30 et seq.), or otherwise characterized as ignitable, corrosive, reactive, or toxic (as defined by Toxicity Characteristic Leaching Procedure, TCLP, analysis) as specified under 40 CFR, Subpart C (ɣ261.20 et seq.), that would be subject to manifest requirements specified in 40 CFR 262. Such substances are defined and regulated by EPA.

Marking - A descriptive name, identification number, instructions, cautions, weight, specification or UN marks, or combination thereof required on outer packaging of hazardous materials.

n.o.i - Not otherwise indicated (may be used interchangeably with n.o.s.).

n.o.s. - Not otherwise specified.

Packaging - A receptacle and any other components or materials necessary for compliance with the minimum packaging requirements of 49 CFR 174, including containers (other than freight containers or overpacks), portable tanks, cargo tanks, tank cars, and multi-unit tank-car tanks to perform a containment function in conformance with the minimum packaging requirements of 49 CFR 173.24(a) & (b).

Placard - Color-coded, pictorial sign which depicts the hazard class symbol and name and which is placed on the side of a vehicle transporting certain hazardous materials.

Common Preservatives:

- Hydrochloric Acid - HCl
- Sulfuric Acid - H_2SO_4
- Nitric Acid - HNO_3
- Sodium Hydroxide - NaOH

Other Preservatives

- Zinc Acetate
- Sodium Thiosulfate - $Na_2S_2O_3$

Normality (N) - Concentration of a solution expressed as equivalent per liter, an equivalent being the amount of a substance containing 1 gram-atom of replaceable hydrogen or its equivalent.

Reportable Quantity (RQ) - For the purposes of this SOP, means the quantity specified in column 3 of the Appendix to DOT 49 CFR ∋172.101 for any material identified in column 1 of the appendix. A spill greater than the amount specified must be reported to the National Response Center.

Sample - A sample is physical evidence collected from a facility or the environment, which is representative of conditions at the location and time of collection.

4.0 RESPONSIBILITIES

Field Operations Leader - Directly responsible for the bottling, preservation, labeling, packaging, shipping, and custody of samples up to and including release to the shipper.

Field Samplers - Responsible for initiating the Chain-of-Custody Record (per SOP SA-6.3), implementing the packaging and shipping requirements, and maintaining custody of samples until they are relinquished to another custodian or to the shipper.

5.0 PROCEDURES

Sample identification, labeling, documentation, and chain-of-custody are addressed by SOP SA-6.3.

5.1 Sample Containers

Different types of chemicals react differently with sample containers made of various materials. For example, trace metals adsorb more strongly to glass than to plastic, whereas many organic chemicals may dissolve various types of plastic containers. Attachments A and B show proper containers (as well as other information) per 40 CFR 136. In general, the sample container shall allow approximately 5-10 percent air space ("ullage") to allow for expansion/vaporization if the sample warms during transport. However, for collection of volatile organic compounds, head space shall be omitted. The analytical laboratory will generally provide certified-clean containers for samples to be analyzed for chemical constituents. Shelby tubes or other sample containers are generally provided by the driller for samples requiring geotechnical analysis. Sufficient lead time shall be allowed for a delivery of sample container orders. Therefore, it is critical to use the correct container to maintain the integrity of the sample prior to analysis.

Once opened, the container must be used at once for storage of a particular sample. Unused but opened containers are to be considered contaminated and must be discarded. Because of the potential for introduction of contamination, they cannot be reclosed and saved for later use. Likewise, any unused containers which appear contaminated upon receipt, or which are found to have loose caps or a missing Teflon liner (if required for the container), shall be discarded.

5.2 Sample Preservation

Many water and soil samples are unstable and therefore require preservation to prevent changes in either the concentration or the physical condition of the constituent(s) requiring analysis. Although complete

and irreversible preservation of samples is not possible, preservation does retard the chemical and biological changes that inevitably take place after the sample is collected. Preservation techniques are usually limited to pH control, chemical addition(s), and refrigeration/ freezing (certain biological samples only).

5.2.1 Overview

The preservation techniques to be used for various analytes are listed in Attachments A and B. Reagents required for sample preservation will either be added to the sample containers by the laboratory prior to their shipment to the field or be added in the field (in a clean environment). Only high purity reagents shall be used for preservation. In general, aqueous samples of low-concentration organics (or soil samples of low- or medium-concentration organics) are cooled to 4EC. Medium-concentration aqueous samples, high-hazard organic samples, and some gas samples are typically not preserved. Low-concentration aqueous samples for metals are acidified with HNO_3, whereas medium-concentration and high-hazard aqueous metal samples are not preserved. Low- or medium-concentration soil samples for metals are cooled to 4EC, whereas high-hazard samples are not cooled.

The following subsections describe the procedures for preparing and adding chemical preservatives. Attachments A and B indicate the specific analytes which require these preservatives.

The FOL is responsible for ensuring that an accurate Chemical Inventory is created and maintained for all hazardous chemicals brought to the work site (see Section 5 of the TtNUS Health and Safety Guidance Manual). Furthermore, the FOL must ensure that a corresponding Material Safety Data Sheet (MSDS) is collected for every substance entered on the site Chemical Inventory, and that all persons using/handling/ disposing of these substances review the appropriate MSDS for substances they will work with. The Chemical Inventory and the MSDSs must be maintained at each work site in a location and manner where they are readily-accessible to all personnel.

5.2.2 Preparation and Addition of Reagents

Addition of the following acids or bases may be specified for sample preservation; these reagents shall be analytical reagent (AR) grade or purer and shall be diluted to the required concentration with deionized water before field sampling commences. To avoid uncontrolled reactions, be sure to Add Acid to water (not vice versa). A dilutions guide is provided below.

Acid/Base	Dilution	Concentration	Estimated Amount Required for Preservation
Hydrochloric Acid (HCl)	1 part concentrated HCl: 1 part double-distilled, deionized water	6N	5-10 mL
Sulfuric Acid (H_2SO_4)	1 part concentrated H_2SO_4: 1 part double-distilled, deionized water	18N	2 - 5 mL
Nitric Acid (HNO_3)	Undiluted concentrated HNO_3	16N	2 - 5 mL
Sodium Hydroxide (NaOH)	400 grams solid NaOH dissolved in 870 mL double-distilled, deionized water; yields 1 liter of solution	10N	2 mL

The amounts required for preservation shown in the above table assumes proper preparation of the preservative and addition of the preservative to one liter of aqueous sample. This assumes that the sample is initially at pH 7, is poorly buffered, and does not contain particulate matter; as these conditions

vary, more preservative may be required. Consequently, the final sample pH must be checked using narrow-range pH paper, as described in the generalized procedure detailed below:

- Pour off 5-10 mL of sample into a dedicated, clean container. Use some of this sample to check the initial sample pH using wide range (0-14) pH paper. Never dip the pH paper into the sample; always apply a drop of sample to the pH paper using a clean stirring rod or pipette.

- Add about one-half of the estimated preservative required to the original sample bottle. Cap and invert gently several times to mix. Check pH (as described above) using medium range pH paper (pH 0-6 or pH 7.5-14, as applicable).

- Cap sample bottle and seal securely.

Additional considerations are discussed below:

- To test if ascorbic acid must be used to remove oxidizing agents present in the sample before it can be properly preserved, place a drop of sample on KI-starch paper. A blue color indicates the need for ascorbic acid addition.

  If required, add a few crystals of ascorbic acid to the sample and retest with the KI-starch paper. Repeat until a drop of sample produces no color on the KI-starch paper. Then add an additional 0.6 grams of ascorbic acid per each liter of sample volume.

  Continue with proper base preservation of the sample as described above.

- Samples for sulfide analysis must be treated by the addition of 4 drops (0.2 mL) of 2N zinc acetate solution per 100 ml of sample.

  The 2N zinc acetate solution is made by dissolving 220 grams of zinc acetate in 870 mL of double-distilled, deionized water to make 1 liter of solution.

  The sample pH is then raised to 9 using the NaOH preservative.

- Sodium thiosulfate must be added to remove residual chlorine from a sample. To test the sample for residual chlorine use a field test kit specially made for this purpose.

  If residual chlorine is present, add 0.08 grams of sodium thiosulfate per liter of sample to remove the residual chlorine.

  Continue with proper acidification of the sample as described above.

For biological samples, 10% buffered formalin or isopropanol may also be required for preservation. Questions regarding preservation requirements should be resolved through communication with the laboratory before sampling begins.

5.3 Field Filtration

At times, field-filtration may be required to provide for the analysis of dissolved chemical constituents. Field-filtration must be performed prior to the preservation of samples as described above. General procedures for field filtration are described below:

- The sample shall be filtered through a non-metallic, 0.45-micron membrane filter, immediately after collection. The filtration system shall consist of dedicated filter canister, dedicated tubing, and a

peristaltic pump with pressure or vacuum pumping squeeze action (since the sample is filtered by mechanical peristalsis, the sample travels only through the tubing).

- To perform filtration, thread the tubing through the peristaltic pump head. Attach the filter canister to the discharge end of the silicon tubing (note flow direction arrow); attach the aqueous sample container to the intake end of the silicon tubing. Turn the peristaltic pump on and perform filtration. Run approximately 100 ml of sample through the filter and discard prior to sample collection.

- Continue by preserving the filtrate (contained in the filter canister), as applicable and generally described above.

5.4 Sample Packaging and Shipping

Only employees who have successfully completed the TtNUS "Shipping Hazardous Materials" training course are authorized to package and ship hazardous substances. These trained individuals are responsible for performing shipping duties in accordance with this training.

Samples collected for shipment from a site shall be classified as either environmental or hazardous material samples. Samples from drums containing materials other than Investigative Derived Waste (IDW) and samples obtained from waste piles or bulk storage tanks are generally shipped as hazardous materials. A distinction must be made between the two types of samples in order to:

- Determine appropriate procedures for transportation of samples (if there is any doubt, a sample shall be considered hazardous and shipped accordingly.)

- Protect the health and safety of transport and laboratory personnel receiving the samples (special precautions are used by the shipper and at laboratories when hazardous materials are received.)

Detailed procedures for packaging environmental samples are outlined in the remainder of this section.

5.4.1 Environmental Samples

Environmental samples are packaged as follows:

- Place properly identified sample container, with lid securely fastened, in a plastic bag (e.g. Ziploc baggie), and seal the bag.

- Place sample in a cooler constructed of sturdy material which has been lined with a large, plastic bag (e.g. "garbage" bag). Drain plugs on coolers must be taped shut.

- Pack with enough cushioning materials such as bubble wrap (shoulders of bottles must be iced if required) to minimize the possibility of the container breaking.

- If cooling is required (see Attachments A and B), place ice around sample container shoulders, and on top of packing material (minimum of 8 pounds of ice for a medium-size cooler).

- Seal (i.e., tape or tie top in knot) large liner bag.

- The original (top, signed copy) of the COC form shall be placed inside a large Ziploc-type bag and taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one COC form, the COC form should be sent with the cooler containing the vials for VOC analysis. The COC form should then state how many coolers are included with that shipment.

- Close and seal outside of cooler as described in SOP SA-6.3. Signed custody seals must be used.

Coolers must be marked as containing "Environmental Samples." The appropriate side of the container must be marked "This End Up" and arrows placed appropriately. No DOT marking or labeling is required; there are no DOT restrictions on mode of transportation.

6.0 REFERENCES

American Public Health Association, 1981. Standard Methods for the Examination of Water and Wastewater, 15th Edition. APHA, Washington, D.C.

International Air Transport Association (latest issue). Dangerous Goods Regulations, Montreal, Quebec, Canada.

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U.S. EPA, 1984. "Guidelines Establishing Test Procedures for the Analysis of Pollutants under Clean Water Act." Federal Register, Volume 49 (209), October 26, 1984, p. 43234.

U.S. EPA, 1979. Methods for Chemical Analysis of Water and Wastes. EPA-600/4-79-020, U.S. EPA-EMSL, Cincinnati, Ohio.

ATTACHMENT A

GENERAL SAMPLE CONTAINER AND PRESERVATION REQUIREMENTS

Sample Type and Concentration		Container[1]	Sample Size	Preservation[2]	Holding Time[2]
WATER					
Organics (GC&GC/MS)	VOC Low	Borosilicate glass	2 x 40 mL	Cool to 4EC HCl to # 2	14 days[9]
	Extractables (Low SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	Cool to 4EC	7 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticide/PCBs)	Amber glass	2x2 L or 4x1 L	None	7 days to extraction; 40 days after extraction
Inorganics	Metals Low	High-density polyethylene	1 L	HNO_3 to pH #2	6 months (Hg-28 days)
	Medium	Wide-mouth glass	16 oz.	None	6 months
	Cyanide Low	High-density polyethylene	1 L	NaOH to pH>12	14 days
	Cyanide Medium	Wide-mouth glass	16 oz.	None	14 days
Organic/ Inorganic	High Hazard	Wide-mouth glass	8 oz.	None	14 days
SOIL					
Organics (GC&GC/MS)	VOC	EnCore Sampler	(3) 5 g Samplers	Cool to 4EC	48 hours to lab preservation
	Extractables (Low SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4EC	14 days to extraction; 40 days after extraction
	Extractables (Medium SVOCs and pesticides/PCBs)	Wide-mouth glass	8 oz.	Cool to 4EC	14 days to extraction; 40 days after extraction
Inorganics	Low/Medium	Wide-mouth glass	8 oz.	Cool to 4EC	6 months (Hg - 28 days) Cyanide (14 days)
Organic/Inorganic	High Hazard	Wide-mouth glass	8 oz.	None	NA
Dioxin/Furan	All	Wide-mouth glass	4 oz.	None	35 days until extraction; 40 days after extraction
TCLP	All	Wide-mouth glass	8 oz.	None	7 days until preparation; analysis as per fraction
AIR					
Volatile Organics	Low/Medium	Charcoal tube -- 7 cm long, 6 mm OD, 4 mm ID	100 L air	Cool to 4EC	5 days recommended

1 All glass containers should have Teflon cap liners or septa.
2 See Attachment E. Preservation and maximum holding time allowances per 40 CFR 136.

ATTACHMENT B

ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS:			
Acidity	P, G	Cool, 4EC	14 days
Alkalinity	P, G	Cool, 4EC	14 days
Ammonia - Nitrogen	P, G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Biochemical Oxygen Demand (BOD)	P, G	Cool, 4EC	48 hours
Bromide	P, G	None required	28 days
Chemical Oxygen Demand (COD)	P, G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Chloride	P, G	None required	28 days
Chlorine, Total Residual	P, G	None required	Analyze immediately
Color	P, G	Cool, 4EC	48 hours
Cyanide, Total and Amenable to Chlorination	P, G	Cool, 4EC; NaOH to pH 12; 0.6 g ascorbic acid[5]	14 days[6]
Fluoride	P	None required	28 days
Hardness	P, G	HNO_3 to pH 2; H_2SO_4 to pH 2	6 months
Total Kjeldahl and Organic Nitrogen	P, G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Nitrate - Nitrogen	P, G	None required	48 hours
Nitrate-Nitrite - Nitrogen	P, G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Nitrite - Nitrogen	P, G	Cool, 4EC	48 hours
Oil & Grease	G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Total Organic Carbon (TOC)	P, G	Cool, 4EC; HCl or H_2SO_4 to pH 2	28 days
Orthophosphate	P, G	Filter immediately; Cool, 4EC	48 hours
Oxygen, Dissolved-Probe	G Bottle & top	None required	Analyze immediately
Oxygen, Dissolved-Winkler	G Bottle & top	Fix on site and store in dark	8 hours
Phenols	G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Phosphorus, Total	P, G	Cool, 4EC; H_2SO_4 to pH 2	28 days
Residue, Total	P, G	Cool, 4EC	7 days
Residue, Filterable (TDS)	P, G	Cool, 4EC	7 days
Residue, Nonfilterable (TSS)	P, G	Cool, 4EC	7 days
Residue, Settleable	P, G	Cool, 4EC	48 hours
Residue, Volatile (Ash Content)	P, G	Cool, 4EC	7 days
Silica	P	Cool, 4EC	28 days
Specific Conductance	P, G	Cool, 4EC	28 days
Sulfate	P, G	Cool, 4EC	28 days

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE TWO

Parameter Number/Name	Container[1]	Preservation[2][3]	Maximum Holding Time[4]
INORGANIC TESTS (Cont'd):			
Sulfide	P, G	Cool, 4EC; add zinc acetate plus sodium hydroxide to pH 9	7 days
Sulfite	P, G	None required	Analyze immediately
Turbidity	P, G	Cool, 4EC	48 hours
METALS:[7]			
Chromium VI (Hexachrome)	P, G	Cool, 4EC	24 hours
Mercury (Hg)	P, G	HNO_3 to pH 2	28 days
Metals, except Chromium VI and Mercury	P, G	HNO_3 to pH 2	6 months
ORGANIC TESTS:[8]			
Purgeable Halocarbons	G, Teflon-lined septum	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]	14 days
Purgeable Aromatic Hydrocarbons	G, Teflon-lined septum	Cool, 4EC; 0.008% $Na_2S_2O_3$[5] HCl to pH 2 [9]	14 days
Acrolein and Acrylonitrile	G, Teflon-lined septum	Cool, 4EC; 0.008% $Na_2S_2O_3$[5] adjust pH to 4-5 [10]	14 days
Phenols[11]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Benzidines[11], [12]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]	7 days until extraction[13]
Phthalate esters[11]	G, Teflon-lined cap	Cool, 4EC	7 days until extraction; 40 days after extraction
Nitrosamines[11], [14]	G, Teflon-lined cap	Cool, 4EC; store in dark; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
PCBs[11]	G, Teflon-lined cap	Cool, 4EC	7 days until extraction; 40 days after extraction
Nitroaromatics & Isophorone[11]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Polynuclear Aromatic Hydrocarbons (PAHs)[11],[14]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]; store in dark	7 days until extraction; 40 days after extraction
Haloethers[11]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction
Dioxin/Furan (TCDD/TCDF)[11]	G, Teflon-lined cap	Cool, 4EC; 0.008% $Na_2S_2O_3$[5]	7 days until extraction; 40 days after extraction

ATTACHMENT B
ADDITIONAL REQUIRED CONTAINERS, PRESERVATION TECHNIQUES, AND HOLDING TIMES
PAGE THREE

(1) Polyethylene (P): generally 500 ml or Glass (G): generally 1L.
(2) Sample preservation should be performed immediately upon sample collection. For composite chemical samples each aliquot should be preserved at the time of collection. When use of an automated sampler makes it impossible to preserve each aliquot, then chemical samples may be preserved by maintaining at 4EC until compositing and sample splitting is completed.
(3) When any sample is to be shipped by common carrier or sent through the United States Mail, it must comply with the Department of Transportation Hazardous Materials Regulations (49 CFR Part 172).
(4) Samples should be analyzed as soon as possible after collection. The times listed are the maximum times that samples may be held before analysis and still be considered valid. Samples may be held for longer periods only if the permittee, or monitoring laboratory, has data on file to show that the specific types of samples under study are stable for the longer periods, and has received a variance from the Regional Administrator.
(5) Should only be used in the presence of residual chlorine.
(6) Maximum holding time is 24 hours when sulfide is present. Optionally, all samples may be tested with lead acetate paper before pH adjustments are made to determine if sulfide is present. If sulfide is present, it can be removed by the addition of cadmium nitrate powder until a negative spot test is obtained. The sample is filtered and then NaOH is added to pH 12.
(7) Samples should be filtered immediately on site before adding preservative for dissolved metals.
(8) Guidance applies to samples to be analyzed by GC, LC, or GC/MS for specific compounds.
(9) Sample receiving no pH adjustment must be analyzed within 7 days of sampling.
(10) The pH adjustment is not required if acrolein will not be measured. Samples for acrolein receiving no pH adjustment must be analyzed within 3 days of sampling.
(11) When the extractable analytes of concern fall within a single chemical category, the specified preservative and maximum holding times should be observed for optimum safeguard of sample integrity. When the analytes of concern fall within two or more chemical categories, the sample may be preserved by cooling to 4EC, reducing residual chlorine with 0.008% sodium thiosulfate, storing in the dark, and adjusting the pH to 6-9; samples preserved in this manner may be held for 7 days before extraction and for 40 days after extraction. Exceptions to this optional preservation and holding time procedure are noted in footnote 5 (re: the requirement for thiosulfate reduction of residual chlorine) and footnotes 12, 13 (re: the analysis of benzidine).
(12) If 1,2-diphenylthydrazine is likely to be present, adjust the pH of the sample to 4.0∀0.2 to prevent rearrangement to benzidine.
(13) Extracts may be stored up to 7 days before analysis if storage is conducted under an inert (oxidant-free) atmosphere.
(14) For the analysis of diphenylnitrosamine, add 0.008% $Na_2S_2O_3$ and adjust pH to 7-10 with NaOH within 24 hours of sampling.
(15) The pH adjustment may be performed upon receipt at the laboratory and may be omitted if the samples are extracted within 72 hours of collection. For the analysis of aldrin, add 0.008% $Na_2S_2O_3$.

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1.0 PURPOSE

The purpose of this Standard Operating Procedure (SOP) is to identify and designate the field data record forms, logs, and reports generally initiated and maintained for documenting Tetra Tech NUS, Inc. (TtNUS) field activities.

2.0 SCOPE

Documents presented within this SOP (or equivalents) shall be used for all TtNUS field activities, as applicable. Other or additional documents may be required by specific client contracts or project planning documents.

3.0 GLOSSARY

None.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager (PM) - The PM is responsible for obtaining hardbound controlled-distribution logbooks (from the appropriate source), as needed. In addition, the Project Manager is responsible for placing all field documentation used in site activities (i.e., records, field reports, sample data sheets, field notebooks, and the site logbook) in the project's central file upon the completion of field work.

Field Operations Leader (FOL) - The FOL is responsible for ensuring that the site logbook, notebooks, and all appropriate and current forms and field reports included in this SOP (and any additional forms required by the contract) are correctly used, accurately filled out, and completed in the required time frame.

General personnel qualifications for field documentation activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate procedures for documentation, handling, packaging, and shipping.

5.0 PROCEDURES

5.1 SITE LOGBOOK

5.1.1 General

The site logbook is a hard-bound, paginated, controlled-distribution record book in which all major on-site activities are documented. At a minimum, record or reference the following activities/events (daily) in the site logbook:

- All field personnel present
- Arrival/departure times and names of site visitors
- Times and dates of health and safety training
- Arrival/departure times of equipment
- Times and dates of equipment calibration

- Start and/or completion of borehole, trench, monitoring well installation activities, etc.
- Daily on-site activities
- Sample pickup information
- Health and safety issues (level of protection, personal protective equipment [PPE], etc.)
- Weather conditions

Maintain a site logbook for each project and initiate it at the start of the first on-site activity (e.g., site visit or initial reconnaissance survey). Make entries every day that on-site activities take place involving TtNUS or subcontractor personnel. Upon completion of the fieldwork, provide the site logbook to the PM or designee for inclusion in the project's central file.

Record the following information on the cover of each site logbook:

- Project name
- TtNUS project number
- Sequential book number
- Start date
- End date

Information recorded daily in the site logbook need not be duplicated in other field notebooks (see Section 5.2) but must summarize the contents of these other notebooks and refer to specific page locations in these notebooks for detailed information (where applicable). An example of a typical site logbook entry is shown in Attachment A.

If measurements are made at any location, either record the measurements and equipment used in the site logbook or reference the field notebook in which the measurements are recorded (see Attachment A).

Make all logbook, notebook, and log sheet entries in indelible ink (black pen is preferred). No erasures are permitted. If an incorrect entry is made, cross out the entry with a single strike mark, initial, and date it. At the completion of entries by any individual, the logbook pages used must be signed and dated by the person making the entries. The site logbook must also be signed by the FOL at the end of each day.

5.1.2 Photographs

Sequentially number movies, slides, or photographs taken of a site or any monitoring location to correspond to logbook/notebook entries. Enter the name of the photographer, date, time, site location, site description, and weather conditions in the logbook/notebook as the photographs are taken. A series entry may be used for rapid-sequence photographs. The photographer is not required to record the aperture settings and shutter speeds for photographs taken within the normal automatic exposure range. However, special lenses, films, filters, and other image-enhancement techniques must be noted in the logbook/notebook. If possible, such techniques shall be avoided because they can adversely affect the accuracy of photographs. Chain-of-custody procedures depend on the subject matter, type of camera (digital or film), and the processing it requires. Follow chain-of-custody procedures for film used for aerial photography, confidential information, or criminal investigation. After processed, consecutively number the slides of photographic prints and label them according to the logbook/notebook descriptions. Docket the site photographs and associated negatives and/or digitally saved images to compact disks into the project's central file.

5.2 FIELD NOTEBOOKS

Key field team personnel may maintain a separate dedicated field notebook to document the pertinent field activities conducted directly under their supervision. For example, on large projects with multiple investigative sites and varying operating conditions, the Health and Safety Officer may elect to maintain a

separate field notebook. Where several drill rigs are in operation simultaneously, each site geologist assigned to oversee a rig must maintain a field notebook.

5.3 FIELD FORMS

All TtNUS field forms (see list in Section 6.0 of this SOP) can be found on the company's intranet site (http://intranet.ttnus.com) under Field Log Sheets. Forms may be altered or revised for project-specific needs, subject to client approval. Care must be taken to ensure that all essential information can be documented. Guidelines for completing these forms can be found in the related sampling SOPs.

5.3.1 Sample Collection, Labeling, Shipment, Request for Analysis, and Field Test Results

5.3.1.1 Sample Log Sheet

Sample log sheets are used to record specified types of data while sampling. The data recorded on these sheets are useful in describing the sample as well as pointing out any problems, difficulties, or irregularities encountered during sampling. Complete a sample log sheet for each sample obtained, including field quality control (QC) samples.

5.3.1.2 Sample Label

A typical sample label is illustrated in Attachment B. Complete the required information on the adhesive labels and apply them to every sample container. Obtain sample labels from the appropriate program/project source, request that they be electronically generated in house, or request them the laboratory subcontractor.

5.3.1.3 Chain-of-Custody Record

The chain-of-custody record is a multi-part form that is initiated as samples are acquired and accompanies a sample (or group of samples) as they are transferred from person to person. This form must be used as follows for any samples collected for chemical or geotechnical analysis whether the analyses are performed on site or off site:

- Retain one carbonless copy of the completed chain-of custody form in the field.
- Send one copy is sent to the PM (or designee)
- Send the original to the laboratory with the associated samples. Place the original (top, signed copy) of the chain-of custody form inside a large Ziploc®-type bag taped inside the lid of the shipping cooler. If multiple coolers are sent but are included on one chain-of custody form, send the form with the cooler containing vials for volatile organic compound (VOC) analysis or the cooler with the air bill attached. Indicate on the air bill how many coolers are included with that shipment.

An example of a chain-of-custody form is provided as Attachment C. After the samples are received at the laboratory, the sample cooler and contents are checked and any problems are noted on the enclosed chain-of custody form (any discrepancies between the sample labels and chain-of custody form and any other problems that are noted are resolved through communication between the laboratory point-of-contact and the TtNUS PM). The chain-of custody form is signed and copied. The laboratory will retain the copy, and the original becomes part of the samples' corresponding analytical data package.

5.3.1.4 Chain-of-Custody Seal

Attachment D is an example of a custody seal. The custody seal is an adhesive-backed label that is part of a chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field and sealed in coolers for transport to the laboratory. Sign and date custody seals

and affix them across the lid and body of each cooler (front and back) containing environmental samples (see SOP SA-6.1). Obtain custody seals from the laboratory (if available) or purchase them from a supplier.

5.3.1.5 Geochemical Parameters Log Sheets

Complete Field Analytical Log Sheets to record geochemical and/or natural attenuation field test results.

5.3.2 Hydrogeological and Geotechnical Forms

5.3.2.1 Groundwater Level Measurement Sheet

Complete a Groundwater Level Measurement Sheet for each round of water level measurements made at a site.

5.3.2.2 Data Sheet for Pumping Test

During the performance of a pumping test (or an in-situ hydraulic conductivity test), a large amount of data must be recorded, often within a short time period. Use a Pumping Test Data Sheet to facilitate this task by standardizing the data collection format for the pumping well and observation wells, and allowing the time interval for collection to be established in advance.

5.3.2.3 Packer Test Report Form

Complete a Packer Test Report Form for each well at which a packer test is conducted.

5.3.2.4 Boring Log

Complete a Summary Log of Boring, or Boring Log for each soil boring performed to document the materials encountered, operation and driving of casing, and locations/depths of samples collected. In addition, if volatile organics are monitored on cores, samples, cuttings from the borehole, or breathing zone, (using a photoionization detector [PID] or flame ionization detector [FID]), enter these readings on the boring log at the appropriate depth. When they become available, enter the laboratory sample number, concentrations of key contaminants, or other pertinent information in the "Remarks" column. This feature allows direct comparison of contaminant concentrations with soil characteristics.

5.3.2.5 Monitoring Well Construction Details Form

Complete a Monitoring Well Construction Details Form for every monitoring well, piezometer, or temporary well point installed. This form contains specific information on length and type of well riser pipe and screen, backfill, filter pack, annular seal and grout characteristics, and surface seal characteristics. This information is important in evaluating the performance of the monitoring well, particularly in areas where water levels show temporal variation or where there are multiple (immiscible) phases of contaminants. Depending on the type of monitoring well (in overburden or bedrock, stick-up or flush mount), different forms are used.

5.3.2.6 Test Pit Log

When a test pit or trench is constructed for investigative or sampling purposes, a Test Pit Log must be filled out by the responsible field geologist or sampling technician.

5.3.2.7 Miscellaneous Monitoring Well Forms

Miscellaneous monitoring well forms that may be required on a project-specific basis include the Monitoring Well Materials Certificate of Conformance and Monitoring Well Development Record. Use a Monitoring Well Materials Certificate of Conformance to document all materials utilized during each monitoring well installation. Use a Monitoring Well Development Record to document all well development activities.

5.3.2.8 Miscellaneous Field Forms – Quality Assurance and Checklists

Miscellaneous field forms/checklists forms that may be required on a project-specific basis include the following:

- Container Sample and Inspection Sheet – use this form when a container (drum, tank, etc.) is sampled and/or inspected.
- QA Sample Log Sheet – use this form when a QA sample such as an equipment rinsate blank, source blank, etc. is collected.
- Field Task Modification Request (FTMR) – use this form to document deviations from the project planning documents. The FOL is responsible for initiating the FTMRs. Maintain copies of all FTMRs with the on-site planning documents, and place originals in the final evidence file.
- Field Project Daily Activities Checklist and Field Project Pre-Mobilization Checklist – used these during both the planning and field effort to ensure that all necessary tasks are planned for and completed. These two forms are not requirements but are useful tools for most field work.

5.3.3 Equipment Calibration and Maintenance Form

The calibration or standardization of monitoring, measuring, or test equipment is necessary to ensure the proper operation and response of the equipment, to document the accuracy, precision, or sensitivity of the measurements, and determine if correction should be applied to the readings. Some items of equipment require frequent calibration, others infrequent. Some are calibrated by the manufacturer, others by the user.

Each instrument requiring calibration has its own Equipment Calibration Log, which documents that the manufacturer's instructions were followed for calibration of the equipment, including frequency and type of standard or calibration device. Maintain an Equipment Calibration Log for each electronic measuring device used in the field; make entries for each day the equipment is used or in accordance with manufacturer recommendations.

5.4 FIELD REPORTS

The primary means of recording on-site activities is the site logbook. Other field notebooks may also be maintained. These logbooks and notebooks (and supporting forms) contain detailed information required for data interpretation or documentation but are not easily used for tracking and reporting of progress. Furthermore, the field logbook/notebooks remain on site for extended periods of time and are thus not accessible for timely review by project management. Other reports useful for tracking and reporting the progress of field activities are described below.

5.4.1 Daily Activities Report

To provide timely oversight of on-site contractors, complete and submit Daily Activities Reports (DARs) as described below.

5.4.1.1 Description

The DAR documents the activities and progress for each day's field work. Complete this report on a daily basis whenever there are drilling, test pitting, well construction, or other related activities occurring that involve subcontractor personnel. These sheets summarize the work performed and form the basis of payment to subcontractors. The DAR form can be found on the TtNUS intranet site.

5.4.1.2 Responsibilities

It is the responsibility of the rig geologist to complete the DAR and obtain the driller's signature acknowledging that the times and quantities of material entered are correct.

5.4.1.3 Submittal and Approval

At the end of the shift, the rig geologist must submit the DAR to the FOL for review and filing. The Daily Activities Report is not a formal report and thus requires no further approval. The DARs are retained by the FOL for use in preparing the site logbook and in preparing weekly status reports for submission to the PM.

5.4.2 Weekly Status Reports

To facilitate timely review by project management, photocopies of logbook/notebook entries may be made for internal use.

In addition to those described herein, other summary reports may also be contractually required.

All TtNUS field forms can be found on the company's intranet site at http://intranet.ttnus.com under Field Log Sheets.

6.0 LISTING OF FIELD FORMS ON THE TtNUS INTRANET SITE

- Boring Log
- Container Sample and Inspection Sheet
- Daily Activities Checklist
- Daily Activities Record
- Equipment Calibration Log
- Field Task Modification Request
- Field Analytical Log sheet - Geochemical Parameters
- Groundwater Level Measurement Sheet
- Groundwater Sample Log Sheet
- Hydraulic Conductivity Test Data Sheet
- Low Flow Purge Data Sheet
- Bedrock Monitoring Well Construction (Stick Up)
- Bedrock Monitoring Well Construction Flush Mount
- Bedrock Monitoring Well Construction Open Hole
- Confining Layer Monitoring Well Construction
- Monitoring Well Development Record

- Monitoring Well Materials Certificate of Conformance
- Overburden Monitoring Well Construction Flush Mount
- Overburden Monitoring Well Construction Stick Up
- Packer Test Report Form
- Pumping Test Data Sheet
- QA Sample Log Sheet
- Soil/Sediment Sample Log Sheet
- Surface Water Sample Log Sheet
- Test Pit Log
- Field Project Pre-Mobilization Checklist

ATTACHMENT A
TYPICAL SITE LOGBOOK ENTRY

START TIME: _____ DATE: _____

SITE LEADER: _____
PERSONNEL:

TtNUS	DRILLER	SITE VISITORS
_____	_____	_____
_____	_____	_____
_____	_____	_____

WEATHER: Clear, 68°F, 2-5 mph wind from SE

ACTIVITIES:

1. Steam jenney and fire hoses were set up.
2. Drilling activities at well ____ resumes. Rig geologist was _____. See Geologist's Notebook, No. 1, page 29-30, for details of drilling activity. Sample No. 123-21-S4 collected; see sample logbook, page 42. Drilling activities completed at 11:50 and a 4-inch stainless steel well installed. See Geologist's Notebook, No. 1, page 31, and well construction details for well _____.
3. Drilling rig No. 2 steam-cleaned at decontamination pit. Then set up at location of well _____.
4. Well _____ drilled. Rig geologist was _____. See Geologist's Notebook, No. 2, page ____ for details of drilling activities. Sample numbers 123-22-S1, 123-22-S2, and 123-22-S3 collected; see sample logbook, pages 43, 44, and 45.
5. Well _____ was developed. Seven 55-gallon drums were filled in the flushing stage. The well was then pumped using the pitcher pump for 1 hour. At the end of the hour, water pumped from well was "sand free."
6. EPA remedial project manger arrives on site at 14:25 hours.
7. Large dump truck arrives at 14:45 and is steam-cleaned. Backhoe and dump truck set up over test pit _____.
8. Test pit _____ dug with cuttings placed in dump truck. Rig geologist was _____. See Geologist's Notebook, No. 1, page 32, for details of test pit activities. Test pit subsequently filled. No samples taken for chemical analysis. Due to shallow groundwater table, filling in of test pit ___ resulted in a very soft and wet area. A mound was developed and the area roped off.
9. Express carrier picked up samples (see Sample Logbook, pages 42 through 45) at 17:50 hours. Site activities terminated at 18:22 hours. All personnel off site, gate locked.

_____

Field Operations Leader

ATTACHMENT B
SAMPLE LABEL

Tetra Tech NUS, Inc. 661 Andersen Drive Pittsburgh, 15220 (412)921-7090	Project: Site: Location:		
Sample No:			Matrix:
Date:	Time:	Preserve:	
Analysis:			
Sampled by:	Laboratory:		

ATTACHMENT C
CHAIN-OF-CUSTODY RECORD FORM

TETRA TECH NUS, INC.

