ENGINEERING EVALUATION/COST ANALYSIS ALTERNATIVES EVALUATION REPORT

Beatrice Former Manufactured Gas Plant Site

B&V PROJECT NO. 175870

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PREPARED FOR

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Executive Summary

An Engineering Evaluation/Cost Analysis (EE/CA) for a non-time-critical removal action was prepared for the Beatrice former manufactured gas plant (MGP) site (Site). The primary goals of the EE/CA were to develop removal action goals for impacted media, to identify potential removal action technologies and approaches, and to develop and evaluate removal action alternatives.

The removal action objective is to appropriately control exposure to MGP residuals on and off Site. Based on the results presented in this Report, shallow soil, sediment, and groundwater are the primary areas to be addressed. Several removal action technologies and approaches were evaluated to determine the most appropriate, effective, and implementable removal action alternatives that adequately achieve the removal action objectives. Technologies evaluated for shallow soil included institutional controls, excavation with offsite disposal, capping, and in situ stabilization of the belowground gas holder contents. Technologies evaluated for impacted sediment in the Big Blue River adjacent to the Site included long-term monitoring and capping with non-reactive and reactive materials. Technologies evaluated to address the groundwater/NAPL plume included groundwater monitoring, in situ treatment, permeable reactive barrier installation to intercept the dissolved-phase plume, direct recovery of NAPL, and construction of a barrier wall.

Selected alternatives were combined into Site-wide alternatives and subsequently evaluated. Based on this evaluation, the preferred alternative is excavation of shallow soil across the majority of the Site, excavation and removal of the belowground gas holder contents, placement of low-permeability backfill material over the excavated portions of the Site, installation of a reactive barrier as a cap over selected areas of sediment along the shoreline of the Big Blue River, and long-term sediment and groundwater monitoring. Continued monitoring of groundwater and sediment will confirm that the groundwater contaminant plume remains stable or decreases in size, and that the reactive sediment capping material is effective in treating residual contaminants and preventing direct exposure to impacted sediment. The recommended Site-wide alternative would be protective of the river because onsite shallow soil with residual MGP contamination would be removed so that surface water runoff from the Site would not come into contact with shallow soil contamination, and the sediment capping material would prevent direct exposure to impacted sediment along the shoreline adjacent to the Site. The cap would also provide treatment of any residual contaminants in the sediment that come into contact with the reactive material.

1.0 Introduction

This report presents the results of an Engineering Evaluation/Cost Analysis (EE/CA) for a non-time critical removal action at the Beatrice former manufactured gas plant (MGP) Site (herein referred to as the Beatrice MGP Site or the Site) located southwest of the intersection of South First and Market Streets in the City of Beatrice, Gage County, NE. Black & Veatch Corporation (B&V) has been retained by Centel Corporation to provide environmental and engineering services for the EE/CA. This EE/CA was conducted in accordance with the U.S. Environmental Protection Agency (EPA) Administrative Settlement Agreement and Order on Consent Docket No. CERCLA-07-2006-0109 (Consent Order, EPA 2007a).

The EE/CA process included performing field investigations and completing risk assessments to characterize and understand Site conditions to be able to assess, develop, and evaluate removal alternatives. The results of the field investigations and risk assessments are presented in the EPA-approved *EE/CA Site Characterization Report* (B&V 2012a), *EE/CA Risk Evaluation Report* (B&V 2013a), *EE/CA Screening Level Ecological Risk Assessment and Problem Formulation Report* (B&V 2012b), and the *EE/CA Final Ecological Risk Assessment Report* (B&V 2013b).

The EE/CA was conducted in accordance with EPA's *Guidance on Conducting Non-Time-Critical Removal Actions Under CERCLA* (EPA 1993).

1.1 PURPOSE AND SCOPE OF THE EE/CA REMOVAL ACTION ALTERNATIVES EVALUATION

Before conducting removal actions at a site, an EE/CA is completed. The overall goals of an EE/CA are to provide adequate environmental characterization of a site, document removal action selection, and provide a framework for evaluating and selecting alternative technologies (EPA 1993).

The results of the EE/CA field investigation activities, conducted between July 2008 and December 2012, along with historical Site data were used to develop and select appropriate, cost effective alternatives to meet the removal action objectives established to address soil, groundwater, and sediment at the Site.

1.2 EE/CA REMOVAL ALTERNATIVES EVALUATION OBJECTIVES

The specific objectives of the EE/CA removal alternatives evaluation were the following:

- Determine chemical-specific, location-specific, and action-specific applicable or relevant and appropriate requirements (ARARs) for the Site.
- Develop removal action goals for impacted media.
- Identify potential removal action technologies and approaches.
- Develop and evaluate removal action alternatives.

1.3 SCOPE OF THE EE/CA ALTERNATIVES EVALUATION REPORT

The report presents the results of the EE/CA process and proposes a recommended removal action for the media of concern (soil, groundwater, and sediment). The report includes the following sections:

- Section 2.0, Site Characterization, presents a summary of background information, Site history, historical investigations, and the EE/CA field investigation activities and results.
- Section 3.0, Identification of Removal Action Objectives, presents the ARARs, Preliminary Removal Goals, and the objectives to be attained through completion of a removal action at the Site.
- Section 4.0, Identification and Analysis of Removal Action Alternatives, presents the results of the technology screening step and onsite soil and groundwater and offsite sediment alternatives to be further developed and evaluated.
- Section 5.0, Removal Action Alternative Development and Evaluation, provides detailed descriptions of alternatives per medium and an evaluation of the alternatives against the criteria of effectiveness, implementability, and cost.
- Section 6.0, Comparative Analysis of Site-Wide Alternatives, groups soil, groundwater, and sediment alternatives for comparative analysis.
- Section 7.0, Recommended Site-Wide Removal Action Alternative, presents the recommended Site-wide alternative that best meets the removal action objectives.
- Section 8.0, References, presents the references cited throughout the report.

2.0 Site Characterization

A summary of Site background information; previous investigations; conceptual site model; nature, source, and extent of contamination; analytical data; the baseline risk assessment; and the ecological risk assessment are included in this section.

2.1 SITE DESCRIPTION

The following subsections provide Site background information including location, description, adjacent land use, and history.

2.1.1 Site Location, Description, and Adjacent Property Use

The City of Beatrice (City) is in the southeastern portion of the State of Nebraska in Gage County. The Site is located southwest of the intersection of South First and Market Streets. The Site consists of parcels currently owned by the City (City Parcel) and the Burlington Northern Santa Fe Railroad (BNSF) (Railroad Parcel).

A concrete building foundation and a circular concrete gas holder base are visible on the City Parcel, which is currently a vacant lot. The locations of several former structures (gas plant building, coke bin, and two oil tanks) are on the Railroad Parcel. The belowground gas holder structure straddles both the Railroad and City parcels.

The Site is bounded to the north and east by light industrial and commercial development. Directly south of the Site is undeveloped land with a City-owned sewage pump station. BNSF railroad tracks border the Site to the east, and the Big Blue River borders the Site to the west. The Site in its existing condition, including the boundaries of the City and BNSF properties, is shown on Figure 2-1.

Because of its location within the floodway, the following use restrictions have been established on the City Parcel portion of the Site through the existing property deed:

- The property must remain in public ownership.
- The property must be used only for open space purposes.
- The property may not be leased.
- No structure or other improvement can be erected, unless the structures are open on all sides (restrooms excepted) and functionally related to open space use.
- No excavation below ground surface of the property.
- No water wells, for the purpose of drinking water or otherwise, can be installed, used, maintained, or renewed on the property.

Commercial properties near the Site include two manufacturing plants, machine shops, an auto supply store, an outdoor and recreational vehicle store, and several iron and metal working shops.

2.1.2 Site History

The manufacture and distribution of coal gas began in mid-1907 by the Beatrice Gas and Power Co. (Brown 1885-1953). According to the 1909 Brown's Directory, the gas plant was owned by City Gas Co., but was not in operation that year (Brown 1885-1953). The company name was changed

to the Gage County Gas, Light and Power Co. in June 1909, and the plant began manufacturing gas by both coal and Lowe water gas processes (Gage County Records 1906-1941; Brown 1885-1953).

The Nebraska Gas & Electric Co. purchased the gas plant in July 1922 and subsequently sold the property to the Iowa-Nebraska Light and Power Co. in August 1927. The gas plant ceased operation in 1929 when natural gas became available. Central Electric & Gas Co. purchased the City Parcel in 1945. The Minnesota Gas Company purchased the City Parcel in 1976, who then sold it to Peoples Natural Gas Company in 1993. The City purchased the City Parcel in 1996 and razed the former facility buildings (NDEQ 2002).

Sanborn Fire Insurance maps from 1913, 1923, and 1948 show MGP structures on the Site. Historically, the gas plant consisted of the following primary structures:

- A main building with a coke storage area on the north end.
- A smaller structure to the west designated as a chemical laboratory (1913 and 1923).
- A 50,000-cubic foot gas holder south of the main building which corresponds with the location of a belowground gas holder (1913 and 1923).
- Two rectangular oil tanks between the main building and the gas holder (1923).
- An unidentified small building along the coke bin (1923).

On the 1948 Sanborn map, all structures except the main gas plant building have been removed and the plant building is marked as not in use. A rectangular office building is located west of the plant building, north of the former location of the chemical laboratory.

The 1953 Sanborn map shows the coke storage area removed, the office building expanded, and the plant building designated as a private garage.

2.2 SITE INVESTIGATIONS

Prior to the EE/CA investigations, four environmental investigations were completed. These investigations included the installation of permanent and temporary monitoring wells, numerous soil borings/probes, and the sampling/analysis of soil, groundwater, and sediment. The locations of historical sampling points are shown on Figures 2-2, 2-3, and 2-4, and a summary of the investigation activities and results is presented in the following paragraphs.

2.2.1 Site Investigation (HDR 1992)

Seven soil borings were advanced and three monitoring wells were installed. MGP-related chemicals including polynuclear aromatic hydrocarbons (PAHs) were detected in 4 of 7 soil borings. The highest concentrations were found within and southwest of the gas holder base.

Three soil borings were completed as monitoring wells MW-03, MW-02, and MW-01. Free product described as a dark brown/orange, oily liquid was observed in the development purge water from wells MW-02 and MW-03.

All groundwater samples contained chemicals, including benzene and PAHs, which may be related to MGP activities. The Maximum Contaminant Levels (MCLs) for benzene and ethylbenzene were exceeded in wells MW-02 and MW-03, and the MCL for lead was exceeded in well MW-1.

2.2.2 Pre-CERCLIS Site Screening Assessment (NDEQ 2001)

As presented on Figure 2-2, four soil probes/temporary wells (P-1, P-2, P-3, and P-4) were installed. The soil samples were analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEXs) by a mobile laboratory and one split sample was analyzed for BTEXs and PAHs by an offsite laboratory. No chemicals were detected in any soil samples.

The water from wells P-1 and P-2 had a visible sheen and a strong diesel odor. Groundwater samples were only collected from wells P-1 and P-2. The highest concentrations were detected in well P-2, with benzene and ethylbenzene exceeding MCLs. The groundwater sample also contained benzo(a)pyrene, arsenic, barium, and chromium at concentrations that exceeded the MCLs.

2.2.3 Preliminary Assessment/Site Investigation (NDEQ 2002)

This investigation consisted of advancing probes to collect soil samples, collecting sediment samples from the Big Blue River, and collecting groundwater samples from the existing monitoring wells. The sediment sample locations are shown on Figure 2-3.

The soil samples collected from the probe advanced in the former area of the oil tanks contained the highest concentrations of volatile organic compounds (VOCs) and PAHs. Lower levels were detected in the other soil probes.

All monitoring well samples contained MGP-related chemicals; however, only samples collected from wells MW-02 and MW-03 exceeded the MCLs. Free product was observed in well MW-03 during purging and sampling activities.

Sediment samples collected from the Big Blue River showed an increase in MGP-related chemicals immediately downstream of the Site, with concentrations decreasing further downstream.

2.2.4 Removal Site Evaluation (Tetra Tech 2004)

The Removal Site Evaluation (RSE) investigation included collecting soil, sediment, and groundwater samples on and adjacent to the Site.

Eighty-five soil samples were collected in a grid pattern across the Site, from the bank of the Big Blue River, and from sediment covering the aboveground gas holder base. The RSE soil sample grid is shown on Figure 2-4.

BTEXs were detected in 6 of 85 surface soil samples. None of the reported concentrations exceeded the EPA Region 9 Preliminary Remediation Goals for industrial soil. The soil samples collected from the southern half of the Site contained the highest levels of PAHs, with five PAHs exceeding the goals.

Benzene and ethylbenzene were the only VOCs detected at concentrations that exceeded the goals in the subsurface samples. With the exception of indeno(1,2,3-cd)pyrene, the same PAHs that exceeded in the surface soil samples exceeded in the subsurface soil. No PAHs were detected in the soil sample collected from the bank of the Big Blue River.

Groundwater samples were collected from monitoring wells MW-01, MW-02, and MW-03 and temporary wells GW-1, GW-2, GW-3, and GW-4. BTEXs were detected at concentrations that

exceeded the MCLs and tap water goals in the samples collected from wells MW-02, MW-03, and GW-3. PAHs were detected in all groundwater samples except well GW-4. Product described as tar was evident in well MW-03 during the investigation.