CHAIN OF CUSTODY | NUMBER 3413 | PAGE ___ OF ___

PROJECT NO: | FACILITY: | PROJECT MANAGER | PHONE NUMBER | LABORATORY NAME AND CONTACT:

SAMPLERS (SIGNATURE) | FIELD OPERATIONS LEADER | PHONE NUMBER | ADDRESS

CARRIER/WAYBILL NUMBER | CITY, STATE

STANDARD TAT ☐
RUSH TAT ☐
☐ 24 hr. ☐ 48 hr. ☐ 72 hr. ☐ 7 day ☐ 14 day

DATE YEAR	TIME	SAMPLE ID	LOCATION ID	TOP DEPTH (FT)	BOTTOM DEPTH (FT)	MATRIX (GW, SO, SW, SD, QC, ETC.)	COLLECTION METHOD GRAP (G) COMP (C)	No. OF CONTAINERS	CONTAINER TYPE PLASTIC (P) or GLASS (G) / PRESERVATIVE USED	TYPE OF ANALYSIS	COMMENTS

	DATE	TIME		DATE	TIME
1. RELINQUISHED BY			1. RECEIVED BY		
2. RELINQUISHED BY			2. RECEIVED BY		
3. RELINQUISHED BY			3. RECEIVED BY		

COMMENTS

DISTRIBUTION: WHITE (ACCOMPANIES SAMPLE) YELLOW (FIELD COPY) PINK (FILE COPY)

4/02R
FORM NO. TtNUS-001

ATTACHMENT D
CHAIN-OF-CUSTODY SEAL

CUSTODY SEAL	**CUSTODY SEAL**
Date _____	**Date** _____
Signature _____	**Signature** _____

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A INVESTIGATION-DERIVED WASTE LABEL 15

1.0 PURPOSE

Decontamination is the process of removing and/or neutralizing site contaminants that have contacted and/or accumulated on equipment. The purpose of this Standard Operating Procedure (SOP) is to protect site personnel, the general public, and the environment while preserving or maintaining sample integrity. It is further intended through this procedure to describe the steps necessary for proper decontamination of drilling equipment, earth-moving equipment , chemical sampling equipment and field operation and analytical equipment.

2.0 SCOPE AND APPLICABILITY

This procedure applies to all equipment used to provide access to/acquire environmental samples that may have become contaminated through direct contact with contaminated media including air, water, and soil. This equipment includes drilling and heavy equipment and chemical sampling and field analytical equipment. Where technologically and economically feasible, single-use sealed disposable equipment will be employed to minimize the potential for cross-contamination. This SOP also provides general reference information on the control of contaminated materials.

Decontamination methods and equipment requirements may differ from one project to another. General equipment items are specified in Section 6.0, but project-specific equipment must be obtained to address the project-specific decontamination procedures presented in Section 7.0 and applicable subsections.

3.0 GLOSSARY

Alconox/Liquinox - A brand of phosphate-free laboratory-grade detergent.

Decontamination Solution - A solution selected/identified in the Health and Safety Plan or Project-Specific Quality Assurance Plan. The solution is selected and employed as directed by the project chemist/health and safety professional.

Deionized Water (DI) - Tap water that has been treated by passing through a standard deionizing resin column. This water may also pass through additional filtering media to attain various levels of analyte-free status. The DI water should meet College of American Pathologists (CAP) and National Committee for Clinical Laboratory Standards (NCCLS) specifications for reagent-grade Type I water.

Potable Water - Tap water from any municipal water treatment system. Use of an untreated potable water supply is not an acceptable substitute for tap water.

Pressure Washing - Process employing a high-pressure pump and nozzle configuration to create a high-pressure spray of potable water. High-pressure spray is employed to remove solids from equipment.

Solvent – A liquid in which solid chemicals or other liquids are dissolved. The solvent of choice is pesticide-grade isopropanol. Use of other solvents (methanol, acetone, or hexane) may be required for particular projects or for a particular purpose (e.g., removal of concentrated waste) and must be justified in the project planning documents. For example, it may be necessary to use hexane when analyzing for trace levels of pesticides, PCBs, or fuels. In addition, because many of these solvents are not miscible in water, the equipment should be air dried prior to use. Solvents should not be used on PVC equipment or well construction materials.

Steam Pressure Washing - A cleaning method employing a high-pressure spray of heated potable water to remove various organic/inorganic chemicals from equipment.

4.0 RESPONSIBILITIES AND PERSONNEL QUALIFICATIONS

Project Manager - Responsible for ensuring that all field activities are conducted in accordance with approved project plan(s) requirements.

Decontamination Personnel - Individuals assigned the task of decontamination. It is the responsibility of these individuals to understand the use and application of the decontamination process and solutions as well as the monitoring of that process to ensure that it is working properly. This is accomplished through visual evaluation, monitoring instrument scanning of decontaminated items, and/or through the collection of rinsate blanks to verify contaminant removal.

Field Operations Leader (FOL) - Responsible for the implementation of project-specific planning documents. This includes on-site verification that all field activities are performed in compliance with approved SOPs or as otherwise dictated by the approved project plan(s). The FOL is also responsible for the completion and accuracy of all field documentation.

Site Safety Officer (SSO) - Exercises shared responsibility with the FOL concerning decontamination effectiveness. All equipment arriving on site (as part of the equipment inspection), leaving the site, and moving between locations is required to go through a decontamination evaluation. This is accomplished through visual examination and/or instrument screening to determine the effectiveness of the decontamination process. Improper or incomplete decontamination is sufficient to restrict equipment from entering the site, exiting the site, or moving to a new location on the site until the objectives are successfully completed.

General personnel qualifications for decontamination activities include the following:

- Occupational Safety and Health Administration (OSHA) 40-hour and applicable refresher training.
- Capability of performing field work under the expected physical and environmental (i.e., weather) conditions.
- Familiarity with appropriate decontamination procedures.

5.0 HEALTH AND SAFETY

In addition to the health and safety issues and reminders specified in subsections of this SOP, the following considerations and requirements must be observed as SOPs for field equipment decontamination activities:

- If any solvents or hazardous chemicals (e.g., isopropyl alcohol) are to be used in equipment decontamination activities, the FOL must first obtain the manufacturer's/supplier's Material Safety Data Sheet (MSDS) and assure that it is reviewed by all users (prior to its use), added to the site Hazardous Chemical Inventory, and maintained on site as part of the project Hazard Communication Program.
- Review and observe specific health and safety requirements (e.g., personal protective equipment [PPE]) specified in the project-specific health and safety plan for this activity.

6.0 EQUIPMENT LIST

- Wood for decontamination pad construction, when applicable (see Section 7.1).

- Tools for constructing decontamination pad frame, when applicable (see Section 7.1).
- Visqueen sheeting or comparable material to cover decontamination pad frame, when applicable (see Section 7.1).
- Wash/drying racks for auger flights and drill/drive rods, when applicable (see Section 7.2).
- PPE as specified in the project health and safety plan.
- Soap and water for washing and rinsing.
- Deionized water for final rinsing.
- Solvents (e.g., pesticide-grade isopropanol) for rinsing (see applicable portions of Section 7.2).
- Tubs, buckets, etc. for containerizing rinse water (see applicable portions of Section 7.2).
- Sample bottles for collecting rinsate blanks (see Section 7.2).
- Calibrated photoionization detector (PID) or flame ionization detector (FID) to monitor decontaminated equipment for organic vapors generated through the existence of residual contamination or the presence of decontamination solvent remaining after the piece was rinsed.
- Aluminum foil or clear clean plastic bag for covering cleaned equipment (see applicable portions of Section 7.2).
- Paper towels or cloths for wiping.
- Brushes, scrapers, or other hand tools useful for removing solid materials from equipment.
- Clear plastic wrap for covering or wrapping large decontaminated equipment items (see Section 7.2.2).
- Drum-moving equipment for moving filled waste drums (optional) (see Section 7.3).
- Drum labels for waste drums (see Attachment A).

7.0 PROCEDURES

The process of decontamination is accomplished through the removal of contaminants, neutralization of contaminants, or isolation of contaminants. To accomplish this activity, preparation is required including site preparation, equipment selection, and evaluation of the decontamination requirements and processes. Site contaminant types, concentrations, and media types are primary drivers in the selection of the types of decontamination and where it will be conducted. For purposes of this SOP, discussion is limited to decontamination procedures for general environmental investigations.

Decontamination processes will be performed at the location(s) specified in project-specific planning documents. Typical decontamination locations include the following:

- Temporary decontamination pads/facilities
- Sample locations
- Centralized decontamination pad/facilities

- Combination of some or all of the above

The following discussion includes general considerations for the decontamination process. Specific construction and implementation procedures will be as specified in the project-specific planning documents and/or may be as dictated by site-specific conditions as long as the intent of the requirements in the planning documents is met. This intent is to contain any residual fluids and solids generated through the decontamination process.

7.1 Decontamination Pad Design/Construction Considerations

7.1.1 Temporary Decontamination Pads

Temporary decontamination pads may be constructed at satellite locations within the site area in support of temporary work areas. These structures are generally constructed to support the decontamination of heavy equipment such as drill rigs and earth-moving equipment but can be employed for smaller articles.

The purpose of the decontamination pad is to contain wash waters and potentially contaminated soil generated during decontamination procedures. Therefore, construction of these pads should take into account the following considerations:

- Site location – The decontamination site selected should be far enough from the work site to maximize decontamination effectiveness while minimizing travel distance. The location of the decontamination site shall be selected to provide, in the judgment of the FOL or FOL designee, compliance with as many of the following characteristics as practicable:

  - Well removed from pedestrian/vehicle thoroughfares.

  - Avoidance of areas where control/custody cannot be maintained.

  - Avoidance of areas where potential releases of contaminated media or decontamination fluids may be compounded through access to storm water transport systems, streams, or other potentially sensitive areas.

  - Avoidance of potentially contaminated areas.

  - Avoidance of areas too close to the ongoing operation, where cross-contamination may occur.

  The selected decontamination site should include the following, where possible:

  - Areas where potable water and electricity are provided.

> ***Safety Reminder***
>
> When utilizing electrical power sources, either hard-wired or portable-generated sources, ensure that:
>
> - All power is routed through a Ground Fault Circuit Interrupter (GFCI).
>
> - All power cords are in good condition (no physical damage), rated for the intended energy load, and designated for outdoor use.
>
> In situations where accomplishing these elements is not possible, it will be necessary to implement a site electrical grounding program.

- Areas where support activities such as removing decontamination waters soil and sediment are possible without entering an active exclusion zone.

- Areas that offer sufficient size to carry out the specific decontamination sequence.

- Decontamination pad (decon pad) – The decon pad shall be constructed to meet the following characteristics:

  - Size – The size of the pad should be sufficient to accept the equipment to be decontaminated as well as permitting free movement around the equipment by the personnel conducting the decontamination. The size should permit these movements utilizing pressure/steam washer wands and hoses and minimizing splash due to work in close quarters.

  - Slope – An adequate slope will be constructed to permit the collection of water and potentially contaminated soil within a trough or sump constructed at one end. The collection point for wash waters should be of adequate distance that the decontamination workers do not have to walk through the wash waters while completing their tasks. Because the pad will be sloped, place a light coating of sand over the plastic to minimize potential slips and falls. See the text about liners below.

  - Sidewalls – The sidewalls shall be at least 6 inches in height (or as high as possible if 6 inches is not achievable) to provide adequate containment for wash waters and soil. If splash represents a potential problem, splash guards should be constructed to control overspray. Sidewalls may be constructed of wood, inflatables, sand bags, etc. to permit containment. Splash guards are typically wood frames with Visqueen coverings to control overspray.

  - Liner – Depending on the types of equipment and decontamination method to be used, the liner should be of sufficient thickness to provide a puncture-resistant barrier between the decontamination operation and the unprotected environment. Care should be taken to examine the surface area prior to placing the liner to remove sharp articles (sticks, stones, debris) that could puncture the liner. Liners are intended to form an impermeable barrier. The thickness may vary from a minimum recommended thickness of 10 mil to 30 mil. The desired thickness may be achieved through layering materials of lighter construction. It should be noted that various materials (rubber, polyethylene sheeting) become slippery when wet. To minimize this potential hazard associated with a sloped liner, a light coating of sand shall be applied to provide traction as necessary.

  - Wash/drying racks – Auger flights, drill/drive rods, and similar equipment require racks positioned off of the ground to permit these articles to be washed, drained, and dried while secured from falling during this process.

For decontamination of direct-push technology (DPT) equipment, the pad may be as simple as a mortar tub containing buckets of soapy water for washing and an empty bucket to capture rinse waters. Decontamination may be conducted at the rear of the rig to permit rapid tool exchange.

- Maintenance – Maintain the decontamination area by:

  - Periodically clearing the work area of standing water, soil, and debris, and coiling hoses to aid in eliminating slip, trip, and fall hazards. In addition, these articles will reduce potential backsplash and cross-contamination.

- Regularly changing the decontamination fluids to ensure proper cleaning and prevent cross-contamination.

- PPE – Periodically evaluate the condition of, and maintain the decontamination equipment, including regular cleaning of face shields and safety glasses. This is critical to ensuring the safety of decontamination personnel and the integrity of the decontamination process, and it will ensure that equipment is functioning properly.

7.1.2 Decontamination Activities at Drill Rigs/DPT Units

During subsurface sampling activities including drilling and DPT activities, decontamination of drive rods, Macro Core Samplers, split spoons, etc. is typically conducted at an area adjacent to the operation. Decontamination is generally accomplished using a soap/water wash and rinse utilizing buckets and brushes. This area requires sufficient preparation to accomplish the decontamination objectives.

Buckets shall be placed within mortar tubs or similar secondary containment tubs to prevent splash and spills from reaching unprotected environmental media. Drying racks shall be employed as directed for temporary pads to permit parts to dry and be evaluated prior to use/reuse. Methodology regarding this activity is provided in Section 7.2.

7.1.3 Decontamination Activities at Remote Sample Locations

When sampling at remote locations, sampling equipment such as trowels and pumps/tubing should be evacuated of potentially contaminated media to the extent possible. This equipment should be wrapped in plastic for transport to the temporary/centralized decontamination location for final cleaning and disposition. Flushing and cleaning of single-use equipment such as disposable trowels, tubing, and surgeon's gloves may allow disposal of this equipment after visible soil and water remnants have been removed.

7.2 Equipment Decontamination Procedures

The following represents procedures to be employed for the decontamination of equipment that may have contacted and/or accumulated contamination through site investigation activities.

7.2.1 Monitoring Well Sampling Equipment

7.2.1.1 Groundwater sampling equipment – This includes pumps inserted into monitoring wells such as bladder pumps, Whale pumps, and Redi-Flo pumps and reusable bailers, etc.

1. Evacuate to the extent possible, any purge water within the pump/bailer.

2. Scrub using soap and water and/or steam clean the outside of the pump/bailer and, if applicable, the pump tubing.

3. Insert the pump and tubing/bailer into a clean container of soapy water. Pump/run a sufficient amount of soapy water through the pump/bailer to flush out any residual well water. After the pump is flushed, circulate soapy water through the pump to ensure that the internal components are thoroughly flushed.

4. Remove the pump and tubing/bailer from the container

5. Rinse external pump components using tap water.

6. Insert the pump and tubing/bailer into a clean container of tap water. Pump/run a sufficient amount of tap water through the pump/bailer to evacuate all of the soapy water (until clear).

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents –
> Use the procedures defined in the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 7 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

7. If groundwater contains or is suspected to contain oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment to be cleaned with pesticide-grade isopropanol.

8. Pass deionized water through the hose to flush out the tap water and solvent residue as applicable.

9. Drain residual deionized water to the extent possible.

10. Allow components of the equipment to air dry.

11. For bladder pumps, disassemble the pump and wash the internal components with soap and water, then rinse with tap water, isopropanol, and deionized water and allow to dry. After the parts are dry, conduct a visual inspection and a monitoring instrument scan to ensure that potential contaminants and all decontamination solvent have been removed. Collect a rinsate blank in accordance with the project-specific planning documents to ensure that the decontamination process is functioning as intended. The typical frequency of collection for rinsate blanks is 1 per 20 field samples. In addition, wipe samples or field tests such as UV light may be used.

12. Wrap pump/bailer in aluminum foil or a clear clean plastic bag for storage.

> ***SAFETY REMINDER***
> Remember when handling powered equipment to disconnect the power source and render the equipment to a zero energy state (both potential and kinetic) before opening valves, disconnecting lines, etc.

7.2.1.2 Electronic Water Level Indicators/Sounders/Tapes

During water level measurements, rinsing the extracted tape and probe with deionized water and wiping the surface of the extracted tape between locations is acceptable. However, periodic full decontamination should be conducted as follows:

1. Wash with soap and water
2. Rinse with tap water
3. Rinse with deionized water

> ***NOTE***
> In situations where oil, grease, free product, other hard to remove materials are encountered, probes and exposed tapes should be washed in hot soapy water. If probes or tapes cannot be satisfactorily decontaminated (they are still stained, discolored, etc.), they should be removed from service.

7.2.1.3 Miscellaneous Equipment

Miscellaneous equipment including analytical equipment (water quality testing equipment) shall be cleaned per manufacturers' instructions. This generally includes wiping the sensor housing and rinsing with tap and deionized water.

Coolers/shipping containers employed to ship samples are received from the laboratory in a variety of conditions including marginal to extremely poor. Coolers shall be evaluated prior to use for the following:

- Structural integrity – Coolers missing handles or having breaks in the outer housing should be removed and not used. Notify the laboratory that the risk of shipping samples in the cooler(s) provided is too great and request a replacement unit.

- Cleanliness – As per protocol, only volatile organic samples are accompanied by a trip blank. If a cooler's cleanliness is in question (visibly dirty/stained) or if there are noticeable odors, the cooler should be decontaminated prior to use as follows:

  1. Wash with soap and water
  2. Rinse with tap water
  3. Dry

If these measures fail to clean the cooler to an acceptable level, remove the unit from use as a shipping container and ask the cooler provider (e.g., the analytical laboratory) to provide a replacement unit.

7.2.2 Downhole Drilling Equipment

This includes any portion of the drill rig that is over the borehole, including auger flights, drill stems, rods, and associated tooling that would extend over the borehole. The following procedure is to be employed prior to initiating the drilling/sampling activity, then between locations:

> ***CAUTION***
> Exercise care when using scrapers to remove soil and debris from downhole drilling equipment. Inadvertent slips of scrapers have resulted in cuts, scrapes, and injured knuckles, so use scrapers carefully when removing soil from these items.

1. Remove loose soil using shovels, scrapers, etc.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment being decontaminated.

> ***CAUTION***
> In Step 3, do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

3. Rinse the equipment with tap water, where applicable (steam cleaning and pressure washing incorporate rinsing as part of the process).

4. If the equipment has directly or indirectly contacted contaminated sample media and is known or suspected of being contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse equipment with pesticide-grade isopropanol

5. To the extent possible, allow components to air dry.

6. If the decontaminated equipment is to be used immediately after decontamination, screen it with a calibrated photoionization detector (PID)/flame ionization detector (FID) to ensure that all contaminants and possible decontamination solvents (if they were used) have been adequately removed.

7. Wrap or cover equipment in clear plastic until it is time to be used.

SAFETY REMINDER

Even when equipment is disconnected from power sources, dangers such as the following may persist:

Falls - An auger flight standing on its end may fall and injure someone. Secure all loose articles to prevent heavy articles from falling onto people or equipment.

Burns - Steam cleaner water is heated to more than 212 ˚F and exhibits thermal energy that can cause burns. Prevent contact of skin with hot water or surfaces.

High water pressure - Pressure washer discharge can have 2,000 to 4,000 psi of water pressure. Water under this amount of pressure can rupture skin and other human tissues. Water at 4,000 psi exiting a 0˚ tip can be dangerous because of its relatively high cutting power. The exit velocity and cutting power of the water are reduced when exiting a 40˚ fan tip, but damage to soft tissues is still possible.

In general, follow the rules below to avoid injury, equipment damage, or incomplete decontamination:

1. Read the operating manual and follow the manufacturers' recommended safety practices before operating pressure washers and steam cleaners.

2. Never point the pressure washer or steam cleaner at another person or use to clean your boots or other parts of your body. Water lacerations and burns may appear to be minor at first but can be life threatening. Do not attempt to hold small parts in your hand while washing them with high-temperature or high-pressure water.

3. Always wear PPE as specified in the HASP such as:

   - Hard hat, safety glasses, splash shield, impermeable apron or splash suit, and hearing protection. Remember that excessive noise is a hazard when operating gas-powered engines and electrically driven pressure washers. PPE will be identified in your project specific planning documents.

4. Inspect each device before use. An inspection checklist will be provided in the project-specific planning documents. If it is a rented device, safety measures are typically provided by the vendor. In all cases, if you are not familiar with the operation of a pressure washer/steam cleaner, do not operate it until you obtain and thoroughly review operating instructions and recommended safety practices.

5. Do not modify equipment unless the manufacturer has approved the modifications.

7.2.3 Soil/Sediment Sampling Equipment

This section applies to soil sampling equipment including but not limited to hand augers, stainless steel trowels/spoons, bowls, dredges, scoops, split spoons, Macro Core samplers, etc.

1. Remove all loose soil from the equipment through manual means.

2. Through a combination of scrubbing using soap and water and/or steam cleaning or pressure washing, remove visible dirt/soil from the equipment.

3. Rinse the equipment with tap water.

> ***CAUTION***
> Do not rinse PE, PVC, and associated tubing with solvents. The appropriate procedures should be defined within the project-specific planning documents. If they are not defined, contact the FOL for guidance. The solvent rinse described in Step 4 may be omitted if groundwater does not contain oil, grease, PAHs, PCBs, or other hard to remove organic materials.

4. If the equipment is contaminated or suspected to be contaminated with oil, grease, PAHs, PCBs, or other hard to remove organic materials, rinse the equipment with pesticide-grade isopropanol.

5. Rinse the equipment with deionized water.

6. To the extent possible, allow components to air dry.

7. If the equipment is to be used immediately after decontamination, screen it with a calibrated PID/FID to ensure that all solvents (if they were used) and trace contaminants have been adequately removed.

8. After the equipment has dried, wrap it in aluminum foil for storage until use.

Dredges employed in sediment sampling are typically decontaminated as follows:

- Remove the sediment sample from the sampling device

- If sufficient associated surface water is available at the sampling site, place the dredge in the water and flush to remove visible sediment.

- Extract the dredge and wash it in soap and water per the project-specific planning documents.

> ***CAUTION***
> When handling dredges, the primary safety concern is trapping fingers or extremities in the larger dredge samplers within the jaws or pinch points of the mechanical jaws. Keep hands, fingers, and extremities away from these pinch and compression points. Either handle the device by the rope or preferably lock the jaws in place to control the potential for closing during maintenance and/or cleaning.

7.3 Contact Waste/Materials

During the course of field investigations, disposable/single-use equipment becomes contaminated. These items include tubing, trowels, PPE (gloves, overboots, splash suits, etc.), and broken sample containers.

With the exception of the broken glass, single-use articles should be cleaned (washed and rinsed) of visible materials and disposed as normal refuse. The exception to this rule is that extremely soiled materials that cannot be cleaned shall be containerized for disposal in accordance with applicable federal, state, and local regulations.

7.3.1 Investigation-Derived Wastes - Decontamination Wash Waters and Sediments

> ***NOTE***
> Requirements for waste storage may differ from one facility to the next. Facility-specific directions for waste storage areas will be provided in project-specific documents, or separate direction will be provided by the Project Manager.

1. Assume that all investigation-derived waste (IDW) generated from decontamination activities contains the hazardous chemicals associated with the site unless there are analytical or other data to the contrary. Waste solution volumes could vary from a few gallons to several hundred gallons in cases where large equipment required cleaning.

2. Where possible, use filtering systems to extend the use of water within a closed system wash unit to recycle water and to reduce possible waste amounts.

> ***NOTE***
> Containerized waste rinse solutions are best stored in 55-gallon drums (or equivalent containers) that can be sealed until ultimate disposal at an approved facility.

3. Label waste storage containers appropriately labeled (see Attachment A).

4. Ensure that the IDW storage area is configured to meet the following specifications to permit access to the containers and to conduct spill/leak monitoring, sampling, and extraction when the disposal route is determined:

   - Enclose areas accessible by the general public using construction fencing and signs.

   - Stored materials in 55-gallon drums on pallets with four (or fewer) drums per pallet.

   - Maintain the retaining bolt and label on the outside of storage containers where readily visible.

   - Provide at least 4 feet of room between each row of pallets to allow access to containers for sampling, drum removal, and spill response.

   - As directed in project-specific planning documents, maintain an IDW Inventory List and provide the list to the site Point of Contact at the termination of each shift.

   - Maintain spill response equipment at the IDW storage area in case it is required for immediate access.

- Where possible, use equipment for moving containers. Where not possible, obtain help to manipulate containers.

CAUTION

Each container of water can weigh up to 490 pounds. Each 55-gallon drum of wet soil can weigh more than 750 pounds. Fill drums and temporary containers to 80 percent capacity to minimize spill and handling difficulties. Use drum carts to move filled drums.

See safe lifting techniques provided in Section 4.4 of the Tetra Tech NUS, Inc. Health and Safety Guidance Manual.

When placing drums, keep your fingers out of pinch and smash points such as between the drums. In some cases such as well development and/or purge water, you can place the drums to be filled on the pallet and transport materials in smaller easier to handle containers.

7.4 Decontamination Evaluation

Upon decontamination of equipment, determine the effectiveness of the decontamination process in the following manner:

- Visual evaluation – A visual evaluation will be conducted to ensure the removal of particulate matter. This shall be done to ensure that the washing/rinsing process is working as intended.

- Instrument Screening – A properly calibrated PID/FID should be used to evaluate the presence of site contaminants and solvents used in the cleaning process. The air intake of the instrument shall be passed over the article to be evaluated. Avoid placing the instrument probe into residual waters. A PID/FID reading greater than the daily established background level requires a repeat of the decontamination process, followed by rescreening with the PID/FID. This sequence must be repeated until no instrument readings greater than the daily established background level are observed. It should be noted that the instrument scan is only viable if the contaminants are detectable within the instrument's capabilities.

NOTE

When required by project-specific planning documents, collection of rinsate blanks (see next step) shall be completed without exception unless approval to not collect these samples is obtained from the Project Manager.

- Collection of Rinsate Blanks – It is recommended that rinsate samples be collected to:

  - Evaluate the decontamination procedure representing different equipment applications (pumps versus drilling equipment) and different decontamination applications.

  - Single-use disposable equipment – The number of samples should represent different types of equipment as well as different lot numbers of single-use articles.

  - The collection and the frequency of collection of rinsate samples are as follows unless specified differently in the project-specific planning documents:

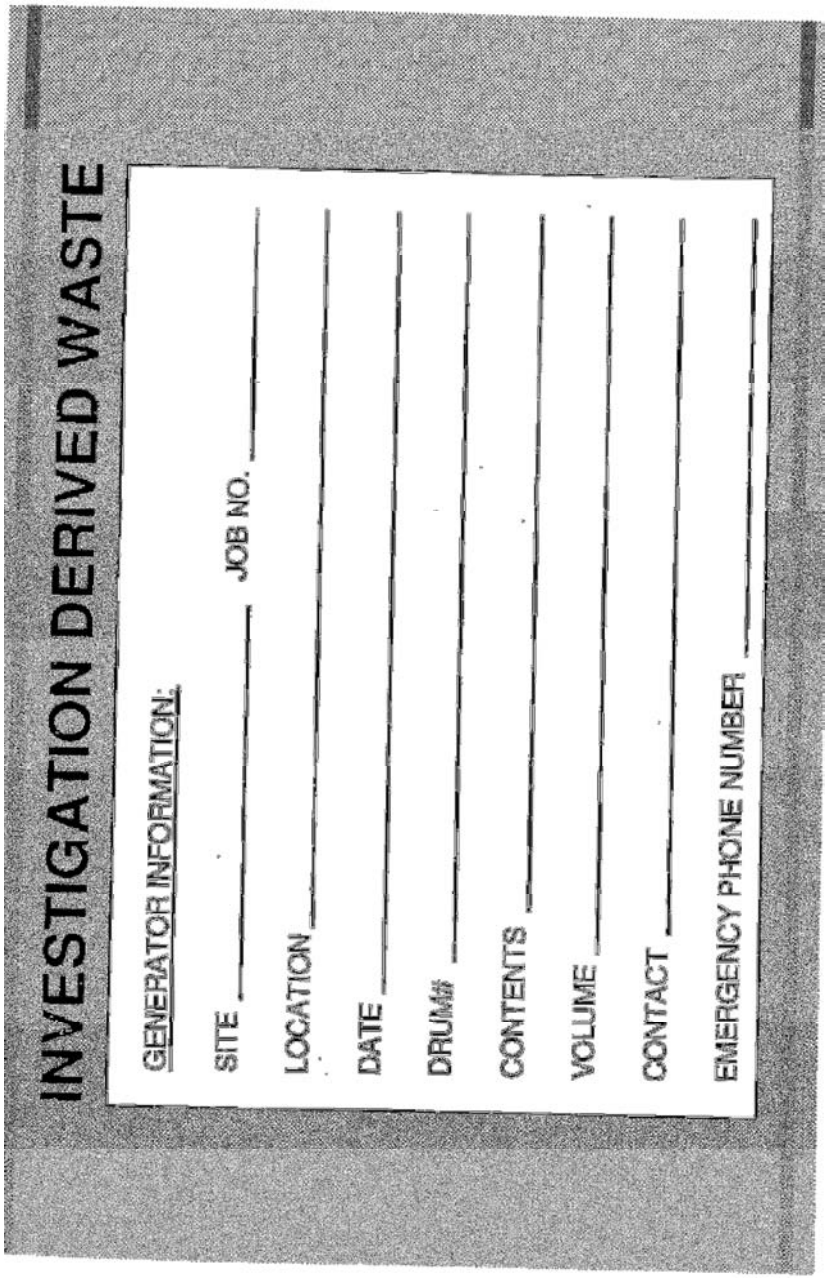
    - Per decontamination method
    - Per disposable article/batch number of disposable articles

NOTE

It is recommended that an initial rinsate sample be collected early in the project to ensure that the decontamination process is functioning properly and to avoid using a contaminated batch of single-use articles. It is recommended that a follow-up sample be collected later during the execution of the project to ensure that those conditions do not change.

Rinsate samples collection may be driven by types of and/or levels of contaminant. Difficult to remove contaminants, oils/greases, some PAHs/PCBs, etc. may also support the collection of additional rinsates due to the obvious challenges to the decontamination process. This is a field consideration to be determined by the FOL.

Attachment A
iDW Label



FIELD SAMPLING DATA SHEETS

- **FIELD DATA – LOCATION AND CLIMATE INFORMATION**
- **FIELD DATA - PHYSICAL CHARACTERIZATION / WATER QUALITY**
- **FIELD DATA - BENTHIC MACROINVERTEBRATE SAMPLE**
- **OHIO EPA QUALITATIVE HABITAT EVALUATION INDEX**
- **PEBBLE COUNT DATA FIELD SHEET**

FIELD DATA – LOCATION AND CLIMATE INFORMATION

STREAM NAME	LOCATION	
STATION #	Latitude	
PHOTO #	Longitude	
INVESTIGATORS		
FORM COMPLETED BY	DATE	REASON FOR SURVEY

SITE LOCATION/MAP	**Draw a map of the site and indicate the areas sampled**	
STREAM CHARACTERIZATION	**Subsystem Classification** ☐ Perennial ☐ Intermittent ☐ Tidal	**Stream Type** ☐ Coldwater ☐ Warmwater
WEATHER CONDITIONS	**Now** **Past 24 hours** ☐ ☐ storm (heavy rain) ☐ ☐ rain (steady rain) ☐ ☐ showers (intermittent) ☐ _____% ☐ _____%cloud cover ☐ ☐ clear/sunny	**Has there been a heavy rain in the last 7 days?** ☐ Yes ☐ No **Air Temperature**_____ ^{0} C **Other**_____

FIELD DATA - PHYSICAL CHARACTERIZATION / WATER QUALITY

RIPARIAN ZONE/ INSTREAM FEATURES	**Predominant Surrounding Landuse** ☐ Forest ☐ Commercial ☐ Field/Pasture ☐ Industrial ☐ Agricultural ☐ Other_____ ☐ Residential **Local Watershed NPS Pollution** ☐ No evidence ☐ Some potential sources ☐ Obvious sources **Canopy Cover** ☐ Partly open ☐ Partly shaded ☐ Shaded **High Water Mark** _____m	**Local Water Erosion** ☐ None ☐ Moderate ☐ Heavy **Estimated Stream Width** _____m **Estimated Stream Depth** ☐ Riffle_____m ☐ Run_____m ☐ Pool_____m **Velocity** _____m/sec **Estimated Reach Length** _____m **Channelized** ☐ Yes ☐ No **Dam Present** ☐ Yes ☐ No
RIPARIAN VEGETATION (18 meter buffer)	**Indicate the dominant type and record the dominant species present** ☐ Trees ☐ Shrubs ☐ Grasses ☐ Herbaceous **dominant species present** _____	
AQUATIC VEGETATION	**Indicate the dominant type and record the dominant species present** ☐ Rooted emergent ☐ Rooted submergent ☐ Rooted floating ☐ Free Floating ☐ Floating Algae ☐ Attached Algae **dominant species present** _____ **Portion of the reach with vegetative cover** _____%	
SEDIMENT/ SUBSTRATE	**Odors** ☐ Normal ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Anaerobic ☐ None ☐ Other_____ **Oils** ☐ Absent ☐ Slight ☐ Moderate ☐ Profuse	**Deposits** ☐ Sludge ☐ Sawdust ☐ Paper fiber ☐ Sand ☐ Relict shells ☐Other_____ **Looking at stones which are not deeply embedded, are the undersides black in color?** ☐ Yes ☐ No
WATER QUALITY	**Temperature**_____ ^{0} C **Specific Conductance**_____ **Dissolved Oxygen** _____ **pH** _____ **Turbidity** _____ **WQ Instrument Used** _____	**Water Odors** ☐ Normal/None ☐ Sewage ☐ Petroleum ☐ Chemical ☐ Fishy ☐ Other_____ **Water Surface Oils** ☐ Slick ☐ Sheen ☐ Globs ☐ Flecks ☐ None ☐Other_____ **Turbidity (if not measured)** ☐ Clear ☐ Slightly turbid ☐ Turbid ☐ Opaque ☐ Water color ☐ Other_____

FIELD DATA - BENTHIC MACROINVERTEBRATE SAMPLE

STREAM NAME	STATION #	
Reference or test?		
FORM COMPLETED BY	DATE _____ TIME _____	REASON FOR SURVEY

HABITAT TYPES	**Indicate the percentage of each habitat type present** ❑ Cobble_____% ❑ Snags_____% ❑ Vegetated Banks_____% ❑ Sand_____% ❑ Submerged Macrophytes_____% ❑ Other ( )_____%
SAMPLE COLLECTION	**How were the samples collected?** ❑ wading ❑ from bank ❑ from boat **Indicate the number of jabs/kicks taken in each habitat type.** ❑ Cobble_____ ❑ Snags_____ ❑ Vegetated Banks_____ ❑ Sand_____ ❑ Submerged Macrophytes_____ ❑ Other ( )_____
GENERAL COMMENTS	

Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

QHEI Score: ____

Stream & Location: _____ **RM:** ___.__ **Date:** __/__/06

Scorers Full Name & Affiliation: _____

River Code: __-__-__ **STORET #:** _____ **Lat./ Long.:** (NAD 83 - decimal °) __.____ /8__.____ Office verified location ☐

1] SUBSTRATE Check ONLY Two substrate TYPE BOXES; estimate % or note every type present

BEST TYPES	POOL	RIFFLE	OTHER TYPES	POOL	RIFFLE
☐☐ BLDR / SLABS [10]	____	____	☐☐ HARDPAN [4]	____	____
☐☐ BOULDER [9]	____	____	☐☐ DETRITUS [3]	____	____
☐☐ COBBLE [8]	____	____	☐☐ MUCK [2]	____	____
☐☐ GRAVEL [7]	____	____	☐☐ SILT [2]	____	____
☐☐ SAND [6]	____	____	☐☐ ARTIFICIAL [0]	____	____
☐☐ BEDROCK [5]	____	____	(Score natural substrates; ignore sludge from point-sources)		

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☐ 3 or less [0]

Check ONE (Or 2 & average)

ORIGIN	QUALITY
☐ LIMESTONE [1]	SILT: ☐ HEAVY [-2] ☐ MODERATE [-1] ☐ NORMAL [0] ☐ FREE [1]
☐ TILLS [1]	
☐ WETLANDS [0]	
☐ HARDPAN [0]	
☐ SANDSTONE [0]	EMBEDDEDNESS: ☐ EXTENSIVE [-2] ☐ MODERATE [-1] ☐ NORMAL [0] ☐ NONE [1]
☐ RIP/RAP [0]	
☐ LACUSTURINE [0]	
☐ SHALE [-1]	
☐ COAL FINES [-2]	

Comments

Substrate ____ Maximum 20

2] INSTREAM COVER Indicate presence 0 to 3: 0-Absent; 1-Very small amounts or if more common of marginal quality; 2-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

____ UNDERCUT BANKS [1]	____ POOLS > 70cm [2]	____ OXBOWS, BACKWATERS [1]
____ OVERHANGING VEGETATION [1]	____ ROOTWADS [1]	____ AQUATIC MACROPHYTES [1]
____ SHALLOWS (IN SLOW WATER) [1]	____ BOULDERS [1]	____ LOGS OR WOODY DEBRIS [1]
____ ROOTMATS [1]		

AMOUNT Check ONE (Or 2 & average)

☐ EXTENSIVE >75% [11]
☐ MODERATE 25-75% [7]
☐ SPARSE 5-<25% [3]
☐ NEARLY ABSENT <5% [1]

Comments

Cover Maximum 20 ____

3] CHANNEL MORPHOLOGY Check ONE in each category (Or 2 & average)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☐ FAIR [3]	☐ RECOVERING [3]	☐ LOW [1]
☐ NONE [1]	☐ POOR [1]	☐ RECENT OR NO RECOVERY [1]	

Comments

Channel Maximum 20 ____

4] BANK EROSION AND RIPARIAN ZONE Check ONE in each category for EACH BANK (Or 2 per bank & average)

River right looking downstream

EROSION (L R)	RIPARIAN WIDTH (L R)	FLOOD PLAIN QUALITY (L R)	(L R)
☐☐ NONE / LITTLE [3]	☐☐ WIDE > 50m [4]	☐☐ FOREST, SWAMP [3]	☐☐ CONSERVATION TILLAGE [1]
☐☐ MODERATE [2]	☐☐ MODERATE 10-50m [3]	☐☐ SHRUB OR OLD FIELD [2]	☐☐ URBAN OR INDUSTRIAL [0]
☐☐ HEAVY / SEVERE [1]	☐☐ NARROW 5-10m [2]	☐☐ RESIDENTIAL, PARK, NEW FIELD [1]	☐☐ MINING / CONSTRUCTION [0]
	☐☐ VERY NARROW < 5m [1]	☐☐ FENCED PASTURE [1]	
	☐☐ NONE [0]	☐☐ OPEN PASTURE, ROWCROP [0]	

Indicate predominant land use(s) past 100m riparian.