2.2.5 EE/CA Site Characterization (B&V 2008-2011)

The EE/CA site characterization field investigation activities were performed in July 2008, September 2009, July 2010, and January 2011. Field investigation activities included advancing soil, electrical conductivity (EC), and groundwater probes; locating buried MGP foundations using magnetometer/conductivity surveys and trenching; installing and developing monitoring wells; measuring groundwater elevations; collecting samples of environmental media; surveying; and measuring the thickness of dense non-aqueous phase liquid (DNAPL) and petroleum-related light non-aqueous phase liquid (LNAPL) in monitoring wells. Sampling activities included collecting subsurface soil and groundwater samples from direct push probes; groundwater samples from newly-installed and existing monitoring wells; and sediment and surface water samples from the Big Blue River. The field activities were designed to gather data to define and characterize the extent of MGP-related soil, sediment, surface water, and ground water contamination, and the extent of DNAPL and LNAPL contamination at the Site.

The site characterization field investigation activities are discussed in detail in the *EE/CA Site Characterization Report* (B&V 2012a). A summary of the information presented and discussed in this report is provided in Sections 2.4 and 2.5.

2.2.6 EE/CA Ecological Risk Assessment (ERA) Investigation (B&V 2012)

A field investigation was conducted in November and December 2012 to collect data to assess ecological risk. Field activities included collecting surface water, sediment, and pore water samples for chemical analysis and toxicity testing. In addition, benthic macroinvertebrate samples were collected to evaluate community metrics in the river. Sampling stations were established at eight locations adjacent and downstream from the Site and two upstream reference area locations.

2.3 OTHER ENVIRONMENTAL SITES

Sanborn Fire Insurance Maps show three bulk oil facilities (Hunkle Oil Company, Continental Oil Company, and Sinclair Refining Company) were historically located on parcels adjacent to the Railroad Parcel. These parcels are between 75 and 175 feet east and upgradient of the Site. It is unknown when these operations ceased; however, the facilities were identified on maps from the years 1948 and 1953. The historical locations of these facilities are shown on several report figures.

An environmental database search was conducted by Environmental Data resources, Inc. (EDR) to identify any nearby properties with environmental concerns (EDR 2011). Within 0.25 mile of the Site, the search identified three leaking underground storage tank (LUST) sites, one leaking aboveground storage tank (LAST) site, and four underground storage tank (UST) sites. Figure 2-5 shows the LUST/LAST locations within 0.25 mile of the Site that were identified through an online search of the NDEQ database (NDEQ 2011) and verified with the EDR report.

2.4 SITE GEOLOGY AND HYDROGEOLOGY

The following subsections present a summary of the geologic and hydrogeologic conditions at the Site. The EE/CA Site Characterization Report presents a detailed discussion on the regional and Site geology and hydrogeology.

2.4.1 Geology

Surface material consists of fill covering alluvial deposits of lean clays, silts, and sands. The cohesive alluvial deposits consist mostly of stiff, non-plastic, dry to moist silt or soft silty/sandy clay with a few discontinuous sand lenses. Granular alluvial deposits consisting of gravelly to silty sand were encountered in most of the probes between the cohesive material and bedrock, and are mostly saturated. East of the Site, on the BNSF property where wells MW-09 and MW-10 were installed, the cohesive material is absent and the soil consists of fill and granular alluvial material.

The bedrock underlying the alluvium consists of shale or limestone, the top few inches of which are typically weathered. Bedrock was encountered from 15 to 25 feet bgs on Site. The top of the bedrock slopes downward from east to west, with the deepest point between the east river bank and the island located in the middle of the river adjacent to the Site.

Adjacent to the Site, the river consists of an east and west channel, dissected by an island in the middle. River sediment consisting of sand and silt were encountered as deep as 8 inches below the base of the river, and cobbles were encountered below the river sediment. The cobbles are likely from deposition during river flooding since they were not observed in the granular material present beneath the Site. Because probes could not be advanced within the river channel, the material below the cobbles is unknown. Data collected during the EE/CA field investigation activities indicate that cohesive material may extend across the base of the river deposits. The granular material is likely present between the cohesive material and the bedrock, consistent with the geology on Site.

2.4.2 Hydrogeology

Groundwater levels were measured in July and September 2010, and January 2011. The groundwater elevations measured indicate that the groundwater flow is to the west, towards the Big Blue River. The July 2010 data were used to generate the potentiometric surface map presented on Figure 2-6.

On the western portion of the Site closest to the river, water-saturated soil was consistently encountered at deeper depths than the water level measured in the wells. The difference between the potentiometric surface and the depth of saturated soil indicates that the silt and clays composing the cohesive alluvial material act as a semi-confining unit.

Based on slug testing of monitoring wells, the average hydraulic conductivity is 2.72×10^{-4} cm/sec. The average horizontal flow velocity was calculated to be 44 feet per year. The moisture content of the cohesive unit (vadose zone) decreased significantly near the river, with saturated soil observed at deeper depths initially on the western portion of the Site. The decreased water content in the thicker cohesive material above the alluvium on the western portion of the Site appears to decrease flow through the alluvium and induce semi-confining conditions closer to the river. These subsurface conditions limit most groundwater flow to the granular material.

The horizontal flow velocity was calculated for wells MW-05 and MW-10 (both screened across granular material) to determine the difference in flow velocity across the Site. The velocities for wells MW-05 and MW-10 were calculated to be 2 and 74 feet per year, respectively. This demonstrates a reduction in the groundwater flow velocity of 72 feet per year from east to west across the Site.

2.5 SUMMARY OF NATURE AND EXTENT OF MGP CONSTITUENTS

The following subsections summarize the nature and extent of MGP-related constituents at the Site. A detailed analysis of these MGP-related constituents is presented in the *EE/CA Site Characterization Report* (B&V 2012a) and the *EE/CA ERA Report* (B&V 2013b). A summary of the results from previous investigations conducted at the Site is presented in Section 2.2 and in the *EE/CA Work Plan* (B&V 2007). Appendix A contains Table 2-1 through Table 2-8 from the EE/CA Work Plan summarizing data from previous investigations.

2.5.1 Soil

Both MGP and non-MGP impacts are present at the Site. Evidence of what appeared to be MGP-related contamination was observed as odor, sheen, stringers, staining, and/or saturated tar in soil probes SP-101 through SP-108, SP-110, SP-115, SP-116, SP-118, SP-120, and SP-121. The probe locations are shown on Figure 2-7. Appendix A contains Tables 4-1, 4-2, and 4-3 from the EE/CA Site Characterization Report presenting field observations during soil probing and soil analytical data results.

Probes advanced east and hydraulically upgradient of the former MGP operations area contained impacts that are not likely to be MGP-related, including probes SP-120, SP-121, and SP-123. Petroleum impacts were noted in probe SP-115 advanced south of the gas holder and in the background probe SP-112.

In some locations, a distinction between MGP-related and non-MGP contamination could not be determined due to co-mingling. The co-mingling of the contamination was observed in probes SP-108, SP-116, and SP-118. Probe SP-108 was advanced on the southwest portion of the Site. Probe SP-116 was advanced southwest of the belowground gas holder, while probe SP-118 was advanced within this structure.

The majority of the visible contamination was found west of the railroad tracks and decreased in thickness and concentration from east to west. MGP and non-MGP related contamination were also found at deeper intervals on the western portion of the Site. No contamination was observed in probes advanced on the island west of the Site in the Big Blue River.

BTEXs were detected in all samples collected. In general, the highest BTEX concentrations were detected in probes advanced between the railroad tracks and the area immediately west and south of the gas holders. The overall highest total BTEX concentration (135 mg/kg) was in the sample collected from soil probe SP-107 at 21 to 22 feet bgs. Probe SP-107 was advanced to 23 feet bgs west of the belowground gas holder. The next highest BTEX concentrations were detected in probes SP-110 (17 to 18 feet bgs) and SP-120 (9 to 10 feet bgs). Probe SP-110 was advanced between the gas holders, and probe SP-120 was advanced east of the aboveground gas holder.

Historically, the highest concentrations in the subsurface soil were detected south and southeast of the aboveground gas holder from 12 to 16 feet bgs (Tetra Tech 2004).

PAHs were detected in 45 of 55 soil samples, with pyrene being the compound most frequently detected. However, the PAH compound with the highest concentrations is naphthalene. As with the BTEXs, the higher PAH concentrations were generally detected in soil probes SP-107, SP-110, and SP-120. Probes SP-109, SP-115, and SP-121, located south/southeast of the belowground gas holder, also contained elevated PAH concentrations compared to the other soil samples. Historically, the highest PAH concentrations were located east, south, or southwest of the aboveground gas holder (Tetra Tech 2004).

Metals were detected in all soil samples. Of the metals analyzed, barium was detected at the highest concentrations, including the sample collected from background probe SP-112. Overall, the highest concentrations of metals were detected in shallow soil samples, with the highest concentrations detected in the sample collected from probe SP-103 at 5 to 6 feet bgs.

Cyanide was detected in 47 of 52 soil samples, with the highest concentration (7.1 mg/kg) in the sample collected from 9 to 10 feet bgs in probe SP-116. The remaining concentrations varied across the Site, with higher concentrations typically found in the shallower intervals, consistent with historical data.

2.5.2 Groundwater

As shown on Figure 2-8 and confirmed by observations during probing, distinct dense non-aqueous phase liquid (DNAPL) and light non-aqueous phase liquid (LNAPL) plumes overlap at the Site. A majority of the LNAPL was observed extending from between the railroad tracks along the west side of the Site to the west toward the river, and from the south edge of the Site to the north past the gas holders. The DNAPL plume is more concentrated west and southwest of the belowground gas holder. Wells MW-03, MW-04, and MW-05 contained DNAPL, with only wells MW-03 and MW-04 containing measurable amounts. Historically, well MW-02 has contained DNAPL, but none was observed during the EE/CA field activities.

Visible contamination was identified while sampling groundwater probes GWP-102, GWP-103, GWP-104, GWP-106, GWP-109, GWP-110, GWP-120, and GWP-124. The groundwater probe and monitoring well locations are shown on Figure 2-7. Appendix A contains Tables 2-2, 3-1, 4-4, and 4-6 from the *EE/CA Site Characterization Report* (B&V 2012) presenting the groundwater observations and analytical data results.

Probes GWP-102, GWP-103, GWP-104, GWP-105, GWP-106, GWP-107, GWP-108, and GWP-109 and wells MW-02, MW-03, MW-04, MW-05, and MW-07contained the highest BTEX concentrations across the Site. All of the groundwater probes were advanced between the railroad tracks and the river. Probes GWP-104, GWP-105, GWP-106, GWP-107, and GWP-108 are downgradient of the gas holders. Probes GWP-102 and GWP-103 are cross-gradient of the belowground gas holder, while probe GWP-109 is located between the gas holders. Wells MW-03 through MW-05 are located downgradient of the belowground gas holder, while wells MW-02 and MW-07 are located upgradient.

PAHs were detected in all groundwater samples except for the samples collected from probes GWP-119, GWP-121, GWP-122, GWP-123, and GWP-125. The highest PAH concentrations were detected in probes GWP-102 through GWP-110, GWP-120, GWP-124, and monitoring well MW-03. In general, the highest PAH concentrations corresponded with the higher BTEX concentrations, although probes GWP-110, GWP-120, and GWP-124 contained high concentrations of PAHs and low concentrations of BTEXs. Probe GWP-110 is cross-gradient and probes GWP-120 and GWP-124 are upgradient of the gas holders. Naphthalene is one of the most prevalent PAHs detected in the groundwater, with the highest concentrations detected in samples collected from areas around and downgradient of the gas holders.

Arsenic concentrations ranged from 5.6 µg/L in well MW-01 to 31.4 µg/L in well MW-07. Wells MW-09 and MW-10 did not contain arsenic. Barium ranged from 47.7 µg/L in well MW-10 to 555 µg/L in well MW-02. Chromium ranged from 0.54 µg/L in well MW-06 to 2.7 µg/L in well MW-07. Chromium was not detected in well MW-10. Cadmium and lead were not detected in any samples.

Cyanide concentrations ranged from non-detect in well MW-06 to 1,200 µg/L in well MW-05.

2.5.3 Surface Water

Thirteen surface water samples were collected from 12 locations during the EE/CA investigation. The surface water sample locations are shown in Figure 2-9, and Appendix A contains Table 4-8 from the EE/CA Site Characterization Report presenting the surface water analytical data results. All samples were analyzed for BTEXs, PAHs, arsenic, barium, cadmium, chromium, lead, and cyanide.

No evidence of seepage was observed along the east river bank. The surface water samples were collected prior to sediment sample collection, and no visible signs of contamination were noted at any of the surface water sample locations.

BTEXs were not detected in any of the samples. Four samples (SW-102, SW-103, SW-107, and SW-111) contained a single detection of either benzo(a)anthracene, chrysene, and fluoranthene, each of which were less than 0.05 µg/L. No other PAHs were detected and none of the other samples contained PAHs.

Metals were detected in all of the surface water samples. Total barium was detected at the highest concentrations ranging from 206 to 267 µg/L. Of the remaining metals, concentrations were relatively consistent between samples collected upstream, adjacent to, or downstream of the Site. Average concentrations of the metals were 12.6 µg/L of total arsenic, 218 µg/L of total barium, 0.27 µg/L of total cadmium, 5.7 µg/L of total chromium, and 9.06 µg/L of total lead.

Total cyanide was detected in three samples (SW-101, SW-111, and SW-112) at concentrations ranging from 20 to 37 µg/L. Sample location SW-101 is located downstream of the Site, and locations SW-111 and SW-112 are located upstream. Cyanide was not detected in any of the samples collected adjacent to the Site.

During the 2012 ERA investigation, surface water was collected from six locations co-located with sediment samples from the Big Blue River and from two upstream reference locations determined during field verification. The sample locations are shown on Figure 2-10. Grab samples were

collected from each location. Field parameter measurements were made using a portable multi-parameter meter.

ERA surface water samples were analyzed for hardness, total and dissolved TAL metals, PAHs, and cyanide. Analytical data for the surface water samples collected during the ERA investigation is provided in Appendix A. The surface water sample analytical results are summarized in Table 3-1, and the water quality field measurements are presented in Table 3-2 of the EE/CA ERA Report.