Comments

Riparian Maximum 10 ____

5] POOL / GLIDE AND RIFFLE / RUN QUALITY

MAXIMUM DEPTH	CHANNEL WIDTH	CURRENT VELOCITY	
Check ONE (ONLY!)	Check ONE (Or 2 & average)	Check ALL that apply	
☐ > 1m [6]	☐ POOL WIDTH > RIFFLE WIDTH [2]	☐ TORRENTIAL [-1]	☐ SLOW [1]
☐ 0.7-<1m [4]	☐ POOL WIDTH = RIFFLE WIDTH [1]	☐ VERY FAST [1]	☐ INTERSTITIAL [-1]
☐ 0.4-<0.7m [2]	☐ POOL WIDTH > RIFFLE WIDTH [0]	☐ FAST [1]	☐ INTERMITTENT [-2]
☐ 0.2-<0.4m [1]		☐ MODERATE [1]	☐ EDDIES [1]
☐ < 0.2m [0]		Indicate for reach - pools and riffles.	

Recreation Potential
Primary Contact
Secondary Contact
(circle one and comment on back)

Comments

Pool / Current Maximum 12 ____

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (Or 2 & average). ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
☐ BEST AREAS > 10cm [2]	☐ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☐ NONE [2]
☐ BEST AREAS 5-10cm [1]	☐ MAXIMUM < 50cm [1]	☐ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]
☐ BEST AREAS < 5cm [metric=0]		☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☐ MODERATE [0]
			☐ EXTENSIVE [-1]

Comments

Riffle / Run Maximum 8 ____

6] GRADIENT (ft/mi) ☐ VERY LOW - LOW [2-4]
DRAINAGE AREA (mi²) ☐ MODERATE [6-10] ☐ HIGH - VERY HIGH [10-6]

%POOL: ____ %GLIDE: ____
%RUN: ____ %RIFFLE: ____

Gradient Maximum 10 ____

EPA 4520 06/16/06

Reviewed By:_____

Page_____of_____

PEBBLE COUNT FIELD DATA SHEET

SITE ID:	DATE: 20___-___ ___- ___ ___ (YYYY-MM-DD)

		Grabs									
Transect	**Feature Type**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Abbreviations:

Silt/Clay	= SC	Sand – Coarse	= C
Sand – Very Fine	= VF	Sand – Very	= VC
Sand – Fine	= F	Small Boulder	= SB
Sand – Medium	= M	Medium	= MB
Hardpan Clay –	= HP	Large Boulder	= LB
Bedrock – BR	= BR		

Feature Types:

Riffle	= RF
Run	= RN
Glide	= G
Pool	

After recording transects above transcribe data into table below. Usually done by data entry person.

Size Class		Size (mm)	Feature	Number	Feature	Number	Feature	Number	Total (for all features)	Cumulative Total (for all sizes)
Silt/Clay		< 0.062								
Sand	Very Fine	0.062-0.125								
	Fine	0.125-0.25								
	Medium	0.25-0.50								
	Coarse	0.50-1.0								
	Very Coarse	1.0-2.0								
Gravel	Very Fine	2-4								
	Fine	4-6								
		6-8								
	Medium	8-12								
		12-16								
	Coarse	16-24								
		24-32								
	Very Coarse	32-48								
		48-64								
Cobble	Small	64-96								
		96-128								
	Large	128-192								
		192-256								
Boulder	Small	256-384								
		384-512								
	Medium	512-1024								
	Large - Very Large	1024-4096								
Bedrock		> 4096								

APPENDIX B

LABORATORY STANDARD OPERATING PROCEDURES

LABORATORY STANDARD OPERATING PROCEDURES

- **TETRA TECH: SORTING MACROINVERTEBRATE SAMPLES**
- **TETRA TECH: IDENTIFICATION OF BENTHIC MACROINVERTEBRATES**
- **ILLINOIS EPA DCN 167: SAMPLE PROCESSING FOR THE MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (MIBI)**
- **ILLINOIS EPA DCN 170: CALCULATION OF THE MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (MIBI)**
- **TETRA TECH: 10-DAY SEDIMENT TOXICITY TEST USING *HYALLELA AZTECA***

SUBJECT: **SORTING ORGANISMS FROM BENTHIC SAMPLES**

Purpose

The purpose of sorting organisms is to remove them from the sediment and debris in the sample prior to identification.

List of Equipment

US standard No. 35 sieve (500 µm mesh)
Wash pans
Forceps
Probes
Teaspoon
Squirt bottles
Subsampling device, if necessary
Lidded sample containers
Laboratory bench sheet
40x dissecting microscope
Gridded glass petri dish or plastic sorting tray
2-dram patent-lip specimen vials with stoppers
100% rag paper or other appropriate label material
Indelible ink pen or pencil for label making
Wood block specimen vial holders
Tally counters
95% ethanol solution

Procedure

1. Select a sample that is to be processed and log it in on the processing log. Fill out laboratory bench sheet with sample information, this information includes: location, sample ID number, date collected, number of containers, and initials of collector.

2. Decant the sample into the 500 µm mesh sieve and remove the fixative from the sample by washing it with regular tap water. To prevent sample spillage place the sieve in a large wash pan. Wash the sample thoroughly with water to dilute the preservative. Large pieces of detritus (twigs, leaves, etc.) or rocks should be rinsed over the sieve area, visually inspected, and discarded. The washed sample is placed into a plastic container and enough water added to prevent desiccation.

3. If the sample is especially large and/or contains numerous organisms, it may be subsampled. The Caton subsampling technique, as described below, will be used to obtain 300 ± 20% randomly selected macroinvertebrates from the 20 jab-sample.

Modified Caton subsampler: For this method, the sample is evenly distributed on a gridded screen (with marked squares each 6 x 6 cm, 500 µm mesh), which has been placed into a slightly larger tray of water. The screen is then lifted out of the tray so the sample contents will settle onto the screen. Grids are then randomly selected for analysis; beginning with the first-four randomly selected grids, the material from the grid is removed from the screen using a scoop aligned by the crosspieces. The selected aliquot is placed into a gridded petri dish for sorting. Enough aliquots are examined until the appropriate number of organisms is reached. An aliquot that has been started must be completed regardless of the number of organisms, to enable a total number to be calculated.

Subsampling will occur only if there are more than 300 organisms found in the first selected aliquot. Otherwise the entire sample will be examined and all of the organisms will be removed.

If it becomes obvious, at any point during the sorting process, that the density of macroinvertebrates contained in the initial four-cells will exceed the subsample target (300 ± 20%), then suspend the sort. Exceeding the target number of organisms before all four cells are sorted essentially amounts to a "*false-start*". If a "*false-start"* occurs, place the just-sorted organisms back in with the unsorted portion of the initial four-cell subsample. Re-homogenize the material in the subsample. At this point, the composition of the re-homogenized material is as if the four cells were never sorted and were just now randomly selected and transferred from the subsample to the sorting tray. Since the "*false-start*" establishes that too many organisms exist in the re-homogenized material, these four cells must undergo a "*Level-2"* subsample before another sort is attempted. To perform the "*Level-2"* subsample, transfer the re-homogenized materials from the initial four cells into a second gridded tray. Distribute these materials evenly over the second tray and randomly select four new cells one at a time. The four newly-selected cells represent the "*Level-2"* subsample. Perform material dispersion and cell selection for the "*Level-2"* subsample in the same manner as for the initial four cells. It is important to note that *if* the target number of organisms is routinely exceeded in the first four cells, the sorter may elect to automatically perform the "*Level-2"* subsample rather than spend time due to "*false-start*" sorting

4. Move all of the sample/subsample container(s) to a sort station. Label wooden vial holders with major taxonomic groups, and place vials in holders. Place a tally counter behind each vial. Fill one half of each vial with 95% ethanol solution. Sort randomly selected aliquots until the number of organisms needed for the designated subsample level has been obtained and the entire aliquot has been sorted regardless if the number sorted is greater than the number needed for the subsample level. Process each sample/subsample by placing a small amount (about 1 teaspoon of material) in a gridded petri dish or sorting tray. Use a light ring (approximately 1.75x) in the sorting process (this provides focused light on the sorting pan and helps standardize the visual acuity among sorters). Place organisms in two-dram vials according to major taxonomic groups for later identification and keep count of organisms on tally counters. Once the dish is examined completely, wash petri dish into a large container and continue to process the rest of the sample/subsample. When sorting is completed, record the number of organisms that was found for each sample/subsample on a bench sheet. Make the labels for each taxonomic group with 100% rag paper and pencil, and place each in the

corresponding vial. Include the following information:

Date Collected	e.g.:03 Jul 01
Station ID	Timberline Lake
Sampler & replicate	Rep 1
Subsample identification	1/8 ss
Taxonomic group	Oligochaeta
Number of organisms	92
Sorter's initials	LSL

Labels should be placed in the vial so that they can be read when the vial is held horizontally and the stopper pointed to the right.

Some organisms are easily damaged when removing them with forceps (e.g., oligochaetes); therefore be very careful not to squeeze too tightly, or else use homemade probes to slip under the worm to lift it. These probes can be made by removing the top rounded end of an insect pin and inserting it into a piece of doweling (2-3 mm diameter, ~10 cm long) which has been soaked in water to soften the wood. Let the wood thoroughly dry, which will contract as it dries. Add a little epoxy between the pin and wood.

5. Complete the laboratory bench sheet as appropriate.

6. The sorted residue is placed into a new container, preserved with 95% alcohol, and appropriately labeled with the site information and the words SORTED RESIDUE for storage. The unsorted remains are placed back into the original container and preserved with 95% alcohol and labeled UNSORTED

SUBJECT: **IDENTIFYING BENTHIC ORGANISMS**

Purpose

To determine the identity of all benthic invertebrate organisms to the lowest practical taxonomic level. The target levels are at least genus for insects and non-sphaeriid/non-unionid bivalves. Classify the remaining macroinvertebrates as Hirudinea, Oligochaeta, Turbellaria, Unionidae, Cambariidae, and Sphaeriidae. Equipment and procedures are listed separately below for non-midges and for midges

List of Equipment for Identification of All Organisms Except Midges

Tally counters
Dissecting microscope capable of up to 80X magnification
95% ethanol solution
Very fine-tip jewelers forceps
Insect pin probes: sizes 00, 0, or 1
Small covered petri dishes
2-dram patent-lip glass specimen vials or screw top glass vials for larger organisms
Size 00 neoprene stoppers or screw caps for vials
Wood block vial holders
100% rag paper or other appropriate label material
Indelible ink pen or pencil for label making
Laboratory bench sheet
Benthic laboratory chain-of-custody log sheet
Various benthic invertebrate keys which provide the most updated classification scheme for the various groups of benthic invertebrates.

Procedure for Identification of All Organisms Except Midges

1. Select a sample for identification from sorted materials. Samples should be roughly sorted into major taxonomic groups at this point, e.g., mollusks, Ephemeroptera.

2. Retrieve the appropriately labeled laboratory bench sheet.

3. Open one vial and place contents into petri dish. Using a dissecting microscope, remove any foreign material from the contents of the petri dish (e.g., detritus).

4. Identify and enumerate all taxa to the lowest practical taxonomic level (generally genus). Place the identified material in 2-dram patent-lip vials or screw top vials containing the95% ethanol solution. The number of individuals in each taxon should be tallied using the tally counters as the taxa are sorted and identified. Each vial from the sample should be worked upon separately, making certain

that any organisms which are found are identified and enumerated properly. Each vial containing a taxon should be appropriately labeled with number of individuals that are in the vial and with the same sample number that appears on the laboratory bench sheet. Care should be taken to the application of stoppers so that leakage does not occur.

5. Identification of the various benthic invertebrates may be accomplished using a variety of available keys. A partial list of taxonomic references is shown below. Take the final identification and recorded name from the references listed under Macroinvertebrate Key, below. Because all of the organisms are not mature larvae or adults, accurate determinations may sometimes be difficult. In such cases, in-house experience is important. If there are any questionable identifications they are checked by other qualified individuals to ensure accurate identification.

6. The number of individuals per vial for each of the taxa should be entered on the laboratory bench sheet.

7. Notation of new taxa should be made, as a species list is developed from these notations. Specimens that are large or in good condition should be marked for use in voucher collections.

List of Equipment for Identification of Midges

Dissecting microscope capable of 40X magnification
Compound microscope capable of 1000X magnification
95% ethanol solution
Very fine tip jewelers forceps
Insect pin probes: sizes 00, 0, or 1
Large probe
Small covered petri dishes
CMCP 10 high viscosity mounting medium
Dropper
Sharpie ink pen
75 mm X 25 mm precleaned plain microscope slides
No. 1 square cover slips (either 22 x 22 mm or 18 x 18 mm)
Self-adhesive slide labels
Laboratory bench sheet for chironomids
Immersion oil
Various keys which provide the most updated classification scheme

Procedure for Identification of Midges

1. Select a sample for identification from sorted materials. Samples should be roughly sorted into major taxonomic groups at this point, i.e., chironomid larvae.

2. Label a laboratory bench sheet so it corresponds with the numbers on the sample vial.

3. Open the vial and place contents into petri dish. Using a dissecting microscope, remove any foreign material from the contents of the petri dish.

4. Line up 3-4 slides and put two drops of mounting medium on each slide. The drops should be equidistant from each other, but enough room should be left to apply a self-adhesive slide label on the left side. Do not place label on slide until the complete set of chironomids has been mounted.

5. Place 3-4 chironomids directly from the95% ethanol solution onto each drop of medium. If the specimen floats away, there is too much medium. If you use less, you must ensure that no air bubbles or pockets occur. Line up each of the chironomids so that the ventral side is up and all of the anterior ends face the same direction. If the chironomids (e.g., 4th instar *Dicrotendipes*) are large, the number placed under one coverslip may vary. Place one cover slip on the specimens, making sure that only the edges of the cover slip are handled--do not put your fingers on the cover slip itself. Make sure that there is only one cover slip.

6. Using a large probe or forceps press gently but firmly on the cover slip to distribute the medium and flatten the specimen without destroying it.

7. Carefully ring the cover slip with medium. Make sure that there is no medium on top of the cover slip and that air bubbles have not occurred. When the entire set has been mounted, place a self-adhesive slide label on the slide and label with appropriate information:

Date Collected	e.g.:	03 Jul 94
Station ID		25139
Sampler & replicate		Basket A
Taxonomic group		Chironomidae
Slide number		1 of 20 (or 1-20)

8. Once the medium has set, use a dissecting microscope to aid in the marking of the specimen position. Use a fine tipped Sharpie pen to put a dot immediately beneath or beside the specimen's head. Do this for every specimen regardless of size.

9. Put the slides on a mounting tray and place them under a hood. Allow the slides to dry for 2-3 days. It is generally a good idea to check each slide once a day to ensure that air bubbles have not developed or to see if more medium is needed.

10. Identification of the taxa may be accomplished by using a variety of available keys (see partial list of taxonomic references below) and a compound microscope. Because all of the organisms are not mature, accurate identifications may sometimes be difficult. In such cases, in-house experience is important. If there are any questionable identifications they are checked by other qualified individuals to ensure accurate identification.

11. Once a specimen has been identified it is recorded on the laboratory bench sheet for that group.

For example	A	B	C
1.	*Chironomus*	*Dicrotendipes*	*Ablabesmyia*
	Tanytarsus	*Polypedilum*	*Thienemanniella*
	Rheotanytarsus	*Microtendipes*	*Corynoneura*
	Rheocricotopus	*Cryptochironomus*	

The three coverslips per slide are treated as sides A, B and C (if only two coverslips, A and B). Consequently the 3-4 midges that are under the cover slip are written down as they appear from left to right under the microscope.

12. Notation of new taxa should be taken, as a species list is developed from these notations. Specimens that are large or in good condition should be marked for use in voucher collection.

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Macroinvertebrate Key

Use any available literature as an aid to identify the organisms. However, take the final identification and recorded name from the following references.

PLATYHELMINTHES
- TURBELLARIA: Family (Pennak, 1989 pgs 124-51)

ANNELIDA
- OLIGOCHAETA: Class (Pennak, 1989 pg 290) / (Kathman and Brinkhurst, 1998)
- HIRUDINEA: Family (Pennak, 1989 pgs 314-333)

ARTHROPODA
- CRUSTACEA
  - ISOPODA: Genus (Pennak, 1989 pgs 462-73)
  - AMPHIPODA
    - Hyalellidae: species (Pennak, 1989 pgs. 474-88)
    - Gammaridae: Genus (Pennak, 1989 pgs. 474-88)

DECAPODA
- Cambaridae: Genus/species (Page, 1985 INHS Bull. 33:4)
- Palaemonidae: species (Page, 1985 INHS Bull. 33:4)

INSECTA
- EPHEMEROPTERA
  - Siphlonuridae: Genus (Merritt and Cummins, 1996)
  - Isonychiidae: Genus (Merritt and Cummins, 1996)
  - Baetidae: Genus/species (Merritt and Cummins, 1996 / Morihara and McCafferty, 1979 TAES V.105 / Burks, 1953)
  - Heptageniidae: Genus/species (Merritt and Cummins, 1996 / Burks, 1953 / Lewis, 1974) / Bednarik and McCafferty, 1979)
  - Ephemerellidae: Genus (Merritt and Cummins, 1996)
  - Tricorythidae: Genus (Merritt and Cummins, 1996)
  - Caenidae: Genus (Merritt and Cummins, 1996)
  - Baetiscidae: Genus (Merritt and Cummins, 1996)
  - Leptophlebiidae: Genus (Merritt and Cummins, 1996)
  - Potamanthidae: Genus (Merritt and Cummins, 1996)
  - Emphemeridae: Genus (Merritt and Cummins, 1996)
  - Palingeniidae: Genus (Merritt and Cummins, 1996)
  - Polymitarcyidae: Genus (Merritt and Cummins, 1996)
- ODONATA
  - ANISOPTERA
  - Cordulegasteridae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1995 / Needham, Westfall and May, 2000).
  - Gomphidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham Westfall and May, 2000)

Aeshnidae (or Aeschnidae): Genus/species (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham, Westfall and May, 2000)
Corduliidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham, Westfall and May, 2000)
Libellulidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 2000)
ZYGOPTERA
Calopterygidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)
Coenagrionidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)
Lestidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)
PLECOPTERA
Pteronarcyidae: Genus (Merritt and Cummins, 1996)
Taeniopterygidae: Genus (Merritt and Cummins, 1996)
Nemouridae: Genus (Merritt and Cummins, 1996)
Leuctridae: Genus (Merritt and Cummins, 1996)
Capniidae: Genus (Merritt and Cummins, 1996)
Perlidae: Genus (Merritt and Cummins, 1996)
Perlodidae: Genus (Merritt and Cummins, 1996)
Chloroperlidae: Genus (Merritt and Cummins, 1996)
HEMIPTERA
Gerridae: Genus (Merritt and Cummins, 1996)
Notonectidae: Genus (Merritt and Cummins, 1996)
Pleidae: Genus (Merritt and Cummins, 1996)
Belostomatidae: Genus (Merritt and Cummins, 1996)
Corixidae: Genus (Merritt and Cummins, 1996)
MEGALOPTERA
Sialidae: Genus (Merritt and Cummins, 1996)
Corydalidae: Genus/species (Merritt and Cummins, 1996)
NEUROPTERA
Sisyridae: Genus (Merritt and Cummins, 1996)
TRICHOPTERA
Hydropsychidae: Genus/species (Merritt and Cummins,1996 / Schmude and Hilsenhoff,1986)
Philopotamidae: Genus (Merritt and Cummins, 1996)
Polycentropodidae: Genus (Merritt and Cummins, 1996)
Psychomyiidae: Genus (Merritt and Cummins, 1996)
Glossosomatidae: Genus (Merritt and Cummins, 1996)
Hydroptilidae: Genus (Merritt and Cummins, 1996)
Rhyacophilidae: Genus (Merritt and Cummins, 1996)
Brachycentridae: Genus (Merritt and Cummins, 1996)
Lepidostomatidae: Genus (Merritt and Cummins, 1996)
Molannidae: Genus (Merritt and Cummins, 1996)
Phryganeidae: Genus (Merritt and Cummins, 1996)
Helicopsychidae: species (Merritt and Cummins, 1996)

Leptoceridae: Genus/species (Merritt and Cummins, 1996 / Glover and Floyd, 2004 / Floyd, 1995)

LEPIDOPTERA

Pyralidae: Genus (Merritt and Cummins, 1996)

COLEOPTERA

Gyrinidae: Genus (Merritt and Cummins, 1996)

Psephenidae (larvae only): Genus (Merritt and Cummins, 1996)

Scirtidae: Genus (Merritt and Cummins, 1996)

Illinois Environmental Protection Agency

Bureau of Water

Document Control Number 167

Standard Operating Procedure for Sample Processing for the Macroinvertebrate Index of Biotic Integrity (mIBI)

Surface Water Section
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276
Contact: Bureau of Water, Quality Assurance Officer 217-782-3362

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1.0 Scope and Application

The instructions included in this Standard Operating Procedure (SOP) describe how to obtain a 300 ± 20% fixed-count macroinvertebrate subsample and how to enumerate and identify the individual members at the proper taxonomic resolution in order to properly compute and interpret the macroinvertebrate Index of Biotic Integrity (mIBI).

The SOP is part of a larger mIBI protocol that includes specific macroinvertebrate collection, identification, computation, and application instructions. To ensure a correct application of the mIBI, follow the protocols outlined in the module *"Calculation of the macroinvertebrate Index of Biotic Integrity (mIBI)"*. To ensure that samples are appropriate for the mIBI, follow the protocol described in *"Methods to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments".*

The mIBI represents how macroinvertebrates respond to and integrate the chemical, physical and biological effects of human-caused impacts on streams and their watersheds when compared to a subset of least disturbed locations sampled during 2001.

2.0 Summary of Method(s)

- Collect samples according to the method outlined in "*Methods to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments*".
- Rinse the sample with water to remove preservatives.
- Assign unique numbers to identify each of the thirty 6x6-cm grid cells in the screened subsample tray.
- Load the rinsed sample materials into the screened subsample tray.
- Evenly distribute the materials over the subsample tray.
- Submerge the loaded subsample tray in water to partially suspend the sample materials.
- Remove the subsample tray from the water to facilitate random distribution of the sample over the entire screen.
- Randomly select four cells from the gridded subsample tray.
- Place the contents of the selected cells into a shallow white pan. Partially fill the pan with liquid to facilitate macroinvertebrate sorting.
- Sort 300 ± 20% aquatic macroinvertebrates using a ring-light magnifier. Exclude macroinvertebrates (e.g., semi-aquatic taxa and others listed in, "*Illinois Environmental Protection Agency Tolerance List and Functional Feeding Group Classification*", in Appendix A.) from the 300 ± 20% count.

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- If fewer than 300 ± 20% macroinvertebrate exist in the initial four cells, randomly select and sort additional sample material, one cell at a time, until the target number of organisms is obtained.

- If greater than 300 ± 20% macroinvertebrates exist in the initial four cells then reduce the amount of material and macroinvertebrates sorted. Place all of the materials from the initial four cells into a second gridded screen and conduct a "*Level-2"* subsample. Subsample the second gridded screen as before and obtain materials from the four ("*Level-2"*) cells. Repeat as necessary (e.g., "*Level-3"*, "*Level-4"* etc.) until the subsample contains 300 ± 20% macroinvertebrates.

- The subsample is complete.

- Identify macroinvertebrate with the taxonomic keys listed below in "*10.0 Macroinvertebrate Keys*".

- Refer to the module "*Calculation of the macroinvertebrate Index of Biotic Integrity (mIBI)"*, for information on the required levels of taxonomic resolution for specimen identification.

3.0 Interferences and Corrective Action

Proper application of the mIBI requires properly collected samples. To collect mIBI samples, follow the instructions outlined in the module "*Method to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments*". In addition, a 300 ± 20% individual fixed-count subsample is required since this sample size was utilized to develop metric score expectations and mIBI interpretation criteria.

4.0 Safety

To reduce exposure to sample preservatives, protective eyewear and latex gloves should be worn. Process samples in a well ventilated area or under a fume hood. Depending on the preservative utilized, several rinsing and soaking steps may be needed to prepare the sample for processing.

5.0 Equipment and Supplies

Standardized gridded screen (595 micron screen, 30 cells, each 6 cm^2), shallow watertight tray for submerging the gridded screen, 6 cm scoop, 6 cm^2 metal dividing frame, forceps, scissors, white plastic or enamel pan for sorting, ring-light, specimen vials with caps or stoppers, sample labels, standard laboratory bench sheets, 95 percent ethanol for storage of specimens, sample log and tracking sheets.

6.0 General Guidelines (in part from Barbour et. al., 1999)

The procedures, outlined below, follow the methods established in the US EPA Rapid Bioassessment Protocol (Barbour et. al. 1999). These procedures use a fixed-count sub-sampling approach for sorting organisms from the materials included in the sample matrix. The reason for the subsample requirement is that the volume of material collected with the proportionally allocated multihabitat

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collection approach is typically impractical to process in its entirety. Sub-sampling reduces the effort required for the sorting and identification aspects of macroinvertebrate samples and provides a more expedient expenditure of time (Barbour and Gerritsen 1996).

To facilitate processing and identification, the randomized 300 ± 20% fixed count subsample is sorted and preserved separately from the remaining sample. Document the level-of-effort, or proportion of sample processed by recording this information on the Laboratory Bench Sheet.

The instructions in this SOP describe two phases of macroinvertebrate sorting. The "*Phase-1"* sort is the source of all mIBI information. A "*Phase-1"* sort refers to the sub-sampling process utilized to randomly select 300 ± 20% macroinvertebrates from the sample. A *"Phase-1"* sort can progress in stages and each stage corresponds to a particular "*sub-sample level*". The level of sub-sampling needed to meet the 300 ± 20% target depends on the density of macroinvertebrates in the sample. "*Phase-2"* sort refers to a fifteen minute search conducted on all remaining unsorted material to check for obviously unique taxa not found during ""*Phase-1"* sub-sampling. "*Phase-2"* organisms are placed in a separate vial and are <u>not</u> included as part of the subsample. Exclude taxa obtained during the "*Phase-2"* sort from all mIBI computations. "*Phase-2"* taxa may be utilized, independent of the mIBI, as an aid when making water quality interpretations.

6.1 Specific Guidelines (in part from Barbour et. al., 1999)

- Record sample collection information on the benthic macroinvertebrate tracking sheets. These sheets are located in the sample log-book. Record sample label information plus the information from the Illinois EPA field assessment form on the benthic macroinvertebrate laboratory bench sheet. This information will include sample ID/station code, method of collection, allocation of jabs, number of containers per sample, initials of collector, start time, duration and sample collection date.

- Thoroughly rinse the sample in a No. 30 mesh (595-µm openings) sieve to remove preservative and fine sediment. Depending on the preservative utilized, this step may need to be initiated several days prior to sub-sampling and this step may need to be repeated daily. The log-book containing sample tracking sheets should be posted in the lab or sorting area to track this process. Large organic material (whole leaves, twigs, algal or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. Use large Rubbermaid type tubs to facilitate this activity. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, which will prevent them from floating on the water surface during sorting. If the sample is stored in more than one container, the contents of all containers for a given sample should be combined and homogenized at this time.

- Use Oregon Department of Environmental Quality standardized sub-sampling gear (Caton, 1991) to obtain 300 ± 20% randomly selected macroinvertebrates from the 20-jab sample. The subsample gear has two parts- the first part is a shallow watertight tray and the second part is a 600-micron screen. The screened tray is equally-divided into a grid of 30 clearly marked cells and each cell measures 6x6-cm. Place the screened tray into the watertight tray and spread the entire sample onto the screened grid. Pour enough water into the gear to immerse the sample. This activity will help suspend the sample and facilitate a more even distribution of sample materials over the screened grid. Then lift the screen out of the tray, which will cause the sample

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materials to settle evenly onto the screen. When samples are too large to be effectively-sorted in a single tray, place half of the homogenized sample in each of two gridded trays.

- Assign a unique number (e.g., 1-30) to each of the 30 cells in the grid of the screened tray. Randomly select four of the thirty gridded tray cells. Use a random number table or computerized random number generator to randomly select the four numbers. If two gridded trays are needed then eight cells should be selected- four from each of the two trays. The material contained in the four, randomly- selected, cells make the subsample.

- Beginning with the first-four randomly-selected cells (eight cells if two trays were used), remove all organisms and debris contained within the boundary of the pertinent cells and place these materials into a white pan to sort. When transferring organisms from the grid to the sorting pan, consider any organisms that straddle adjoining cells to be on the cell containing the head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organism is considered to be in the cell containing most of its body. When a selected cell has organic debris lying over or entangled among the materials in an adjacent cells, it may be necessary to use a pair of scissors to cut materials along the gridline. Cutting will help prevent the unintended transfer of debris-entangled macroinvertebrates from one cell to another.

- After placing the randomly-selected materials into a shallow white pan, add a small amount of liquid to facilitate sorting. Use a ring light (approximately 1.75X) in the sorting process (this provides focused light on the sorting pan and helps standardize the visual acuity among sorters). Sort through the debris, and remove and count <u>all</u> the macroinvertebrates in the pan.

- If it becomes obvious, at any point during the sorting process, that the density of macroinvertebrates contained in the initial four-cells will exceed the subsample target (300 ± 20%), then suspend the sort. Exceeding the target number of organisms before all four cells are sorted essentially amounts to a "*false-start*". If a "*false-start"* occurs, place the just-sorted organisms back in with the unsorted portion of the initial four-cell subsample. Re-homogenize the material in the subsample. At this point, the composition of the re-homogenized material is as if the four cells were never sorted and were just now randomly selected and transferred from the subsample to the sorting tray. Since the "*false-start*" establishes that too many organisms exist in the re-homogenized material, these four cells must undergo a "*Level-2"* subsample before another sort is attempted. To perform the "*Level-2"* subsample, transfer the re-homogenized materials from the initial four cells into a second gridded tray. Distribute these materials evenly over the second tray and randomly select four new cells one at a time. The four newly-selected cells represent the "*Level-2"* subsample. Perform material dispersion and cell selection for the "*Level-2"* subsample in the same manner as for the initial four cells. It is important to note that <u>*if*</u> the target number of organisms is routinely exceeded in the first four cells, the sorter may elect to automatically perform the "*Level-2"* subsample rather than waste time due to "*false-start*" sorting.

- If the density of organisms is large enough that many more than the targeted number of organisms are contained in the four cells, then transfer the contents of the cells to a third gridded pan and continue as before. If the targeted subsample amount of 300 <u>+</u> 20% organisms is reached, the subsample is finished. If less than the targeted 300 <u>+</u> 20% organisms exist, continue randomly selecting and sorting cells, one-at-a-time, until the targeted subsample number is obtained. If picking through the entire next cell is likely to result in a subsample with greater than 300 ± 20% organisms, then subsample that single cell in the same manner as before. That

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is, spread the contents of the last cell into another gridded pan. Pick cells, one-at-a-time, until 300 ± 20% organisms are reached. The total number of cells for each subsample level should be noted on the laboratory bench sheet. Each cell selected for sorting, must be sorted in its entirety.

- Except for one situation, a 300 ± 20% organism fixed count subsample is required for all macroinvertebrate samples utilized for the mIBI. The exception occurs when the entire sample contains fewer than 240 total individuals. In this situation, the subsample will never reach the 300 ± 20% organism target. Use extreme caution when interpreting mIBI results based on fewer than 240 macroinvertebrates. A 300 ± 20% individuals fixed-count subsample is required since this sample size was utilized to develop metric score expectations and mIBI interpretation criteria

- Until the target number of organisms is obtained, be careful not to accidentally disturb the subsample tray between these activities (e.g., removing cell contents or while sorting) because this may cause a redistribution of specimens that could possibly change the probability of selection if additional cells must be sorted.

- It is important to note that organisms, which are damaged beyond recognition, should not be included in the subsample count. Likewise, exclude all Hemiptera and most semi-aquatic Coleoptera from the subsample count. Regardless of the number of semi-aquatic taxa omitted, the subsample procedure continues until the fixed-count target of 300 ± 20% organisms is attained. Refer to the tolerance assignments in Appendix A, to identify ineligible semi-aquatic taxa. The ineligible taxa have tolerance values of 99.9.

- Once this initial phase of sorting is completed and the target number of organisms is obtained, a fifteen minute "*Phase-2"* sort is conducted on all remaining unsorted material to check for obviously unique taxa not found while obtaining the require 300 ± 20% macroinvertebrates. "*Phase-2"* organisms will be placed in a separate vial and will not be included as part of the initial subsample. Also, exclude taxa obtained during the "*Phase-2"* sort from all mIBI computations. "*Phase-2"* taxa may be useful, independent of the m-IBI, as an aid when making site quality interpretations.

- Note the type of sample, sample ID/station code, sorter, date sorted and any comments regarding the sample (e.g., description of organic material in sample -- sand, fine organics), and sorting time on the bench sheet.

- For 10% of the samples, save the unsorted sample residue in a container labeled "sample residue"; this container should include the original sample label. Save the sorted debris in a separate container labeled "sorted residue" in addition to original label information. Length of storage and archival is to be determined.

- Place specimens sorted as the subsample **(**300 ± 20% organisms) into a glass vial, and preserve in 95 percent ethanol. Label the vial inside with the station code, stream name, collection date and sample ID/station code.

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- Any entirely-sorted sample that falls below the designated subsample size of 300 ± 20% may provide spurious information. Use extreme caution when interpreting mIBI results based on fewer than 240 macroinvertebrates. A 300 ± 20% individuals fixed-count subsample is required since this sample size was utilized to develop metric score expectations and mIBI interpretation criteria

7.0 Quality Control (QC) for mIBI samples

- Ten percent of the sorted samples in each lot should be examined by laboratory QC personnel or a qualified co-worker. A lot is defined as a special study, basin study, entire index period, or individual sorter. The QC worker will examine the cells chosen and the tray used for sorting and will look for organisms missed by the sorter. Organisms found will be added to the sample vial. If the QC worker finds that less than 10% of the organisms remain in the sorting tray, the sample passes; if more than 10% are found, the sample fails. If 10 percent of the sample lot fails, another 10 percent is randomly selected until failure no longer occurs or the entire lot is checked. Sorters in-training will have their samples 100 percent checked until sorting efficiency reaches 90%. The results of the QC check are recorded on the Benthic Macroinvertebrate Laboratory Bench Sheet.

- After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris.

8.0 Organism Identification for mIBI Calculations

8.1 General Guidelines

- The taxonomic resolution of macroinvertebrate identification varies for mIBI calculations. In general, it is preferred to identify organisms to species level whenever practical. However, for mIBI calculations use generic resolution for insects and non-sphaerid bivalves, class resolution for leeches, worms and flatworms, and family resolution for crayfish, fingernail clams, and mussels. the taxonomic keys listed below for macroinvertebrate identification. Refer to "*Calculation of the macroinvertebrate Index of Biotic Integrity (mIBI)"* for specific information about the level of taxonomic resolution required for a given taxonomic group.

- When there is a question concerning the correct identification of a specimen, send it to other recognized authorities for confirmation.

- A voucher (reference) collection must be maintained to help resolve questions regarding the accuracy of taxonomic identifications. These specimens should be properly labeled, preserved and stored in the laboratory for future reference. Specimen labels should include the name(s) of the verifying person(s). Senior taxonomist must verify 10% of the sample identifications.

- Information on samples completed (through the taxonomy process) is recorded in the sample notebook or bench sheet to track the progress of each sample within the sample lot. The tracking of each sample will be updated as each step is completed (i.e., rinsing, sub-sampling, sorting and taxonomy).

8.1.1 Specific Guidelines for Organism Identification

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- For identification and enumeration, examine organisms under a stereoscopic dissecting microscope. The microscope should have a magnification range of 7X to 120X. After they are identified and counted, all organisms are returned to a single sample vial containing 95% ethanol and the original field sample label, OR original field sample label information (see previous page, section 6.1. "For 10% of the samples, save the unsorted sample residue in a container labeled "sample residue"; this container should include the original sample label. Save the sorted debris in a separate container labeled "sorted residue" in addition to original label information."

- Some taxa require slide mounts for proper identification (e.g., chironomid larvae). Before mounting chironomids, the larvae are made more transparent (cleared) to facilitate the observation of internal structures utilized in taxonomic identification. The process of clearing and mounting the larvae may make certain characteristics difficult to see. Membranous structures such as the Lauterborn organs and the antennal blade become very faint after treatment in warm KOH. Overnight clearing in cool (room temperature) KOH is less damaging and will make structures more visible (Simpson and Bode, 1980). The anal and ventral tubules, preanal papillae, eyespots and body coloration should be observed under a dissecting microscope before the specimen is cleared. Another clearing/mounting agent is CMC-10 mounting media from Masters Group, Inc..

- After being picked from the sample, chironomid larvae should be sorted into groups based on location of eyespots, shape of head and possession of ventral tubules.

- Clear the larvae of soft tissue by placing them in cool 10% potassium hydroxide (KOH) overnight;

  Or

- Heat the KOH on a hot plate (low only) until the head capsule clears, approximately 20-30 minutes.

- Rinse out the KOH by soaking the larvae in distilled water approximately 10 minutes.

- Place the larvae through a graded alcohol series (50%, 70% and 95%) to remove all the water. Failure to remove the water may cause bubbles to appear. Minimum time per rinse is 10 minutes.

- Place approximately two drops of Canada balsam (Permount or other suitable mounting medium) on a microscope slide and arrange the midge with the ventral side up.

- Cover with a coverslip and press down on the head capsule to expose the mouthparts.

- Note: On large larvae the abdomen may prevent the depression of the head capsule. In such cases, mount the abdomen under a separate coverslip, but on the same slide.

9.0 Sample Integrity and Disposition

- To ensure the integrity of each sample, a label containing the information discussed in the subsection on labeling is included in each vial. In order to maintain chain-of-custody, samples

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are the responsibility of the collecting biologist. Keep samples in a secure location at all times (e.g. lock the vehicle whenever vacant). Final disposition of samples is also the responsibility of the collecting biologist.

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10.0 Macroinvertebrate Keys

Use any available literature as an aid to identify the organisms. However, take the final identification and recorded name from the following references.

PLATYHELMINTHES
- TURBELLARIA: Family (Pennak, 1989 pgs 124-51)

ANNELIDA
- OLIGOCHAETA: Class (Pennak, 1989 pg 290) / (Kathman and Brinkhurst, 1998)
- HIRUDINEA: Family (Pennak, 1989 pgs 314-333)

ARTHROPODA
- CRUSTACEA
  - ISOPODA: Genus (Pennak, 1989 pgs 462-73)
  - AMPHIPODA
    - Hyalellidae: species (Pennak, 1989 pgs. 474-88)
    - Gammaridae: Genus (Pennak, 1989 pgs. 474-88)
  - DECAPODA
    - Cambaridae: Genus/species (Page, 1985 INHS Bull. 33:4)
    - Palaemonidae: species (Page, 1985 INHS Bull. 33:4)
- INSECTA
  - EPHEMEROPTERA
    - Siphlonuridae: Genus (Merritt and Cummins, 1996)
    - Isonychiidae: Genus (Merritt and Cummins, 1996)
    - Baetidae: Genus/species (Merritt and Cummins, 1996 / Morihara and McCafferty, 1979 TAES V.105 / Burks, 1953)
    - Heptageniidae: Genus/species (Merritt and Cummins, 1996 / Burks, 1953 / Lewis, 1974) / Bednarik and McCafferty, 1979)
  - Ephemerellidae: Genus (Merritt and Cummins, 1996)
    - Tricorythidae: Genus (Merritt and Cummins, 1996)
    - Caenidae: Genus (Merritt and Cummins, 1996)
    - Baetiscidae: Genus (Merritt and Cummins, 1996)
    - Leptophlebiidae: Genus (Merritt and Cummins, 1996)
    - Potamanthidae: Genus (Merritt and Cummins, 1996)
    - Emphemeridae: Genus (Merritt and Cummins, 1996)
    - Palingeniidae: Genus (Merritt and Cummins, 1996)
    - Polymitarcyidae: Genus (Merritt and Cummins, 1996)
  - ODONATA
    - ANISOPTERA
    - Cordulegasteridae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1995 / Needham, Westfall and May, 2000).
    - Gomphidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham Westfall and May, 2000)
    - Aeshnidae (or Aeschnidae): Genus/species (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham, Westfall and May, 2000)
    - Corduliidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 1955 / Needham, Westfall and May, 2000)
    - Libellulidae: Genus (Merritt and Cummins, 1996 / Needham and Westfall, 2000)

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ZYGOPTERA
Calopterygidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)
Coenagrionidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)
Lestidae: Genus (Merritt and Cummins, 1996 / Westfall and May, 1996)

PLECOPTERA
Pteronarcyidae: Genus (Merritt and Cummins, 1996)
Taeniopterygidae: Genus (Merritt and Cummins, 1996)
Nemouridae: Genus (Merritt and Cummins, 1996)
Leuctridae: Genus (Merritt and Cummins, 1996)
Capniidae: Genus (Merritt and Cummins, 1996)
Perlidae: Genus (Merritt and Cummins, 1996)
Perlodidae: Genus (Merritt and Cummins, 1996)
Chloroperlidae: Genus (Merritt and Cummins, 1996)
HEMIPTERA
Gerridae: Genus (Merritt and Cummins, 1996)
Notonectidae: Genus (Merritt and Cummins, 1996)
Pleidae: Genus (Merritt and Cummins, 1996)
Belostomatidae: Genus (Merritt and Cummins, 1996)
Corixidae: Genus (Merritt and Cummins, 1996)
MEGALOPTERA
Sialidae: Genus (Merritt and Cummins, 1996)
Corydalidae: Genus/species (Merritt and Cummins, 1996)
NEUROPTERA
Sisyridae: Genus (Merritt and Cummins, 1996)
TRICHOPTERA
Hydropsychidae: Genus/species (Merritt and Cummins,1996 / Schmude and Hilsenhoff,1986)
Philopotamidae: Genus (Merritt and Cummins, 1996)
Polycentropodidae: Genus (Merritt and Cummins, 1996)
Psychomyiidae: Genus (Merritt and Cummins, 1996)
Glossosomatidae: Genus (Merritt and Cummins, 1996)
Hydroptilidae: Genus (Merritt and Cummins, 1996)
Rhyacophilidae: Genus (Merritt and Cummins, 1996)
Brachycentridae: Genus (Merritt and Cummins, 1996)
Lepidostomatidae: Genus (Merritt and Cummins, 1996)
Molannidae: Genus (Merritt and Cummins, 1996)
Phryganeidae: Genus (Merritt and Cummins, 1996)
Helicopsychidae: species (Merritt and Cummins, 1996)
Leptoceridae: Genus/species (Merritt and Cummins, 1996 / Glover and Floyd, 2004 / Floyd, 1995)
LEPIDOPTERA
Pyralidae: Genus (Merritt and Cummins, 1996)
COLEOPTERA
Gyrinidae: Genus (Merritt and Cummins, 1996)
Psephenidae (larvae only): Genus (Merritt and Cummins, 1996)
Scirtidae: Genus (Merritt and Cummins, 1996)

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Haliplidae: Genus (Merritt and Cummins, 1996)
Hydrophilidae: Genus (Merritt and Cummins, 1996)
Dytiscidae: Genus (Merritt and Cummins, 1996)
Dryopidae: Genus (Merritt and Cummins, 1996)
Elmidae: Genus (Merritt and Cummins, 1996)
DIPTERA
Tipulidae: Genus (Merritt and Cummins, 1996)
Chaoboridae: Genus (Merritt and Cummins, 1996)
Culicidae: Genus (Merritt and Cummins, 1996)
Dixidae: Genus (Merritt and Cummins, 1996)
Psychodidae: Genus (Merritt and Cummins, 1996)
Simuliidae: Genus (Merritt and Cummins, 1996)
Chironomidae: Genus/species (Merritt and Cummins, 1996 / Epler, 1992)
Stratiomyidae: Genus (Merritt and Cummins, 1996)
Tabanidae: Genus (Merritt and Cummins, 1996)
Empididae: Genus (Merritt and Cummins, 1996)
Syrphidae: Genus (Merritt and Cummins, 1996)
Ephydridae: Genus (Merritt and Cummins, 1996)
Sciomyzidae: Genus (Merritt and Cummins, 1996)
Muscidae: Genus (Merritt and Cummins, 1996)
Athericidae: Genus (Merritt and Cummins, 1996)

MOLLUSCA
GASTROPODA: Genus (Pennak, 1989)
PELECYPODA
Corbiculidae: species (Pennak, 1989 / Cummings and Mayer, 1992)
Sphaeriidae: Genus (Pennak, 1989 / Cummings and Mayer, 1992)
Unionidae: Genus/species (Pennak, 1989 / Cummings and Mayer, 1992)

Note:
Class = key to the class level
Family = key to the family level
Genus = key to the genus level
Genus/species = contain genera with only one species for our area <u>or</u> genera which add large numbers and diversity to our samples at the species level. Current species level key are indicated for those genera.
species = only one species should occur for this group in our Illinois occurrence list.

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DRAFT

Illinois Environmental Protection Agency

Bureau of Water

Document Control Number 170

Standard Operating Procedure for Calculation of the Macroinvertebrate Index of Biotic Integrity (mIBI)

DRAFT

Surface Water Section
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1.0 Scope and Application

The instructions included in this Standard Operating Procedure (SOP) describe how to compute the macroinvertebrate Index of Biotic Integrity (mIBI). The mIBI provides a measurement of select attributes of a macroinvertebrate assemblage. In turn, these measurements position the sample along a gradient of human-induced impact relative to the best benthic samples collected in Illinois. Use the mIBI to identify physical and chemical impacts to the macroinvertebrate community.

The mIBI calculations in this SOP apply statewide provided the macroinvertebrate samples are collected:

- between June 1st and October 15th;
- from perennial, wadeable streams;
- by using 20-jabs with a 18x9-inch rectangular ~~d~~-frame dip-net that has a net with 600-micron openings;
- with jabs proportionally allocated in bank-zone and bottom-zone habitat according to the specified stream size and substrate criteria;
- the samples are properly subsampled to 300 individuals ± 20%;
  and provided
- the macroinvertebrates in the 300 individual ± 20% subsamples are identified to the specified taxonomic resolution (see below).

2.0 Summary of Method(s)

- Verify that the specified macroinvertebrate collection protocols were utilized.
- Verify that the fixed-count subsample method was utilized and verify that the subsample contains the specified 300 ± 20% individuals. Herein the randomly selected, 300 individual ± 20% subsample is referred to as "*subsample*".
- Verify that the subsample excludes Hemipterans and semi-aquatic organisms.
- Verify that the subsample excludes individuals from the phase-II sort (Sample processing for the macroinvertebrate index of biotic integrity (mIBI) 6.1) .
- Standardize all subsample macroinvertebrates to the specified levels of taxonomic resolution.

  - Classify the insects, non-cambarid crustacea, non-sphaerid and non-unionid bivalves plus gastropod snails according to the various genera present in the subsample.

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Classify the remaining macroinvertebrates as hirudineans, oligochaetes, turbellarians, unionids, cambarids, and sphaerids. Classify damaged specimens at the finest resolution possible (Section 4.2.2).

- Refer to each of these taxonomic groups as mIBI Taxanomic Unit(s) (mIBITU). For mIBI metric calculations, the terms mIBITU and taxa are synonymous (e.g., Total MIBITU=Total Taxa). See Section 4.2.2.1 for the mIBITU definition.

- Use "*Illinois Environmental Protection Agency Macroinvertebrate-Index of Biotic Integrity (m-IBI) Tolerance List and Functional Feeding Group Classification, January, 2010*", in Appendix C, to assign Functional Feeding Group (FFG) and Tolerance Value (TV) per each of the several mIBITU(s) that occur in the subsample (Section 4.2.2.2). Do not substitute a member FFG or TV for the parent group mIBITU assignment.

- Use the subsample mIBITU(s) and the corresponding FFG, TV and abundance total(s) to compute the seven mIBI metric values (Section 4.3).
- Use the pre-existing best values (Section 4.4) to transform each of the seven metric values to a scale of 0-100.
- Obtain the mIBI by averaging the seven metric scores obtained in the previous step (Section 4.5).

3.0 Interferences and Corrective Action

The mIBI applies to macroinvertebrate results obtained from prescribed protocols. Improper collection, subsample or identification techniques can invalidate mIBI results and subsequent mIBI interpretation.

4.0 General Guidelines

4.1 Data Applicability

Follow the guidelines outlined in "*Method to Collect Aquatic Macroinvertebrates from Wadeable Streams for Biotic Integrity Assessments*" to ensure that each macroinvertebrate sample is appropriate for the mIBI. Follow the guidelines in "*Sample Processing for the macroinvertebrate IBI (mIBI)*" to ensure that the subsample procedure is properly applied to each sample. Lastly, follow the sample standardization instructions listed below to ensure that taxonomic resolution and consistency are appropriate for mIBI calculations.

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It is important to note that the guidelines, cited above, provide critical information about taxa omission in the subsample. For example, omit Hemiptera and most semi-aquatic Coleoptera during the fixed-count macroinvertebrate subsample procedure. Regardless of the number of semi-aquatic taxa omitted, the subsample procedure continues until the fixed-count target of 300 ± 20% randomly selected individuals is obtained. Refer to Appendix C for a list of semi-aquatic taxa. In this list, semi-aquatic taxa have tolerance assignments of 99.9. Also, make sure to omit all phase-2 sort macroinvertebrates from subsequent mIBI calculations. Be sure to read and follow the information cited in the previous paragraph because additional collection and processing guidelines do exist.

4.2 Definitions and Taxonomic Standardization

4.2.1 Definitions

Macroinvertebrate Index of Biotic Integrity Taxonomic Unit (MIBITU)- The MIBITU is essentially the basic taxonomic unit utilized to properly complete metric calculations and obtain the mIBI. Refer to Section 4.2.2 for additional details about MIBITU use.

Metric Value- Metric value refers to the simplest possible measure of an assemblage characteristic (Section 4.3) and it is required to compute mIBI. In terms of mIBI, a metric value is a metric result prior to transformation.

Metric Score- Metric score refers to the outcome of metric value transformation into a unitless quantity. Transformations are required in order to aggregate the seven metrics that form the mIBI (Section 4.4).

Best Value- Best value represents the best value a metric will likely attain in Illinois. The best value is a transformation function, which is applied to a metric score in order to obtain a unitless metric score. Despite the original measurement scale, dividing a metric value by the corresponding best value will result in a unitless metric score that ranges from 0-1. Unitless metric scores allow aggregation and computation of the mIBI. Refer to Section 4.4 for additional explanation.

4.2.2 Taxonomic Standardization

In order to obtain a valid index result, organize the subsample macroinvertebrates as: Oligochaeta, Turbellaria, Hirudinea, Cambaridae, Sphaeriidae and Unionidae and group the remaining portion of the subsample according to genus. In general, the genus designation

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applies to insects; however, the occasional non-bivalve gastropods will also be included at this taxonomic resolution.

Follow the resolution stipulated in the preceding paragraph- even when exact species identifications are available within a given genus. There are two exceptions to the stipulated taxonomic resolution. These exceptions are required because of the inability to obtain confident identifications- at the stipulated taxonomic resolution- when specimens are damaged or diminutive (e.g., very early life-stages). For both exceptions, identify the specimens at the finest taxonomic resolution possible.

These atypical taxonomic resolution exceptions have potential consequences when computing mIBI metric values. Since the exact identity of a damaged individual is unknown- at the specified resolution - the possibility exists that the specimen is truly a unique taxa in the subsample. It is also plausible that the damaged specimen is a member of a previously identified taxon; specifically, one that was identified at the stipulated taxonomic resolution. In the later case "*double counting*" will occur. "*Double counted taxa*" are identical macroinvertebrates that are counted once as a taxon identified at the stipulated resolution and another time as a taxon identified at an atypical level of resolution. *"Double counting"* will cause an artificial inflation of taxa counts in the subsample, which may affect summary measures such as the total taxa and the number of sensitive taxa metrics. Macroinvertebrate identification based on atypical taxonomic levels should be relatively rare occurrences and it is important to note that more than one or two atypical classifications within a subsample may invalidate mIBI interpretation.

4.2.2.1 Macroinvertebrate index of biotic integrity taxonomic unit (mIBITU)

Organize the individuals in the subsample per each of the specified taxonomic groups (Section 4.2.2). Similarly organize individuals when an atypical classification results in a unique taxonomic group. Once the organization is complete to the specified taxonomic resolution (e.g., 12 individuals as Oligochaeta etc.), refer to each of the subsequent taxonomic groups (e.g., Oligochaeta) as an macroinvertebrate index of biotic integrity taxonomic unit (mIBITU). For mIBI metric calculations, the terms mIBITU and taxa are synonymous (e.g., Total mIBITU=Total Taxa).

4.2.2.2 Functional Feeding Group (FFG) and Tolerance Value (TV)

Use Appendix C and assign the following FFG and TV for each mIBITU: Turbellaria (non-Scraper, 6), Oligochaeta (non-Scraper, 10), Hirudinea (non-Scraper, 8), Unionidae (non-Scraper, 1.5), Sphaeriidae (non-Scraper, 5) and Cambaridae (non-Scraper, 5). Assign genus level FFG and TV classifications for MIBITUs based on genus identifications (e.g., Stenacron sp. SC, 4).

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Assign the corresponding FFG and TV for any specimens with atypical classifications (e.g., Heptageniidae SC, 3.5). Always use the specified FFG and TV for an MIBITU regardless of the fact that individual members within the group may occasionally have different FFG or TV assignments (Appendix C). Never substitute a member (e.g., species) FFG or TV for the group mIBITU assignment (e.g., genus).

4.3 **Compute Metric Values**

Total Taxa = ∑X

Where, X is a unique MIBITU of the subsample. The Total Taxa metric value is the sum of MIBITUs in the subsample. Note that the Total Taxa metric is susceptible to "*double counting"*. Section 4.2.1 includes additional information about "*double counted taxa*".

Coleoptera Taxa = ∑X

Where, X is a unique Coleoptera MIBITU in the subsample. The Coleoptera Taxa metric provides a measure of the number of unique Coleoptera MIBITUs in the subsample. Note that the Coleoptera Taxa metric is susceptible to *"double counting"*. Make sure not to include semi-aquatic coleoptera taxa that do not have a tolerance value (i.e. 99.9).

Ephemeroptera Taxa = ∑X

Where, X is a unique Ephemeroptera MIBITU in the subsample. The Ephemeroptera Taxa metric provides a measure of the number of unique Ephemeroptera MIBITUs in the subsample. Note that the Ephemeroptera Taxa metric is susceptible to *"double counting"*. Section 4.2.1 includes additional information about *"double counted taxa"*.

Intolerant Taxa = ∑X

Where, X is a unique intolerant MIBITU in the subsample. The Intolerant Taxa metric provides a measure of the number of unique intolerant MIBITUs in the subsample. Intolerant MIBITUs have TV assignments of 3.0 or less. Exclusively, use Appendix C to assign the corresponding TV for each MIBITU. Follow the designated MIBITU assignments in Appendix C. Do not substitute a member TV for the designated MIBITU assignment.

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Tolerance values generally represent organism tolerance to deoxygenating waste and range from 0-11. The most tolerant individuals have a value of 11.0 and lesser values indicate greater sensitivity to deoxygenating waste. Note that the Intolerant Taxa metric is susceptible to *"double counting"*. Section 4.2.1 includes additional information about *"double counted taxa"*.

Macroinvertebrate Biotic Index = $\sum (n_i * t_i)/N$

Where, n_i is the number of individuals in each MIBITU, t_i is the tolerance value assigned to the given MIBITU and N is the total number of individuals in the subsample. Use Appendix C to assign the corresponding TV(s) for each MIBITU in the subsample. Do not substitute a member TV for the designated MIBITU TV assignment.

Tolerance values generally represent organism tolerance to deoxygenating waste. Thus, the Macroinvertebrate Biotic Index (MBI) reflects MIBITU tolerance weighted by abundance. MBI scores range from 0-11. An MBI score of 11 represents the most perturbation with an assemblage dominated by taxa tolerant of low dissolved oxygen concentrations. On the other end of the gradient, an MBI score of zero represents the least perturbation with an assemblage comprised of taxa extremely sensitive to reduced dissolved oxygen concentrations.

Percent Scrapers= $(n_i/N)*100$

Where, n_i is the number of individual members within scraper MIBITUs and N is the total number of individuals in the subsample. The Percent Scraper metric provides a measure of the total number of Scraper individuals relative to the total number of individuals in the subsample. Use Appendix C to assign the corresponding FFG for each MIBITU in the subsample. Do not substitute a member FFG for the designated MIBITU FFG assignment.

Percent EPT = $(n_i/N)*100$

Where, n_i is the total number of individuals that are members of an Ephemeroptera, Plecoptera or Trichoptera MIBITU and N is the total number of individuals in the subsample. The Percent EPT metric provides a measure of the total number of EPT individuals relative to the total number of individuals in the subsample.

4.4 **Compute Metric Scores (Tetra Tech, 2007)**

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Do not aggregate individual metrics in an index until each undergoes transformation to a standardized measurement scale. Use pre-established best values to make these transformations. A best value represents the best metric value one would typically expect to encounter. Best value transformations convert each metric value to a relative percentage of the best achievable value and this adjustment effectively standardizes each metric score on a scale of 0-100. Transformations allow meaningful comparisons and aggregation of metrics and the use of best values can help counter the effects of omitting rare taxa when fixed-count subsampling is performed (Barbour and Yoder, 2006). Table 1 provides a list of best values for each metric.

Table 1. Best metric values.

Metric	Response to Perturbation	Best Value
Coleoptera taxa	Decrease	5
Ephemeroptera taxa	Decrease	10.2
Total Taxa	Decrease	46
Intolerant taxa	Decrease	9
MBI	Increase	4.9
Percent Scraper	Decrease	29.6
Percent EPT	Decrease	74

For metrics that decrease in value with perturbation, metric values greater than or equal to the standard best value receive a score of 100, those less than the best value are scored as a percentage of the best value:

$$\text{Standardized Score} = \frac{X - X_{min}}{X_{best} - X_{min}} * 100,$$

Where X is the metric value; X_{best} is the metric best value; and X_{min} is the metric minimum possible score (typically 0).

Simplified, the Standardized Score for Coleoptera taxa, Ephemeropter taxa, total taxa, Intolerant taxa, Percent Scraper and Pecent EPT, becomes:

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$$\text{Standardized Score} = \frac{X}{X_{best}} * 100$$

For the one metric that increases in value with perturbation (i.e., MBI), metric values less than or equal to the standard best value get a score of 100, those greater than the best value are scored as a percentage of the best value.

$$\text{Standardized Score} = \frac{X_{max} - X}{X_{max} - X_{best}} * 100,$$

Where X is the metric value; X_{best} is the metric best value; and X_{max} is the metric maximum possible score (e.g., 11 for MBI).

Simplified, the Standardized Score for MBI becomes:

$$\text{Standardized Score} = \frac{11 - X}{11 - X_{best}} * 100,$$

4.5 Compute mIBI

Average the seven individual metric scores to obtain the mIBI score for the sample.

5 Interpret mIBI

Following Table 2, scores closer to 100 are optimal.

Table 2 Macroinvertebrate IBI quality categories.

Index Score			
lower boundary	upper boundary	Comparison to Reference	Narrative Description
73.0	100.0	>75th percentile	Exceptional
41.8	72.9	>10th percentile	Good
20.9	41.8	bisect 10th percentile (upper)	Fair
0.0	20.8	bisect 10th percentile (lower)	Poor

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Literature Cited

Barbour, M. T. and C. O. Yoder. 2006. Critical Technical Elements of a Bioassessment Program. Draft

Tetra Tech. 2007. Illinois Benthic Macroinvertebrate Collection Method Comparison and Stream Condition Index Revision (November 2004 Revised: March 2007). Tetra Tech, Inc., 10045 Red Run Boulevard, Suite 110, Owings Mill, MD 21117.

DRAFT

Standard Operating Procedure TT-BRF/TX-SOP-O-017

10-Day Sediment Toxicity Test Using *Hyallela azteca*

Prepared by:	Name Marcus Bowersox	Title BRF Manager
	Signature _____	Date _____
Approved by:	Name Jerry Diamond	Title BRF Director
	Signature _____	Date _____
Approved by:	Name John O'Donnell	Title BRF QA Officer
	Signature _____	Date _____

Created: February 3, 2012

Scope and Applicability: This method describes the process for performing 10-day sediment toxicity testing using *Hyallela azteca*.

Responsibility and Personnel Qualifications: Completion of standard training

References: ASTM. 2010. Standard Test Method for Measuring the Toxicity of Sediment-Associated Contaminants with Freshwater Invertebrates. E1706-05.

Precautions: Sediments may contain chemicals harmful if inhaled or irritants to eyes and skin, proper ventilation, eyewear, and gloves should be used when handling them.

Equipment/Materials:

Analytical balance
Wash bottles
Transfer containers
Calibrated thermometers (glass or electronic)
Permanent marker
pH meter
Synthetic freshwater
Reference weights, Class S
H. azteca Survival and Growth Test Data Sheet
Environmental chamber
Distilled water purification system
Dissolved oxygen (DO) meter
Conductivity/salinity meter
Environmental chamber (incubator) with 10-20 :E/m^2/s or 50-100 ft-c light source and automatic timer set to a 16 hours light to 8 hours dark cycle
Test chambers (300-mL high-form lipless beakers)

Wide-bore pipettes
Burettes (for hardness and alkalinity determinations)
Stainless-steel sieves (e.g., U.S. Standard No. 25, 30, 35, 10, 50 mesh)
Ammonia kit
Drying oven
Balance (0.01 mg sensitivity)
Blender
Refrigerator
Vacuum
Aluminum weight pans
White plastic dish pan
Detergent (non-phosphate)
Hydrochloric acid (reagent grade)
Potassium chloride
Reagents for reconstituting water

Procedures:

Test Chamber Preparation

1) The test chambers consist of 300 mL high-form lipless beakers.

2) Test chambers are properly cleaned following the procedures outlined in TT-BRF/TX-SOP-O-011 Cleaning Glassware and Plasticware.

3) Test chambers are labeled with site and replicate number prior to test initiation.

Day -1 - Test Sediment Preparation

1) One day (Day -1) prior to test initiation:

    a. The sediments are homogenized to an even color and texture, before being placed into the test chambers.
    b. 100 ml of sediment is added to each of the eight replicate test chambers.
    c. 175 ml of overlying synthetic freshwater is added to the test chambers (synthetic freshwater is prepared by following procedures outlined in TT-BRF/TX-SOP-O-038 Preparation of Synthetic, Moderately Hard, Reconstituted Freshwater Using Reagent Grade Chemicals).
        i. This is accomplished by placing 500 mL plastic cups that have small holes in the bottom to allow a slow filling of the test on top of the test chambers. Approximately 350 mL of synthetic freshwater is added to the filling chambers and water is able to fill the test chambers without disturbing the sediment.
    d. Test chambers are placed in controlled environmental chambers and twice daily renewals are initiated.

Day 0 - Test Organisms Preparation and Loading

1) Seven (7) to fourteen (14) day old *Hyallela azteca* are obtained from a reputable supplier (e.g., Aquatic Biosystems Inc., Fort Collins, CO).

2) *H. azteca* are pre-counted into 10 organism parcels and kept in 60 mL containers on the day of loading.

    a. If the optional growth endpoint is necessary, four, 10-organisms subsets should be humanely euthanized in a 70% ethanol solution and dried in a constant temperature drying oven at 60°C for 24-hours. The initial weight of the four subsets should be recorded on the *Hyallela azteca* Growth data sheet.

3) Eight of the holding chambers should be randomly assigned to each site and one subset of organisms should be placed into the overlying water below the air-water interface of each replicate.

4) Test conditions are outlined in Attachment 1.

5) Test chambers are placed in control environment incubators at constant temperature of 23°C and 16L:8D photoperiod.

Day 0 – 9 – Test Chamber Renewal and Feeding

1) Each test chamber is renewed twice daily with a full volume addition each time.

2) Overlying water is removed by vacuum extraction and fresh synthetic water is supplied as described above (Day -1, 1 c).

3) For each beaker, 1.0 mL of YCT is added from Day 0 to Day 9. Suspension of food should be thoroughly mixed before aliquots are taken. Food is added after the first renewal each day to provide adequate time for feeding.

Day 10 – Test Organisms Retrieval and Test Termination

1) After 10-days the test organisms are removed from the sediment.

2) Any of the surviving amphipods in the water column or on the surface of the sediment should be pipetted from the test chamber before sieving the sediment.

3) Immobile organisms isolated from the sediment surface or from sieved material should be considered dead.

4) A #40 sieve (425-µm mesh) can be used to remove amphipods from sediment.

5) The number of surviving amphipods is recorded on the *Hyallela azteca* 10-Day Survival data sheet.

    a. If the optional growth endpoint is necessary, all surviving amphipods are humanely euthanized in a 70% ethanol solution and placed on pre-tared aluminum weight boats marked with the site identification and replicate. The aluminum weight boats are dried in a constant temperature drying oven at 60°C for 24-hours. After 24-hours the aluminum weight boats are allowed to cool in a dessicator. Once cool, the aluminum weight boats are weighted and the weight of the surviving amphipods is determined. The weight of the surviving amphipods should be recorded on the *Hyallela azteca* Growth data sheet.

Pertinent QA and QC Procedures:

1) All test chamber materials including should be washed according to TT-BRF/TX-SOP-O-011.

2) A clean laboratory control sediment should always be used as a negative control.

Attachment 1. Summary of Test Conditions for *Hyallela azteca* 10-Day Sediment Survival Test.

PARAMETER	CONDITIONS
1. Test type:	10-Day Survival
2. Test duration:	10 Days
3. Temperature:	23°C ± 1°C ; measured continuously in ambient environment (Instantaneous temperature must always be within ± 3°C of 23 °C).
4. Light quality:	Wide-spectrum fluorescent lights
5. Light intensity:	~ 100-1000 lux
6. Photoperiod:	16L:8D
7. Test chamber size:	300-mL high-form lipless beaker
8. Sediment volume:	100 mL
9. Overlying water volume:	175 mL
10. Age of test organisms:	7 – 14 days (1- to 2-d range in age)
11. No. organisms per test chamber	10
12. No. replicate chambers per site:	8
13. No. organisms per site:	80
14. Feeding regime:	YCT food, fed 1.0 mL daily (1800 mg/L stock) to each test chamber
15. Aeration	None unless DO in overlying water drops below 2.5 mg/L.
16. Overlying water quality	Hardness and alkalinity at the beginning and end of a sediment exposure (Day 0 and Day 10). Temperature and dissolved oxygen daily. Conductivity, ammonia and pH three times over the 10-day exposure.
17. Endpoint:	Survival (optional growth)
18. Sampling and sample holding requirements	Samples used within 14 days of sampling. Samples are stored in the dark at 4^0C in sealed containers with no air space.
19. Sample volume required:	2 L
20. Test Acceptability	Minimum mean control survival of 80% on Day 10.

APPENDIX C

LABORATORY ACCREDITATION

LABORATORY ACCREDITATION BUREAU

Certificate of Accreditation

ISO/IEC 17025:2005 ***Certificate Number L2226***

Empirical Laboratories, LLC

621 Mainstream Drive, Suite 270
Nashville, TN 37228

has met the requirements set forth in L-A-B's policies and procedures, all requirements of ISO/IEC 17025:2005 "General Requirements for the competence of Testing and Calibration Laboratories" and the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP).*

The accredited lab has demonstrated technical competence to a defined "Scope of Accreditation" and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009).

Accreditation Granted through: November 30, 2012

R. Douglas Leonard, Jr., Managing Director
Laboratory Accreditation Bureau
Presented the 30th of November 2009

*See the laboratory's Scope of Accreditation for details of the DoD ELAP requirements
Laboratory Accreditation Bureau is found to be in compliance with ISO/IEC 17011:2004 and recognized by ILAC (International Laboratory Accreditation Cooperation) and NACLA (National Cooperation for Laboratory Accreditation).