2.5.4 Sediment

Eleven sediment samples were collected from ten locations in the Big Blue River during the EE/CA investigation. Samples were collected upstream, adjacent to, and downstream from the Site. The sediment sample locations are shown on Figure 2-9, and Appendix A contains Table 4-9 from the EE/CA Site Characterization Report presenting the sediment analytical data results. Large gravel/cobble encountered below the river sediment prevented the collection of deep sediment samples, so only shallow samples were collected. Sediment depth ranged from 3 to 8 inches. Visible contamination was observed only during the collection of samples from locations SD-107 and SD-113, which were collected from 0 to 8 inches below the river sediment surface (brss). At both of these locations, tar-coated sediment was observed and tar droplets/oil sheen rose to the water surface following sample collection. No sheen or tar was observed prior to sediment sampling activities. No evidence of visible contamination was observed at any other sediment sample locations.

Overall, with the exception of samples SD-107 and SD-113, BTEX and PAH concentrations are similar at all sample locations, including the most upstream sample SD-111 and the most downstream sample SD-101.

BTEXs were only detected in three sediment samples: SD-105 collected from 0-3 inches brss, SD-107 collected from 0-8 inches brss, and SD-113 collected from 0-8 inches brss. Two of the locations are west of the gas holders and one is southwest. Sample SD-113 contained the highest overall concentrations, with BTEXs totaling 8.9 mg/kg (average of primary and duplicate sample results). Benzene was only detected at two locations with concentrations less than 0.10 mg/kg.

PAHs were detected in all 11 samples, although only acenaphthene, anthracene, chrysene, fluorene, naphthalene, and phenanthrene were detected consistently. Samples SD-107 and SD-113 contained the overall highest concentrations, ranging from 0.405 mg/kg of dibenzo(a,h)anthracene to 102 mg/kg of naphthalene. The remaining samples contained detections several orders of magnitude lower. Sample SD-105 was collected on the east bank of the river, closest to well MW-05, and contained fewer PAHs than sample SD-109, which is located upstream of the Site.

Metals were detected in all of the sediment samples. Total barium was consistently detected at higher concentrations than other metals, with the highest detections found in samples collected from locations furthest up and downstream of the Site. Sample SD-101 contained the overall highest metal concentrations, ranging from 0.33 mg/kg of total cadmium to 207 mg/kg of total barium, and was collected at the farthest downstream location from the Site. The concentration in sample SD-103, which was collected upstream of location SD-101, were almost half the levels in sample SD-101, and ranged from 0.18 mg/kg of total cadmium to 119 mg/kg of total barium.

Total cyanide was detected in all samples, with concentrations ranging between 1.4 and 3.3 mg/kg. Little variability was noted between total cyanide concentrations upstream, adjacent to, or downstream from the Site.

During the 2012 ERA investigation, sediment samples were collected from six stations in the Big Blue River near the site and two stations at a reference area located upstream of the Site. The sample locations are shown on Figure 2-10. These sediment samples were collected for purposes of the 10-day chronic toxicity tests with the amphipod (Hyalella azteca) and sediment analytical chemistry and were co-located with the surface water sample locations.

Sediment samples for purposes of the sediment toxicity tests and analytical chemistry were collected from a depth of 0 to 0.5 foot.

ERA sediment samples were analyzed for PAHs, total organic carbon, and grain size.

Analytical data for the sediment samples collected during the ERA investigation is provided in Appendix A and the analytical results are summarized in Table 3-3 of the EE/CA ERA report.

2.5.5 Pore Water

Sediment pore water samples were collected from the Big Blue River during the 2012 ERA investigation. The objective for pore water sampling was to determine if groundwater from the Site may be discharging into the Big Blue River. Interstitial sediment pore water was also required for analytical chemistry to determine exposure concentrations to aquatic life.

Sediment pore water samples were collected at five locations as shown on Figure 2-10. The pore water sampling locations were determined based on the areas where groundwater from the Site was suspected to discharge into the river.

Sediment samples for purposes of the pore water analytical chemistry were collected from a depth greater than 1.0 foot. Three of the sediment pore water samples (Station 4, 6, and 8) were collected within the bank of the river. These sample stations were in an area of sediment erosion, and sediment samples appropriate for pore water analysis could not be obtained with the Ponar grab sampler. Field personnel dug into the bank using a stainless steel shovel to the soil water interface (water table), and then approximately 1.0 foot into the saturated sediments.

Pore water was extracted in the laboratory by centrifugation. Extracted pore water was analyzed for hardness, BTEXs, PAHs, total and dissolved TAL metals, and cyanide. Analytical data for the pore water samples is provided in Appendix A and the analytical results are summarized in Table 3-5 from the EE/CA ERA Report.

2.6 SUMMARY OF BASELINE RISK ASSESSMENT

The baseline risk assessment completed for the Site included both a human health risk assessment and a screening-level ecological risk assessment (SLERA) (B&V 2013). The purpose of the human health risk assessment was to evaluate the potential risks to current and future receptor populations resulting from exposure to chemicals associated with the Site. The SLERA was performed to evaluate the potential for ecological risk and to identify any data gaps that need to be addressed to characterize ecological risk.

The human health assessment determined that future populations could potentially be exposed to unacceptable risks due to contact with contaminated surface soil and groundwater. Summaries of the potential non-carcinogenic and carcinogenic risks are presented in Tables 2-1 and 2-2, respectively.

Table 2-1 Summary of Non-Carcinogenic Risks

Scenario Timeframe	Receptor Population	Chemicals of Concern (HI>0.1)	Hazard Index
Current	Trespasser	None	0.07
Current/ Future	Adult/Child Receptor (Surface Water)	None	0.0002
	Adult Receptor (Sediment)	None	0.0008
Future	Site Commercial/Industrial Worker (Soil, 0-2 feet)	Arsenic	0.15
	Site Construction/Utility Worker (Soil, 2-10 feet)	None	0.11

Table 2-2 Summary of Cancer Risks

Scenario Timeframe	Receptor Population	Chemicals of Concern (Risk > $1x10^{-6}$)	Carcinogenic Risk
Current	Trespasser	None	1.9×10^{-5}
Current/ Future	Adult/Child Receptor (Surface Water)	Arsenic, Benzo(a)anthracene	8.7×10^{-6}
	Adult Receptor (Sediment)	Benzo(b)fluoranthene, Benzo(g,h,i)perylene	5.0×10^{-6}
Future	Site Commercial/Industrial Worker (Soil, 0-2 feet)	Arsenic, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene	2.1×10^{-3}
	Site Construction/Utility Worker (Soil, 2-10 feet)	Benzo(a)pyrene	6.6×10^{-6}

With the Site currently being unoccupied, the only current exposure pathway between impacted soil and receptor populations is through a trespasser scenario; however, the risk associated with this potential exposure is below a level of concern. Based on some of the use restrictions stipulated in the warranty deed when the City acquired the City Parcel of the Site (property shall remain in public ownership and shall only be used for open-space purposes), no residential or commercial development of the property will be performed. Therefore, the future residential scenario presented in the Risk Evaluation Report is not applicable.

In addition, based on one of the current property deed restrictions (no water wells shall be installed, used, maintained, or renewed on the property), the future installation of wells on the property is not permitted. Comparison of groundwater data with indoor air screening levels indicate a potential for unacceptable risks if chemical constituents were to migrate through the soil

gas and into any future onsite building. However, risk can only occur if the exposure pathway is complete, and no onsite buildings would be built based on the current deed. Therefore, the vapor intrusion pathway is not complete and would not be completed in the future.

The SLERA determined that a potential ecological risk exists at the Site and additional data collection was necessary to fully characterize identified assessment endpoints. The following assessment endpoints were identified:

- The potential risks to insectivorous birds and mammals in the terrestrial riparian habitat. Because this endpoint will be addressed by soil removal activities, no additional ecological investigation of the habitat was determined to be necessary.
- The potential risks to aquatic invertebrate and fish populations in the Big Blue River.
- The potential risks to benthic invertebrate populations in the Big Blue River.
- The potential risks to birds that consume benthic invertebrates in the Big Blue River.

Because any actions necessary to protect bird populations would be driven by the need to protect aquatic and benthic populations, the SLERA recommend that additional ecological investigation focus on the aquatic riverine habitat at the Site, including measuring sediment and surface water toxicity, collecting samples of sediment pore water, and conducting a benthic population evaluation.

2.7 SUMMARY OF ECOLOGICAL RISK ASSESSMENT

A field investigation was conducted in November and December 2012 to collect Site-specific ecological data to address risk questions developed during the SLERA process.

Field activities included collecting surface water, sediment, and pore water samples for chemical analysis and toxicity testing. In addition, benthic macroinvertebrate samples were collected to evaluate community metrics in the river. Sampling stations were established at eight locations adjacent and downstream of the Site and two upstream reference area locations. The results of the ERA identify the following:

- Adverse impacts from the Site to benthic invertebrates are isolated to a small area along the shoreline adjacent to the Site.
- Adverse impacts from the Site to aquatic life are not occurring in the river.
- Results of the detailed food chain modeling indicate there are no potential risks to aquatic mammalian herbivores or aquatic avian benthivores from the Site.
- Concentrations of some MGP-related chemicals appear to be discharging to the river in the immediate vicinity of the Site (along the east bank of the river).

The evidence demonstrates that there are no current risks to the aquatic riverine habitat from the MGP Site. The onsite identified MGP-related impacts are not adversely affecting the quality and ecological habitats of the Big Blue River. However, measures need to be considered that reduce direct exposure to sediment along the shoreline adjacent to the Site. This recommendation is based on the results of the sediment toxicity tests, as well as the assumption that the presence of contamination in the floodplain soil and groundwater will likely result in continued discharges to the river, even after any onsite removal actions are completed.

3.0 Identification of Removal Action Objectives

This section describes the scope and objectives of a removal action for the Site based on EPA EE/CA guidance (EPA 1993). It includes the following information:

- Removal Action Objectives
- Removal Action Scope
- ARARs
- Preliminary Removal Goals (PRGs)
- Removal Action Schedule

3.1 REMOVAL ACTION OBJECTIVES

The specific removal action objectives for each area of concern are as follows:

- Onsite Soil: To appropriately control exposure to MGP residual constituents in soil and to minimize the threat of chemical migration to the surrounding soil, soil gas, and shallow groundwater. Because of the Site's location within a floodway and the light industrial use of the general area, the extent of the removal/treatment area will be based on cleanup to non-residential soil cleanup levels. Additionally, an environmental covenant pursuant to the Nebraska Uniform Environmental Covenants Act will be recorded on the property in conjunction with the use controls on the existing property deed to restrict future development of the Site.
- Groundwater: There is no exposure route between groundwater and potential human receptor populations near the Site due to the lack of private and public wells. The removal action objective will be to prevent migration of MGP-related constituents into the Big Blue River at levels that would pose an ecological risk.
- Sediment: The removal action objective will be to prevent direct exposure to sediment along the shoreline adjacent to the Site. To achieve this objective, stable concentrations in sediment will need to be demonstrated post-removal action.
- Surface Water: There are no removal action objectives for surface water because no adverse impacts to aquatic life in the Big Blue River were identified.
- Vapor Intrusion: There are no removal action objectives for vapor intrusion because no onsite structures are present and there will be no structures on the Site in the future based on the property deed restrictions. Therefore, the vapor intrusion pathway would not be complete.

3.2 REMOVAL ACTION SCOPE

The intent of the removal action is to appropriately control exposure of site workers, recreational users, and adjacent occupants to MGP-related chemicals of concern present in the Site area and to minimize the potential for further migration of impacted groundwater and NAPL. Based on the results presented in Section 2.4, shallow soil (0-2 feet bgs) and groundwater are the primary areas to be addressed. Additionally, measures will be taken to reduce direct exposure to sediment along the shoreline adjacent to the Site.

The groundwater area to be addressed by this removal action is bounded east/west between the eastern site boundary and the river and north/south between monitoring wells MW-08 and MW-06. Outside of this boundary, groundwater probe and/or monitoring well analytical results were near or below detection limits, as discussed in the *EE/CA Site Characterization Report* (B&V 2012a).

3.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The National Oil and Hazardous Substances Pollution Contingency Plan states that a removal action shall, to the extent practicable given the exigencies of the situation, attain ARARs.

EPA's CERCLA Compliance with Other Laws Manual, Parts I and II, Interim Final (EPA 1988, 1989) establishes how requirements of federal and state laws are generally identified and applied to removal actions. ARARs are identified by applying a two-tier test to first determine if the requirement is applicable, and second, if it is not applicable, to determine if it is relevant and appropriate. The guidance provides the following definitions of "applicable" and "relevant and appropriate" requirements:

- Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant or contaminant, removal action, location, or other circumstances at a CERCLA site" (EPA 1988).
- Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental requirements promulgated under federal or state law that, while not 'applicable' to a hazardous substance, pollutant, contaminant, removal action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. However, in some circumstances, a requirement may be relevant but not appropriate for the site-specific situation" (EPA 1988).

The judgment as to the relevance and appropriateness of a requirement can be made on the basis of several factors, including the type of the removal action contemplated, the hazardous substances in question, or the physical characteristics of a site. Only portions of requirements may be relevant and appropriate for a particular removal action; however, any requirement or portion thereof that is determined to be relevant and appropriate must be fulfilled to the same degree as if it were applicable.

There are three types of ARARs. Chemical-specific ARARs establish health or risk-based concentration limits for constituents of concern found in the various environmental media. Action-specific ARARs establish controls on the removal activities that are a part of the removal solution. Location-specific ARARs set limitations on removal activities as a result of the location of the constituents of concern or the location of the activities being considered. Location-specific ARARs can restrict activities performed in wetlands, flood plains, and historical sites.