LABORATORY ACCREDITATION BUREAU

Certificate # L2226

Scope of Accreditation For Empirical Laboratories, LLC

621 Mainstream Drive, Suite 270
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Marcia K. McGinnity
877-345-1113

In recognition of a successful assessment to ISO/IEC 17025:2005 and the requirements of the DoD Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1) based on the National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003), accreditation is granted to Empirical Laboratories, LLC to perform the following tests:

Accreditation granted through: **November 30, 2012**

Testing - Environmental

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B	1,1,1-Trichloroethane (1,1,1-TCA)
GC/MS	EPA 8260B	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	EPA 8260B	1,1,2-Trichloroethane
GC/MS	EPA 8260B	1,1-Dichloroethane (1,1-DCA)
GC/MS	EPA 8260B	1,1-Dichloroethene (1,1-DCE)
GC/MS	EPA 8260B	1,1-Dichloropropene
GC/MS	EPA 8260B	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B	1,2,3-Trichloropropane
GC/MS	EPA 8260B	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B	1,2-Dichlorobenzene
GC/MS	EPA 8260B	1,2-Dichloroethane (EDC)
GC/MS	EPA 8260B	1,2-Dichloropropane
GC/MS	EPA 8260B	1,3,5-Trimethylbenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	1,3-Dichlorobenzene
GC/MS	EPA 8260B	1,3-Dichloropropane
GC/MS	EPA 8260B	1,4-Dichlorobenzene
GC/MS	EPA 8260B	1,4-Dioxane
GC/MS	EPA 8260B	1-Chlorohexane
GC/MS	EPA 8260B	2,2-Dichloropropane
GC/MS	EPA 8260B	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	EPA 8260B	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B	2-Chlorotoluene
GC/MS	EPA 8260B	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	EPA 8260B	4-Chlorotoluene
GC/MS	EPA 8260B	4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)
GC/MS	EPA 8260B	Acetone
GC/MS	EPA 8260B	Acetonirile
GC/MS	EPA 8260B	Acrolein
GC/MS	EPA 8260B	Acrylonitrile
GC/MS	EPA 8260B	Allyl chloride
GC/MS	EPA 8260B	Benzene
GC/MS	EPA 8260B	Bromobenzene
GC/MS	EPA 8260B	Bromochloromethane
GC/MS	EPA 8260B	Bromodichloromethane
GC/MS	EPA 8260B	Bromoform
GC/MS	EPA 8260B	Bromomethane
GC/MS	EPA 8260B	Carbon Disulfide
GC/MS	EPA 8260B	Carbon Tetrachloride
GC/MS	EPA 8260B	Chlorobenzene
GC/MS	EPA 8260B	Chloroethane
GC/MS	EPA 8260B	Chloroform
GC/MS	EPA 8260B	Chloromethane
GC/MS	EPA 8260B	Chloroprene
GC/MS	EPA 8260B	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	EPA 8260B	cis-1,3-Dichloropropene
GC/MS	EPA 8260B	cis-1,4-Dichloro-2-butene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	Cyclohexane
GC/MS	EPA 8260B	Dibromochloromethane
GC/MS	EPA 8260B	Dibromomethane
GC/MS	EPA 8260B	Dichlorodifluoromethane (CFC-12)
GC/MS	EPA 8260B	Di-isopropyl ether
GC/MS	EPA 8260B	ETBE
GC/MS	EPA 8260B	Ethyl methacrylate
GC/MS	EPA 8260B	Ethylbenzene
GC/MS	EPA 8260B	Hexachlorobutadiene
GC/MS	EPA 8260B	Hexane
GC/MS	EPA 8260B	Iodomethane
GC/MS	EPA 8260B	Isobutyl alcohol
GC/MS	EPA 8260B	Isopropylbenzene (Cumene)
GC/MS	EPA 8260B	Methacrylonitrile
GC/MS	EPA 8260B	Methyl Acetate
GC/MS	EPA 8260B	Methyl methacrylate
GC/MS	EPA 8260B	Methyl Tertiary Butyl Ether (MTBE)
GC/MS	EPA 8260B	Methylcyclohexane
GC/MS	EPA 8260B	Methylene Chloride, or Dichloromethane
GC/MS	EPA 8260B	Naphthalene
GC/MS	EPA 8260B	n-Butylbenzene
GC/MS	EPA 8260B	n-Propylbenzene
GC/MS	EPA 8260B	p-Isopropyltoluene
GC/MS	EPA 8260B	Propionitrile
GC/MS	EPA 8260B	sec-Butylbenzene
GC/MS	EPA 8260B	Styrene
GC/MS	EPA 8260B	t-Butyl alcohol
GC/MS	EPA 8260B	tert-Amyl methyl ether
GC/MS	EPA 8260B	tert-Butylbenzene
GC/MS	EPA 8260B	Tetrachloroethene (PCE; PERC)
GC/MS	EPA 8260B	Tetrahydrofuran
GC/MS	EPA 8260B	Toluene
GC/MS	EPA 8260B	trans-1,2-Dichloroethene (trans-1,2-DCE)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	trans-1,3-Dichloropropene
GC/MS	EPA 8260B	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B	Trichloroethene (TCE)
GC/MS	EPA 8260B	Trichlorofluoromethane (CFC-11)
GC/MS	EPA 8260B	Vinyl acetate
GC/MS	EPA 8260B	Vinyl Chloride (VC)
GC/MS	EPA 8260B	Xylenes (Total)
GC/MS	EPA 8270C/D	1,1'-Biphenyl
GC/MS	EPA 8270C/D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/D	1,2-Dichlorobenzene
GC/MS	EPA 8270C/D	1,2-Diphenylhydrazine
GC/MS	EPA 8270C/D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dioxane
GC/MS	EPA 8270C/D	1-Methylnaphthalene
GC/MS	EPA 8270C/D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D	2,4,6-Trichlorophenol (TCP)
GC/MS	EPA 8270C/D	2,4-Dichlorophenol (DCP)
GC/MS	EPA 8270C/D	2,4-Dimethylphenol
GC/MS	EPA 8270C/D	2,4-Dinitrophenol
GC/MS	EPA 8270C/D	2,4-Dinitrotoluene (DNT)
GC/MS	EPA 8270C/D	2,6-Dichlorophenol
GC/MS	EPA 8270C/D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D	2-Chloronaphthalene
GC/MS	EPA 8270C/D	2-Chlorophenol
GC/MS	EPA 8270C/D	2-Methylnaphthalene
GC/MS	EPA 8270C/D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C/D	2-Nitroaniline
GC/MS	EPA 8270C/D	2-Nitrophenol (ONP)
GC/MS	EPA 8270C/D	3,3'-Dichlorobenzidine (DCB)
GC/MS	EPA 8270C/D	3-Methylphenol

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/D	3-Nitroaniline
GC/MS	EPA 8270C/D	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	EPA 8270C/D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D	4-Chloroaniline
GC/MS	EPA 8270C/D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Methylphenol (p-Cresol)
GC/MS	EPA 8270C/D	4-Nitroaniline (PNA)
GC/MS	EPA 8270C/D	4-Nitrophenol (PNP)
GC/MS	EPA 8270C/D	7,12-Dimethylbenz(a)anthracene
GC/MS	EPA 8270C/D	Acenaphthene
GC/MS	EPA 8270C/D	Acenaphthylene
GC/MS	EPA 8270C/D	Acetaphenone
GC/MS	EPA 8270C/D	Aniline
GC/MS	EPA 8270C/D	Anthracene
GC/MS	EPA 8270C/D	Atrazine
GC/MS	EPA 8270C/D	Benzaldehyde
GC/MS	EPA 8270C/D	Benzidine
GC/MS	EPA 8270C/D	Benzo(a)anthracene
GC/MS	EPA 8270C/D	Benzo(a)pyrene
GC/MS	EPA 8270C/D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D	Benzoic Acid
GC/MS	EPA 8270C/D	Benzyl alcohol
GC/MS	EPA 8270C/D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C/D	bis(2-Chloroethyl)ether (BCEE)
GC/MS	EPA 8270C/D	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)
GC/MS	EPA 8270C/D	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	EPA 8270C/D	Butyl benzyl phthalate (BBP)
GC/MS	EPA 8270C/D	Caprolactam
GC/MS	EPA 8270C/D	Carbazole

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/D	Chrysene
GC/MS	EPA 8270C/D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/D	Dibenzofuran (DBF)
GC/MS	EPA 8270C/D	Diethyl phthalate (DEP)
GC/MS	EPA 8270C/D	Dimethyl phthalate (DMP)
GC/MS	EPA 8270C/D	Di-n-butyl phthalate (DBP)
GC/MS	EPA 8270C/D	Di-n-octyl phthalate (DNOP)
GC/MS	EPA 8270C/D	Fluoranthene
GC/MS	EPA 8270C/D	Fluorene
GC/MS	EPA 8270C/D	Hexachlorobenzene (HCB)
GC/MS	EPA 8270C/D	Hexachlorobutadiene (HCBD)
GC/MS	EPA 8270C/D	Hexachlorocyclopentadiene (HCCPD)
GC/MS	EPA 8270C/D	Hexachloroethane (HCE)
GC/MS	EPA 8270C/D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D	Isophorone
GC/MS	EPA 8270C/D	Naphthalene
GC/MS	EPA 8270C/D	Nitrobenzene
GC/MS	EPA 8270C/D	N-Nitrosodimethylamine
GC/MS	EPA 8270C/D	N-Nitroso-di-n-propylamine (NDPA)
GC/MS	EPA 8270C/D	N-nitrosodiphenylamine (NDPHA)
GC/MS	EPA 8270C/D	Pentachlorophenol
GC/MS	EPA 8270C/D	Phenanthrene
GC/MS	EPA 8270C/D	Phenol
GC/MS	EPA 8270C/D	Pyrene
GC/MS	EPA 8270C/D	Pyridine
GC/ECD	EPA 8081A/B	4,4'-DDD
GC/ECD	EPA 8081A/B	4,4'-DDE
GC/ECD	EPA 8081A/B	4,4'-DDT
GC/ECD	EPA 8081A/B	Aldrin
GC/ECD	EPA 8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	EPA 8081A/B	alpha-Chlordane
GC/ECD	EPA 8081A/B	beta-BHC (beta-HCH)
GC/ECD	EPA 8081A/B	delta-BHC (delta-HCH)

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8081A/B	Dieldrin
GC/ECD	EPA 8081A/B	Endosulfan I
GC/ECD	EPA 8081A/B	Endosulfan II
GC/ECD	EPA 8081A/B	Endosulfan sulfate
GC/ECD	EPA 8081A/B	Endrin
GC/ECD	EPA 8081A/B	Endrin aldehyde
GC/ECD	EPA 8081A/B	Endrin ketone
GC/ECD	EPA 8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	EPA 8081A/B	gamma-Chlordane
GC/ECD	EPA 8081A/B	Heptachlor
GC/ECD	EPA 8081A/B	Heptachlor epoxide
GC/ECD	EPA 8081A/B	Methoxychlor
GC/ECD	EPA 8081A/B	Chlordane
GC/ECD	EPA 8081A/B	Toxaphene
GC/ECD	EPA 8082 /A	Aroclor-1016
GC/ECD	EPA 8082 /A	Aroclor-1221
GC/ECD	EPA 8082 /A	Aroclor-1232
GC/ECD	EPA 8082 /A	Aroclor-1242
GC/ECD	EPA 8082 /A	Aroclor-1248
GC/ECD	EPA 8082 /A	Aroclor-1254
GC/ECD	EPA 8082 /A	Aroclor-1260
GC/ECD	EPA 8082 /A	Aroclor-1262
GC/ECD	EPA 8082 /A	Aroclor-1268
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4,5-TP (Silvex)
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichlorprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP (Mecoprop)

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330A/B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A/B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A/B	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330A/B	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330A/B	2,4-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330A/B	2,6-Dinitrotoluene
HPLC/UV	EPA 8330A/B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A/B	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330A/B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/B	3-Nitrotoluene
HPLC/UV	EPA 8330A/B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A/B	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330A/B	Nitrobenzene
HPLC/UV	EPA 8330A/B	Nitroglycerin
HPLC/UV	EPA 8330A/B	Nitroguanidine
HPLC/UV	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330A/B	3,5-Dinitroaniline
HPLC/UV	EPA 8330A/B	PETN
GC/FID	FLPRO	Petroleum Range Organics
GC/FID	EPA 8015B	TPH DRO
GC/FID	EPA 8015B	TPH GRO
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-chloropropane (DBCP)
HPLC/MS	EPA 6850	Perchlorate
ICP	EPA 6010B/C	Aluminum
ICP	EPA 6010B/C	Antimony
ICP	EPA 6010B/C	Arsenic
ICP	EPA 6010B/C	Barium
ICP	EPA 6010B/C	Beryllium

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP	EPA 6010B/C	Boron
ICP	EPA 6010B/C	Cadmium
ICP	EPA 6010B/C	Calcium
ICP	EPA 6010B/C	Chromium, total
ICP	EPA 6010B/C	Cobalt
ICP	EPA 6010B/C	Copper
ICP	EPA 6010B/C	Iron
ICP	EPA 6010B/C	Lead
ICP	EPA 6010B/C	Magnesium
ICP	EPA 6010B/C	Manganese
CVAA	EPA 7470A	Mercury
ICP	EPA 6010B/C	Molybdenum
ICP	EPA 6010B/C	Nickel
ICP	EPA 6010B/C	Potassium
ICP	EPA 6010B/C	Selenium
ICP	EPA 6010B/C	Silver
ICP	EPA 6010B/C	Sodium
ICP	EPA 6010B/C	Strontium
ICP	EPA 6010B/C	Thallium
ICP	EPA 6010B/C	Tin
ICP	EPA 6010B/C	Titanium
ICP	EPA 6010B/C	Vanadium
ICP	EPA 6010B/C	Zinc
IC	EPA 300.0	Chloride
IC	EPA 300.0	Fluoride
IC	EPA 300.0	Nitrate
IC	EPA 300.0	Nitrite
IC	EPA 300.0	Sulfate
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate

Non-Potable Water		
Technology	**Method**	**Analyte**
Titration	SM 2320B 20th/21st edition	Alkalinity
Colorimetric	SM 4500 B, G, 20th/21st edition	Ammonia
Colorimetric	EPA 410.4	COD
UV/Vis	EPA 7196A	Hexavalent Chromium
Colorimetric	EPA 353.2	Nitrocellulose
Colorimetric	EPA 353.2	Nitrate/Nitrite
Gravimetric	EPA 1664A	O&G
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	SM 4500 S-2CF, 20th/21st edition	Sulfide
UV/Vis	SM 4500 P B5, E, 20th/21st edition	Total Phosphorus (as P)
UV/Vis	SM 4500 PE, 20th/21st edition	Ortho-Phosphate (as P)
TOC	9060A/SM5310C, 20th/21st edition	Total Organic Carbon
Gravimetric	SM 2540C, 20th/21st edition	TDS
Gravimetric	SM 2540D, 20th/21st edition	TSS
Colorimetric	EPA 9012A/B	Cyanide
Physical	EPA 1010A	Ignitability
Physical	EPA 9095B	Paint Filter
Probe	EPA 9040B/C	pH
Preparation	**Method**	**Type**
Preparation	EPA 1311	TCLP
Preparation	EPA 3005A	Metals digestion
Preparation	EPA 3010A	Metals digestion
Preparation	EPA 3510C	Organics Liquid Extraction
Preparation	EPA 5030A/B	Purge and Trap Water

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	1,1,1-Trichloroethane (1,1,1-TCA)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B	1,1,2-Trichloro-1,2,2-trifluoroethane (CFC-113; Freon 113)
GC/MS	EPA 8260B	1,1,2-Trichloroethane
GC/MS	EPA 8260B	1,1-Dichloroethane (1,1-DCA)
GC/MS	EPA 8260B	1,1-Dichloroethene (1,1-DCE)
GC/MS	EPA 8260B	1,1-Dichloropropene
GC/MS	EPA 8260B	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B	1,2,3-Trichloropropane
GC/MS	EPA 8260B	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B	1,2-Dibromoethane (EDB)
GC/MS	EPA 8260B	1,2-Dichlorobenzene
GC/MS	EPA 8260B	1,2-Dichloroethane (EDC)
GC/MS	EPA 8260B	1,2-Dichloropropane
GC/MS	EPA 8260B	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B	1,3-Dichlorobenzene
GC/MS	EPA 8260B	1,3-Dichloropropane
GC/MS	EPA 8260B	1,4-Dichlorobenzene
GC/MS	EPA 8260B	1,4-Dioxane
GC/MS	EPA 8260B	2,2-Dichloropropane
GC/MS	EPA 8260B	2-Butanone (Methyl ethyl ketone; MEK)
GC/MS	EPA 8260B	2-Chlorotoluene
GC/MS	EPA 8260B	2-Hexanone (Methyl butyl ketone; MBK)
GC/MS	EPA 8260B	4-Chlorotoluene
GC/MS	EPA 8260B	4-Methyl-2-pentanone (Methyl isobutyl ketone; MIBK)
GC/MS	EPA 8260B	Acetone
GC/MS	EPA 8260B	Acetonitrile
GC/MS	EPA 8260B	Acrolein
GC/MS	EPA 8260B	Acrylonitrile
GC/MS	EPA 8260B	Allyl chloride

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	Benzene
GC/MS	EPA 8260B	Bromobenzene
GC/MS	EPA 8260B	Bromochloromethane
GC/MS	EPA 8260B	Bromodichloromethane
GC/MS	EPA 8260B	Bromoform
GC/MS	EPA 8260B	Bromomethane
GC/MS	EPA 8260B	Carbon Disulfide
GC/MS	EPA 8260B	Carbon Tetrachloride
GC/MS	EPA 8260B	Chlorobenzene
GC/MS	EPA 8260B	Chloroethane
GC/MS	EPA 8260B	Chloroform
GC/MS	EPA 8260B	Chloromethane
GC/MS	EPA 8260B	Chloroprene
GC/MS	EPA 8260B	cis-1,2-Dichloroethene (cis-1,2-DCE)
GC/MS	EPA 8260B	cis-1,3-Dichloropropene
GC/MS	EPA 8260B	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B	Cyclohexane
GC/MS	EPA 8260B	Dibromochloromethane
GC/MS	EPA 8260B	Dibromomethane
GC/MS	EPA 8260B	Dichlorodifluoromethane (CFC-12)
GC/MS	EPA 8260B	Ethyl methacrylate
GC/MS	EPA 8260B	Ethylbenzene
GC/MS	EPA 8260B	Hexachlorobutadiene
GC/MS	EPA 8260B	Hexane
GC/MS	EPA 8260B	Iodomethane
GC/MS	EPA 8260B	Isobutyl alcohol
GC/MS	EPA 8260B	Isopropylbenzene (Cumene)
GC/MS	EPA 8260B	Methacrylonitrile
GC/MS	EPA 8260B	Methyl Acetate
GC/MS	EPA 8260B	Methyl methacrylate
GC/MS	EPA 8260B	Methyl Tertiary Butyl Ether (MTBE)
GC/MS	EPA 8260B	Methylcyclohexane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B	Methylene Chloride, or Dichloromethane
GC/MS	EPA 8260B	Naphthalene
GC/MS	EPA 8260B	n-Butylbenzene
GC/MS	EPA 8260B	n-Propylbenzene
GC/MS	EPA 8260B	p-Isopropyltoluene
GC/MS	EPA 8260B	Propionitrile
GC/MS	EPA 8260B	sec-Butylbenzene
GC/MS	EPA 8260B	Styrene
GC/MS	EPA 8260B	tert-Butylbenzene
GC/MS	EPA 8260B	Tetrachloroethene (PCE; PERC)
GC/MS	EPA 8260B	Toluene
GC/MS	EPA 8260B	trans-1,2-Dichloroethene (trans-1,2-DCE)
GC/MS	EPA 8260B	trans-1,3-Dichloropropene
GC/MS	EPA 8260B	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B	Trichloroethene (TCE)
GC/MS	EPA 8260B	Trichlorofluoromethane (CFC-11)
GC/MS	EPA 8260B	Vinyl acetate
GC/MS	EPA 8260B	Vinyl Chloride (VC)
GC/MS	EPA 8260B	Xylenes (Total)
GC/MS	EPA 8270C/D	Bis(2-chloroisopropyl)ether, or 2,2'-oxybis (1-Chloropropane)
GC/MS	EPA 8270C/D	1,1'-Biphenyl
GC/MS	EPA 8270C/D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270C/D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270C/D	1,2-Dichlorobenzene
GC/MS	EPA 8270C/D	1,2-Diphenylhydrazine
GC/MS	EPA 8270C/D	1,3-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dichlorobenzene
GC/MS	EPA 8270C/D	1,4-Dioxane
GC/MS	EPA 8270C/D	1-Methylnaphthalene
GC/MS	EPA 8270C/D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270C/D	2,4,5-Trichlorophenol
GC/MS	EPA 8270C/D	2,4,6-Trichlorophenol (TCP)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/D	2,4-Dichlorophenol (DCP)
GC/MS	EPA 8270C/D	2,4-Dimethylphenol
GC/MS	EPA 8270C/D	2,4-Dinitrophenol
GC/MS	EPA 8270C/D	2,4-Dinitrotoluene (DNT)
GC/MS	EPA 8270C/D	2,6-Dichlorophenol
GC/MS	EPA 8270C/D	2,6-Dinitrotoluene
GC/MS	EPA 8270C/D	2-Chloronaphthalene
GC/MS	EPA 8270C/D	2-Chlorophenol
GC/MS	EPA 8270C/D	2-Methylnaphthalene
GC/MS	EPA 8270C/D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270C/D	2-Nitroaniline
GC/MS	EPA 8270C/D	2-Nitrophenol (ONP)
GC/MS	EPA 8270C/D	3,3'-Dichlorobenzidine (DCB)
GC/MS	EPA 8270C/D	3-Methylphenol
GC/MS	EPA 8270C/D	3-Nitroaniline
GC/MS	EPA 8270C/D	4,6-Dinitro-2-methylphenol (DNOC)
GC/MS	EPA 8270C/D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Chloro-3-methylphenol
GC/MS	EPA 8270C/D	4-Chloroaniline
GC/MS	EPA 8270C/D	4-Chlorophenyl phenyl ether
GC/MS	EPA 8270C/D	4-Methylphenol (p-Cresol)
GC/MS	EPA 8270C/D	4-Nitroaniline (PNA)
GC/MS	EPA 8270C/D	4-Nitrophenol (PNP)
GC/MS	EPA 8270C/D	Acenaphthene
GC/MS	EPA 8270C/D	Acenaphthylene
GC/MS	EPA 8270C/D	Acetaphenone
GC/MS	EPA 8270C/D	Aniline
GC/MS	EPA 8270C/D	Anthracene
GC/MS	EPA 8270C/D	Atrazine
GC/MS	EPA 8270C/D	Benzaldehyde
GC/MS	EPA 8270C/D	Benzidine
GC/MS	EPA 8270C/D	Benzo(a)anthracene

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/D	Benzo(a)anthracene
GC/MS	EPA 8270C/D	Benzo(a)pyrene
GC/MS	EPA 8270C/D	Benzo(b)fluoranthene
GC/MS	EPA 8270C/D	Benzo(g,h,i)perylene
GC/MS	EPA 8270C/D	Benzo(k)fluoranthene
GC/MS	EPA 8270C/D	Benzoic Acid
GC/MS	EPA 8270C/D	Benzyl alcohol
GC/MS	EPA 8270C/D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270C/D	bis(2-Chloroethyl)ether (BCEE)
GC/MS	EPA 8270C/D	bis(2-Ethylhexyl)phthalate (BEHP)
GC/MS	EPA 8270C/D	Butyl benzyl phthalate (BBP)
GC/MS	EPA 8270C/D	Caprolactam
GC/MS	EPA 8270C/D	Carbazole
GC/MS	EPA 8270C/D	Chrysene
GC/MS	EPA 8270C/D	Dibenz(a,h)anthracene
GC/MS	EPA 8270C/D	Dibenzofuran (DBF)
GC/MS	EPA 8270C/D	Diethyl phthalate (DEP)
GC/MS	EPA 8270C/D	Dimethyl phthalate (DMP)
GC/MS	EPA 8270C/D	Di-n-butyl phthalate (DBP)
GC/MS	EPA 8270C/D	Di-n-octyl phthalate (DNOP)
GC/MS	EPA 8270C/D	Fluoranthene
GC/MS	EPA 8270C/D	Fluorene
GC/MS	EPA 8270C/D	Hexachlorobenzene (HCB)
GC/MS	EPA 8270C/D	Hexachlorobutadiene (HCBD)
GC/MS	EPA 8270C/D	Hexachlorocyclopentadiene (HCCPD)
GC/MS	EPA 8270C/D	Hexachloroethane (HCE)
GC/MS	EPA 8270C/D	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270C/D	Isophorone
GC/MS	EPA 8270C/D	Naphthalene
GC/MS	EPA 8270C/D	Nitrobenzene
GC/MS	EPA 8270C/D	N-Nitrosodimethylamine
GC/MS	EPA 8270C/D	N-Nitroso-di-n-propylamine (NDPA)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270C/D	N-nitrosodiphenylamine (NDPHA)
GC/MS	EPA 8270C/D	Pentachlorophenol
GC/MS	EPA 8270C/D	Phenanthrene
GC/MS	EPA 8270C/D	Phenol
GC/MS	EPA 8270C/D	Pyrene
GC/MS	EPA 8270C/D	Pyridine
GC/ECD	EPA 8081A/B	4,4'-DDD
GC/ECD	EPA 8081A/B	4,4'-DDE
GC/ECD	EPA 8081A/B	4,4'-DDT
GC/ECD	EPA 8081A/B	Aldrin
GC/ECD	EPA 8081A/B	alpha-BHC (alpha-HCH)
GC/ECD	EPA 8081A/B	alpha-Chlordane
GC/ECD	EPA 8081A/B	beta-BHC (beta-HCH)
GC/ECD	EPA 8081A/B	delta-BHC (delta-HCH)
GC/ECD	EPA 8081A/B	Chlordane
GC/ECD	EPA 8081A/B	Dieldrin
GC/ECD	EPA 8081A/B	Endosulfan I
GC/ECD	EPA 8081A/B	Endosulfan II
GC/ECD	EPA 8081A/B	Endosulfan sulfate
GC/ECD	EPA 8081A/B	Endrin
GC/ECD	EPA 8081A/B	Endrin aldehyde
GC/ECD	EPA 8081A/B	Endrin ketone
GC/ECD	EPA 8081A/B	gamma-BHC (Lindane; gamma-HCH)
GC/ECD	EPA 8081A/B	gamma-Chlordane
GC/ECD	EPA 8081A/B	Heptachlor
GC/ECD	EPA 8081A/B	Heptachlor epoxide
GC/ECD	EPA 8081A/B	Methoxychlor
GC/ECD	EPA 8081A/B	Toxaphene
GC/ECD	EPA 8082 /A	Aroclor-1016
GC/ECD	EPA 8082 /A	Aroclor-1221
GC/ECD	EPA 8082 /A	Aroclor-1232
GC/ECD	EPA 8082 /A	Aroclor-1242

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082 /A	Aroclor-1248
GC/ECD	EPA 8082 /A	Aroclor-1254
GC/ECD	EPA 8082 /A	Aroclor-1260
GC/ECD	EPA 8082 /A	Aroclor-1262
GC/ECD	EPA 8082 /A	Aroclor-1268
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4,5-TP (Silvex)
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichlorprop
GC/ECD	EPA 8151A	Dinoseb
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP (Mecoprop)
HPLC/UV	EPA 8330A	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330A	1,3-Dinitrobenzene
HPLC/UV	EPA 8330A	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330A	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330A	2,4-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330A	2,6-Dinitrotoluene
HPLC/UV	EPA 8330A	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330A	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330A	3-Nitrotoluene
HPLC/UV	EPA 8330A	3,5-Dinitroaniline
HPLC/UV	EPA 8330A	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330A	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330A	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330A	Nitroglycerin
HPLC/UV	EPA 8330A	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330A	Nitrobenzene
HPLC/UV	EPA 8330A	Nitroguanidine

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
HPLC/UV	EPA 8330A	PETN
HPLC/UV	EPA 8330B	1,3,5-Trinitrobenzene
HPLC/UV	EPA 8330B	1,3-Dinitrobenzene
HPLC/UV	EPA 8330B	2,4,6-Trinitrophenylmethylnitramine (Tetryl)
HPLC/UV	EPA 8330B	2,4,6-Trinitrotoluene (TNT)
HPLC/UV	EPA 8330B	2,4-Dinitrotoluene (DNT)
HPLC/UV	EPA 8330B	2,6-Dinitrotoluene
HPLC/UV	EPA 8330B	2-Amino-4,6-dinitrotoluene
HPLC/UV	EPA 8330B	2-Nitrotoluene (ONT)
HPLC/UV	EPA 8330B	3-Nitrotoluene
HPLC/UV	EPA 8330B	3,5-Dinitroaniline
HPLC/UV	EPA 8330B	4-Amino-2,6-dinitrotoluene
HPLC/UV	EPA 8330B	4-Nitrotoluene (PNT)
HPLC/UV	EPA 8330B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC/UV	EPA 8330B	Nitroglycerin
HPLC/UV	EPA 8330B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC/UV	EPA 8330B	Nitrobenzene
HPLC/UV	EPA 8330B	Nitroguanidine
HPLC/UV	EPA 8330B	PETN
GC/FID	FLPRO	Petroleum Range Organics
GC/FID	EPA 8015B	TPH DRO
GC/FID	EPA 8015B	TPH GRO
HPLC/MS	EPA 6850	Perchlorate
ICP	EPA 6010B/C	Aluminum
ICP	EPA 6010B/C	Antimony
ICP	EPA 6010B/C	Arsenic
ICP	EPA 6010B/C	Barium
ICP	EPA 6010B/C	Beryllium
ICP	EPA 6010B/C	Boron
ICP	EPA 6010B/C	Cadmium
ICP	EPA 6010B/C	Calcium
ICP	EPA 6010B/C	Chromium, total

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP	EPA 6010B/C	Cobalt
ICP	EPA 6010B/C	Copper
ICP	EPA 6010B/C	Iron
ICP	EPA 6010B/C	Lead
ICP	EPA 6010B/C	Magnesium
ICP	EPA 6010B/C	Manganese
CVAA	EPA 7471A/B	Mercury
ICP	EPA 6010B/C	Molybdenum
ICP	EPA 6010B/C	Nickel
ICP	EPA 6010B/C	Potassium
ICP	EPA 6010B/C	Selenium
ICP	EPA 6010B/C	Silver
ICP	EPA 6010B/C	Sodium
ICP	EPA 6010B/C	Strontium
ICP	EPA 6010B/C	Tin
ICP	EPA 6010B/C	Titanium
ICP	EPA 6010B/C	Thallium
ICP	EPA 6010B/C	Vanadium
ICP	EPA 6010B/C	Zinc
UV/Vis	EPA 7196A	Hexavalent Chromium
TOC	Lloyd Kahn	Total Organic Carbon
Colorimetric	EPA 353.2	Nitrocellulose
Colorimetric	EPA 9012A/B	Cyanide
Titration	Chap.7, Sect. 7.3.4 Mod.	Reactive Sulfide
Titration	EPA 9034	Sulfide
Probe	EPA 9045C/D	pH
Preparation	**Method**	**Type**
Preparation	EPA 1311	TCLP
Preparation	EPA 1312	SPLP
Preparation	NJ Modified 3060A	Hexavalent Chromium
Preparation	EPA 3050B	Metals Digestion
Preparation	EPA 3546	Organics Microwave Extraction

LABORATORY ACCREDITATION BUREAU

Certificate # L2226

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
Preparation	EPA 3550B/C	Organics Sonication
Preparation	SM 2540B 20th/21st edition	Percent Solids (Percent Moisture)
Preparation	EPA 5035 /A	Purge and Trap Solid

Notes:

1) This laboratory offers commercial testing service.

Approved By: _____ Date: April 8, 2011

R. Douglas Leonard
Chief Technical Officer

Issued: 11/30/09 Revised: 2/9/10 Revised: 3/31/10 Revised: 10/8/10 Revised: 1/25/11 Revised: 4/8/11

STATE OF ILLINOIS

ENVIRONMENTAL PROTECTION AGENCY
NELAP - RECOGNIZED
ENVIRONMENTAL LABORATORY ACCREDITATION

is hereby granted to

EMPIRICAL LABORATORIES, LLC

621 MAINSTREAM DRIVE, SUITE 270

NASHVILLE, TN 37228

NELAP ACCREDITED
ACCREDITATION NUMBER #200072

According to the Illinois Administrative Code, Title 35, Subtitle A, Chapter II, Part 186, ACCREDITATION OF LABORATORIES FOR DRINKING WATER, WASTEWATER AND HAZARDOUS WASTES ANALYSIS, the State of Illinois formally recognizes that this laboratory is technically competent to perform the environmental analyses listed on the scope of accreditation detailed below.

The laboratory agrees to perform all analyses listed on this scope of accreditation according to the Part 186 requirements and acknowledges that continued accreditation is dependent on successful ongoing compliance with the applicable requirements of Part 186. Please contact the Illinois EPA Environmental Laboratory Accreditation Program (IL ELAP) to verify the laboratory's scope of accreditation and accreditation status. Accreditation by the State of Illinois is not an endorsement or a guarantee of validity of the data generated by the laboratory.

Primary Accrediting Authority: NJ Department of Environmental Protection

Gary Germann
Manager
Environmental Laboratory Accreditation Program

Janet Cruse
Accreditation Officer
Environmental Laboratory Accreditation Program

Certificate No.: 002790
Expiration Date: 09/13/2012
Issued On: 09/21/2011

State of Illinois
Environmental Protection Agency

Certificate No.: 002790

Awards the Certificate of Approval

Empirical Laboratories, LLC
621 Mainstream Drive, Suite 270
Nashville, TN 37228

According to the Illinois Administrative Code, Title 35, Subtitle A, Chapter II, Part 186, ACCREDITATION OF LABORATORIES FOR DRINKING WATER, WASTEWATER AND HAZARDOUS WASTES ANALYSIS, the State of Illinois formally recognizes that this laboratory is technically competent to perform the environmental analyses listed on the scope of accreditation detailed below.

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Hazardous and Solid Waste, Inorganic

1010

Ignitability

1311

TCLP (Organic and Inorganic)

1312

Synthetic Precipitation Leaching Procedure

6010B

Aluminum	Antimony	Arsenic
Barium	Beryllium	Boron (NPW Matrix Only)
Cadmium	Calcium	Chromium
Cobalt	Copper	Iron
Lead	Magnesium	Manganese
Molybdenum	Nickel	Potassium
Selenium	Silver	Sodium
Strontium	Thallium	Tin
Titanium	Vanadium	Zinc

6010C

Aluminum	Antimony	Arsenic
Barium	Beryllium	Boron (NPW Matrix Only)
Cadmium	Calcium	Chromium
Cobalt	Copper	Iron
Lead	Magnesium	Manganese
Molybdenum	Nickel	Potassium
Selenium	Silver	Sodium
Strontium	Thallium	Tin
Titanium	Vanadium	Zinc

7196A

Chromium VI

7470A

Mercury

7471A

Mercury

9010B

Cyanide

9012A

Cyanide

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Empirical Laboratories, LLC
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Hazardous and Solid Waste, Inorganic

9045C

Hydrogen Ion (pH)

9056

Bromide	Chloride	Fluoride
Nitrate	Nitrite	Sulfate

9060

Total Organic Carbon (TOC)

9095B

Paint Filter

Hazardous and Solid Waste, Organic

8011 (NPW Matrix Only)

1,2-Dibromo-3-chloropropane (DBCP)	1,2-Dibromoethane (EDB)

8015B

Diesel range organics (DRO)	Gasoline range organics (GRO)

8015C

Diesel range organics (DRO)	Gasoline range organics (GRO)

8081A

4,4'-DDD	4,4'-DDE	4,4'-DDT
Aldrin	alpha-BHC	alpha-Chlordane
beta-BHC	Chlordane - not otherwise specified	delta-BHC
Dieldrin	Endosulfan I	Endosulfan II
Endosulfan sulfate	Endrin	Endrin aldehyde
Endrin ketone	gamma-BHC (Lindane)	gamma-Chlordane
Heptachlor	Heptachlor epoxide	Methoxychlor
Toxaphene		

8082

PCB-1016	PCB-1221	PCB-1232
PCB-1242	PCB-1248	PCB-1254
PCB-1260		

8151A

2,4,5-T	2,4,5-TP (Silvex)	2,4-D
2,4-DB	Dalapon	Dicamba
Dichloroprop	Dinoseb	MCPA
MCPP		

8260B

1,1,1,2-Tetrachloroethane	1,1,1-Trichloroethane	1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene
1,2,3-Trichlorobenzene	1,2,3-Trichloropropane	1,2,4-Trichlorobenzene
1,2,4-Trimethylbenzene	1,2-Dibromo-3-chloropropane (DBCP)	1,2-Dibromoethane (EDB)
1,2-Dichlorobenzene	1,2-Dichloroethane	1,2-Dichloropropane
1,3,5-Trimethylbenzene	1,3-Dichlorobenzene	1,3-Dichloropropane
1,4-Dichlorobenzene	1,4-Dioxane	2-Butanone (Methyl ethyl ketone, MEK)
2-Chloroethyl vinyl ether	2-Chlorotoluene	2-Hexanone
2-Methyl-1-propanol (Isobutyl alcohol)	4-Chlorotoluene	4-Methyl-2-pentanone (Methyl isobutyl ketone
Acetone	Acetonitrile	Acrolein (Propenal)

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Hazardous and Solid Waste, Organic

8260B

Acrylonitrile	Benzene	Bromobenzene
Bromochloromethane	Bromodichloromethane	Bromoform
Bromomethane	Carbon disulfide	Carbon tetrachloride
Chlorobenzene	Chlorodibromomethane (Dibromochloromethan	Chloroethane
Chloroform	Chloromethane	cis-1,2-Dichloroethene
cis-1,3-Dichloropropene	Dibromomethane	Dichlorodifluoromethane
Dichloromethane (Methylene chloride)	Ethyl methacrylate	Ethylbenzene
Hexachlorobutadiene	Isopropylbenzene	Methacrylonitrile
Methyl iodide (Iodmethane)	Methyl methacrylate	Methyl-t-butyl ether
m-Xylene	Naphthalene	n-Butylbenzene
n-Propylbenzene	o-Xylene	p-Isopropyltoluene
Propionitrile (Ethyl cyanide)	p-Xylene	sec-Butylbenzene
Styrene	tert-Butylbenzene	Tetrachloroethene
Toluene	trans-1,2-Dichloroethene	trans-1,3-Dichloropropene
trans-1,4-Dichloro-2-butene	Trichloroethene	Trichlorofluoromethane
Trichlorotrifluoroethane	Vinyl acetate	Vinyl chloride
Xylenes (total)		