The universe of potential ARARs and to-be-considered criteria evaluated for the soil and groundwater removal actions (which will also prevent exposure to sediments on the shoreline adjacent to the Site) are presented in Appendix B along with the respective citations. This tabular summary is based in part on the ARARs evaluated for other MGP sites and from information provided by the NDEQ. The overall intent of Appendix B is to remove non-relevant environmental requirements from further consideration by focusing on the type of MGP-related constituents present at the Site, the specific media impacted by those constituents, and the actions that are retained for detailed analysis.

3.4 PRELIMINARY REMOVAL GOALS

PRGs are chemical-specific risk-based cleanup objectives. PRGs were developed directly from the risk equations developed and presented in the *EE/CA Risk Evaluation Report* (B&V 2013a).

3.4.1 Soil

Because the future use of the Site is expected to remain the same as the current use (open/green space), with the possibility of a biking/walking trail constructed along a portion of the property, PRGs were developed for exposure of commercial/industrial workers to shallow soil (0-2 feet). PRGs were developed based on the $1x10^{-6}$ excess cancer risk and a non-cancer hazard index of 1.0. Based on risk, cleanup to meet the future commercial/industrial worker PRGs is actually more protective than PRGs developed for a future trespasser scenario for biking/walking trail use. Exposure assumptions used to determine the PRGs are outlined in Table 3-1. The PRGs for soil chemicals of concern (COCs) are presented in Table 3-2. For chemicals with both carcinogenic and non-carcinogenic effects, the lower value of the two calculated PRGs is used.

Table 3-1 Exposure Assumptions for Calculating Soil PRGs

Exposure Assumption	Commercial/Industrial Worker
Body Weight (kg)	70
Averaging Time (years), carcinogenic	70
Averaging Time (years), non-carcinogenic	25
Exposure Duration (years)	25
Exposure Frequency (days/year)	225
Slope Factor (kg-day/mg)	(1)
Reference Dose (mg/kg-day)	(1)
Ingestion Rate (mg/day)	100
Inhalation Rate (m^3/hour)	20
Particulate Emission Factor (m^3/kg)	$1.4x10^9$
Volatilization Factor (m^3/kg)	(1)
Soil to Skin PAH Adherence Factor (mg/cm^2)	0.2
Surface Area Exposed Skin (cm^2/day)	3,300
Absorption Factor for PAHs	0.13

Note:
(1) Chemical-specific value; refer to the *EE/CA Risk Evaluation Report* (B&V 2013a).

The commercial/industrial worker values were used to determine the extent of impacted material to be addressed between ground surface and 2 feet. Figure 3-1 presents the estimated extent of soil contamination in excess of these criteria. The actual area of soil removal will be field-determined based on the results of confirmation samples collected from the excavation sidewalls.

Table 3-2 PRGs for Soil COCs

Chemical of Concern	Commercial-Industrial Worker PRG (mg/kg)
Arsenic	1.77
Benzene	5.96
Benzo(a)anthracene	2.34
Benzo(a)pyrene	0.234
Benzo(b)fluoranthene	2.34
Dibenzo(a,h)anthracene	0.234
Indeno(1,2,3-cd)pyrene	2.34

3.4.2 Groundwater

PRGs were calculated to be within the acceptable risk of $1x10^{-6}$ and a hazard index of 1.0 for MGP COCs and both child and adult exposures. The exposure assumptions used to determine the PRGs are outlined in Table 3-3. Maximum contaminant levels (MCLs) and PRGs are presented in Table 3-4. For chemicals of concern with a MCL, the MCL will be used as the PRG. For chemicals without an established MCL, the calculated PRG will be used. The PRGs were calculated based on the carcinogenic and non-carcinogenic effects of the overall dermal, ingestion, and inhalation exposure pathways.

Table 3-3 Exposure Assumptions for Calculating Groundwater PRGs

Exposure Assumption	Adult/Child Resident
Adult/Child Body Weight (kg)	70/15
Adult/Child Averaging Time (years), carcinogenic	70
Adult/Child Averaging Time (years), non-carcinogenic	24/6
Adult/Child Exposure Duration (years)	24/6
Adult/Child Exposure Frequency (days/year)	350
Dose Adsorbed per unit area per event (mg/cm^2-event)	(1)
Slope Factor (kg-day/mg)	(1)
Reference Dose (mg/kg-day)	(1)
Adult/Child Ingestion Rate (L/day)	2/1
Adult/Child Event Frequency (event/day)	1
Adult/Child Surface Area (cm^2)	18,000/6,600
Volatilization Factor (L/m^3)	0.5
Adult/Child Inhalation Rate (m^3/day)	20/10

Note:
(1) Chemical-specific value; refer to the *EE/CA Risk Evaluation Report* (B&V 2013a).

Table 3-4 PRGs for Groundwater COCs

Chemical of Concern	EPA MCL (µg/L)	Calculated PRG (µg/L)
Benzene	5	---
Ethylbenzene	700	---
Total Xylenes	10,000	---
Arsenic	10	---
Acenaphthene	--	400
Benzo(a)anthracene	--	0.029
Benzo(a)pyrene	0.2	--
Benzo(b)fluoranthene	--	0.029
Benzo(k)fluoranthene	--	0.29
Chrysene	--	2.9
Dibenzo(a,h)anthracene	--	0.0029
Indeno(1,2,3-cd)pyrene	--	0.029
Naphthalene	--	0.14
Pyrene	--	87

3.5 REMOVAL ACTION SCHEDULE

Depending on which removal alternative is implemented, the implementation time will likely range from 6 to 24 months, not including any ongoing operation and maintenance (O&M) requirements. The completion date of any removal action will be dependent upon the weather and site conditions. The optimum time to complete excavation activities is during the winter months when the cold temperatures reduce chemical volatilization and odors.

4.0 Identification of Removal Action Alternatives

The purpose of this section is to identify potentially applicable technologies by media and the rationale for eliminating some technologies, and carrying selected alternatives on for further development and evaluation.

The methodology used to identify potential removal action technologies and process options, and to develop the selected options into alternatives is per EPA guidance (EPA 1988). Following the screening process, the retained technologies and process options are assembled into removal action alternatives.

4.1 SOIL

The screening of potential technologies and process options applicable to contaminated soil is provided in Appendix B. Based on this screening, the following potential removal action alternatives were identified:

- No Action
- Institutional Controls
- Excavation with Offsite Thermal Desorption
- Excavation with Offsite Disposal
- In Situ Thermal Desorption
- In Situ Chemical Oxidation (ISCO)
- Capping
- In Situ Soil Stabilization (within gas holder)

After further consideration, three alternatives were eliminated from additional evaluation: excavation with offsite thermal desorption, in situ thermal desorption, and ISCO. These alternatives were eliminated based on the relatively low volume of soil and contaminant concentrations that are required to be removed/treated. These alternatives would not be cost effective compared to the other available options and would likely require additional time to complete.

4.2 SEDIMENT

Based on the ERA results, options will be considered that reduce direct exposure to sediment along the shoreline. Potential measures to be considered include:

- No Action
- Long-Term Monitoring
- Non-Reactive Capping
- Reactive Capping
- Excavation/Dredging

The excavation/dredging alternative was eliminated from further consideration due to the potential for creating more contamination in the river if sediment contaminants are released during removal.

4.3 GROUNDWATER/NAPL

The screening of potential technologies and process options applicable to groundwater is provided in Appendix B. Based on this screening, the following potential removal action alternatives were identified:

- No Action
- Institutional Controls
- Groundwater Monitoring
- ISCO
- Permeable Reactive Barrier (PRB)
- Extraction/Treatment
- Barrier System
- Self–sustaining Treatment for Active Remediation (STAR)
- Direct Recovery of NAPL

After further consideration, the extraction/treatment alternative was eliminated from further development and evaluation based on the presence of the river. It is likely that a groundwater extraction/treatment system would pull in additional water from the river, which would require an impracticable volume to be removed/treated.

5.0 Removal Action Alternative Development and Evaluation

In this section, conceptual designs of the soil, groundwater, and sediment alternatives are presented and the alternatives are compared on the basis of effectiveness, implementability, and cost.

5.1 SOIL ALTERNATIVES

This section presents descriptions and evaluates alternatives to meet the removal action objectives presented in Section 3.1, based on the data collected during Site investigations to delineate the extent of contaminated soil.

5.1.1 Description of Soil Alternatives

The alternatives address soil with levels of COCs exceeding the PRGs presented in Section 3.0. Figure 3-1 presents the estimated extent of excavation/treatment to be protective of a future commercial/industrial worker from shallow soil (0-2 feet). According to the City, the future use of the property will be open/green space only, with the possibility of a biking/walking trail constructed along a portion of the property. Based on risk, cleanup to meet the future commercial/industrial worker PRGs is actually more protective than PRGs developed for a future trespasser/pedestrian scenario for biking/walking trail use.

Although there is no unacceptable risk associated with soil below 2 feet, there is a potential for the walls of the belowground gas holder to shift in the subsurface, causing impacts to the grading on the surface in the form of a sinkhole. Alternatives to address the belowground gas holder will also be evaluated, although the selection will not be based on risk associated with the soil below 2 feet.

For all alternatives, it has been determined that the future use of the Site will be non-residential and that the property will only be used for open-space purposes. This use will be maintained by establishing, as necessary, additional environmental use restrictions on the property besides the restrictions already established in the existing property deed.

To evaluate removal action alternatives, the volume of impacted soil was estimated based on samples exceeding the PRGs. For purposes of developing alternative costs, cleanup to meet PRGs for individual COCs at a $1x10^{-6}$ risk level was assumed.

5.1.1.1 Soil Alternative A – No Action. The no action alternative is a baseline against which the effectiveness of the other alternatives is evaluated. Under this alternative, no removal actions would be performed to address soil contamination.

5.1.1.2 Soil Alternative B – Institutional Controls. Institutional or environmental use controls are generally considered to administratively prevent public exposure. Under this alternative, an environmental use control would be placed on the property in addition to the use restrictions already in place on the existing property deed. These controls would limit excavation and restrict future use. These restrictions would be designed to prohibit future use scenarios which could result in an unacceptable level of exposure to soil contaminants.

5.1.1.3 Soil Alternative C – Excavation and Offsite Disposal. This alternative consists of two scenarios. The first scenario consists of excavating shallow contaminated soil and disposing the material in an approved landfill. The material in the belowground gas holder remains undisturbed in this scenario. Soil volume calculations are included in Table C-1.1 of Appendix C. Excavation to a 2-foot depth was considered across the area shown on Figure 3-1. This results in an excavation volume of approximately 2,800 cubic yards (4,200 tons).

The second scenario consists of excavating the material in the belowground gas holder in addition to the shallow contaminated soil, with excavation of the gas holder contents to approximately 21 feet. This results in an excavation volume of approximately 4,800 cubic yards (7,200 tons).

In both scenarios, if highly contaminated material is encountered, it will be mixed with less contaminated soil to improve handling characteristics and to eliminate any free liquids before transportation to an approved landfill for disposal. The Waste Connections G&P Landfill, located approximately 60 miles northwest of Beatrice near Milford, NE, is the closest landfill acceptable for disposal of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) offsite waste material.

Excavation would be completed in the areas shown on Figure 3-1, and then confirmation samples would be collected from the shallow excavation sidewalls to determine if contaminant concentrations in the surrounding soil meet the PRGs. If sampling shows that soil concentrations are above the PRGs, additional excavation would be completed where possible and as necessary to achieve the PRGs.

The belowground gas holder is suspected to have a competent base. During investigation, the water level within the walls of the structure was higher than in the soil surrounding the structure, indicating that water and possibly heavily contaminated MGP residuals may be contained within the structure. The gas holder is also suspected to be filled with brick, concrete, and other debris based on the presence of brick/rubble in the soil probe advanced into the structure during the EE/CA investigation. This probe did not provide much evidence of highly-concentrated MGP residuals.

Air monitoring would be completed during the excavation and loading of material to ensure that the levels of airborne contaminants do not exceed applicable action levels. Air monitoring would also be conducted for the protection of removal action workers. To the extent possible, excavation would be conducted during the winter months, when the colder temperatures should greatly reduce the volatility of COCs. Dust controls, such as water and foam spray, would also be used as required to minimize emissions and odors from the excavation and any stockpile areas.

As needed, berms and sumps would be used around the excavation and any stockpile areas to control surface water run-on and run-off. In addition, any stockpiled material would be covered with plastic tarps as needed to alleviate run-off or contact with contaminated spoils. Temporary construction fencing would be erected around the excavation and operations area to restrict access.

Accumulated rainwater, water used for decontamination, and any water collected during excavation dewatering, if required, would be treated, sampled, and discharged to the local sanitary sewer system. Because it is not intended that the excavation extend below the water table, dewatering is not expected to be necessary unless the gas holder structure is excavated. A pretreatment and discharge agreement would be set up with the City to discharge treated water.

After the removal action objectives are achieved, the excavated areas will be backfilled with clean fill material to within 2 feet of final grade. The remaining 2 feet would be backfilled using low-permeability clay-rich soil and seeded.

It is estimated that the excavation, disposal, and backfilling would be completed within 6 to 8 weeks.

5.1.1.4 Soil Alternative D – Capping. This alternative involves placing a multi-layer cover over the majority of the Site area without any contaminated soil excavation. Capping material estimates are included in Table C-1.1 of Appendix C. A cap would not destroy or remove contaminants. Instead, it would isolate the contaminants and keep them in place to avoid the spread of contamination. A cap would also prevent people or wildlife from coming in contact with contaminants.

Because the future use of the Site would be as an open/green space, the cap would be constructed as a layered system consisting of a vegetative cover, natural soil, sand, and clay instead of asphalt or concrete. The potential future use of the property is already restricted based on an existing deed restriction that prevents residential or commercial development.

Since contaminants have already migrated to the groundwater, a cap would isolate and prevent the spread of contamination by keeping storm water run-off from carrying contaminated material offsite or into the river, preventing wind from blowing contaminated material off Site, control the release of volatiles, and keep people and wildlife from coming into contact with contaminated material and tracking contaminants off site.

This alternative would involve long-term inspection and operation and maintenance (O&M) of the cap.

5.1.1.5 Soil Alternative E – In Situ Soil Stabilization. This alternative involves using soil mixing technology to blend impacted material in the belowground gas holder structure with Portland cement and/or other admixtures to immobilize contaminants and solidify the contents. Shallow soil across the Site would not be stabilized. Soil volume calculations are included in Table C-1.1 of Appendix C. Air monitoring and site restoration considerations are similar to that of excavation. Before implementation, a treatability evaluation of the materials within the gas holder would be required to select a mix design.

Stabilization chemically immobilizes hazardous materials or reduces their solubility through a chemical reaction. It is assumed that all material within the gas holder would be stabilized, which results in a treatment volume of approximately 1,990 yd^3. However, depending on the extent and nature of rubble in the holder compared to MGP residuals, it

may not be practicable to stabilize all of this material but, rather, dispose of it in a landfill able to accept construction debris.

5.1.2 Evaluation of Soil Alternatives

In this subsection, the five alternatives for addressing onsite soil contamination are evaluated on the basis of effectiveness, implementability, and cost.

These criteria are defined in EE/CA guidance (EPA 1993) as follows:

Effectiveness refers to the ability of each alternative to protect human health and the environment, and the ability of the alternative to meet the removal action objectives. The two major factors that influence the effectiveness are the protectiveness of the alternative, and its ability to reduce the toxicity, mobility, and volume of the contaminants.

Implementability refers to both technical and administrative (or institutional) feasibility. The technical implementability of an alternative is the feasibility of physically constructing, operating, and maintaining the removal action alternative at a site. Administrative implementability refers to the ability to obtain regulatory approval necessary to employ the alternative, community acceptance, and the availability of the materials and services needed to successfully use the alternative.

Costs of each removal action alternative are estimated as part of the EE/CA. For alternatives that will last longer than 12 months, both capital and annual costs are estimated so the present worth of the alternative can be calculated.

5.1.2.1 Effectiveness. The no action alternative would not be protective of human health and the environment. Although the property already has several use restrictions placed on the existing deed, establishing additional environmental use controls may further limit the potential for exposure to human populations by preventing contact with soil contamination, and would be recorded as a separate document but part of the property deed. However, institutional controls do not address the contamination directly and achieve no reduction in the toxicity, mobility, or volume of contaminants. Therefore, institutional controls alone would not meet the removal action objectives.

Excavation is a highly effective method of addressing contaminated soil. Removal of soil exceeding PRGs would result in removing all or most MGP-impacted material from the Site, which protects both human health and the environment. Residual levels of PAHs in soil would be low and exposure easily restricted through institutional controls. During excavation, visual evaluation of the extent of contamination would ensure that contaminated materials are removed and soil sampling would verify that the PRGs have been met. Landfill disposal of excavated material would meet the removal action objectives by removing material posing an exposure concern to populations on or adjacent to the Site. While landfill disposal indirectly reduces the mobility of contaminants through placement in a regulated and maintained facility, there is a potential for future release of contaminants. However, landfills are equipped with controls and are monitored and maintained to ensure integrity and to manage leachate generated from landfill operations.

Capping is an effective method of preventing the offsite migration of shallow contaminated soils, although none of the contaminated soil would be removed or treated. The purpose of capping is to prevent surface water from infiltrating the surface and subsurface soil at the Site, and to prevent surface water from coming into contact with contaminated soil with subsequent offsite run-off to adjacent properties and the river. Flood waters from the river could also affect the integrity of the cap over the long-term.

In situ soil stabilization has been shown to be effective in immobilizing MGP contaminants, thereby protecting both human health and the environment from exposure to contaminants leaching into the groundwater as well as reducing the potential for direct exposure to contaminants. By reducing the mobility of contaminants, this alternative would meet the removal action objectives. However, implementation actually increases the volume of impacted material, some of which would require landfill disposal. Chemical analysis of stabilized material would likely indicate reduced contaminant concentrations; however, this decrease in concentration is the result of reduced availability rather than contaminant destruction. While the long-term permanence of in situ stabilization of MGP-contaminated material is unknown, effective stabilization of MGP contamination has been documented as part of a 10-year study (EPRI 2003). Further evidence of this persistence is based on the durability of concrete structures, which have lasted for centuries. The inclusion of cement into the soil matrix would make future excavation more difficult, and could restrict future use of the Site.

5.1.2.2 Implementability. The alternatives involving soil removal or capping would require clearing/grubbing of portions of the Site. It is estimated that these activities would add 2 to 3 weeks to the project duration, but not otherwise affect the implementability of an alternative. Seasonal conditions like temperature and precipitation would affect elements of each alternative, such as air monitoring or management of water and spoils.

All of the alternatives have been demonstrated at MGP sites as technically feasible, although significant debris that may be present in the gas holder structure would make implementation of in situ stabilization of the gas holder contents difficult or impractical. Excavation, capping, and in situ soil stabilization would require the mobilization of heavy equipment to the Site. Excavation would also require the procurement of backfill material. In addition, equipment to dewater the gas holder excavation and contain and treat wastewater may be needed. These items and the techniques applied are reasonably available from numerous suppliers.

The excavation, capping, and in situ stabilization alternatives would result in increases in truck traffic and noise associated with heavy equipment operations. Coordination with adjacent property owners would be required to address concerns and adjust work schedules accordingly. However, the duration of these alternatives would be relatively short.

5.1.2.3 Cost. The costs for each of the soil removal action alternatives are presented below and are based on the conceptual design presented in Section 5.1.1. The capital costs include both direct and indirect costs. No post-removal site control (PRSC) costs, such as O&M, are

applicable to the soil alternatives except for capping. The tables referenced below are presented in Appendix C.

Soil Alternative A - No Action. There is no capital cost associated with this alternative.

Soil Alternative B - Institutional Controls. The cost associated with implementing this alternative is estimated to be $50,000.

Soil Alternative C1 - Excavation and Offsite Disposal of Shallow Soil. The cost associated with implementing this alternative is presented in Table C-2.1. The capital cost is approximately $750,000.

Soil Alternative C2 - Excavation and Offsite Disposal of Shallow Soil and Gas Holder Material. The cost associated with implementing this alternative is presented in Table C-2.2. The capital cost is approximately $1,110,000.

Soil Alternative D - Capping. The cost associated with implementing this alternative is presented in Table C-2.3. The capital and O&M costs for a period of 20 years are approximately $950,000.

Soil Alternative E - In Situ Stabilization of Gas Holder Material. The cost associated with implementing this alternative is presented in Table C-2.4. The capital cost is approximately $880,000.

5.2 SEDIMENT ALTERNATIVES

This section presents a description and evaluation of the removal action alternatives addressing the sediment along the shoreline adjacent to the Site.

5.2.1 Description of Sediment Alternatives

The alternatives address sediment along the Site shoreline with removal action objectives presented in Section 3.1.

5.2.1.1 Sediment Alternative A – No Action. The no action alternative is a baseline against which the effectiveness of the other alternatives is evaluated. Under this alternative, no removal action would be performed to address sediment contamination.

5.2.1.2 Sediment Alternative B – Sediment Monitoring. This alternative would consist of the periodic monitoring and evaluation of sediment conditions for at least 10 years as the PRSC to address long-term sediment contamination concerns.

Monitoring would involve routinely collecting sediment and pore water samples and submitting them for chemical analysis of COCs. Sediment and pore water monitoring would not begin until after completion of any onsite soil removal action. Annual sampling, evaluation, and reporting of the data would be completed for the 10-year monitoring period, including a statistical evaluation of concentration trends. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding sediment in connection with the MGP Site following the 10-year monitoring period.

5.2.1.3 Sediment Alternative C – Non-reactive Capping. This alternative would consist of the use of a non-reactive barrier such as AquaBlok® designed to contain and isolate contamination in subaqueous sediments in predominantly non-terrestrial settings. The material is generally applied as a dry product through the water column to the surface of contaminated subaqueous sediments and hydrates to form a continuous and impermeable isolation cap.

Because of the steep river bank in this area, the material would be placed from within the river. Temporary dams would be required in the river to divert water around the operating area. The dams would extend from the shoreline out to the island in the Big Blue River on both upstream and downstream ends. It is estimated that the total length of application would be the length of the river bank adjacent to the Site (approximately 360 feet) with a width of 50 feet, and that an approximate quantity of 270 tons of material would be required for a cap thickness of 2-inches. A 12-inch layer of coarse sand/gravel would be placed over the capping material for added protection against flooding/increased flow rates and ice scouring, followed by a layer of rip-rap/cobbles and shotcrete.

Periodic inspection of the cap would be required to ensure that the cover layer remained in place. Sediment monitoring would also be conducted to verify that exposure to benthic invertebrates is being effectively controlled by the cap. Annual sampling, evaluation, and reporting of the data would be completed for the 10-year monitoring period. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding sediment in connection with the MGP Site following the 10-year monitoring period.

5.2.1.4 Sediment Alternative D – Reactive Capping. This alternative would consist of the use of permeable, treatment/adsorptive materials (such as AquaGate®) as a means to remove contamination from pore water and/or reduce potential of contaminant break-through. These materials can be used in a reactive cap, for in-situ treatment, or in a range of other applications to control contaminant migration. Powdered organoclay could be used as part of the AquaGate® system to form a reactive permeable barrier layer. The material can be handled and placed in bulk either alone or in combination with other granular materials (i.e., sand, gravel) to achieve uniform distribution of the adsorptive material. Organoclays are able to mitigate the movement of a wide range of hydrocarbon-based contaminants.

As with the non-reactive capping alternative, the material would be placed from within the river with the use of temporary dams to divert water around the operating area. The reactive capping material would be applied over a limited length of the river bank to isolate the area of impacted sediment at sample locations SD-107 and SD-113. A 12-inch layer of coarse sand/gravel would be placed over the barrier for added protection of the reactive material against flooding/increased flow rates and ice scouring, followed by a layer of rip-rap/cobbles and shotcrete. As necessary to provide continuity, rip-rap material and shotcrete may also be placed on either end of the capped portion of the river bank.

Periodic inspection of the cap would be required to ensure that the cover layer remained in place. Sediment monitoring would also be conducted to verify that exposure to benthic invertebrates is being effectively controlled by the cap. Annual sampling, evaluation, and reporting of the data would be completed for the 10-year monitoring period. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding sediment in connection with the MGP Site following the 10-year monitoring period.

5.2.2 Evaluation of Sediment Alternatives

In this subsection, the alternatives for addressing sediment are evaluated on the basis of effectiveness, implementability, and cost.

5.2.2.1 Effectiveness. The no action alternative would not be protective of human health and the environment.

Sediment monitoring would not reduce contaminant toxicity, mobility, or mass because it merely permits observation of the changes in COC concentrations over time. However, monitoring is relatively inexpensive and would confirm whether the contaminants are stable and not migrating or migrating further into the river.

The advantages of a non-reactive capping material such as AquaBlok® include low permeability and transmissivity and a high degree of cohesiveness and cap uniformity. The cohesiveness provides higher resistance to physical erosion and higher contaminant attenuation capacities.

Reactive capping provides a means for treatment of contaminants in the sediment that are in contact with the cap.

5.2.2.2 Implementability. Although both reactive and non-reactive capping are relatively easy to implement and can reduce exposure to sediment contaminants, significant disturbance of the cap material could result in re-exposure of sediment contaminants. Both capping alternatives would require the removal of some concrete debris and large rip-rap from specific areas to provide a uniform subbase, although the removal would be fairly straightforward to perform if the temporary dams are effective in diverting water around the operations area. Both capping alternatives would also require the use of a gravel/sand cover on top of the cap material to provide additional protection. O&M may be higher for the reactive cap, especially if replacement of the reactive material is required.

All of the alternatives have been demonstrated at MGP sites as technically feasible. Seasonal conditions like temperature, precipitation, and flow conditions in the river would affect elements of the capping and monitoring alternatives, such as access and safety. Working in a river for construction of the sediment barrier would be moderately difficult considering the erection of temporary barriers to divert flow around the operations area, and mobilizing/staging equipment and supplies at the work area. Sediment capping alternatives would also require coordination with the City and the U.S. Army Corps of Engineers during design and installation.

5.2.2.3 Cost. The costs for each of the sediment removal action alternatives are presented below and are based on the conceptual design presented in Section 5.2.1. The capital costs include both direct and indirect costs. The tables referenced below are presented in Appendix C.

Sediment Alternative A – No Action. There is no capital cost associated with this alternative.

Sediment Alternative B – Sediment Monitoring. The cost associated with implementing this alternative is presented in Table C-3.1. The PRSC cost is approximately $211,000 for a 10-year period.

Sediment Alternative C – Non-reactive Capping. The cost associated with implementing this alternative is presented in Table C-3.2. The capital and PRSC costs for annual sediment monitoring and cap O&M for a period of 10 years is approximately $1,040,000.

Sediment Alternative D – Reactive Capping. The cost associated with implementing this alternative is presented in Table C-3.3. The capital and PRSC costs for annual sediment monitoring and cap O&M is approximately $830,000.

5.3 GROUNDWATER/NAPL ALTERNATIVES

This section presents a description and evaluation of the removal action alternatives addressing the groundwater and NAPL contamination.