8270C

1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene
1,3,5-Trinitrobenzene (1,3,5-TNB)	1,3-Dichlorobenzene	1,4-Dichlorobenzene
1-Methylnaphthalene	2,3,4,6-Tetrachlorophenol	2,4,5-Trichlorophenol
2,4,6-Trichlorophenol	2,4-Dichlorophenol	2,4-Dimethylphenol
2,4-Dinitrophenol	2,4-Dinitrotoluene (2,4-DNT)	2,6-Dichlorophenol
2,6-Dinitrotoluene (2,6-DNT)	2-Chloronaphthalene	2-Chlorophenol
2-Methylnaphthalene	2-Methylphenol (o-Cresol)	2-Nitroaniline
2-Nitrophenol	3,3'-Dichlorobenzidine	3-Methylphenol (m-Cresol)
3-Nitroaniline	4,6-Dinitro-2-methylphenol	4-Bromophenyl phenyl ether
4-Chloro-3-methylphenol	4-Chloroaniline	4-Chlorophenyl phenyl ether
4-Methylphenol (p-Cresol)	4-Nitroaniline	4-Nitrophenol
Acenaphthene	Acenaphthylene	Acetophenone
Aniline	Anthracene	Benzo(a)anthracene
Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(g,h,i)perlyene
Benzo(k)fluoranthene	Benzyl alcohol	Bis(2-chloroethoxy) methane
Bis(2-chloroethyl) ether	Bis(2-chloroisopropyl) ether	Bis(2-ethylhexyl) phthalate
Butyl benzyl phthalate	Carbazole	Chrysene
Dibenz(a,h)anthracene	Dibenzofuran	Diethyl phthalate
Dimethyl phthalate	Di-n-butyl phthalate	Di-n-octyl phthalate
Fluoranthene	Fluorene	Hexachlorobenzene
Hexachlorobutadiene	Hexachlorocyclopentadiene	Hexachloroethane
Indeno(1,2,3-cd) pyrene	Isophorone	Naphthalene
Nitrobenzene	N-Nitrosodimethylamine	N-Nitrosodi-n-propylamine
N-Nitrosodiphenylamine	Pentachlorophenol	Phenanthrene
Phenol	Pyrene	Pyridine

8270D

1,2,4,5-Tetrachlorobenzene	1,2,4-Trichlorobenzene	1,2-Dichlorobenzene
1,3,5-Trinitrobenzene (1,3,5-TNB)	1,3-Dichlorobenzene	1,4-Dichlorobenzene
1-Methylnaphthalene	2,3,4,6-Tetrachlorophenol	2,4,5-Trichlorophenol

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Environmental Protection Agency

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Empirical Laboratories, LLC
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Nashville, TN 37228

Hazardous and Solid Waste, Organic

8270D

2,4-Dichlorophenol	2,4-Dimethylphenol	2,4,6-Trichlorophenol
2,4-Dinitrotoluene (2,4-DNT)	2,6-Dichlorophenol	2,4-Dinitrophenol
2-Chloronaphthalene	2-Chlorophenol	2,6-Dinitrotoluene (2,6-DNT)
2-Methylphenol (o-Cresol)	2-Nitroaniline	2-Methylnaphthalene
3,3'-Dichlorobenzidine	3-Methylphenol (m-Cresol)	2-Nitrophenol
4,6-Dinitro-2-methylphenol	4-Bromophenyl phenyl ether	3-Nitroaniline
4-Chloroaniline	4-Chlorophenyl phenyl ether	4-Chloro-3-methylphenol
4-Nitroaniline	4-Nitrophenol	4-Methylphenol (p-Cresol)
Acenaphthylene	Acetophenone	Acenaphthene
Anthracene	Benzo(a)anthracene	Aniline
Benzo(b)fluoranthene	Benzo(g,h,i)perlyene	Benzo(a)pyrene
Benzyl alcohol	Bis(2-chloroethoxy) methane	Benzo(k)fluoranthene
Bis(2-chloroisopropyl) ether	Bis(2-ethylhexyl) phthalate	Bis(2-chloroethyl) ether
Carbazole	Chrysene	Butyl benzyl phthalate
Dibenzofuran	Diethyl phthalate	Dibenz(a,h)anthracene
Di-n-butyl phthalate	Di-n-octyl phthalate	Dimethyl phthalate
Fluorene	Hexachlorobenzene	Fluoranthene
Hexachlorocyclopentadiene	Hexachloroethane	Hexachlorobutadiene
Isophorone	Naphthalene	Indeno(1,2,3-cd) pyrene
N-Nitrosodimethylamine	N-Nitrosodi-n-propylamine	Nitrobenzene
Pentachlorophenol	Phenanthrene	N-Nitrosodiphenylamine
Pyrene	Pyridine	Phenol

8330

1,3,5-Trinitrobenzene (1,3,5-TNB)	1,3-Dinitrobenzene (1,3-DNB)	2,4,6-Trinitrotoluene (2,4,6-TNT)
2,4-Dinitrotoluene (2,4-DNT)	2,6-Dinitrotoluene (2,6-DNT)	2-Amino-4,6-dinitrotoluene (2-Am-DNT)
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
m-Nitrotoluene (3-Nitrotoluene, 3-NT)	Nitrobenzene	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocin
o-Nitrotoluene (2-Nitrotoluene, 2-NT)	p-Nitrotoluene (4-Nitrotoluene, 4-NT)	

8330A

1,3,5-Trinitrobenzene (1,3,5-TNB)	1,3-Dinitrobenzene (1,3-DNB)	2,4,6-Trinitrotoluene
2,4,6-Trinitrotoluene (2,4,6-TNT)	2,4-Dinitrotoluene (2,4-DNT)	2,6-Dinitrotoluene (2,6-DNT)
2-Amino-4,6-dinitrotoluene (2-Am-DNT)	2-Nitrotoluene (2-NT)	3-Nitrotoluene (3-NT)
4-Amino-2,6-dinitrotoluene (4-Am-DNT)	4-Nitrotoluene (4-NT)	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
Methyl-2,4,6-trinitrophenylnitramine (Tetryl)	Nitrobenzene	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocin

APPENDIX D

SITE-SPECIFIC HEALTH AND SAFETY PLAN

Health and Safety Plan for Surface Sediment and Biological Sampling in Pettibone Creek at Naval Station Great Lakes, Illinois

Naval Facilities Engineering Command
Midwest

Naval Facilities Engineering Command Midwest

Contract Number N62467-04-D-0055
Contract Task Order 474

February 2012

HEALTH AND SAFETY PLAN

SURFACE, SEDIMENT AND BIOLOGICAL SAMPLING IN PETTIBONE CREEK AT THE NAVAL STATION GREAT LAKES, ILLINOIS

COMPREHENSIVE LONG-TERM ENVIRONMENTAL ACTION NAVY (CLEAN) CONTRACT

Submitted to:
Naval Facilities Engineering Command Midwest
201 Decatur Avenue, Building 1A
Great Lakes, Illinois 60088

Submitted by:
Tetra Tech
234 Mall Boulevard, Suite 260
King of Prussia, Pennsylvania 19406

CONTRACT NUMBER N62467-04-D-0055
CONTRACT TASK ORDER 474

FEBRUARY 2012

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1.0 INTRODUCTION

This Health and Safety Plan (HASP) has been developed to provide practices and procedures for Tetra Tech and subcontractor personnel engaged in investigatory activities during the surface sediment and water sampling and biological sampling in Pettibone Creek at the Naval Station Great Lakes, Illinois. This HASP must be used in conjunction with the Tetra Tech Health and Safety Guidance Manual. Both of these documents must be present at the site during the performance of all site activities to achieve compliance with the requirements stipulated in 29 CFR 1910.120 (OSHA's Hazardous Waste Operations and Emergency Response Standard), OSHA's Construction Industry Standards, 29 CFR 1926. Changes to the HASP will be made with the approval of the Tetra Tech Site Safety Officer (SSO) and the Tetra Tech Health and Safety Manager (HSM). Requests for modifications to the HASP will be directed to the SSO who will determine whether to make the changes. The SSO will notify the Project Manager (PM), who will notify the affected personnel of changes.

1.1 AUTHORITY

This work is authorized under the Comprehensive Long-term Environmental Action Navy (CLEAN) Contract Number N62467-04-D-0055, Contract Task Order (CTO) Number 474.

1.2 KEY PROJECT PERSONNEL AND ORGANIZATION

This section defines the positions responsible for site safety and health for Tetra Tech and subcontractor employees engaged in onsite activities. These persons will be the primary points of contact for any questions regarding the safety and health procedures and the selected control measures that are to be implemented for onsite activities.

- The Tetra Tech PM is responsible for the overall direction of health and safety for this project.

- The Project Health and Safety Officer (PHSO) is responsible for developing this HASP in accordance with applicable OSHA regulations. Specific responsibilities include:

  i. Providing information regarding site contaminants and physical hazards associated with the site and tasks to be conducted.
  ii. Establishing air monitoring and decontamination procedures.
  iii. Assigning personal protective equipment based on task and potential hazards.
  iv. Determining emergency response procedures and emergency contacts.
  v. Stipulating training requirements and reviewing appropriate training and medical surveillance certificates.
  vi. Providing standard work practices to minimize potential injuries and exposures associated with hazardous waste work.

vii. Modifying this HASP, as it becomes necessary.

- The Tetra Tech Field Operations Leader (FOL) is responsible for implementation of the HASP with the assistance of an appointed Site Safety Officer (SSO). The FOL manages field activities, executes the work plan, and enforces safety procedures as applicable to the work plan.

- The SSO supports site activities by advising the FOL on all aspects of health and safety on site. These duties may include:

  i. Coordinating all health and safety activities with the FOL.
  ii. Selecting, applying, inspecting, and maintaining personal protective equipment.
  iii. Establishing work zones and control points in areas of operation.
  iv. Implementing air monitoring program for onsite activities.
  v. Verifying training and medical clearance of onsite personnel status in relation to site activities.
  vi. Implementing Hazard Communication, Respiratory Protection Programs, and other associated health and safety programs as they may apply to site activities.
  vii. Coordinating emergency services.
  viii. Providing site-specific training for all onsite personnel.
  ix. Investigating all accidents and injuries (see Attachment I Incident Report Form)
  x. Providing input to the PHSO regarding the need to modify this HASP, or applicable health and safety associated documents as per site-specific requirements.

- Compliance with the requirements stipulated in this HASP are monitored by the HSM with the assistance of the SSO.

Note: In some cases one person may be designated responsibilities for more than one position. For example, for the sediment sampling activities, the FOL may also be responsible for SSO duties. This action will be performed only as credentials, experience, or the tasks involved permits.

1.3 STOP WORK AUTHORIZATION

All employees are empowered, authorized, and responsible to stop work at any time when an imminent and uncontrolled safety or health hazard is perceived. In a Stop Work event (immediately after the involved task has been shut down and the work area has been secured in a safe manner) the employee shall contact the Project Manager and the Corporate HSM. Through observations and communication, all parties involved shall then develop, communicate, and implement corrective actions necessary and appropriate to modify the task and to resume work.

1.4 SITE INFORMATION AND PERSONNEL ASSIGNMENTS

Site Name: Naval Station Great Lakes

Address: NAVFAC Midwest
Building 1A, Code N457
201 Decatur Avenue
Great Lakes, IL 60088

Naval Station Great Lakes Points-of-Contact:

Name	Phone Number	Cell Phone
Ben Simes	(847) 688-2600 ext. 320	(415) 828-9326
Howard Hickey	(847) 688-2600 ext. 243	(847) 815-6719
Mark Schultz	(847) 688-2600 ext. 361	(847) 744-8579

Fax Number: (847) 688-2319

U.S. Navy Remedial Project Manager/Engineer-In-Charge: Ben Simes (Code N45313)

Address: 201 Decatur Avenue
Great Lakes, Illinois 60088

Phone Number: (847) 688-2600 Ext. 0
Fax Number: (847) 688-2319
E-mail Address: Benjamin.Simes@navy.mil

Base Pass and Security: Building 130 (near Main Gate); Hours of Operation 0600 – 1800

Phone Number: (847) 688-5648

Proposed Dates of Work: February 2012 till completion

Project Team:

Tetra Tech Management Personnel:	Discipline/Tasks Assigned:	Contact Information
Robert F. Davis, P.E.	Project Manager (PM)	(412) 921-7251 Cell (412) 417-8106
TBD	Field Operations Leader (FOL)	
TBD	Site Safety Officer (SSO)	
Matthew M. Soltis, CIH, CSP	CLEAN Health and Safety Manager (HSM)	(412) 921-8912
Clyde Snyder	Project Health and Safety Officer (PHSO)	(412) 921-8904 Cell (724) 516-0907

Other Project Personnel	Affiliation/Discipline/Tasks Assigned	Contact Information

Hazard Assessment (for purpose of 29 CFR 1910.132) for HASP preparation has been conducted by:

Clyde Snyder

2.0 EMERGENCY ACTION PLAN

2.1 INTRODUCTION

This section is to direct and guide field personnel in the event of an emergency. Site activities will be coordinated through the client contact Ben Simes. In the event of an emergency that cannot be mitigated using onsite resources, personnel will evacuate to a safe place of refuge and the appropriate emergency response agencies will be notified. It has been determined that the majority of potential emergency situations would be better supported by outside emergency responders. Based on this determination, Tetra Tech and subcontractor personnel will not provide emergency response support beyond the capabilities of onsite response. Workers who are ill or who have suffered a non-serious injury may be transported by site personnel to nearby medical facilities, provided that such transport does not aggravate or further endanger the welfare of the injured/ill person.

The emergency response agencies listed in this plan are capable of providing the most effective response, and as such, will be designated as the primary responders. These agencies are located within a reasonable distance from the area of site operations, which ensures adequate emergency response time. The Naval Station, Great Lakes contact Ben Simes will be notified when emergency response agencies are contacted. This Emergency Action Plan conforms to the requirements of 29 Code of Federal Regulations (CFR) 1910.38(a), as allowed in 29 CFR 1910.120(I)(1)(ii).

Tetra Tech will, through necessary services, include initial response measures for incidents such as:

- Initial fire-fighting support and prevention
- Initial spill control and containment measures and prevention
- Removal of personnel from emergency situations
- Provision of initial medical support for injury/illness requiring only first-aid level support
- Provision of site control and security measures as necessary

2.2 EMERGENCY PLANNING

Through the initial hazard/risk assessment effort, emergencies resulting from chemical, physical, or fire hazards are the types of emergencies that could be encountered during site activities.

To mitigate the potential for these emergency situations, emergency planning activities under the direction of the SSO and/or the FOL will include the following:

- Coordinating with Emergency Response personnel to ensure that Tetra Tech emergency action activities are compatible with existing emergency response procedures. Fire Protection and Emergency Services will be notified of scheduled events and activities. This is most imperative in situations where their services may be required.

- Establishing and maintaining information at the project staging area (Support Zone) for easy access in the event of an emergency. This information will include the following:

  - Chemical Inventory of chemicals used onsite, with Material Safety Data Sheets.
  - Onsite personnel medical records (Medical Data Sheets, Attachment II).
  - A log book identifying personnel onsite each day.
  - Hospital route maps with directions (these shall also be placed in each site vehicle).
  - Emergency Notification - phone numbers.

The Tetra Tech FOL will be responsible for the following tasks:

- Identifying a chain of command for emergency action. The FOL and/or the SSO will exercise primary responsibility for directing the actions of Tetra Tech and subcontractor personnel during emergency actions.

- Educating site workers to the hazards and control measures associated with planned activities at the site, and providing early recognition and prevention, where possible. This shall occur through site specific training and periodic safety briefings.

- Providing the necessary equipment to safely accomplish identified tasks.

- In coordination with the Emergency Services this plan will be presented and exercised as deemed necessary by the Chief of the local emergency services or Fire Department.

2.3 EMERGENCY RECOGNITION AND PREVENTION

Site personnel should be constantly alert for indicators of potentially hazardous situations and for signs and symptoms of over exposure in themselves and others that warn of hazardous conditions. Early recognition of dangerous situations can prevent them from becoming emergency situations.

2.3.1 Recognition

Emergency situations that may be encountered during site activities will generally be recognized by visual observation. To adequately recognize chemical exposures, site personnel must have a clear knowledge of signs and symptoms of exposure associated with site contaminants (See Section 6.1 for more information on the general site contaminants). Tasks to be performed at the site, potential hazards associated with those tasks and the recommended control methods are discussed in detail in this HASP.

Additionally, early recognition of hazards will be supported by daily site surveys to eliminate any situation predisposed to an emergency. The FOL and/or the SSO will be responsible for performing surveys of work areas prior to initiating site operations and periodically while operations are being conducted. Survey findings will be documented by the FOL and/or the SSO in the Site Health and Safety logbook; however, site personnel will be responsible for reporting hazardous situations. Where potential hazards exist, Tetra Tech will initiate control measures to prevent adverse effects to human health and the environment.

The above actions will provide early recognition for potential emergency situations, and allow Tetra Tech to instigate necessary control measures. However, if the FOL and the SSO determine that control measures are not sufficient to eliminate the hazard; Tetra Tech will withdraw from the site and notify the appropriate response agencies listed in Table 2-1.

2.4 EVACUATION ROUTES, PROCEDURES, AND PLACES OF REFUGE

An evacuation will be initiated whenever recommended hazard controls are insufficient to protect the health, safety or welfare of site workers. Specific examples of conditions that may initiate an evacuation include, but are not limited to the following:

- Severe weather conditions.
- Fire or explosion
- Monitoring instrumentation readings indicating contamination level of greater than action level
- Evidence of personnel overexposure to potential site contaminants.

In the event of an emergency requiring evacuation, personnel will immediately stop activities and report to the designated safe place of refuge unless doing so would pose additional risks. This place of refuge will be determined by the FOL once on site and communicated to site personnel during the site specific training. The evacuation safe place of refuge will be off site. When evacuation to the primary place of refuge is not possible, personnel will proceed to a designated alternate location and remain until further

notification from the Tetra Tech FOL. Safe places of refuge will be identified prior to the commencement of site activities by the SSO and will be conveyed to personnel as part of the pre-activities training session. This information will be reiterated during daily safety meetings. Whenever possible, the safe place of refuge will also serve as the telephone communications point for that area. During an evacuation, personnel will remain at the refuge location until directed otherwise by the Tetra Tech FOL or the on-site Incident Commander of the Emergency Response Team. The FOL or the SSO will perform a head count at this location to account for and to confirm the location of site personnel. Emergency response personnel will be immediately notified of any unaccounted personnel. The SSO will document the names of personnel onsite (on a daily basis) in the site Health and Safety Logbook. This information will be utilized to perform the head count in the event of an emergency.

Evacuation procedures will be discussed during the pre-activities training session, prior to the initiation of project tasks. Evacuation routes from the site and safe places of refuge are dependent upon the location at which work is being performed and the circumstances under which an evacuation is required. Additionally, site location and meteorological conditions (i.e., wind speed and direction) may dictate evacuation routes. As a result, assembly points will be selected and communicated to the workers relative to the site location where work is being performed. Evacuation should always take place in an upwind direction from the site. Since this work is being conducted along the Pettibone Creek which is a distance of over 3600 feet with two evacuation points have been identified on the map in Figure 2-1. Based on the work location for that day the FOL/SSO will determine the appropriate evacuation route and communicate that route to the field teams at the daily safety meeting.

2.5 EMERGENCY CONTACTS

Prior to initiating field activities, personnel will be thoroughly briefed on the emergency procedures to be followed in the event of an accident. Table 2-1 provides a list of emergency contacts and their associated telephone numbers. This table must be posted where it is readily available to site personnel. Figures 2-2 and 2-3 show routes and directions to the nearest hospital.

- Facility maps shall also be posted showing potential evacuation routes and designated meeting areas.

- As soon as possible, the Navy contact will be informed of any incident or accident that requires medical attention.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite (Attachment II).

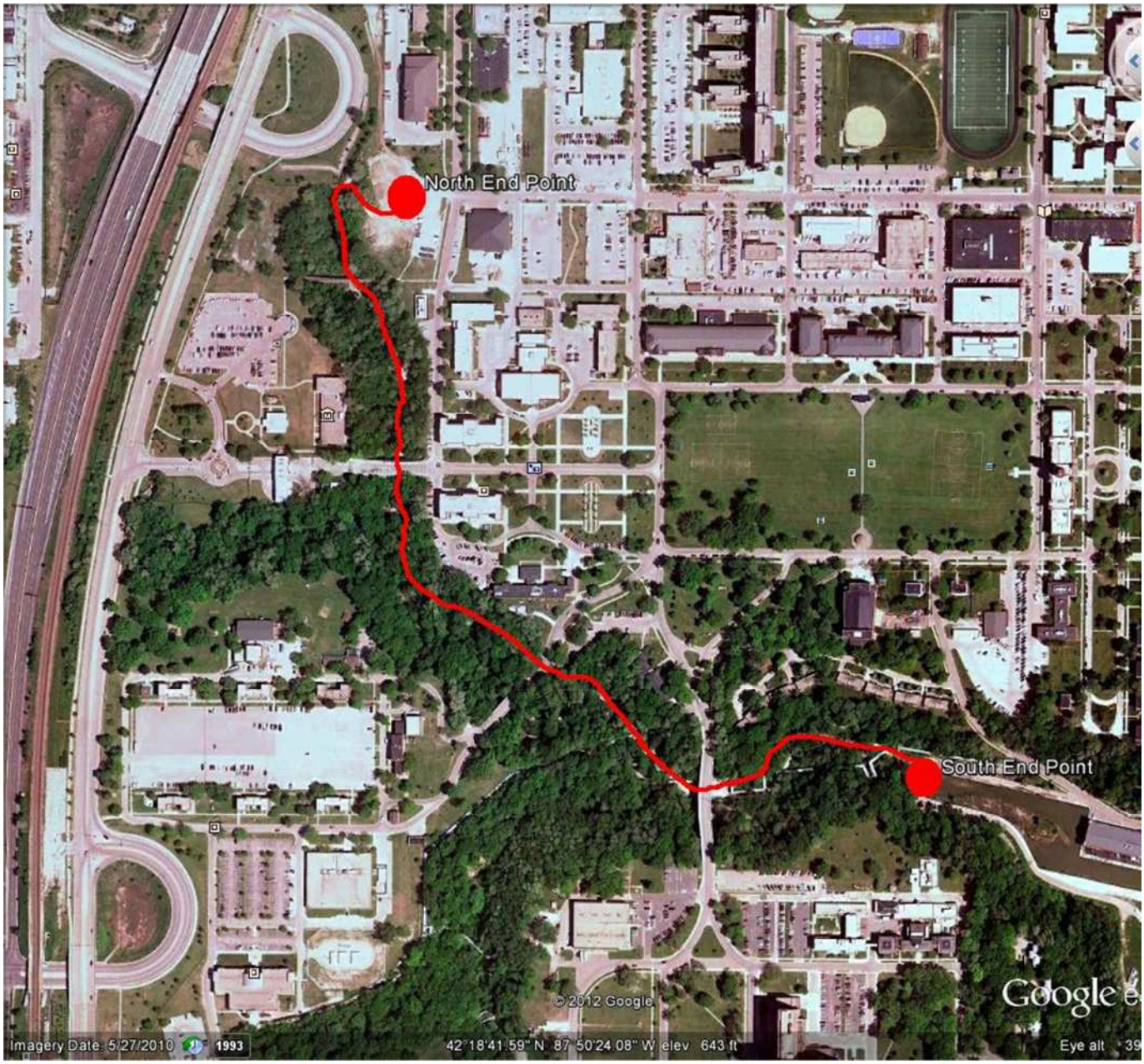
TABLE 2-1

EMERGENCY REFERENCE
NAVAL STATION GREAT LAKES

AGENCY	TELEPHONE
EMERGENCY	**9-1-1**
Police, Fire/Rescue/Hazardous Materials, EMS	(847) 688-3333
Base Contact, Mr. Howard Hickey	(847) 688-2600 x 243 Cell - (847) 815-6719
Base Contact, Mr. Ben Simes	(847) 688-2600 x 320 Cell - (415) 828-9326
North Chicago VA Medical Center	(847) 473-7830
Chemtrec	(800) 424-9300
National Response Center	(800) 424-8802
Poison Control Center	(800) 222-1222
Task Order Manager, Robert Davis	(412) 921-7251 Cell - (412) 417-8106
FOL TBD	TBD
CLEAN Health and Safety Manager, Matthew Soltis, CIH, CSP	(412) 921-8912
Project Health and Safety Officer, Clyde Snyder	(412) 921-8904
Tetra Tech, Pittsburgh Office	(412) 921-7090

.

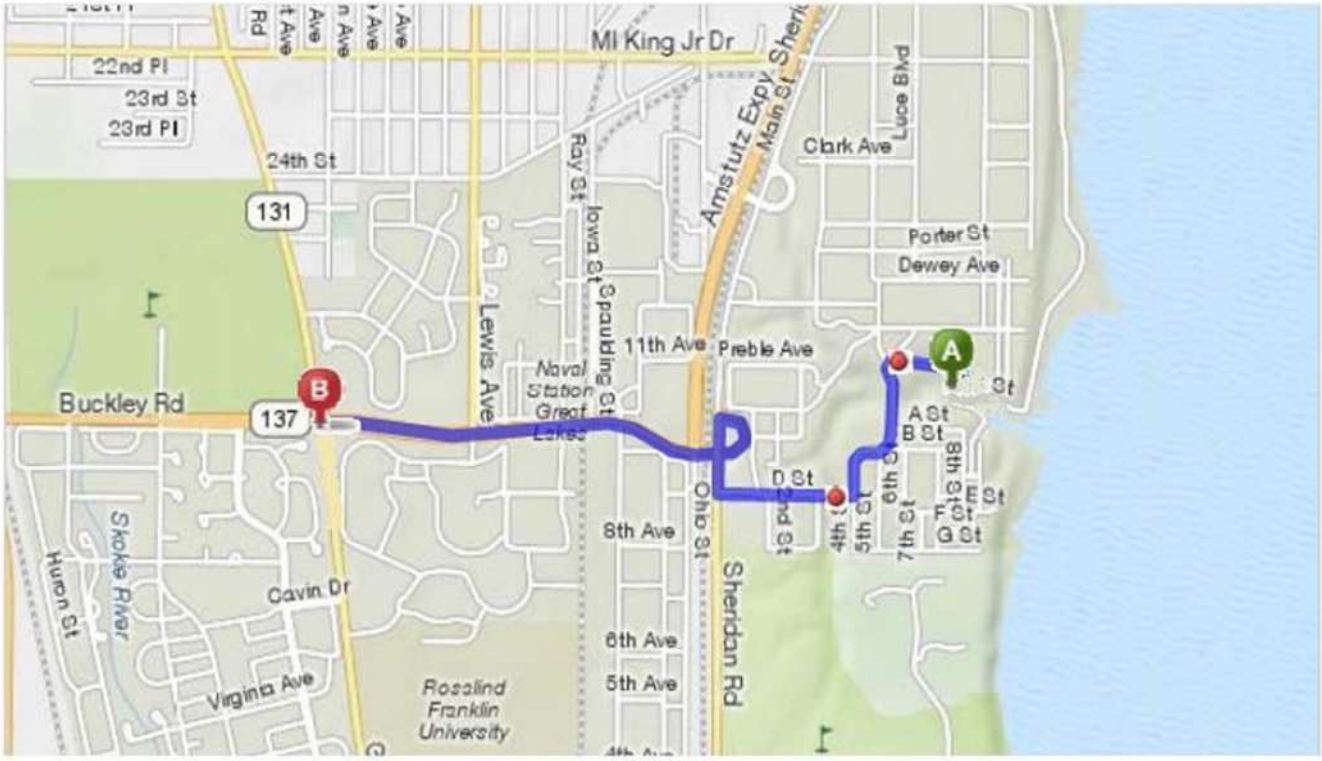
FIGURE 2-1
PETTIBONE CREEK
EVACUATION MAP



2.6 EMERGENCY ROUTE AND DIRECTIONS TO HOSPITAL

FIGURE 2-2
ROUTE 1 TO HOSPITAL

Total Travel Estimate: **2.54 miles - about 9 minutes**



VA Medical Center
3001 Green Bay Rd
North Chicago, IL 60064
(224) 610-3757
2.54 miles / 9 minutes

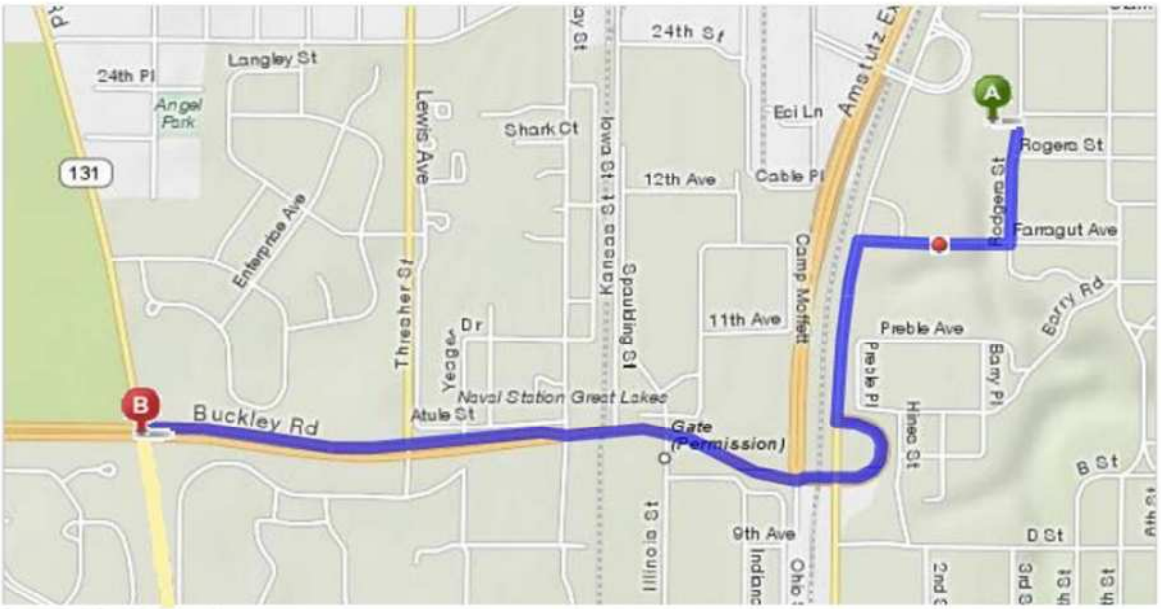
10th St, Great Lakes, IL 6008842.30964579451809 87.83615705937276
(Address is approximate)

	1. Start out going **north** on **10th St** toward **Ziegemeier St**.	**0.1 Mi** *0.1 Mi Total*
	2. Turn **sharp left** onto **Mahan Rd**.	**0.1 Mi** *0.2 Mi Total*
	3. Take the 1st **left** onto **Downes Dr**.	**0.2 Mi** *0.4 Mi Total*
	4. Take the 1st **left** onto **Fisher Rd**.	**0.02 Mi** *0.4 Mi Total*
	5. Turn **slight left** onto **Sampson St**.	**0.2 Mi** *0.6 Mi Total*
	6. Turn **slight right** onto **B St**	**0.06 Mi** *0.6 Mi Total*
	7. **B St** becomes **4th St**.	**0.07 Mi** *0.7 Mi Total*
	8. Turn **right** onto **D St** (Gate access required).	**0.3 Mi** *1.0 Mi Total*
	9. Turn **right** onto **Sheridan Rd**.	**0.2 Mi** *1.1 Mi Total*
RAMP	10. Take the **IL-137** ramp.	**0.2 Mi** *1.3 Mi Total*
WEST 137	11. Turn **slight right** onto **IL-137 W / Buckley Rd / Downey Rd**.	**0.8 Mi** *2.2 Mi Total*
131	12. Turn **left** onto **IL-131 / Green Bay Rd**.	**0.2 Mi** *2.4 Mi Total*
131	13. Make a **U-turn** onto **Green Bay Rd / IL-131**.	**0.2 Mi** *2.5 Mi Total*
	14. **3001 GREEN BAY RD** is on the **right**.	

VA Medical Center
3001 Green Bay Rd, North Chicago, IL 60064
(224) 610-3757

FIGURE 2-3
ROUTE 2 TO HOSPITAL

Total Travel Estimate: **1.96 miles - about 6 minutes**



VA Medical Center
3001 Green Bay Rd
North Chicago, IL 60064-3048
1.96 miles / 6 minutes

Turn right onto
Rodgers St, Great Lakes, IL 6008842.314291, -87.842303
(Address is approximate)

	1. Start out going **south** on **Rodgers St** toward **Rogers St**.	**0.1 Mi** *0.1 Mi Total*
	2. Take the 1st **right** onto **Farragut Ave** (Gate access required).	**0.2 Mi** *0.3 Mi Total*
	3. Turn **left** onto **Sheridan Rd / Main St**. Continue to follow **Sheridan Rd**.	**0.2 Mi** *0.6 Mi Total*
RAMP	4. Turn **left** to take the **Buckley Rd / IL-137 W** ramp.	**0.2 Mi** *0.8 Mi Total*
WEST 137	5. Turn **slight right** onto **IL-137 W / Buckley Rd / Downey Rd**.	**0.8 Mi** *1.6 Mi Total*
131	6. Turn **left** onto **IL-131 / Green Bay Rd**.	**0.2 Mi** *1.8 Mi Total*
131	7. Make a **U-turn** onto **Green Bay Rd / IL-131**.	**0.2 Mi** *2.0 Mi Total*
	8. **3001 GREEN BAY RD** is on the **right**.	

3001 Green Bay Rd, North Chicago, IL 60064-3048
VA medical Center

2.7 EMERGENCY ALERTING AND ACTION/RESPONSE PROCEDURES

Tetra Tech personnel will be working in close proximity to each other at Pettibone Creek. As a result, hand signals, voice commands, and line of site communication will be sufficient to alert site personnel of an emergency. When project tasks are performed simultaneously on different sites, vehicle horns will be used to communicate emergency situations.

If an emergency warranting evacuation occurs, the following procedures are to be initiated:

- Initiate the evacuation via hand signals, voice commands, or two-way radio communication. Report to the designated refuge point.
- Once non-essential personnel are evacuated, appropriate response procedures will be enacted to control the situation.
- Describe to the FOL (FOL will serve as the Incident Coordinator) pertinent incident details.

In the event that site personnel cannot mitigate the hazardous situation, the FOL and SSO will enact emergency notification procedures to secure additional assistance in the following manner:

- Call the appropriate emergency contacts (Table 2-1) and report the emergency.
- Give the emergency operator the location of the emergency, the type of emergency, the number of injured, and a brief description of what occurred.
- Stay on the phone and follow the instructions given by the operator.
- The operator will then notify and dispatch the proper emergency response agencies.

2.8 PPE AND EMERGENCY EQUIPMENT

A first-aid kit, eye wash units (or bottles of disposable eyewash solution) and fire extinguishers (strategically placed) will be maintained onsite and shall be immediately available for use in the event of an emergency. This equipment will be located in each site vehicle. At least one first aid kit supplied with equipment to protect against bloodborne pathogens will also be available on site. Personnel identified within the field crew with bloodborne pathogen and first-aid training will be the only personnel permitted to offer first-aid assistance.

2.9 DECONTAMINATION PROCEDURES / EMERGENCY MEDICAL TREATMENT

During any site evacuation, decontamination procedures will be performed only if doing so does not further jeopardize the welfare of site workers. Decontamination will be postponed if the incident warrants

immediate evacuation. However, it is unlikely that an evacuation would occur which would require workers to evacuate the site without first performing the necessary decontamination procedures.

Tetra Tech personnel will perform rescue operations from emergency situations and may provide initial medical support for injury/illnesses requiring only "Basic First-Aid" level support, and only within the limits of training obtained by site personnel. One Tetra Tech field person will be required to possess First Aid training and be currently certified. Basic First-Aid is considered treatment that can be rendered by a trained first aid provider at the injury location and not requiring follow-up treatment or examination by a physician (for example; minor cuts, bruises, stings, scrapes, and burns). Not included as Basic First-Aid are second or third degree burns, cuts, lacerations requiring stitches or butterfly bandaging, heat exhaustion, severe poisonous plant or insect bite reactions. Personnel providing medical assistance are required to be trained in First-Aid. Medical attention above First-Aid level support will require assistance from the designated emergency response agencies. Attachment I provides the procedure to follow when reporting an injury/illness, and the form to be used for this purpose.

2.10 INJURY/ILLNESS REPORTING

If any Tetra Tech personnel are injured or develop an illness as a result of working on site, the Tetra Tech “Injury/Illness Procedure” (Attachment I) must be followed. Following this procedure is necessary for documenting of the information obtained at the time of the incident.

Any pertinent information regarding allergies to medications or other special conditions will be provided to medical services personnel. This information is listed on Medical Data Sheets filed onsite. If an exposure to hazardous materials has occurred, provide information on the chemical, physical, and toxicological properties of the subject chemical(s) to medical service personnel.

2.10.1 TOTAL Incident Reporting System

TOTAL is Tetra Tech’s new online incident reporting system. Use TOTAL to directly report health and safety incidents, notify key personnel, and initiate the process for properly investigating and addressing the causes of incidents, including near-miss events. An incident is considered any unplanned event. It may include several types of near misses, events where no loss was incurred, or incidents that resulted in injuries or illness, property or equipment damage, chemical spills, fires, or damage to motor vehicles.