5.3.1 Description of Groundwater/NAPL Alternatives

DNAPL was observed in the area west and southwest of the belowground gas holder (horizontal extent of approximately 160 feet) as shown on Figure 2-8. The area impacted by DNAPL is estimated to be approximately 17,000 square feet. As shown on Figure 2-8, LNAPL was observed over a larger portion of the Site. The area impacted by LNAPL is estimated to be approximately 38,000 square feet. As discussed in Section 2.0, the most heavily-impacted area appears to be within the Site boundary around the belowground gas holder. While the DNAPL plume is associated with historical MGP operations, the source of the LNAPL appears to be the bulk oil storage facilities historically located upgradient of the MGP Site.

Alternatives include scenarios that incorporate actions to address only MGP-impacted areas, as well as both LNAPL and DNAPL-impacted areas since the plumes are co-mingled.

Unless removal action objectives are met sooner, it is assumed that the duration of any action is 10 years. At the end of this period, an evaluation of the status of COCs within the groundwater plume will be made. If it can be demonstrated that the plume is either stable or decreasing, groundwater remediation will be considered complete.

5.3.1.1 Groundwater Alternative A – No Action. The no action alternative is a baseline against which the effectiveness of the other alternatives is evaluated. Under this alternative, no removal actions would be performed to address groundwater or DNAPL/LNAPL.

5.3.1.2 Groundwater Alternative B – Groundwater Monitoring. This alternative would consist of the periodic monitoring and evaluation of groundwater conditions for at least 10 years as the PRSC to address long-term groundwater contamination concerns. Although the Big Blue River is a potential receptor of groundwater from the Site, there are no direct groundwater receptors on or near the Site. Therefore, the objective of the monitoring would be to ensure that the contaminant plume remains stable or decreases in size and does not impact the river.

Groundwater monitoring would involve routinely collecting samples from wells within the existing monitoring network and submitting them for chemical analysis of COCs. Results from samples collected during the EE/CA site characterization indicate that the highest MGP-related contaminant concentrations in the groundwater were detected on Site near the gas holders and that detections decrease downgradient/west of the gas holders, toward the river. Monitoring would be conducted immediately upgradient of the Site, on Site, and at the side and downgradient extents of the DNAPL, LNAPL, and DNAPL/LNAPL mixture plumes to monitor the horizontal and vertical distribution of COCs.

Groundwater monitoring would not begin until after completion of any onsite soil removal action. Quarterly monitoring would be completed for two years to distinguish trends associated with seasonal variation and to document the impact of a soil removal action on groundwater conditions. Thereafter, annual sampling would be conducted for the remainder of the 10-year monitoring period. Annual evaluation and reporting of the data would be completed, including a statistical evaluation of concentration trends.

Compliance with the removal action objective of demonstrating plume stability would be achieved by monitoring groundwater conditions at wells MW-02, MW-03, MW-04, and MW-05. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding groundwater in connection with the MGP Site if after the 10-year monitoring period the contaminant plume is either stable and/or decreasing.

5.3.1.3 Groundwater Alternative C – In Situ Treatment. In situ treatment technologies would potentially be applicable for DNAPL, LNAPL, and groundwater. In situ treatment of the DNAPL and LNAPL may eliminate or significantly reduce the levels of dissolved-phase contamination and, therefore, prevent further migration. The in situ technologies selected for evaluation include in situ chemical oxidation (ISCO) and in situ geochemical stabilization (ISGS).

ISCO would involve injecting a chemical oxidant into the subsurface to treat and reduce the groundwater and NAPL contaminant mass. An oxidant would be injected into the impacted areas using direct-push probing equipment or through injection wells in a pattern to allow the chemical to migrate through the subsurface in a radial configuration. Two ISCO treatment scenarios were considered–full-scale treatment across the entire Site (addressing both DNAPL and LNAPL impacted areas), and partial treatment of the more highly contaminated area west/southwest of the belowground gas holder.

The oxidation reaction occurs wherever there is contact between the chemical and organic contaminants. The oxidation of an organic contaminant theoretically results in a reduction to carbon dioxide and water. As the dissolved fraction of the contaminant mass is oxidized, more contaminants are drawn into solution from the solid and free product phases and similarly destroyed. An effective oxidant is one that either aggressively draws contaminants into solution for destruction or persists in the subsurface long enough to allow sufficient desorption of contaminants from the soil matrix to solution. In either case, the measure of an effective oxidant is the percent reduction of the contaminant mass per application. This would first be determined in a laboratory bench test and then confirmed in the field through soil sampling. Common oxidizing agents include ozone, hydrogen peroxide, potassium permanganate, persulfate, and Fenton's reagent (hydrogen peroxide and iron).

The key to effective ISCO implementation is to achieve contact between the ISCO reagent (oxidant) and the contaminated material. Because rebounding of chemical concentrations in groundwater is possible after injection, multiple injection events may be required to meet removal action objectives.

ISGS uses a modified permanganate solution formulated for contaminants commonly associated with MGP sites, refineries, and wood treatment facilities. The ISGS alternative would be implemented by injecting the solution into the subsurface in the more highly contaminated DNAPL-impacted area west/southwest of the belowground gas holder using direct-push technology. The treatment is designed to immobilize DNAPL by creating a "crust" around the DNAPL surface, reducing the permeability of the soil and the dissolution of contaminants into the ground water. Adventus Americas, Inc. estimates that crust life is up to 400 years and that less oxidant is generally needed when using ISGS compared with ISCO due to the rapid rate of encrustation, which results in less time and material cost.

Groundwater monitoring would be conducted before, during, and after implementation of either technology to assess the success of the technology in treating DNAPL or LNAPL and the contaminated groundwater. Monitoring before injection would establish baseline conditions, while monitoring during implementation would determine effectiveness and allow adjustments to be made to maximize treatment. In addition, groundwater monitoring would be conducted as outlined for Alternative C to verify that treatment objectives have been met and to monitor for rebounding of chemical concentrations.

For purposes of developing cost estimates, it was assumed that ISCO implementation would involve a combination of hydrogen peroxide and ozone injection through 30 injection wells with 10 vapor extraction wells (full-scale treatment for both DNAPL/LNAPL plumes) and 12 injection wells with 4 vapor extraction wells (partial treatment for DNAPL plume). Costs were developed for one and two year treatment periods. The second year was evaluated as a contingency based on if there is a rebound in contaminant concentrations after the initial treatment which would require additional treatment or if additional time is required for the oxidants to degrade the contaminants.

For ISGS, it was assumed that a series of injection probes would be installed in a grid pattern over an approximate 8,100 square foot area in the southwest corner of the Site accessible to probing equipment.

5.3.1.4 Groundwater Alternative D – Permeable Reactive Barrier. This alternative would involve installing a PRB, which consists of reactive materials through which a dissolved contaminant plume would pass through and be treated in situ under natural gradient. The PRB would consist of a 'funnel' type impermeable barrier wall with a permeable 'gate' that contains treatment media. The 'funnel' directs the groundwater through the 'gate' for treatment. Two types of gates are evaluated – a trenched gate backfilled with reactive media (e.g., activated carbon with peat moss) and a gate consisting of a line of seven permanent ISCO injection wells. The entire length of the PRB would be approximately 300 feet to span across the entire width of the dissolved-phase contamination, with 100 feet of impermeable side curtains on each end of the gate to direct the water into the gate. The wall would be approximately 3 feet thick and extend approximately 25 feet deep and be keyed into the bedrock.

The PRB would be installed in an approximately north-south alignment perpendicular to the groundwater flow direction. The PRB would extend from a point approximately 30 feet north of monitoring well MW-01 and 40 feet west of the former chemical laboratory and run along the western portion of the Site to a point approximately 60 feet east of the southwest corner of the MGP Site boundary. Due to the presence of dense vegetation and/or steep terrain in this area, the exact location would depend on accessibility and practicality. The majority of material displaced during installation would likely be disposed of in a landfill based on historical concentrations of contaminants in soil. Dewatering and water treatment would likely be required during construction of the PRB.

To monitor the PRB's effectiveness, upgradient, downgradient, and side gradient wells would be sampled. Wells immediately upgradient of the gate would establish baseline conditions. Monitoring side gradient wells would determine if the plume is following its natural gradient as it flowed through the PRB or is being deflected and moving around it. Downgradient wells would indicate how effective the reactive media was in treating groundwater contaminants.

For this alternative, O&M costs and assumptions would include replacement or reinjection of the treatment media in the gate portion of the PRB due to the presence of DNAPL. Treatment media replacement from a trench system could be accomplished by vacuuming out the spent media using aboveground pumps or excavating the material. However, dewatering the gate and water treatment would likely be necessary so fresh media could be placed in the gate.

5.3.1.5 Groundwater Alternative E – Self Sustaining Treatment for Active Remediation (STAR). The STAR process would involve the insertion of one or more heating elements into the target treatment zone in the area southwest of the belowground gas holder. A short duration input of high energy is then applied to heat the DNAPL adjacent to the heating element to the target ignition temperature. Once this temperature is attained (typically

between 200 and 400 °C), air is injected through vent pipes inserted into the treatment area to ignite the DNAPL. The DNAPL combusts, releasing heat energy which is retained by the porous medium and used to pre-heat DNAPL material farther away from the ignition point. At this stage, the heating element can be turned off, and as long as sufficient air is supplied, the combustion process will continue, propagating away from the air injection point and destroying DNAPL material in contact with the combustion zone. In addition to the targeted DNAPL-impacted material in the area downgradient of the gas holder, the STAR process may also residually treat the surrounding LNAPL material.

5.3.1.6 Groundwater Alternative F – DNAPL Recovery. This alternative would involve the installation of an extraction/recovery system on the downgradient edge of the MGP Site to address DNAPL. For DNAPL extraction, the system would involve placing extraction wells to collect DNAPL migrating along the bedrock surface and conducting pump tests to determine the amount of product that could potentially be recovered from a well. Removal of DNAPL from the wells could create an induced gradient that should theoretically cause the flowable mass around the well to move into it. The wells could be equipped with permanent submersible pumps with finger heaters to heat the subsurface at the well to facilitate, and possibly, accelerate the flow of DNAPL.

Assuming four extraction wells are installed in the southwest corner of the Site where DNAPL impacts are known, one enclosure could be constructed between the wells to house the extraction recovery system. DNAPL storage containers would be located inside the enclosure, and the extraction system programmed to pump intermittently to minimize the recovery of water. Underground piping/conduits from the wells to the enclosure would be installed, and recovered DNAPL would be periodically collected and transported to an offsite facility for treatment or energy recovery. The extraction wells would be strategically placed at low points in the bedrock near the downgradient edge of the DNAPL plume to take advantage of natural DNAPL flow gradients.

Previous measurements at the Site indicate that the potential is low for any significant product to be recoverable, and the majority of the subsurface geology beneath the Site is composed of fill and cohesive material which tends to restrict the flow of DNAPL; therefore, the amount of recoverable DNAPL is assumed to be relatively low (<50 gallons/well/year).

5.3.1.7 Groundwater Alternative G – Barrier System. Physical barriers used to prevent the flow of groundwater include slurry walls and grout curtains, and may be used to contain contaminated groundwater or prevent the flow of clean groundwater into a zone of contamination. A barrier that completely encircles a contaminated region will provide better containment than a straight barrier, because groundwater can flow around the ends of a straight-line barrier. The more impermeable barriers (such as slurry walls or grout curtains) are typically used along with other remedial alternatives such as an extraction and treatment system for improved hydraulic control across the slurry wall/grout curtain. Therefore, these technologies will not be considered for further development.

However, a containment barrier constructed of ISGS-injections could be created to form a zone of reduced permeability around the NAPL plume that would not require groundwater

extraction/treatment. The ISGS zone would be used to both trap NAPL within the injected perimeter and to effectively introduce a low permeability barrier around the remaining untreated NAPL material. The ISGS barrier would be installed over a 20-foot wide strip consisting of a series of two probes at 10-foot intervals along the treatment strip. The total length of a perimeter barrier around the Site is estimated to be 950 feet and would extend to the bedrock surface (20 to 25 feet bgs).

5.3.2 Evaluation of Groundwater/NAPL Alternatives

In this subsection, the alternatives for addressing groundwater are evaluated on the basis of effectiveness, implementability, and cost.

5.3.2.1 Effectiveness. The no action alternative would not be protective of human health and the environment. Groundwater monitoring also does not reduce contaminant toxicity, mobility, or mass-it provides indication of the changes in COC concentrations over time. However, monitoring would confirm whether the plume is stable and not migrating or continuing to migrate toward the river. In addition, there are no direct receptors to groundwater impacts since a deed restriction is already in place that prevents installation of wells on the City property.

ISCO has been demonstrated to reduce contaminant mass associated with both dissolved-phase and DNAPL/LNAPL plumes. Bench-scale and pilot testing would likely be required to determine if the groundwater and soil chemistry is conducive for ISCO, as well as determine well spacing, appropriate chemical oxidants, and treatment duration. Effectiveness is determined by monitoring the groundwater contaminant plume over time. Long-term monitoring is necessary because rebound in chemical concentrations after stopping injection is not uncommon with ISCO. This could be the result of not completely surrounding the target area, desorption of additional chemicals from the DNAPL/LNAPL mass, or an insufficient treatment period. While ISCO could be implemented to treat the entire mass of contaminants, it is difficult to ensure that all residual DNAPL/LNAPL has been addressed and that chemicals do not become soluble and contribute to the dissolved-phase groundwater contaminant plume.

If injection points cannot be installed within 10 to 15 feet of DNAPL/LNAPL because of obstructions, the effectiveness of ISCO in treating the entire plume would likely decrease and DNAPL/LNAPL would continue to be a long-term source of dissolved-phase contamination and likely result in rebounding of chemical concentrations.

Some ISCO technologies, such as Fenton's reagent which creates an exothermic reaction, can result in increased chemical concentrations during the first stages of treatment. Because of the injection pressures, this could result in a temporary expansion of the groundwater plume before treatment is accomplished. Because of the proximity of the river, this could adversely impact the river unless actions are taken to mitigate the issue.

Because of difficulties in surrounding the contaminant mass and rebounding, more than one application period is often required to remediate a plume.

If complete contact with the contaminant plume can be achieved, ISCO would likely meet the removal action objectives. Achieving this contact is complicated by limited access on steep and heavily vegetated terrain at the Site. However, if the most heavily-impacted areas can be successfully treated, there should be significantly less residual DNAPL in the subsurface and the extent of the dissolved-phase contaminant plume should correspondingly decrease.

With the ISGS approach, rather than treating the entire mass of contamination, reagents are injected to create a barrier "crust" around the residual DNAPL. If successful, a decrease in the overall mass flux of chemicals released to groundwater should be achieved. If the DNAPL plume can be completely encapsulated, ISGS would meet all of the remedial action objectives to a greater extent than extraction technologies. However, if the contaminant mass cannot be completely encapsulated, the DNAPL mass would continue to be a long-term source of dissolved-phase contamination. As with ISCO, bench and pilot scale testing would likely be required to determine if the technology is truly implementable at the site and to design a full-scale application.

Trenched PRBs are effective in treating dissolved-phase contamination; however, this technology would not be effective in treating DNAPL. In addition, there is the potential that DNAPL material may accumulate in the treatment media and reduce the PRB's permeability and, thus, its effectiveness. Precipitants formed during the treatment process can also reduce the PRB's permeability. The PRB material would have to be monitored to verify that the material's capacity to treat the contaminants has not been expended. The material may also have to be periodically replaced. In addition, any contaminated residuals beyond where the PRB is installed would continue to be a source of contamination and not be treated.

The STAR method is a fairly new and innovative technology in treating DNAPL/LNAPL. If DNAPL/LNAPL impacts are not continuous, complete combustion may not be achieved. The presence of contamination below the water table may reduce efficiency of contaminant reduction since water is a heat sink and its presence consumes energy that could reduce the progress rate or maximum temperature of the STAR propagation front. This method would only treat DNAPL/LNAPL source areas and not dissolved-phase contamination. Off-gases are typically produced that require collection and treatment. A treatability study and laboratory testing designed to evaluate the suitability of STAR for the treatment of specific soils and contaminants would be required, as well as to determine off-gas emissions and expected combustion temperatures.

Based on field observations during probing and drilling and the lack of accumulation of any DNAPL in monitoring wells, the effectiveness of DNAPL recovery in reducing the overall mass in the subsurface is likely to be poor. It is likely that any recovery attempt would result in more groundwater to manage, treat, and dispose of than product recovered. Therefore, it is not anticipated that this alternative would achieve any reduction in the overall size and mass of contamination at the Site.

5.3.2.2 Implementability. Groundwater monitoring is readily implementable, as monitoring wells are currently in place. Additional wells could be added to the network, as needed, to expand the monitoring capabilities or to adjust to observed changes in the status of the contaminant plume.

Although the technologies should theoretically treat COCs, ISCO and ISGS may be difficult to successfully and safely implement because of Site conditions. Application of ISCO technologies has become fairly conventional in the last few years. The key to effective implementation is to achieve contact between the reagent and material to be treated. Because it is necessary to have contact between the source and reagent, some areas with steep terrain and dense vegetation may not be accessible. Considering the bench and field testing required, material handling/preparation, and the number of injection points required, these technologies would be moderately difficult to implement. In a full-scale application, coordination with the railroad would be required to obtain any necessary permits for probing activities within their right-of-way.

Construction of a trenched PRB would be difficult to implement given the existing constraints and depth to bedrock (approximately 25 feet bgs) along the western/downgradient edge of the Site. Deep excavation/trenching methods would need to be used along with proper contaminated material handling procedures. All material removed during trenching would require offsite disposal.

Although a relatively new technology, STAR treatment would be easier to implement than the other in situ technologies because access to the steep terrain and dense vegetation would not be required to maintain operation, as long as DNAPL/LNAPL impacts are continuous across at the Site. Implementation would require an air injection grid and power source, as well as collection and treatment of off-gases. As with ISCO and ISGS, bench-scale and pilot testing would be required to determine if implementation is feasible. Only one vendor of this technology is currently available, which could limit or delay implementation.

Although DNAPL recovery through well extraction would be readily implementable, it is unlikely that sufficient DNAPL could be collected to affect the overall extent of contamination at the Site.

5.3.2.3 Cost. The costs for each alternative are presented below and are based on the conceptual design presented in Section 5.3.1. The capital costs include both direct and indirect costs. PRSC costs are based on a 10-year design period to allow a minimum of 5 years of observation to monitor the long-term effect of any removal action undertaken. Present worth is based on inflation rates of 3 percent. The tables referenced below are presented in Appendix C.

<u>Groundwater Alternative A - No Action.</u> There is no cost associated with this alternative.

<u>Groundwater Alternative B - Groundwater Monitoring.</u> The cost associated with implementing this alternative is presented in Table C-4.1. The range in costs is based on quarterly monitoring for 5 years with annual monitoring thereafter for five years. There is

no significant capital cost associated with this alternative. The PRSC costs are approximately $540,000 for 10 years of monitoring.

Groundwater Alternative C1 - In Situ Chemical Oxidation. The costs associated with implementing this alternative are presented in Table C-4.2 and Table C-4.3. Table C-4.2 presents the cost of ISCO treatment over the entire Site. The range of costs is based on the time the system needs to operate to treat the plume. The construction/implementation/ PRSC costs range from $3,150,000 to $4,050,000 for one and two year treatment times, respectively.

Table C-4.3 presents the cost of ISCO for only the DNAPL impacted area downgradient/southwest of the belowground gas holder. The range of costs is based on the time the system needs to operate to treat the plume. The construction/implementation/ PRSC costs range from $2,140,000 to $2,550,000 for one and two year treatment times, respectively.

Groundwater Alternative C2 - In Situ Geochemical Stabilization. The costs associated with implementing this alternative are presented in Table C-4.4 and represents the cost of ISGS treatment for only the area with DNAPL impacts downgradient/southwest of the belowground gas holder with an approximate accessible area of 8,100 square feet. The construction/implementation/PRSC cost is approximately $1,420,000.

Groundwater Alternative D - Permeable Reactive Barrier. The costs associated with implementing this alternative are presented in Table C-4.5 and Table C.4.6. Table C-4.5 presents the costs based on a trenched PRB along the western edge of the Site with a funnel and gate structure totaling 300 feet long and associated O&M. The construction/ implementation/PRSC cost is approximately $2,540,000.

Table C-4.6 presents the costs based on a PRB composed of a row of ISCO injection points as the treatment gate, trenched slurry walls as funnels, and associated O&M. The construction/implementation/PRSC cost is approximately $1,600,000.

Groundwater Alternative E – Self-sustaining Treatment for Active Remediation. The cost associated with implementing this alternative is presented in Table C-4.7. The costs are based on STAR treatment of the area with DNAPL impacts downgradient/southwest of the belowground gas holder (approximately 17,000 sq ft), with minimal ongoing energy use following the initial short-term energy intensive ignition phase. The construction/ implementation/PRSC cost is approximately $2,040,000.

Groundwater Alternative F – DNAPL Recovery. The cost associated with implementing this alternative is presented in Table C-4.8. The costs are based on direct recovery of NAPL for a period of 10 years and associated O&M. The construction/implementation/PRSC cost is approximately $1,310,000.

Groundwater Alternative G – Barrier System. The cost associated with implementation of this alternative is presented in Table C-4.9. The costs are based on using ISGS encapsulation through direct injection to create a low permeability barrier strip around the Site. The construction/implementation/PRSC cost is approximately $2,290,000.

6.0 Comparative Analysis of Site-Wide Alternatives

Based on the remedial action objectives and the evaluations presented in the previous section, alternatives to be used in the development of a Site-wide remedy are as follows:

Soil
- Institutional controls
- Excavation and offsite disposal

The full-scale capping alternative was eliminated from further consideration due to limitations on the constructability and long-term inspection/O&M and potential flooding of the Site area. In situ stabilization of the belowground gas holder material was also eliminated due to the specialized equipment required, higher mobilization costs, and no positive cost/benefit compared to excavation and offsite disposal of the material within the structure, especially debris such as concrete and brick.

Sediment
- Sediment monitoring
- Non-reactive capping
- Reactive capping

All of the options considered for sediment were carried through to be incorporated into Site-wide alternatives.

Groundwater/NAPL
- Groundwater monitoring
- Limited ISCO treatment
- Limited ISGS treatment
- PRB with ISCO injection points
- STAR treatment

Full-scale ISCO treatment across the Site and construction of a barrier around the perimeter of the Site were eliminated from further consideration because a significant area of treatment would involve non-MGP related residual contamination rather than the more-heavily contaminated MGP-impacted areas downgradient of the gas holder. The trenched PRB option was eliminated due to constructability issues along the downgradient side of the Site and the higher cost compared to the PRB injection option. The impermeable barrier system along the perimeter of the Site was also eliminated due to potential constructability issues and possible long-term hydraulic pumping that may be required to maintain the integrity of the barrier. DNAPL recovery using extraction wells was eliminated from further consideration due to the low potential for any significant product recovery based on field observations and Site geology.

Throughout the remainder of this section, combinations of media-specific alternatives are assembled into Site-wide alternatives and compared based on the advantages and disadvantages of each. Each combination includes an alternative for soil, groundwater, and sediment, and discusses the benefits and drawbacks of the alternatives as they relate to the other combinations. Table 6-1 presents the estimated range of costs for each Site-wide

Table 6-1 Estimated Range of Costs for Site-Wide Alternatives

Site-Wide Alternative	Probable Cost [1]
Excavation/Sediment and Groundwater Monitoring	Shallow soil excavation only - $1,500,000
	Shallow soil and gas holder excavation - $1,860,000
Excavation/Sediment Capping/Groundwater Monitoring	Shallow soil excavation with non-reactive cap - $2,329,000
	Shallow soil excavation with reactive cap - $2,119,000
	Shallow soil and gas holder excavation with non-reactive cap - $2,689,000
	Shallow soil and gas holder excavation with reactive cap - $2,479,000
Excavation/Sediment Capping/ISCO[2]	Shallow soil excavation with non-reactive cap - $4,340,000
	Shallow soil excavation with reactive cap - $4,130,000
	Shallow soil and gas holder excavation with non-reactive cap - $4,700,000
	Shallow soil and gas holder excavation with reactive cap - $4,490,000
Excavation/Sediment Capping/ISGS	Shallow soil excavation with non-reactive cap - $3,210,000
	Shallow soil excavation with reactive cap - $3,000,000
	Shallow soil and gas holder excavation with non-reactive cap - $3,570,000
	Shallow soil and gas holder excavation with reactive cap - $3,360,000
Excavation/Sediment Capping/PRB[2]	Shallow soil excavation with non-reactive cap - $3,390,000
	Shallow soil excavation with reactive cap - $3,180,000
	Shallow soil and gas holder excavation with non-reactive cap - $3,750,000
	Shallow soil and gas holder excavation with reactive cap - $3,540,000
Excavation/Sediment Capping/STAR	Shallow soil excavation with non-reactive cap - $3,830,000
	Shallow soil excavation with reactive cap - $3,620,000
	Shallow soil and gas holder excavation with non-reactive cap - $4,190,000
	Shallow soil and gas holder excavation with reactive cap - $3,980,000

Notes:
(1) Assumes 10 years of post-removal action groundwater and sediment monitoring.
(2) Assumes two years of ISCO injections and/or system operation.

alternative. Both of the soil excavation alternatives are presented as two options within a single alternative, although removal of the shallow soil combined with excavation of the gas holder material would result in a further reduction in the extent of contamination on Site assuming that the gas holder structure contains contaminated material. Similarly, both the non-reactive and reactive barrier capping for sediment are presented as two options within a single alternative. All Site-wide alternatives include implementing institutional controls as necessary to prevent residential development, deep soil excavation, and groundwater use on the Site, as well as sediment and groundwater monitoring to determine contaminant and plume decrease and/or stability.

6.1 SOIL EXAVATION, SEDIMENT AND GROUNDWATER MONITORING

This combination includes excavation of the soil, and sediment/pore water and groundwater monitoring for 10 years. The two options for soil excavation include leaving the belowground gas holder material undisturbed and excavation/blending and offsite disposal of the gas holder material. Both options involve the excavation of shallow soil across the majority of the Site, with low-permeability backfill material placed over the excavated areas. Excavation with landfill disposal of soil is the most readily implementable soil alternative. Additionally, it is the most commonly applied alternative at MGP sites to remove highly contaminated MGP residuals. The bulk of contaminated material would be removed from the Site, thereby eliminating both current and future concerns regarding exposure through contact with soil. Excavation and site restoration would take approximately two months.

Although the Big Blue River is a potential receptor of groundwater from the Site, there are no direct groundwater receptors on or near the Site based on the known extent of contamination and groundwater usage. In addition, there is an upgradient contaminant plume in the Site area. Monitoring the groundwater plume would confirm that the contaminant plume remains stable or decreases in size and does not impact the river. Monitoring COC concentrations at select monitoring wells over the 10-year monitoring period would confirm a stable or decreasing plume. Plume stability would be determined through evaluation of data and statistical analysis of COC concentrations over time. Deed restrictions are already in place on the Site preventing use of groundwater.

Similar to groundwater monitoring, sediment and pore water monitoring would confirm that MGP contaminants in the sediment are not migrating further away from the shoreline or increasing in concentration over time. Stability would be determined through statistical evaluation of COC concentrations over time.

The cost for this alternative is dependent on the volume of contaminated material that would be excavated.