TOTAL looks like the incident reporting form in Attachment I. TOTAL is an intuitive system that will guide you through the necessary steps to report an incident within 24 hours of its occurrence. Behind the scenes, TOTAL is a powerful tool for H&S professionals, and will help Tetra Tech to better track incidents,

analyze root causes, implement corrective action plans, and share lessons learned. The ultimate result is a more safe and healthy working environment for us all.

TOTAL is maintained on the Tetra Tech Intranet site at https://my.tetratech.com/

Once on the “My Tetratech” site, TOTAL can be found under the Health and Safety tab, Incident Reporting section, select “Report an Incident (TOTAL)”. This will connect you directly to TOTAL. TOTAL can also be accessed directly from the internet using the following web address: http://totalhs.tetratech.com/

Note: When using the system outside the Tetra Tech intranet system or when operating in a wireless mode, a VPN connection will be required. The speed of the application may be affected dependent upon outside factors such as connection, signal strength, etc. Enter the system using your network user name and password. The user name should be in the following format - TT\nickname.lastname.

2.11 DRILL/INCIDENT AFTER ACTION CRITIQUE

The FOL will conduct a drill or exercise to test the Emergency Action Plan. A critique with the site personnel after each drill or incident will be conducted. This critique provides a mechanism to review the incidents and exercises or drills to determine where improvements can be made. For incidents recorded in TOTAL, the FOL will utilize the Lessons Learned component for the critique.

3.0 SITE BACKGROUND

3.1 SITE DESCRIPTION AND HISTORY

The Naval Station Great Lakes is located in Lake County, Illinois, on the shore of Lake Michigan about 50 miles north of downtown Chicago. Dedicated in 1911, Great Lakes is the only Recruit Training Command (RTC) in the United States. Great Lakes is the largest military installation in Illinois and the largest training center in the U.S. Navy. Great Lakes consists of approximately 1,200 acres with 1,153 buildings. Approximately 9,000 officers and personnel are stationed at Great Lakes, maintaining facilities and conducting training of about 80,000 recruits annually.

3.1.1 Site 17 – Pettibone Creek/Boat Basin

Site 17 includes Pettibone Creek and the Boat Basin. Pettibone Creek starts as a culvert at the north end of Great Lakes and flows through a branching ravine that defines the north and south branches of Pettibone Creek. Pettibone Creek generally flows eastward, eventually discharging into the Boat Basin. Pettibone Creek is approximately 6100 feet long and ranges from between 15 and 30 feet in width and from several inches to 2 feet in depth. The Boat Basin is approximately 2.6 acres and was the location for mooring recreational watercraft. However sediment has accumulated in the basin restricting access and use. Previous investigations identified contaminated sediments in Pettibone Creek and the Boat Basin.

Previous investigations have been conducted at Site 17 - Pettibone Creek/Boat Basin. The predominant contaminants indicated are metals, polycyclic aromatic hydrocarbons (PAHs), pesticides and polychlorinated biphenyl (PCB). The most predominant concentrations of these contaminants are associated with the northern tributary.

4.0 SCOPE OF WORK

This section describes the project tasks that will be performed at Pettibone Creek during the investigations. Each task has been evaluated and the associated hazards and recommended control measures are provided in the Activity Hazard Analysis provided in Attachment III of this HASP.

Activities that will be performed as part of the scope of work include:

- Mobilization and demobilization
- Biologic Sampling
- Sediment sampling at various locations on Pettibone Creek
  - Surface sediment sampling via trowels or shovels
  - Suspended sediment in water will be collected with a sediment trap over an extended period*.
  - Decontamination of sampling equipment

If any changes or additions/deletions are made from this list of task, the PHSO must be contacted and this HASP amended to include the new tasks.

* Collection of sediment samples for laboratory analysis from stormwater outfalls and within the ditch. A sediment trap will be installed at each outfall pipe and remain in place for a minimum of 2-3 rain events (estimated 1 to 2 months). The traps will be constructed from 4” PVC pipe and filter bags, be designed/installed in such a way as to collect and direct a portion of the stormwater discharge into the 7” x 32” filter bag. The filter bag will have a pore size of between 1 and 25 microns to trap fine silt/clay size (≤.003 inches) fine suspended solids from the stormwater discharge. After sufficient fine material has accumulated in each bag the collected sediment will be placed into a stainless steel bowl and processed, removing rocks, trash, organic material etc. and placed into sample jars.

5.0 SUMMARY OF TASKS/HAZARDS/ASSOCIATED CONTROL MEASURES

The anticipated hazards, recommended control measures, air monitoring recommendations, required Personal Protective Equipment (PPE), and decontamination measures for each site task are discussed in detail.

As discussed earlier, a Health and Safety Guidance Manual accompanies this HASP. The manual is designed to further explain supporting programs and elements for other site-specific aspects as required by 29 CFR 1910.120. The Guidance Manual should be referenced for additional information regarding decontamination activities, emergency response, hazard assessments, hazard communication program, medical surveillance, PPE, site control measures, standard work practices, and training requirements. Many of Tetra Tech' SOPs are also provided in this Guidance Manual.

Activity Hazard Analysis (AHA) issued for sampling and decontamination activities (see Attachment III) using elements defined in this section.

5.1 GENERAL SAFE WORK PRACTICES

In addition to the task-specific safe work practices they will also be identified in the Activity Hazard Analysis issued for the specific task. These safe work practices establish a pattern of general precautions and measures for reducing risks associated with hazardous site operations.

- Refrain from eating, drinking, chewing gum or tobacco, taking medication, or smoking in contaminated or potentially contaminated areas or where the possibility for the transfer of contamination exists.
- Wash hands and face prior to breaks and prior to lunch and associated hand to mouth activities.
- Keep the work area clean. Clean up spills to avoid spreading sediment.
- Be familiar with and adhere to all instructions provided within this site-specific HASP.
- Be aware of the location of the nearest telephone and all emergency telephone numbers. See Section 2.0, Table 2-1.
- Attend briefings on anticipated hazards, equipment requirements, Activity Hazard Analysis, emergency procedures, and communication methods before going on site.
- Use the "buddy system".
- Observe coworkers for signs of heat or cold stress.
- Inform co-workers of potential symptoms of illness, such as headaches, dizziness, nausea, or blurred vision.

5.2 WATER HAZARDS

Some of the primary hazards associated with this project are:

- Persons in the water
  - Drowning
  - Hypothermia
  - Slips, trips, and falls in the stream bed.

5.2.1 Planned Activities

Planned activities are to be performed in Pettibone Creek . The FOL will coordinate with (site contact) to coordinate and perform creek sampling. In order to safely perform the sampling activities Tetra Tech and the subcontractor will abide by this HASP.

In general to avoid potential hazards associated with working in water, the field team shall:

- Employ lifelines (tie-off procedure), safety harnesses, when working in areas that could pose a slip trip and or fall hazard.

- When working in high water waders are to be worn by the sampling crew. They will also employ U.S. Coast Guard (USCG) approved personal flotation devices (PFDs), if the water is high (above waist level).

- Wear slip resistant footwear when sampling in the creek or stream. Wear shoes or similar footwear intended for aquatic purposes. Steel toed work boots are required when working in a stream, if waders are not being worn.

5.2.2 Hazardous Terrain

A routine part of sediment sampling and biologic sampling is traveling over rough terrain to access the sample site. One of the risks arising from this aspect of the sampling is the possibility of injury from falling. To minimize this risk, the following preventive actions are recommended:

- When necessary, the FOL will make a determination that access to the sampling site is not possible and the site will be deemed un-sampleable.
- When traveling over any extensive distance, appropriate footwear should be worn instead of waders or hip boots.

- Equipment should be distributed equitably among crew members for transport from the vehicle to the site; if determined to be necessary by the FOL, more than one trip to transport equipment should be made.
- To the greatest extent possible, travel between the vehicle and the sample site should occur during daylight hours.

5.2.3 Fast or Deep Water

During the sediment and biologic sampling, some sampling sites may be visited which have fast and/or deep water in them. Sampling in locations which are too deep or too fast for wading could result in injury or drowning. To minimize health and safety risks associated with sampling in fast and/or deep waters, the following steps should be taken:

- Prior to sampling, the FOL should ensure that all crew members who are to enter the stream are physically fit to do so and are aware of any specific sampling risks at the site.
- Prior to sampling, the FOL should make a determination as to whether the site can be sampled by wading without undue risks. If a negative determination is reached, the site should be revisited at another time or not sampled.
- All field crew members should wear chest waders in water above the boot and will be outfitted with waist belts and felt soles or cleats should be used in rocky areas.

5.2.4 Slippery Substrate

During the sediment and biologic sampling at some sites could be hazardous due to slippery substrate. Examples of stream types which may have treacherous substrates include those affected by acid mine drainage and streams with high silt loads. To minimize the risks associated with slippery substrates, the following measures are recommended:

- The FOL should factor the degree of slipperiness of the substrate into decisions as to whether a site can be sampled and any extra precautions to be taken by the field crew; and all wading gear should have felt soles and/or cleats.

5.2.5 Dangerous Animals or Plants

Sampling at some sites during the biologic sampling will include risks associated with dangerous animals and/or plants. Poison ivy is likely to be common along many travel routes used by the sampling crew, as well as in riparian vegetation. Poison ivy roots on tree trunks offer particular risks since they are often unnoticed. Another plant which occurs in boggy areas and should be avoided is poison sumac. Contact with bees, wasps, and certain caterpillars can cause allergic reactions and should also be avoided. A

number of other animals also present serious risks including: northern copperheads, timber rattlesnakes, free-ranging domestic dogs, rabid animals of any species, and ticks. To minimize the risks associated with dangerous animals and plants during the biologic sampling, the following measures are recommended:

- All field survey personnel should receive training in field identification, avoidance of, and first aid for dangerous plants and animals which may be encountered during the sampling event.
- Crew members should inform the FOL of any known allergies and record that info on the Medical Data Sheet.
- Keep appropriate medical relief in the field first aid kit (at a minimum, each crew should keep an emergency supply of benadryl – gel caps or liquid are preferred because they enter the bloodstream more quickly than tablet form.
- The FOL should make all crew members aware of site or situation-specific dangers as they are noted. Similarly, field crew members should inform the FOL as soon as these conditions are discovered.
- All crew members should be informed of the risks of lyme disease and should check each other after conducting field work for ticks that may have become attached to the body. Crew members will employ universal methods to prevent tick contact.

5.2.6 High Bacterial Levels

When sampling in areas downstream of sewage or other organic waste sources, potentially dangerous bacterial levels may exist. In urban areas, the presence of such inputs may be clearly evident by smell, observation of solids and floatables, and/or the presence of sewage fungus on bottom substrates. However, in some areas, potentially dangerous bacterial levels could be present in a stream without any obvious evidence. To minimize the health risks associated with high bacterial levels in streams, the following measures should be incorporated into the sampling procedure:

- Prior to entering the stream, the FOL will make note of any evidence of high bacterial levels and inform the field crew.
- The use of gloves should be maximized during the sampling process.
- Open wounds should not be exposed to contact with stream water.
- After exposure to stream water, all crew members should use hand sanitizer prior to consuming any food or drink.

5.2.7 Hazardous Waste

Because of historical disposal practices, hazardous wastes may be present at an unknown number of sites at Naval Station Great Lakes. Risks of relatively brief exposure to hazardous wastes are likely to be low, but precautions still need to be taken to minimize exposure probabilities. These include:

- Prior to commencement of field sampling, existing information (through the Navy) about known or probable hazardous waste sites near Pettibone Creek should be reviewed. This information is included in this HASP (Section 6). After review of available hazardous site information, the crew should be informed of any hazardous waste sites in areas designated to be sampled.
- All sampling will be conducted in accordance with this HASP.
- After sampling, all exposed equipment will be decontaminated and thoroughly rinsed, including waders and any exposed personal equipment
- The remote location of some areas may necessitate a lunch break on the site. No food will be consumed at known hazardous waste sites and following sampling, food will only be consumed after thorough hand washing along with moving away from locations where waste materials may be encountered.

5.2.8 Hypothermia

These sites could be sampled during winter/early spring and at remote locations. At these locations, the potential for stranding and prolonged exposure to extreme weather conditions is of concern, especially when sampling is conducted during cold weather. There is also a potential for prolonged exposure to cold water in the case of accidents, emergencies or other unusual conditions. Recommended precautions to reduce the possibility of hypothermia or related illnesses include:

- The field crew will carry several space blankets in the field during the times of cold weather or encountering stream water.
- The FOL will be responsible for monitoring weather conditions and adjusting or postponing sampling plans as appropriate.
- Prior to leaving the vehicle for a sampling site, the FOL should ensure that crew members are properly clothed and that emergency supplies are taken to the site.

5.2.9 Lightning Strike

As sampling will occur in winter/spring, exposure of field crews to electrical storms is unlikely, but could be a hazard during the late spring if sampling is delayed till late spring. To minimize risks associated with a lightning strike the following measures should be taken:

- FOL should be responsible for monitoring weather conditions, adjusting sampling schedules as appropriate to minimize the chance of a field crew being exposed to an electrical storm while in a remote location.
- In the event of an electrical storm while sampling, sampling activities should be halted and the FOL should determine whether to return to the vehicle or seek local shelter

5.2.10 Dehydration and Hyperthermia

The most prevalent risk to sampling crews is the risk of dehydration. Freshwater should be kept with sampling crews at all times and crew members should be encouraged to drink plenty of water. In the event that a crew member suffers from dehydration or heat related illness, all possible attempts should be made to cool and hydrate the person. Make sure to have plenty of fresh drinking water readily available.

5.2.11 U.S.C.G. Flotation Device Types

Use the following information to determine the proper type of U.S.C.G. PFD.

Near Shore Buoyant Vest (Type II, 15.5lbs buoyancy)

Type II is a good choice for calmer waters. It will turn most unconscious persons face-up in the water. Though it is less bulky than Type I, it is not intended for long hours in calm or rough water.

Flotation Aid (Type III, 15.5lbs buoyancy)

Type III is probably the most comfortable device offering more freedom of movement, such as water skiing or fishing, but is not intended for rough water. Also, an unconscious person may end up face-down in the water. It is at the discretion of the FOL/SSO to determine if personnel floatation devices are needed or required. All personnel working on or near water will do so using the buddy system to assist in rescue efforts, if needed.

6.0 CHEMICAL HAZARD INFORMATION/ASSESSMENT

6.1 SITE CONTAMINANTS

A wide range of chemicals were identified during previous sampling on the site, including:

- Metals
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Pesticides
- Polychlorinated Biphenyl Compounds (PCB's)

Previous investigations indicate that these chemical contaminants are in relatively low concentrations. While theses concentrations may threaten marine ecosystems, exposure of site personnel via inhalation is considered negligible to non-existent. This assumption is based on the concentration as well as the fact that the samples will be collected in a wet condition, it is not anticipated that any airborne particulates will be generated during these activities.

It should be well understood that ingestion and dermal contact are still possible routes of exposure.

6.1.1 Metals

The physical effects of poisoning from the heavy metals tend to be a very slow process and occur over a long period of continued exposure to the source of the toxic metal. The physical symptoms which are typically induced by the presence of toxic metals in the body tend to be very vague and can include symptoms such as persistent fatigue, the appearance of splitting and blinding headaches, the presence of an upset stomach, disorders such as colic and even anemia in some cases. The central nervous system is the main part of the human body likely to be affected by the presence of toxic metals. Symptoms of a disrupted central nervous system include the appearance of muscular tremors, the development of spells of dizziness, the presence of insomnia, the poor concentration abilities in the person and a sudden lack of muscular coordination in the body.

Lead - Although children are primarily at risk, lead poisoning is also dangerous for adults. Even exposure to amounts of lead too low to cause symptoms in the short term may increase the risk of high blood pressure and mental decline in the future. Symptoms in adults may include:

- Pain, numbness or tingling of the extremities
- Muscular weakness

- Headache
- Abdominal pain
- Memory loss
- Mood disorders
- Reduced sperm count, abnormal sperm
- Miscarriage or premature birth in pregnant women
- Fatigue

6.1.2 Polycyclic Aromatic Hydrocarbons (PAHs)

A PAH is a water or soil contaminant such as diesel and motor oils, herbicides, pesticides, and combustion residues. A PAH is an organic compound which has a boiling point higher than water and which may vaporize when exposed to temperatures above room temperature. PAHs include a variety of chemicals, which may have short and long term adverse health effects. The health effects can vary greatly from those that are highly toxic, to those which at present, have no known health effects. Many are suspected to be cancer causing in humans and some are known to be carcinogenic in animals and humans e.g. benzo (a) pyrene. Other PAHs have also been shown to be reproductive toxicants based on animal studies and have been linked to asthma, allergies, and other bronchial irritations. Organ system toxicity (non-reproductive), cancer, birth or developmental effects, brain and nervous system, Reproduction and fertility, Immune system (including sensitization and allergies). The three primary routes of exposure for humans are:

- Ingestion (swallowing),
- Respiration (lungs), and
- Dermal absorption (through the skin).

The suspected health effects cover a broad range including, but not limited to, sensory irritation symptoms, allergies and asthma, neurological and liver toxicity, and cancer. PAHs volatilize slowly at standard temperature (20 degrees C and 1 atm pressure).

6.1.3 Pesticides

Effects of exposure to pesticides generally fall into three categories: allergic, acute and delayed effects.

Allergic effects

Some people develop a reaction after being exposed to a certain pesticide, a process known as sensitization. Such effects include asthma, skin irritation and eye and nose irritation. Not all people develop allergies; however, certain people seem to be more sensitive than others to chemical irritants.

Acute effects

Acute effects appear immediately or within 24 hours of exposure. These are more accurately diagnosed than delayed effects because they tend to be more obvious. Often they are reversible if appropriate medical care is given promptly, but may be fatal if not treated. Acute effects of pesticides are classified according to the site of the exposure: oral, inhalation, dermal and eye exposures.

Delayed effects

Sometimes, the term "chronic effects" is used to describe delayed effects, but this is only one type of delayed effect. Delayed effects also include developmental, reproductive and systemic effects. Chronic effects are illnesses or injuries that persist over long periods and may not appear until several years after exposure to a pesticide. Chronic effects include production of tumors, malignancy or cancer and changes in the genes or chromosomes. Developmental and reproductive effects occur to the fetus in the womb or by exposure to the reproductive system in men as well as women. These effects include birth defects, miscarriage or stillbirth, infertility or sterility in men or women and impotence in men. A delayed systemic effect is an illness or injury that does not appear within 24 hours of exposure. Such effects include blood disorders such as anemia or an inability to coagulate; nerve or brain disorders such as paralysis, tremor, behavioral changes and brain damage; skin disorders such as rash; lung and respiratory disorders such as emphysema and asthma; and liver and kidney disorders such as jaundice and kidney failure.

6.1.4 Polychlorinated Biphenyls PCB's

PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor.

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. PCBs have been found in at least 500 of the 1,598 National Priorities List sites identified by the Environmental Protection Agency (EPA).

The EPA has set a limit of 0.0005 milligrams of PCBs per liter of drinking water (0.0005 mg/L). Discharges, spills or accidental releases of 1 pound or more of PCBs into the environment must be reported to the EPA. The Food and Drug Administration (FDA) requires that infant foods, eggs, milk and other dairy products, fish and shellfish, poultry and red meat contain no more than 0.2-3 parts of PCBs per million parts (0.2-3 ppm) of food. Many states have established fish and wildlife consumption advisories for PCBs.

Aroclor - is a PCB mixture produced from approximately 1930 to 1979. It is one of the most commonly known trade names for PCB mixtures. There are many types of Aroclor and each has a distinguishing suffix number that indicates the degree of chlorination. The numbering standard for the different Aroclor is as follows: The first two digits generally refer to the number of carbon atoms in the phenyl rings (for PCBs this is 12), the second two numbers indicate the percentage of chlorine by mass in the mixture. For example, the name Aroclor 1254 means that the mixture contains approximately 54% chlorine by weight.

6.1.5 Exposure Potential

The potential contaminant listed above present a reasonable occupational exposure concern via inhalation when collected from the water. In this case, potential dust evolution is minimized and exposure is not anticipated, provided good work hygiene practices are employed including:

- Changing out gloves regularly.
- Minimizing the potential for splash when collecting the sample media. Cleaning up incidental splashes.
- Keeping sample media contained within secondary containment tubs.
- Minimizing hand to mouth activities with dirty hands or gloved hands. Washing hands and face before breaks and lunch when hand to mouth activities are conducted.
- Employing diligent decontamination practices for persons and equipment.
- General housekeeping

6.2 NATURAL HAZARDS

6.2.1 Inclement Weather

All of the project tasks under this Scope of Work will be performed outdoors. As a result, inclement weather (electrical storms, tornadoes, etc.) may be encountered. In the event that adverse weather conditions arise, the FOL and/or the SSO will be responsible for temporarily suspending or terminating activities until hazardous conditions no longer exist. In the event of severe weather conditions, report to a safe location within suitable shelter (preferably in a facility building). In the event of an electrical storm, immediate stop site activities and report to a safe location such as a building.

These are examples of these practices. Diligent employment of these practices will minimize the potential exposure concern through ingestion.

7.0 AIR MONITORING

The contaminants of concern previously detected at the site some are not readily detected using direct read air monitoring instruments. Contaminants of concern were previously detected at concentrations in sediment that are unlikely to pose a significant exposure threat to site personnel via inhalation, negating the need to monitor airborne concentration.

Additionally, site activities will involve collecting samples that will be wet and/or saturated with water which will further minimize the exposure potential. Therefore, air monitoring **will not** be performed as part of the activities being performed under this HASP.

The FOL will have the authority to implement the use of monitoring instruments if situations dictate. Changes in the air monitoring strategy shall be coordinated with the PHSO.

8.0 TRAINING/MEDICAL SURVEILLANCE REQUIREMENTS

8.1 INTRODUCTORY/REFRESHER/SUPERVISORY TRAINING

This section specifies health and safety training and medical surveillance requirements for both Tetra Tech and subcontractor personnel participating in on site activities.

8.1.1 Requirements for Tetra Tech, Inc. and Subcontractor Personnel

Tetra Tech and subcontractor personnel who will engage in field associated activities as described in this HASP must have:

- Completed 40 Hours of introductory hazardous waste site training or 24-Hours Occasional Site Worker without respiratory protection or equivalent work experience as defined in OSHA Standard 29 CFR 1910.120(e). If the recipient has recently had 40-Hours of training documented 3-days of on-site supervision (OJT) is required.
- Completed 8-Hour Refresher Training, if the identified persons had introductory training more than 12 months prior to site work.
- Completed 8-Hour Supervisory training in accordance with 29 CFR 1910.120(e)(4), if their assigned function will involve the supervision of subordinate personnel.

Documentation of introductory training or equivalent work experience, supervisory, and refresher training as well as site-specific training will be maintained at the site. Copies of certificates or other official documentation will be used to fulfill this requirement.

These training requirements will be required unless subcontractors meet and are granted the exception requirements as stated in Section 8.4.

8.2 SITE-SPECIFIC TRAINING (1910.120)

Tetra Tech will provide site-specific training to Tetra Tech employees and subcontractor personnel who will perform work on this project.

Figure 8-1 will be used to document the provision and content of the project-specific and associated training. Site personnel will be required to sign this form prior to commencement of site activities.

Tetra Tech will conduct a pre-activities training session prior to initiating site work. Additionally, a brief meeting will be held daily to discuss operations planned for that day. At the end of the workday, a short

meeting may be held to discuss the operations completed and any problems encountered. This activity will be supported through the use of a Activity Hazard Analysis System (See Section 10.2).

8.3 MEDICAL SURVEILLANCE

8.3.1 Medical Surveillance Requirements for Tetra Tech and Subcontractor Personnel

Tetra Tech and subcontractor personnel participating in project field activities will have had a physical examination. Physical examinations shall meet the minimum requirements of paragraph (f) of OSHA 29 CFR 1910.120. The physical examinations will be performed to ensure that personnel are medically qualified to perform hazardous waste site work using respiratory protection (with the exception of the 24-Hour Occasional Site Worker Training).

Documentation for medical clearances will be maintained at the job site and made available, as necessary. Subcontractor personnel may use an alternative documentation for this purpose. The "Subcontractor Medical Approval Form" can be used to satisfy this requirement, or a letter from an officer of the company. The letter should state that the persons listed in the letter participate in a medical surveillance program meeting the requirements contained in paragraph (f) of Title 29 of the Code of Federal Regulations (CFR), Part 1910.120, entitled "Hazardous Waste Operations and Emergency Response." The letter should further state the following:

- The persons listed have had physical examinations under this program within the frequency as determined sufficient by their occupational health care provider

- Date of the exam

- The persons identified have been cleared, by a licensed physician, to perform hazardous waste site work. In the case of 40-Hour trained personnel the additional provision will be identified that they will also be able to perform this work wearing positive- and negative- pressure respiratory protection.

A sample Subcontractor Medical Approval Form and form letter have been provided to eligible subcontractors in the Bid Specification package.

These medical surveillance requirements will be required unless subcontractors meet and are granted the exception requirements as stated in Section 8.4.

8.3.2 Requirements for Field Personnel

Each field team member, including subcontractors and visitors, entering the exclusion zone(s) shall be required to complete and submit a copy of the Medical Data Sheet that is available in Attachment II of this HASP. This shall be provided to the SSO, prior to participating in site activities. The purpose of this document is to provide site personnel and emergency responders with additional information that may be necessary in order to administer medical attention.

8.4 SUBCONTRACTOR EXCEPTION

If through the execution of their contract elements the subcontractor will not enter the exclusion zone and there is no potential for exposure to site contaminants, subcontractor personnel may be exempt from the training and medical surveillance requirements with the exception of Section 8.2. Examples of subcontractors who may qualify as exempt from training and medical surveillance requirements may include surveyors who perform surveying activities in site perimeter areas or areas where there is no potential for exposure to site contaminants and support or restoration services or personnel who by way of their duties will not come in contact with contaminated media. **Use of this Subcontractor Exception is strictly limited to the authority of the CLEAN Health and Safety Manager.**

FIGURE 8-1

SITE-SPECIFIC TRAINING DOCUMENTATION

My signature below indicates that I am aware of the potential hazardous nature of performing field investigation activities at Naval Station Great Lakes and that I have received site-specific training that included the elements presented below:

- Names of designated personnel and alternates responsible for site safety and health
- Safety, health, and other hazards present on site
- Use of personal protective equipment
- Safe use of engineering controls and equipment
- Medical surveillance requirements
- Signs and symptoms of overexposure
- Contents of the Health and Safety Plan
- Emergency response procedures (evacuation and assembly points)
- Incipient response procedures
- Review of the contents of relevant Material Safety Data Sheets
- Review of the use of Activity Hazard Analysis
- Stop Work Procedures

I have been given the opportunity to ask questions and that my questions have been answered to my satisfaction and that the date of my training and my medical surveillance requirements indicated below are accurate.

Name (Printed and Signature)	Site-Specific Training Date	40-Hour Training (Date)	8-Hour Refresher Training (Date)	8-Hour Supervisory Training (Date)	Medical Exam

Instructor(s):_____

_____

9.0 SPILL CONTAINMENT PROGRAM

Project activities will not require significant quantities of potentially hazardous materials to be handled. Sampling media to be collected will include small quantities of decontamination fluids, which do not constitute a spill hazard which could potentially harm human health or the environment. As a result, a Spill Containment Program will not be necessary for planned site activities.

General refuse (including PPE) will be collected in garbage bags and disposed of in an approved dumpster.

10.0 SITE CONTROL

This section outlines the means by which Tetra Tech will delineate work zones and use these work zones in conjunction with decontamination procedures to prevent the spread of contaminants into previously unaffected areas of the site. Planned work will be conducted on or near water, and will involve minimal potential for exposure to site contaminants. The "concept" of a three-zone approach (routinely used in hazardous waste activities conducted on-shore) will not be used during work at this site due to a somewhat cramped working area.

10.1 EXCLUSION ZONE

- Sediment sampling. The exclusion zone for this activity will be set at immediately surrounding the sample processing point.

- Decontamination operation. This operation will be conducted on the site. The exclusion zone for this activity will be set at the location employed for this purpose.

As sampling and decontamination is conducted, dedicated sampling devices and PPE will be washed of gross contamination, removed, separated, and bagged. Proper decontamination will then proceed as discussed in Section 5.6. Personnel will use hygienic wipes, such as Handy Wipes. At the first available opportunity personnel will wash their face and hands. This is critical prior to breaks and lunch when contamination can be transferred to the mouth through hand to mouth contact.

10.2 CONTAMINATION REDUCTION ZONE

The CRZ is the buffer area between the Exclusion Zone and any area of a site where contamination is not suspected. Given the nature of planned site activities, all decontamination will occur immediately adjacent to sampling points. The establishment of a formal CRZ, therefore, is not necessary. Personnel will take every reasonable precaution to contain any media or biota potentially contaminated to prevent further spread of contamination.

10.3 SUPPORT ZONE

The Support Zone is the staging area where site vehicles will be parked, equipment will be unloaded, and where food and drink containers will be maintained. For this project the Support Zone will be considered the areas where exposure to site contaminants would not be expected during normal working conditions

or foreseeable emergencies. A formal Support Zone will not be established given the nature of site activities.

10.4 SITE VISITORS

Site visitors for the purpose of this document are identified as representing the following groups of individuals:

- Personnel invited to observe or participate in operations by Tetra Tech
- Regulatory personnel (EPA, OSHA, etc.)
- Naval Station Great Lakes and other authorized personnel

All site visitors will be routed to the FOL, who will sign them into the field logbook. Information to be recorded in the logbook will include the individual's name (proper identification required), the entity which they represent, and the purpose of the visit. Once the above items have been documented for each visitor, he/she will be permitted to enter the operational zone. All visitors are required to observe the protective equipment and site restrictions in effect at the site at the time of their visit. Any and all visitors not meeting the requirements stipulated in this plan will not be permitted to enter the site operational zones during planned activities. Any incidence of unauthorized site visitation will cause the termination of all onsite activities until the unauthorized visitor is removed from the premises. Removal of unauthorized visitors will be accomplished with support from the FOL or on-site security personnel.

10.5 SITE SECURITY

Site security will be accomplished using existing base security resources and procedures, supplemented by Tetra Tech or subcontractor personnel, if necessary. Tetra Tech will retain control over active operational areas. The first line of security will take place at the base boundaries restricting the general public. The second line of security will take place at the work site referring interested parties to the FOL. The FOL will serve as a focal point for site personnel, and will serve and the final line of security and the primary enforcement contact.

10.6 BUDDY SYSTEM

Personnel engaged in onsite activities will practice the "buddy system" to ensure the safety during this operation.

10.7 MATERIAL SAFETY DATA SHEET (MSDS) REQUIREMENTS

Tetra Tech and subcontractor personnel will provide MSDSs for all chemicals brought on site. The contents of these documents will be reviewed by the FOL with the user(s) of the chemical substances prior to any actual use or application of the substances on site. A chemical inventory of all chemicals used on site will be developed using Section 5.0 of the Health and Safety Guidance Manual. The MSDSs will then be maintained in a central location and will be available for anyone to review upon request.

10.8 COMMUNICATION

Site personnel will be working in close proximity during proposed field activities. In the event that site personnel are in isolated areas or are separated by significant distances, a supported means of communication between field crews will be utilized.

Cellular phones will be used to contact emergency services as necessary. Prior to the commencement of site activities, the FOL will determine and arrange for telephone communications, if it is determined a cellular means will not be used.

10.9 ACTIVITY HAZARD ANALYSIS

Work conducted in support of this project will be performed using AHAs to guide and direct field crews on a task by task basis. It is the SSO's responsibility review the AHA with the field personnel.

11.0 CONFINED SPACE ENTRY

It is not anticipated, under the proposed scope of work, that confined space and permit-required confined space activities will be conducted. **Therefore, personnel under the provisions of this HASP are not allowed, under any circumstances, to enter confined spaces**.

A confined space is a space that:

- Is large enough and so configured that an employee can bodily enter and perform assigned work,
- Has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry), and
- Is not designed for continuous employee occupancy.

A Permit-Required Confined Space is a confined space that:

- Contains or has a potential to contain a hazardous atmosphere, or
- Contains a material that has the potential to engulf an entrant, or
- Has an internal configuration such that an entrant could be trapped or asphyxiated by inwardly converging walls or by a floor which slopes downward and tapers to a smaller cross-section, or
- Contains any other recognized, serious, safety or health hazard.

For further information on confined space, consult the Health and Safety Guidance Manual or call the PHSO. If confined space operations are to be performed as part of the scope of work, detailed procedures and training requirements will have to be addressed.

12.0 MATERIALS AND DOCUMENTATION

The Tetra Tech FOL shall ensure the following materials/documents are taken to the project site and used when required.

- A complete copy of this HASP (Signed)
- Health and Safety Guidance Manual
- Incident Reports
- Medical Data Sheets (multiple copies)
- Material Safety Data Sheets for all chemicals brought on site, including deacon solutions, fuels, lime, sample preservatives, calibration gases, etc.
- A full-size OSHA Job Safety and Health Poster (see Attachment IV)
- Training/Medical Surveillance Documentation Form (Blank) (multiple copies)
- Emergency Reference Information (Section 2.0, extra copy for posting)

12.1 MATERIALS TO BE POSTED OR MAINTAINED AT THE SITE

The following documentation is to be posted or maintained at the site for quick reference purposes. In situations where posting of these documents is not feasible (such as no office trailer), these documents should be filed in a transportable file container and immediately accessible. The file should remain in the FOL's possession.

Chemical Inventory Listing (posted) - This list represents all chemicals brought on site, including decontamination solutions, sample preservatives, fuel, calibration gases, etc.. This list should be posted in a central area.

Material Safety Data Sheets (MSDSs) (maintained) - The MSDSs should also be in a central area accessible to all site personnel. These documents should match all the listings on the chemical inventory list for all substances employed on site. It is acceptable to have these documents within a central folder and the chemical inventory as the table of contents.

The OSHA Job Safety & Health Protection Poster (posted) - This poster, as directed by 29 CFR 1903.2 (a)(1), should be conspicuously posted in places where notices to employees are normally posted. Each FOL shall ensure that this poster is not defaced, altered, or covered by other material.

Site Clearance (maintained) - This is found within the training section of the HASP (See Figure 8-1). This list identifies all site personnel, dates of training (including site-specific training), and medical surveillance and indicates not only clearance but also status. If personnel do not meet these requirements, they do not enter the site while site personnel are engaged in activities.

Emergency Phone Numbers and Directions to the Hospital(s) (maintained) - This list of emergency numbers and hospital directions will be maintained at all phone communications points and in each site vehicle.

Medical Data Sheets/Cards (maintained) - Medical Data Sheets will be filled out by all onsite personnel and filed in a central location. The Medical Data Sheet will accompany any injury or illness requiring medical attention to the medical facility. A copy of this sheet or a wallet card will be given to all personnel to be carried on their person.

13.0 GLOSSARY

ACGIH	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
CNS	Central Nervous System
CRZ	Contamination Reduction Zone
DOD	Department of Defense
EPA	Environmental Protection Agency
HASP	Health and Safety Plan
HAZWOPER	Hazardous Waste Operations and Emergency Response
N/A	Not Available
NIOSH	National Institute Occupational Safety and Health
OSHA	Occupational Safety and Health Administration (U.S. Department of Labor)
PEL	Permissible Exposure Limit
PHSO	Project Health and Safety Officer
PM	Project Manager
PPE	Personal Protective Equipment
SSO	Site Safety Officer
STEL	Short Term Exposure Limit

ATTACHMENT I

INCIDENT REPORT FORM

TETRA TECH, INC.
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INCIDENT REPORT

Report Date	Report Prepared By	Incident Report Number

INSTRUCTIONS:

All incidents (including those involving subcontractors under direct supervision of Tetra Tech personnel) must be documented on the IR Form.

Complete any additional parts to this form as indicated below for the type of incident selected.

TYPE OF INCIDENT (Check all that apply)	Additional Form(s) Required for this type of incident
Near Miss (No losses, but could have resulted in injury, illness, or damage)	☐ Complete IR Form Only
Injury or Illness	☐ Complete Form IR-A; Injury or Illness
Property or Equipment Damage, Fire, Spill or Release	☐ Complete Form IR-B; Damage, Fire, Spill or Release
Motor Vehicle	☐ Complete Form IR-C; Motor Vehicle

INFORMATION ABOUT THE INCIDENT

Description of Incident

_____

_____

_____

_____

Date of Incident	Time of Incident
	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐
Weather conditions at the time of the incident	**Was there adequate lighting?**
	_____ Yes ☐ No ☐

Location of Incident

_____ Was location of incident within the employer's work environment? Yes ☐ No ☐

Street Address	City, State, Zip Code and Country
Project Name	**Client:**
Tt Supervisor or Project Manager	**Was supervisor on the scene?**
	Yes ☐ No ☐

WITNESS INFORMATION (attach additional sheets if necessary)

Name	Company
Street Address	**City, State and Zip Code**

Telephone Number(s)

CORRECTIVE ACTIONS

Corrective action(s) immediately taken by unit reporting the incident:

_____

_____

_____

_____

Corrective action(s) still to be taken (by whom and when):

_____

_____

_____

_____

ROOT CAUSE ANALYSIS LEVEL REQUIRED

Root Cause Analysis Level Required: Level - 1 ☐ Level - 2 ☐ None ☐

Root Cause Analysis Level Definitions

Level - 1	**Definition:** A Level 1 RCA is conducted by an individual(s) with experience or training in root cause analysis techniques and will conduct or direct documentation reviews, site investigation, witness and affected employee interviews, and identify corrective actions. Activating a Level 1 RCA and identifying RCA team members will be at the discretion of the Corporate Administration office. The following events may trigger a Level 1 RCA: ▪ Work related fatality ▪ Hospitalization of one or more employee where injuries result in total or partial permanent disability ▪ Property damage in excess of $75,000 ▪ When requested by senior management
Level - 2	**Definition:** A Level 2 RCA is self performed within the operating unit by supervisory personnel with assistance of the operating unit HSR. Level 2 RCA will utilize the 5 Why RCA methodology and document the findings on the tools provided. The following events will require a Level 2 RCA: ▪ OSHA recordable lost time incident ▪ Near miss incident that could have triggered a Level 1 RCA ▪ When requested by senior management

Complete the Root Cause Analysis Worksheet and Corrective Action form. Identify a corrective action(s) for each root cause identified within each area of inquiry.

NOTIFICATIONS

Title	Printed Name	Signature	Telephone Number	Date
Project Manager or Supervisor				
Site Safety Coordinator or Office H&S Representative				
Operating Unit H&S Representative				
Other: _____				

The signatures provided above indicate that appropriate personnel have been notified of the incident.

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INCIDENT FORM IR-A

INSTRUCTIONS:

Complete all sections below for incidents involving injury or illness.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

EMPLOYEE INFORMATION

Company Affiliation

Tetra Tech Employee? ☐ TetraTech subcontractor employee (directly supervised by Tt personnel)? ☐

Full Name	**Company (if not Tt employee)**
Street Address, City, State and Zip Code	**Address Type**
_____	Home address (for Tt employees) ☐
_____	Business address (for subcontractors) ☐

Telephone Numbers

Work: _____	Home: _____	Cell: _____

Occupation (regular job title)	**Department**
Was the individual performing regular job duties?	**Time individual began work**
Yes ☐ No ☐	_____ AM ☐ PM ☐ *OR* Cannot be determined ☐

Safety equipment

Provided? Yes ☐ No ☐

Used? Yes ☐ No ☐ If no, explain why

_____

_____

_____

Type(s) provided:
- ☐ Hard hat
- ☐ Protective clothing
- ☐ Gloves
- ☐ High visibility vest
- ☐ Eye protection
- ☐ Fall protection
- ☐ Safety shoes
- ☐ Machine guarding
- ☐ Respirator
- ☐ Other (list)

_____

NOTIFICATIONS

Name of Tt employee to whom the injury or illness was first reported	**Was H&S notified within one hour of injury or illness?**
	Yes ☐ No ☐
Date of report	**H&S Personnel Notified**
Time of report	**Time of Report**

If subcontractor injury, did subcontractor's firm perform their own incident investigation?

Yes ☐ No ☐ If yes, request a copy of their completed investigation form/report and attach it to this report.

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INCIDENT FORM IR-A

INJURY / ILLNESS DETAILS

What was the individual doing just before the incident occurred? Describe the activity as well as the tools, equipment, or material the individual was using. Be specific. Examples: "Climbing a ladder while carrying roofing materials"; "Spraying chlorine from a hand sprayer"; "Daily computer key-entry"

_____

_____

_____

What Happened? Describe how the injury occurred. Examples: "When ladder slipped on wet floor and worker fell 20 feet"; "Worker was sprayed with chlorine when gasket broke during replacement"; Worker developed soreness in wrist over time"

_____

_____

_____

_____

Describe the object or substance that directly harmed the individual: Examples: "Concrete floor"; "Chlorine"; "Radial Arm Saw". If this question does not apply to the incident, write "Not Applicable".

_____

_____

MEDICAL CARE PROVIDED

Was first aid provided at the site: Yes ☐ No ☐ If yes, describe the type of first aid administered and by whom?

_____

Was treatment provided away from the site: Yes ☐ No ☐ If yes, provide the information below.

Name of physician or health care professional	**Facility Name**
Street Address, City State and Zip Code	**Type of Care?**
_____ _____	Was individual treated in emergency room? Yes ☐ No ☐ Was individual hospitalized overnight as an in-patient? Yes ☐ No ☐ Did the individual die? Yes ☐ No ☐ If yes, date: _____ Will a worker's compensation claim be filed? Yes ☐ No ☐
Telephone Number	

NOTE: Attach any police reports or related diagrams to this report.

SIGNATURES

I have reviewed this report and agree that all the supplied information is accurate

Affected individual (print)	**Affected individual (signature)**	**Telephone Number**	**Date**

This form contains information relating to employee health and must be used in a manner that protects the confidentiality of the employee to the extent possible while the information is being used for occupational safety and health purposes.

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INCIDENT FORM IR-B

INSTRUCTIONS:

Complete all sections below for incidents involving property/equipment damage, fire, spill or release.
Do NOT leave any blanks.
Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

TYPE OF INCIDENT (Check all that apply)

Property Damage ☐ Equipment Damage ☐ Fire or Explosion ☐ Spill or Release ☐

INCIDENT DETAILS

Results of Incident: Fully describe damages, losses, etc.

_____

_____

_____

Response Actions Taken:

_____

_____

_____

Responding Agency(s) (i.e. police, fire department, etc.)	**Agency(s) Contact Name(s)**

DAMAGED ITEMS (List all damaged items, extent of damage and estimated repair cost)

Item:	**Extent of damage:**	**Estimated repair cost**

SPILLS / RELEASES (Provide information for spilled/released materials)

Substance	**Estimated quantity and duration**	**Specify Reportable Quantity (RQ)**
		_____ Exceeded? Yes ☐ No ☐ NA ☐

FIRES / EXPLOSIONS (Provide information related to fires/explosions)

Fire fighting equipment used? Yes ☐ No ☐ If yes, type of equipment: _____

NOTIFICATIONS

Required notifications	**Name of person notified**	**By whom**	**Date / Time**
Client: _____ Yes ☐ No ☐			
Agency: _____ Yes ☐ No ☐			
Other: _____ Yes ☐ No ☐			

Who is responsible for reporting incident to outside agency(s)? Tt ☐ Client ☐ Other ☐ Name: _____

Was an additional written report on this incident generated? Yes ☐ No ☐ If yes, place in project file.

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INCIDENT FORM IR-C

INSTRUCTIONS:

Complete all sections below for incidents involving motor vehicle accidents. Do NOT leave any blanks. Attach this form to the IR FORM completed for this incident.

Incident Report Number: (From the IR Form)	

INCIDENT DETAILS

Name of road, street, highway or location where accident occurred		**Name of intersecting road, street or highway if applicable**
County	**City**	**State**

Did police respond to the accident?	**Did ambulance respond to the accident?**
Yes ☐ No ☐	Yes ☐ No ☐
Name and location of responding police department	**Ambulance company name and location**
Officer's name/badge #	

Did police complete an incident report? Yes ☐ No ☐ If yes, police report number: _____
Request a copy of completed investigation report and attach to this form.

VEHICLE INFORMATION

How many vehicles were involved in the accident? _____ (Attach additional sheets as applicable for accidents involving more than 2 vehicles.)

Vehicle Number 1 – Tetra Tech Vehicle		**Vehicle Number 2 – Other Vehicle**	
Vehicle Owner / Contact Information		**Vehicle Owner / Contact Information**	
Color		**Color**	
Make		**Make**	
Model		**Model**	
Year		**Year**	
License Plate #		**License Plate #**	
Identification #		**Identification #**	
Describe damage to vehicle number 1		**Describe damage to vehicle number 2**	
Insurance Company Name and Address		**Insurance Company Name and Address**	
Agent Name		**Agent Name**	
Agent Phone No.		**Agent Phone No.**	
Policy Number		**Policy Number**	

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INCIDENT FORM IR-C

DRIVER INFORMATION

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
Driver's Name		**Driver's Name**	
Driver's Address		**Driver's Address**	
Phone Number		**Phone Number**	
Date of Birth		**Date of Birth**	
Driver's License #		**Driver's License #**	
Licensing State		**Licensing State**	
Gender	Male ☐ Female ☐	**Gender**	Male ☐ Female ☐
Was traffic citation issued to Tetra Tech driver? Yes ☐ No ☐		Was traffic citation issued to driver of other vehicle? Yes ☐ No ☐	
Citation #		**Citation #**	
Citation Description		**Citation Description**	

PASSENGERS IN VEHICLES (NON-INJURED)

List all non-injured passengers (excluding driver) in each vehicle.
Driver information is captured in the preceding section.
Information related to persons injured in the accident (non-Tt employees) is captured in the section below on this form.
Injured Tt employee information is captured on FORM IR-A

Vehicle Number 1 – Tetra Tech Vehicle		Vehicle Number 2 – Other Vehicle	
How many passengers (excluding driver) in the vehicle? ____		How many passengers (excluding driver) in the vehicle? ____	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	
Non-Injured Passenger Name and Address		**Non-Injured Passenger Name and Address**	

INJURIES TO NON-TETRATECH EMPLOYEES

Name of injured person 1				Address of injured person 1		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐
Name of injured person 2				**Address of injured person 2**		
Age	**Gender**	**Car No.**	**Location in Car**	**Seat Belt Used?**	**Ejected from car?**	**Injury or Fatality?**
	Male ☐ Female ☐			Yes ☐ No ☐	Yes ☐ No ☐	Injured ☐ Died ☐

OTHER PROPERTY DAMAGE

Describe damage to property other than motor vehicles	
Property Owner's Name	**Property Owner's Address**

COMPLETE AND SUBMIT DIAGRAM DEPICTING WHAT HAPPENED

ATTACHMENT II

MEDICAL DATA SHEET

MEDICAL DATA SHEET

This Medical Data Sheet must be completed by on-site personnel and kept in the command post during the conduct of site operations. This data sheet will accompany any personnel when medical assistance is needed or if transport to hospital facilities is required.

Project _____

Name _____ Home Telephone _____

Address _____

Age _____ Height _____ Weight _____

Person to notify in the event of an emergency: Name: _____

Phone: _____

Drug or other Allergies: _____

Particular Sensitivities : _____

Do You Wear Contacts?_____

What medications are you presently using? _____

_____

Name, Address, and Phone Number of personal physician: _____

_____

_____

Note: Health Insurance Portability and Accountability Act (HIPAA) Requirements

HIPAA took effect April 14, 2003. Loosely interpreted, HIPAA regulates the disclosure of Protected Health Information (PHI) by the entity collecting that information. PHI is any information about health status (such as that you may report on this Medical Data Sheet), provision of health care, or other information. HIPAA also requires Tetra Tech to ensure the confidentiality of PHI. This Act can affect the ability of the Medical Data Sheet to contain and convey information you would want a Doctor to know if you were incapacitated. So before you complete the Medical Data Sheet understand that this form will not be maintained in a secure location. It will be maintained in a file box or binder accessible to other members of the field crew so that they can accompany an injured party to the hospital.

DO NOT include information that you do not wish others to know, only information that may be pertinent in an emergency situation or treatment.

_____ _____ _____

Name (Print clearly) Signature Date

ATTACHMENT III

ACTIVITY HAZARD ANALYSIS

ACTIVITY HAZARD ANALYSIS

Activity/Work Task: Mobilization / Demobilization	Overall Risk Assessment Code (RAC) (Use highest code)	**L**
Project Location: Naval Station Great Lakes	**Risk Assessment Code (RAC) Matrix**	
Contract Number: N62467-04-D-0055		
Date Prepared: January 2012		
Prepared by: Clyde Snyder		
Reviewed by Jennifer Carothers, PhD		
Notes: (Field Notes, Review Comments, etc.)		

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Step 1: Review each **"Hazard"** with identified safety "Controls" and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and Identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

RAC Chart
E= Extremely High Risk
H= High Risk
M= Moderate Risk
L= Low Risk

JOB STEPS	HAZARDS	CONTROLS	RAC
Mobilization / Demobilization • Assembling equipment and supplies • Performing initial/exit inspections of the intended work areas • Arranging for utilities, site access, notifying appropriate client contacts • Performing equipment inspections of vehicles and equipment arriving/preparing to depart the site • Collecting and confirming applicable worker training and medical compliance documentation	1. Water Hazards 2. Minor cuts, abrasions or contusions 3. Heavy lifting (muscle strains and pulls) 4. Vehicular traffic when moving equipment to the support area 5. Intermittent high noise levels	1. Wear cut-resistant gloves when handling items with sharp or rough edges. 2. Practice safe lifting techniques (use mechanical lifting devices such as a dolly whenever possible, ensure clear path of travel, good grasp on object, perform "test lift" to gauge ability to safely make the lift, lift with legs not back, obtain help when needed to lift large, bulky, or heavy items). 3. Where water proof boots with good soles determine stable foot location prior to collecting sample. 4. Designate/demarcate vehicle and equipment staging areas. Inform all site personnel of equipment areas and of their responsibility to stay clear of moving vehicles. In high traffic areas, wear high-visibility vests. 5. Operators/nearby personnel are to wear hearing protection if noise levels are such that they must raise their voice in order to communicate with someone who is within arm's reach (approx. 2') of them. SSO is responsible for determining and designating when hearing protection is required. Hearing protection is to consist of either ear muffs or plugs that have a noise reduction rating (NRR) of at least 25 dB.	**L** **L**

JOB STEPS	HAZARDS	CONTROLS	RAC
	6. Equipment moving parts	6. Ensure that workers are thoroughly trained and competent to perform their assigned task with the equipment used in investigation. Ensure that back-up alarms are functional on motorized equipment. The equipment operators and on-site Supervisors responsible for the equipment are to ensure that the equipment has been inspected and accepted for onsite use. Check/test all emergency stop controls.	

EQUIPMENT TO BE USED	INSPECTION REQUIREMENTS	TRAINING REQUIREMENTS
Hand tools (dollies, hand carts, hand knives, etc.)	Visual inspection prior to use by user.	Review of AHA during pre-task tailgate safety briefing with all intended task participants.
Personal Protective Equipment: **Minimum**: Safety toe boots, safety glasses. Optional items: Hardhat, hearing protection. **HTRW**: None anticipated for this task.	Initial PPE inspection performed by SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the SSO through initial training documentation and review prior to permitting personnel to participate in any onsite activities, and will be confirmed by visual observations of worker activities.

I have read and understand this AHA:

Name (Printed)	Signature	Date

ACTIVITY HAZARD ANALYSIS

Activity/Work Task: Sediment* and Biologic Sampling	Overall Risk Assessment Code (RAC) (Use highest code)	**M**
Project Location: Naval Station Great Lakes	**Risk Assessment Code (RAC) Matrix**	
Contract Number: N62467-04-D-0055		
Date Prepared: January 2012		
Prepared by: Clyde Snyder		
Reviewed by Jennifer Carothers, PhD		

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Notes: The work to be performed will include the collection of sediment samples in surface water. A sediment trap will be installed at each outfall pipe and remain in place for a minimum of 2-3 rain events (estimated 1 to 2 months).

Step 1: Review each **"Hazard"** with identified safety "Controls" and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and
Identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

RAC Chart

- **E= Extremely High Risk**
- **H= High Risk**
- **M= Moderate Risk**
- **L= Low Risk**

JOB STEPS	HAZARDS	CONTROLS	RAC
Sediment and Biologic Sampling	1. Minor cuts, abrasions or contusions handling equipment and tools	1. Wear cut-resistant gloves when handling items with sharp or rough edges.	L
	2. Weather	1. Obtain the weather forecast conditions prior to departure. If conditions are poor, then the sampling trip should be postponed.	L
	3. Safety Hazards	1. Wear approved personal flotation devices (PFDs) U.S.C.G. See Flotation Device Types see Section 5.2. if required 2. Wear slip resistant footwear or waders when sampling or similar footwear intended for aquatic purposes.	M
	4. Muscle strain and pinch points.	1. Stretching before physically taxing activities. 2. Take breaks when needed. This is especially needed during the activities that place you in a position where stress and strain maybe experienced over time such as driving sediment samples. 3. Use multiple persons to switch on and off when heavy labor is being conducted.	L
	5. Pinch/Compression Points	1. Wear gloves to minimize this potential. 2. Wear safety glasses in the event of chips and flying projectiles caused by collecting sediment samples..	L
	6. Hazardous Terrain	1. A routine part of sediment sampling and biologic sampling is traveling over rough terrain to access the sample site. One of the risks arising from this aspect of the sampling is the possibility of injury from falling. To minimize this risk, the following preventive actions are recommended: • When necessary, the FOL will make a determination that access to the sampling	

JOB STEPS	HAZARDS	CONTROLS	RAC
		site • Not possible and the site will be deemed unsampleable. • When traveling over any extensive distance, appropriate footwear should be worn instead of • Waders or hip boots. • Equipment should be distributed equitably among crew members for transport from the • Vehicle to the site; if determined to be necessary by the FOL, more than one trip to transport equipment should be made. • To the greatest extent possible, travel between the vehicle and the sample site should occur	
	7. Fast or Deep Water	1. During the sediment and biologic sampling, some sampling sites may be visited which have fast and/or deep water in them. Sampling in locations which are too deep or too fast for wading could result in injury or drowning. To minimize health and safety risks associated with sampling in fast and/or deep waters, the following steps should be taken: • Prior to sampling, the FOL should ensure that all crew members who are to enter the stream are physically fit to do so and are aware of any specific sampling risks at the site. • Prior to sampling, the FOL should make a determination as to whether the site can be sampled by wading without undue risks. If a negative determination is reached, the site should be revisited at another time or not sampled. • All field crew members should wear chest waders in water above the boot and will be outfitted with waist belts and felt soles or cleats should be used in rocky areas.	M
	8. Slippery Substrate	1. During the sediment and biologic sampling at some sites could be hazardous due to slippery substrate. Examples of stream types which may have treacherous substrates include those affected by streams with high silt loads. To minimize the risks associated with slippery substrates, the following measures are recommended: • The FOL should factor the degree of slipperiness of the substrate into decisions as to whether a site can be sampled and any extra precautions to be taken by the field crew; and all wading gear should have felt soles and/or cleats.	M
	9. Dangerous Animals or Plants	1. Sampling at some sites during the biologic sampling will include risks associated with dangerous animals and/or plants. Poison ivy is likely to be common along	

JOB STEPS	HAZARDS	CONTROLS	RAC
		many travel routes used by the sampling crew, as well as in riparian vegetation. Poison ivy roots on tree trunks offer particular risks since they are often unnoticed. Another plant which occurs in boggy areas and should be avoided is poison sumac. Contact with bees, wasps, and certain caterpillars can cause allergic reactions and should also be avoided. A number of other animals also present serious risks including: free-ranging domestic dogs, rabid animals of any species, and ticks. To minimize the risks associated with dangerous animals and plants during the biologic sampling, the following measures are recommended: • All field survey personnel should receive training in field identification, avoidance of, and first aid for dangerous plants and animals which may be encountered during the sampling event. • Crew members should inform the FOL of any known allergies and record that info on the Medical Data Sheet. • Keep appropriate medical relief in the field first aid kit (at a minimum, each crew should keep an emergency supply of benadryl – gel caps or liquid are preferred because they enter the bloodstream more quickly than tablet form. • The FOL should make all crew members aware of site or situation-specific dangers as they are noted. Similarly, field crew members should inform the FOL as soon as these conditions are discovered. • All crew members should be informed of the risks of lyme disease and should check each after conducting field work for ticks that may have become attached to the body. Crew members will employ universal methods to prevent tick contact.	M M
	10. High Bacterial Levels	1. When sampling in areas downstream of sewage or other organic waste sources, potentially dangerous bacterial levels may exist. In urban areas, the presence of such inputs may be clearly evident by smell, observation of solids and floatables, and/or the presence of sewage fungus on bottom substrates. However, in some areas, potentially dangerous bacterial levels could be present in a stream without any obvious evidence. To minimize the health risks associated with high bacterial levels in streams, the following measures should be incorporated into the sampling procedure: • Prior to entering the stream, the FOL will make note of any evidence of high bacterial levels and inform the field crew. • The use of gloves should be maximized during the sampling process. • Open wounds should not be exposed to contact with stream water. • After exposure to stream water, all crew members should wash their hands with hand sanitizer prior to consuming any food or drink.	

JOB STEPS	HAZARDS	CONTROLS	RAC
	11. Hazardous Waste	1. Because of historical disposal practices, hazardous wastes may be present at an unknown number of sites at Naval Station Great Lakes. Risks of relatively brief exposure to hazardous wastes are likely to be low, but precautions still need to be taken to minimize exposure probabilities. These include: • Prior to commencement of field sampling, existing information (through the Navy) about known or probable hazardous waste sites near Pettibone Creek should be reviewed. This information is included in HASP (Section 6). After review of available hazardous site information, the crew should be informed of any hazardous waste sites in areas designated to be sampled. • All sampling will be conducted in accordance with this HASP. • After sampling, all exposed equipment will be decontaminated and thoroughly rinsed, including waders and any exposed personal equipment • The remote location of some areas may necessitate a lunch break on the site. No food will be consumed at known hazardous waste sites and following sampling, food will only be consumed after thorough hand washing along with moving away from locations where waste materials may be encountered.	
Taking sediment samples and placing into sample containers	1. Chemical exposure to concentrations of metals, PCB's, PAHs, metals, and pesticides.	1. Air monitoring not required due to sampling sediment and biologic samples in a wet state. 2. Wear surgeons gloves when handling potentially-contaminated media and samples, avoid contact with potentially-contaminated media to the extent possible, follow good decontamination and practice good personal hygiene (hands and face washing) when exiting work area, hand-to-mouth activities in the work area will be prohibited (eating, drinking, smoking, etc.). 3. Exposure via dermal contact and ingestion represent some limited concern during this task. 4. PPE will be used to control this hazard. 5. Due to the nature of this operation and contaminants monitoring instruments will not be required for this activity.	L

EQUIPMENT	INSPECTION	TRAINING
Personal Protective Equipment: **Minimum**: nitrile surgeon's type gloves, safety toe boots, PFD's, safety glasses **Optional items**: Hardhat, hearing protection. **HTRW**: Nitrile gloves	Initial PPE inspection performed by SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	OSHA 40 Hazardous Waste Operations and Emergency Response (HAZWOPER) training, plus appropriate 8-hour annual refresher training for all task participants. Supervisors must have completed additional 8 hours of HAZWOPER training. ALSO: Review of AHA during pre-task tailgate safety briefing with all intended task participants. PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities.

I have read and understand this AHA:

Name (Printed)	Signature	Date

Activity Hazard Analysis (AHA)

Activity/Work Task: Decontamination	Overall Risk Assessment Code (RAC) (Use highest code)	**M**
Project Location: Naval Station Great Lakes	**Risk Assessment Code (RAC) Matrix**	
Contract Number: N62467-04-D-0055		
Date Prepared: January 2012		
Prepared by: Clyde Snyder		
Reviewed by Jennifer Carothers, PhD		
Notes: (Field Notes, Review Comments, etc.)		

Severity	**Probability**				
	Frequent	Likely	Occasional	Seldom	Unlikely
Catastrophic	**E**	**E**	**H**	**H**	**M**
Critical	**E**	**H**	**H**	**M**	**L**
Marginal	**H**	**M**	**M**	**L**	**L**
Negligible	**M**	**L**	**L**	**L**	**L**

Step 1: Review each **"Hazard"** with identified safety "Controls" and determine RAC (See above)

"Probability" is the likelihood to cause an incident, near miss, or accident and
Identified as: Frequent, Likely, Occasional, Seldom, or Unlikely.

"Severity" is the outcome/degree if an incident, near miss, or accident did occur and identified as: Catastrophic, Critical, Marginal, or Negligible

Step 2: Identify the RAC (Probability/Severity) as E, H, M, or L for each "Hazard" on AHA. Annotate the overall highest RAC at the top of AHA.

RAC Chart

- **E= Extremely High Risk**
- **H= High Risk**
- **M= Moderate Risk**
- **L= Low Risk**

JOB STEPS	HAZARDS	CONTROLS	RAC
Personal Decontamination • Equipment drop • Segregated removal of PPE (wash and rinse reusable items, dispose of non-reusable items)	1. Slips, Trips, Falls 2. Exposure to contaminated media	1. Clear intended decon area location of ground hazards. Practice good housekeeping to keep the site clear of obstructions, materials, equipment and other tripping hazards. Wear appropriate foot protection to prevent slips and trips. Use caution when working on uneven and wet surfaces. 2. Follow good decontamination practices (work from top down and outside in). Nitrile gloves are to be the last item of PPE removed. Wash hands and face following personal decontamination and prior to performing any hand-to-mouth activity.	L
Decontamination of Hand tools (hand brushes, garden sprayers, etc.) sampling equipment	Visual inspection prior to use by user. Check wooden handles for cracks or splinters.	1. Wear apron and nitrile gloves decontaminating sampling equipment according to protocol outlined in Sampling and Analysis Plan	L

EQUIPMENT	INSPECTION	TRAINING
Personal Protective Equipment: Minimum: Safety toe boots, safety glasses **Optional items**: Hardhat, hearing protection. **HTRW**: Decontamination wear safety glasses with side shields and brow protection and nitrile gloves. If contact with overspray cannot be avoided, rain suit or moisture-repellant disposable coveralls may be specified by the SSO.	Initial PPE inspection performed by SSO. Ongoing (prior to each use) inspections responsibilities of PPE users.	OSHA 40 Hazardous Waste Operations and Emergency Response (HAZWOPER) training, plus appropriate 8-hour annual refresher training for all task participants. Supervisors must have completed additional 8 hours of HAZWOPER training. Also Review of AHA during tailgate safety briefing with the intended task participants. PPE training in proper use, care, storage, and limitations. It is anticipated that this has been covered in employees' 40 hour HAZWOPER training, which is to be verified by the SSO through initial training documentation and review prior to permitting personnel to participate in site activities, and will be confirmed by visual observations of worker activities.

I have read and understand this AHA:

Name (Printed)	Signature	Date

ATTACHMENT IV

OSHA POSTER

Job Safety and Health

It's the law!

OSHA

Occupational Safety and Health Administration
U.S. Department of Labor

EMPLOYEES:

- You have the right to notify your employer or OSHA about workplace hazards. You may ask OSHA to keep your name confidential.
- You have the right to request an OSHA inspection if you believe that there are unsafe and unhealthful conditions in your workplace. You or your representative may participate in that inspection.
- You can file a complaint with OSHA within 30 days of retaliation or discrimination by your employer for making safety and health complaints or for exercising your rights under the *OSH Act*.
- You have the right to see OSHA citations issued to your employer. Your employer must post the citations at or near the place of the alleged violations.
- Your employer must correct workplace hazards by the date indicated on the citation and must certify that these hazards have been reduced or eliminated.
- You have the right to copies of your medical records and records of your exposures to toxic and harmful substances or conditions.
- Your employer must post this notice in your workplace.
- You must comply with all occupational safety and health standards issued under the *OSH Act* that apply to your own actions and conduct on the job.

EMPLOYERS:

- You must furnish your employees a place of employment free from recognized hazards.
- You must comply with the occupational safety and health standards issued under the *OSH Act*.

This free poster available from OSHA –
The Best Resource for Safety and Health

Free assistance in identifying and correcting hazards or complying with standards is available to employers, without citation or penalty, through OSHA-supported consultation programs in each state.

1-800-321-OSHA
www.osha.gov

OSHA 3165-12-06R

March 22, 2012

RESPONSE TO COMMENTS
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY COMMENTS
MARCH 13, 2012
DRAFT SITE 17 TIER II SAMPLING AND ANALYSIS PLAN
NAVAL STATION GREAT LAKES

1) **Section 4.4** – It is listed here that the elevation of the top of the bluffs is approximately 600 feet and the elevation at the Boat Basin is 577 feet above mean sea level. If the bluffs rise 70 feet above the beach as is stated in Section 4.2, the then the elevation of the bluffs must be approximately 650 feet above mean sea level.

***Response*: The text will be corrected to indicate the bluffs are approximately 650 feet above mean sea level.**

2) **Section 7.0** – There are 3 sediment samples to be collected in the North Branch of Pettibone Creek upstream of Navy property. Has a right-of-entry been obtained for access to this property?

***Response*: The sediment samples upstream will be collected from public property and entry to Pettibone Creek will be obtained from the Illinois DOT exit ramp from the Amstutz Expressway.**

3) **Section 8.1** – There is mention here of a 100-particle Wolman pebble count. There is no description included of how this is conducted, either in the text or the appendices. A short explanation should be provided.

***Response*: After the statement "In addition to collecting the benthic samples, the field crew will make field observations related to stream habitat conditions and will conduct a visual-based physical habitat assessment and a modified 100-particle Wolman pebble count at each sample location.", the following text will be added to Section 8.1: "The modified 100-particle Wolman pebble count will be conducted by dividing the sampling location into 10 transects based upon the percentage of features present within the stream reach (e.g., pools, riffles). Ten particles will be measured in each transect using calipers to determine the size class."**

4) **Section 8.1** – It states under Investigation-Derived Waste Management that "Discarded alcohol used for sample preservative will be diluted and discarded". In what manner will it be discarded? It should be containerized, sampled, and disposed of in accordance with the appropriate regulations. Please provide the specifics of how the discarded alcohol will be disposed.

***Response*: The sentence will be modified as follows: Ethanol used for sample preservative will be decanted from the samples and stored in a 5 gallon bucket with a screw on lid. The bucket and material safety data sheet (MSDS) for ethanol will be provided to NSGL for proper disposal.**

5) **Section 8.1** – It is noted on page 40 that the analytical "laboratory SOPs are not included in this SAP, but have been reviewed to make sure they are suitable for use on this project." Illinois EPA has no way of verifying that statement. However, the generated data will ultimately reveal whether those procedures were acceptable or not. Therefore, the Agency will withhold judgment until the data has been collected, validated, and submitted for review.

***Response*: Comment noted. The criteria provided in the Sampling and Analysis Plan are primarily to guide analytical method selection and current criteria will be used for decision making. The laboratory SOPs are not included in the Tier II SAPs as part of the Navy's streamlined SAP approach (see the response to Comment 8 below). As part of the streamlining the Navy recognized that the laboratories that are being utilized were accredited in the U.S. Department of Defense Environmental Laboratory Accreditation Program (DoD ELAP) as detailed in the DoD Quality Systems Manual for Environmental Laboratories (DoD QSM v4.1) based on the**

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RESPONSE TO COMMENTS
ILLINOIS ENVIRONMENTAL PROTECTION AGENCY COMMENTS
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NAVAL STATION GREAT LAKES

National Environmental Laboratory Accreditation Conference Chapter 5 Quality Systems Standard (NELAC Voted Revision June 5, 2003) and for Naval Station Great Lakes in the State of Illinois Environmental Protection Agency Environmental Laboratory Accreditation Program (NELAP) for drinking water, wastewater, and hazardous waste analysis.

6) **Section 9.0** – The Project Screening Levels listed in the table in this section are consistent with the values used for screening in the original remedial investigation for this site. However, that investigation was conducted roughly 10 years ago. A thorough review of the listed values to confirm that they remain current could not be completed in the time allotted. Therefore, the Agency reserves the right to request revisions to these values once a more complete review has been conducted. (This may occur as part of the draft report review.)

Response: Comment noted.

7) **Health and Safety Plan** – There are several instances (e.g. Sections 2.5 and 2.7) where a sentence or several sentences are repeated in succession. The Navy should delete the duplicate lines.

Response: The duplicate sentences will be deleted.

8) **General Comment** – The submitted plan is stated to be a Uniform Federal Policy (UFP) – Sampling and Analysis Plan (SAP). A UFP-SAP incorporates informational inputs on 37 numbered worksheets. The submitted plan doesn't really provide worksheets. It provides references to the associated worksheets, which is a deviation from the guidance as written. It is noted that the majority of the specified information has been provided, but not all. The Navy should ensure that all of the necessary information has been included and the proper references added, if not following the guidance strictly.

Response: The Navy has streamlined their UFP-SAP approach by revising the 37-worksheet UFP-SAP to remove redundant information. The 12 worksheets submitted to Illinois EPA is the result of that streamlining and contains all the necessary information to complete the work. The text referenced above will be revised to state that "the SAP contains all necessary information to complete the project and is a streamlined approach based on the standard worksheets as specified in the Uniform Federal Policy (UFP) QAPP guidance documents (USEPA, 2005). References to the UFP-QAPP manual will be removed from the beginning of each section. The Tier II SAP is the preferred format based on Navy guidance. The SAP has been reviewed and the necessary information for the project is included.

March 22, 2012

RESPONSE TO COMMENTS
ILLINOIS DEPARTMENT OF NATURAL RESOURCES COMMENTS
MARCH 16, 2012
DRAFT SITE 17 TIER II SAMPLING AND ANALYSIS PLAN
NAVAL STATION GREAT LAKES

1) **General Comment 1** – Although March is not the optimal time to sample benthic invertebrates for multiple reasons, as long as reference streams are sampled at the same time, IDNR has less issue with the proposed March sampling date.

Response: ***Comment noted. Site and reference streams will be sampled within the same week.***

2) **General Comment 2** – The comparison between reference data and Navy property data would have more statistical power if the same number of samples were collected from reference locations that are being collected from Navy property locations.

Response: ***Because the North Branch (site) is longer than the South Branch (reference), an unequal number of samples is planned. The North Branch and South Branch including tributaries are approximately 3600 feet and 2400 feet in length, respectively. The number of samples will meet the statistical objectives for the project. As the sample design is now, we will be able to differentiate conditions between the south and north branches, as well as between individual reaches, with known uncertainty (90% confidence).***

3) **General Comment 3** – The Navy continues to ignore the IDNR Consultation recommendation to include the mudpuppy as a species of concern in Pettibone Creek.

Response: ***Benthic macroinvertebrates were selected as the receptor of concern for this SAP based on the conclusions from the RI report. However, because the mudpuppy was recently listed as a Threatened Species in Illinois, and based on previous concerns expressed by the Illinois DNR, the Navy is in the process of conducting a study to determine whether the mudpuppy is present in the Harbor and Pettibone Creek at NSGL. The study began last year and is continuing this year. For the study, take permits were obtained from Illinois DNR for the collection and incidental take of endangered or threatened species. During the course of the study to date, which includes the placement of traps, no mudpuppies have been found. Therefore, benthic macroinvertebrates are considered an appropriate receptor of concern. If during the proposed sampling investigation mudpuppies are found, their presence will be recorded in the field log book.***

4) **General Comment 4** – Limiting the sediment investigation to the top 4 cm of sediment has the potential to overlook contaminated sediments below 4 cm. IDNRs understanding is that if the top 4 cm are deemed "clean," then no sediments will be removed, when in fact, sediments below 4 cm **(or 1 ½ inches)** may be contaminated.

Response: ***While contaminated sediments may exist beneath cleaner surface sediment, benthic macroinvertebrates are not expected to be substantially exposed to the deeper sediment, which is below the biotic zone.. However, although the determination of whether the sediment needs removed will be made in part based on the sediment chemistry, the more important factor will be whether the benthic macroinvertebrate community is being impacted.***

5) **Section 7.0** – On page 30 the sampling reaches are summarized as follows: "At this time, 13 reaches are targeted for sampling to adequately characterize Pettibone Creek (see Figure 7-1). Nine of these reaches represent the site and will be located along the preferential pathway of the North Branch of Pettibone Creek, while four are reference areas, located in the South Branch of

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RESPONSE TO COMMENTS
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Pettibone Creek.....Each of the sample locations (NTC17PCSD53, NTC17PCSD54, NTC17PCSD58 through NTC17PCSD68) will consist of samples collected along a 300 foot long creek reach....Although the western fork of the South Branch of Pettibone Creek receives more urban runoff than does the southern fork, one reference sample (NTC17PCSD69) will be collected from this area as the stream is not influenced by potential Navy sources." With the inclusion of the South Western reference site – NTC17PCSD69, there is a total of 14 reaches (9 test sites and 5 reference sites). This SW reference site should also be included with the summary: NTC17PCSD58 through NTC17PCSD69.

***Response*: The text will be corrected to indicate 14 reaches are targeted for sampling. The reference site NTC17PCSD69 will be added to the following summary identifying locations along 300 foot reaches: "Each of the sample locations (NTC17PCSD53, NTC17PCSD54, NTC17PCSD58 through NTC17PCSD69) will consist of samples collected along a 300 foot long creek reach."**