6.2 SOIL EXCAVATION, SEDIMENT CAPPING, GROUNDWATER MONITORING

This Site-wide alternative incorporates soil excavation and groundwater monitoring as described in Section 6.1, and installation of a barrier for sediment. Sediment monitoring

without pore water sampling would be conducted for 10 years as part of any sediment barrier alternative.

Although some removal of cobbles and debris along the river bank would be required to achieve a uniform layer of sediment capping material installed, both non-reactive and reactive barriers are relatively easy to implement for sediment contamination. While a non-reactive barrier does not treat contamination, it would be effective in immediately reducing exposure to sediment contaminants. A reactive barrier, on the other hand, would provide some treatment of contaminants beneath the cap. Although the treatment duration of the cap material may be limited, it would still provide a barrier to the impacted sediment beneath the cap material. Monitoring of the sediment above the cap material would be implemented to verify that the cap is preventing exposure to residual sediment contamination below the cap.

6.3 SOIL EXCAVATION, SEDIMENT CAPPING, ISCO

This Site-wide alternative incorporates soil excavation as described in Section 6.1, installation of a barrier for sediment as described in Section 6.2, and ISCO treatment of the DNAPL plume for groundwater.

Bench and pilot scale testing would be required to determine if ISCO is truly implementable at the Site and to design a full-scale application. ISCO application can be adjusted to apply the most efficient amount of oxidant and it can be applied sparingly at first. If groundwater concentrations do not sufficiently improve, additional oxidant can be applied to treat the DNAPL mass. With treatment of the DNAPL mass, concentrations of the dissolved-phase contamination should be reduced over time. The ability to adjust oxidant application rates between groundwater monitoring events would allow the effect on the groundwater contaminant plume to be measured.

Regardless of the presence of residual contamination between the treatment area and the river, the decreased migration of DNAPL from the treated area should effectively reduce the migration of DNAPL and dissolved-phase contaminants toward the river over time.

The initial treatment could be completed in approximately 4 to 6 months. However, groundwater monitoring would need to continue to determine if any rebounding of contaminant concentrations occurs. The time needed to observe changes in downgradient groundwater concentrations could be from 1 to 2 years. If removal action objectives are achieved before completion of 10 years of monitoring, a cost savings could be achieved.

Depending on the groundwater chemistry, the type and amount of oxidant to be applied per cubic yard, and other site specific factors, the total expected costs can vary dramatically and are difficult to estimate at this stage of the project. In addition, the upgradient contaminant plumes could migrate into the MGP treatment area, thus affecting the treatment system's performance.

6.4 SOIL EXCAVATION, SEDIMENT CAPPING, ISGS

This combination includes excavation of the soil as described in Section 6.1, capping of the sediment as described in Section 6.2, and limited ISGS to treat the DNAPL-impacted area downgradient/southwest of the belowground gas holder.

The ISGS should result in the DNAPL within the injection zone radius of influence to be encapsulated, with elimination or great reduction of measurable DNAPL in the treatment zone and a corresponding decrease in the overall mass flux of chemicals released to groundwater. Bench and pilot scale testing would be required to determine if this technology is truly implementable at the Site and to design a full-scale application. To determine if DNAPL encapsulation results from ISGS treatment, soil probes would be advanced and soil samples collected to verify that injected oxidant is in contact with DNAPL and a "crust" has developed. Depending on the radius of influence achieved during injection and if daylighting of the ISGS solution occurs during injection, a secondary application of ISGS solution may be required to establish a stable and continuous encapsulation.

Regardless of the presence of residual contamination between the treatment area and the river, the decreased migration of DNAPL from the treated area should effectively reduce the migration of DNAPL and dissolved-phase contaminants toward the river over time.

The initial treatment could be completed in approximately 1 to 2 months. However, groundwater monitoring would need to continue to determine if there is any reduction in the flux of chemicals from the stabilized mass and if contaminant concentrations decrease. The time needed to observe changes in downgradient groundwater concentrations could be from 1 to 2 years. If removal action objectives are achieved before completion of 10 years of monitoring, a cost savings could be achieved.

6.5 SOIL EXCAVATION, SEDIMENT CAPPING, PRB

This combination includes excavation of the soil as described in Section 6.1, capping of the sediment as described in Section 6.2, and installing a PRB to treat the dissolved-phase groundwater contaminants.

The PRB would passively treat the dissolved-phase groundwater contaminants. However, a significant number of challenges would need to be overcome to successfully implement this alternative, including construction of the PRB in an area as close to the river as possible in areas of steep terrain and dense vegetation.

Drawbacks to the PRB are that it would not treat any contamination that has already migrated past where the PRB is installed and it is not an effective treatment technology for DNAPL. Without addressing DNAPL, there would continue to be a source of dissolved-phase contaminants. Although the PRB could be constructed in 2 to 3 months, it is unknown how long it would take to achieve groundwater removal goals using this alternative.

The cost for this alternative is dependent on the length of the barrier/treatment wall, volume of soil excavated or removed during wall construction, dewatering and water

treatment required for installation, and the long term O&M costs. The O&M costs include replacement/reinjection of the treatment media and groundwater sampling.

6.6 SOIL EXCAVATION, SEDIMENT CAPPING, STAR

This combination includes excavation of the soil as described in Section 6.1, capping of the sediment as described in Section 6.2, and the use of the STAR technology to treat the DNAPL-impacted area downgradient/southwest of the belowground gas holder.

The STAR method would treat DNAPL in the more concentrated area of the Site. Bench and pilot scale testing would be required to determine if this technology is truly implementable at the Site and to design a full-scale application. Accessibility to areas of the Site for treatment using this technology would be easier than the other active remedies. However, if DNAPL impacts are not continuous, complete combustion may not be achieved. The presence of contamination below the water table may also reduce the efficiency of contaminant reduction and increase energy requirements. It is unknown how long it would take to achieve groundwater removal goals using this alternative.

The initial treatment could be completed in approximately 3 to 6 months. However, groundwater monitoring would need to continue to determine if there is any reduction in contaminant concentrations. The time needed to observe changes in downgradient groundwater concentrations could be from 1 to 2 years. If removal action objectives are achieved before completion of 10 years of monitoring, a cost savings could be achieved.

7.0 Recommended Site-Wide Alternative

This section presents the recommended Site-wide removal action alternative to address soil, sediment, and groundwater/NAPL contamination at the Beatrice MGP Site. Based on the evaluation provided in Section 6.0, the preferred alternative is shallow soil excavation across the majority of the Site, excavation and removal of the belowground gas holder contents, placement of low-permeability backfill material over the excavated portions of the Site, placement of reactive barrier material over the areas along the river bank adjacent to the Site where sediment samples SD-107 and SD-113 were collected, and groundwater/sediment monitoring for a minimum period of 10 years. The removal action is protective of human health and the environment and will achieve the removal action objectives for soil, sediment, and groundwater/NAPL.

Excavation of contaminated soil and the material within the gas holder and offsite disposal in a landfill will adequately and protectively achieve the removal action objectives. Confirmation soil sampling along the final limits of the shallow soil excavation will document compliance with removal action objectives. Shallow soil cleanup to meet PRGs will result in all of the soil exceeding risk-based cleanup criteria to be removed from the Site.

Sediment capping would directly reduce the mobility of the sediment contaminants and would minimize the potential for sediment contaminants to come into contact with ecological and human receptors. Although a potential long-term risk would be associated with the contaminated sediment because it would be left in place, the risk could be effectively controlled by inspection and maintenance of the cap and annual sediment monitoring. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding sediment in connection with the MGP Site following the 10-year monitoring period.

Although the Big Blue River is a potential receptor of groundwater from the Site, there are no direct groundwater receptors on or near the Site based on the known extent of contamination and groundwater usage. In addition, existing use controls on the property deed prevent groundwater use. Therefore, the objective for the groundwater alternative is to prevent migration of MGP-related constituents into the river at levels that would pose an ecological risk. In conjunction with sediment capping that would minimize or prevent groundwater contamination from the Site from entering the river, groundwater monitoring would be used to monitor the stability of the groundwater plume and determine if the plume is increasing or decreasing in size. The EPA will make the determination that the removal action objectives have been met and no further action is warranted regarding groundwater in connection with the MGP Site if after the 10-year monitoring period the groundwater contaminant plume is either stable and/or decreasing in size.

The minimum estimated cost of implementing this alternative is $2,479,000. The actual cost will depend on the duration of groundwater and sediment monitoring required.

8.0 References

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Figures

LEGEND

- RAILROAD
- MGP SITE
- ABOVEGROUND GAS HOLDER BASE
- BNSF PROPERTY

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- COKE BIN
- GAS PLANT BUILDING
- CHEMICAL LABORATORY

NOTE

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

N E S W

0 150
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS
(1913, 1923, 1948, 1953)

FIGURE 2-1
SITE MAP

EE/CA ALTERNATIVES EVALUATION REPORT

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LEGEND

- TETRA TECH SOIL PROBES (2002)
- JHC SOIL PROBES/TEMPORARY MONITORING WELLS (2002)
- HDR MONITORING WELLS AND/OR SOIL BORINGS (1992)
- TETRA TECH TEMPORARY MONITORING WELL (2004)
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

NOTES

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

2. SAMPLE LOCATIONS ARE APPROXIMATE.

N E S W

0 60
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS
(1913, 1923, 1948, 1953)

FIGURE 2-2
HISTORICAL SOIL BORING AND MONITORING WELL LOCATIONS (1992 - 2004)

EE/CA ALTERNATIVES EVALUATION REPORT

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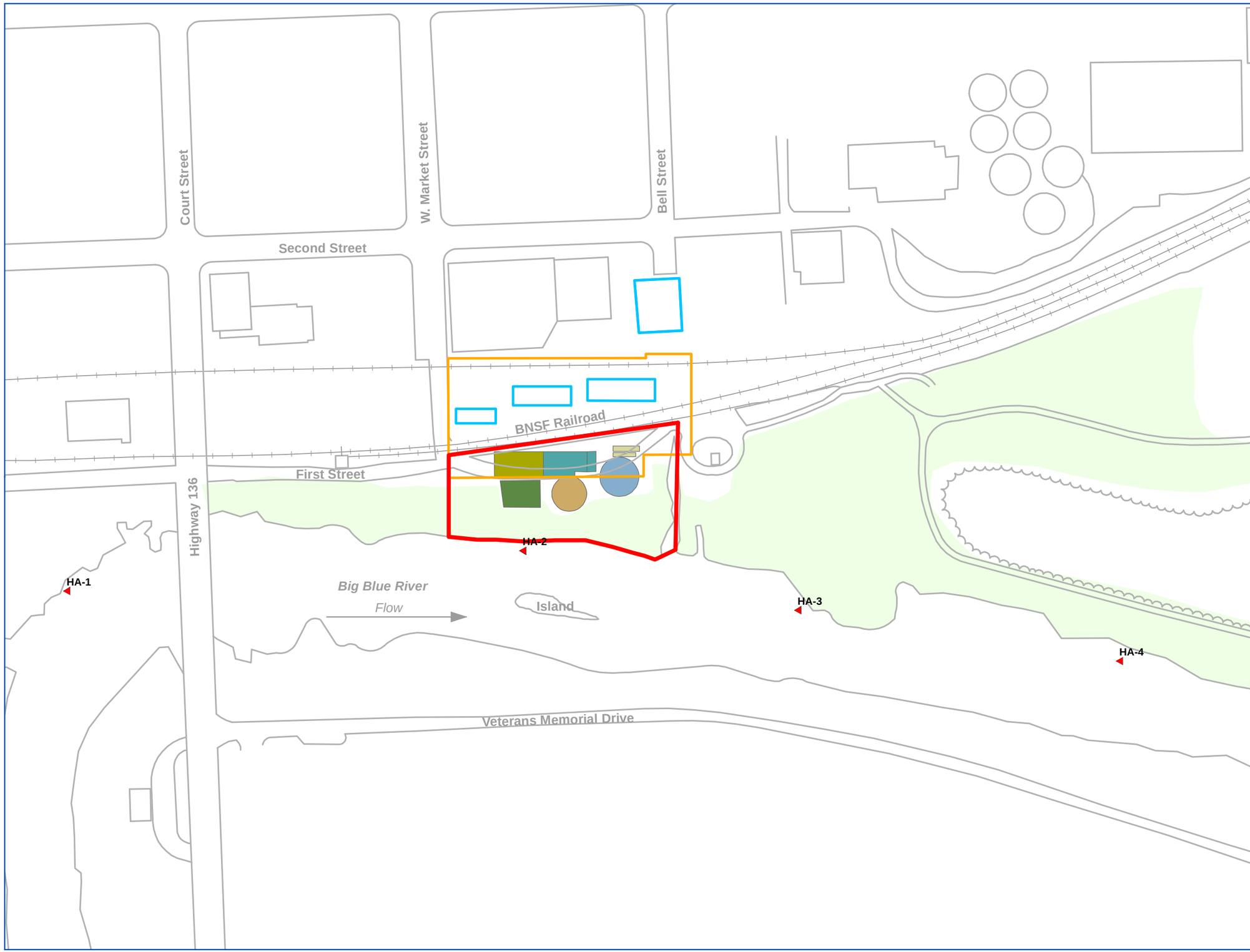

LEGEND

- TETRA TECH SEDIMENT SAMPLE LOCATIONS (2002)
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

NOTES

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION

2. SAMPLE LOCATIONS ARE APPROXIMATE.

N E S W

0 150
Feet

SOURCES
NDEQ 2002;
SANBORN MAPS
(1913, 1923, 1948, 1953)

FIGURE 2-3
HISTORICAL SEDIMENT SAMPLE LOCATIONS

EE/CA ALTERNATIVES EVALUATION REPORT

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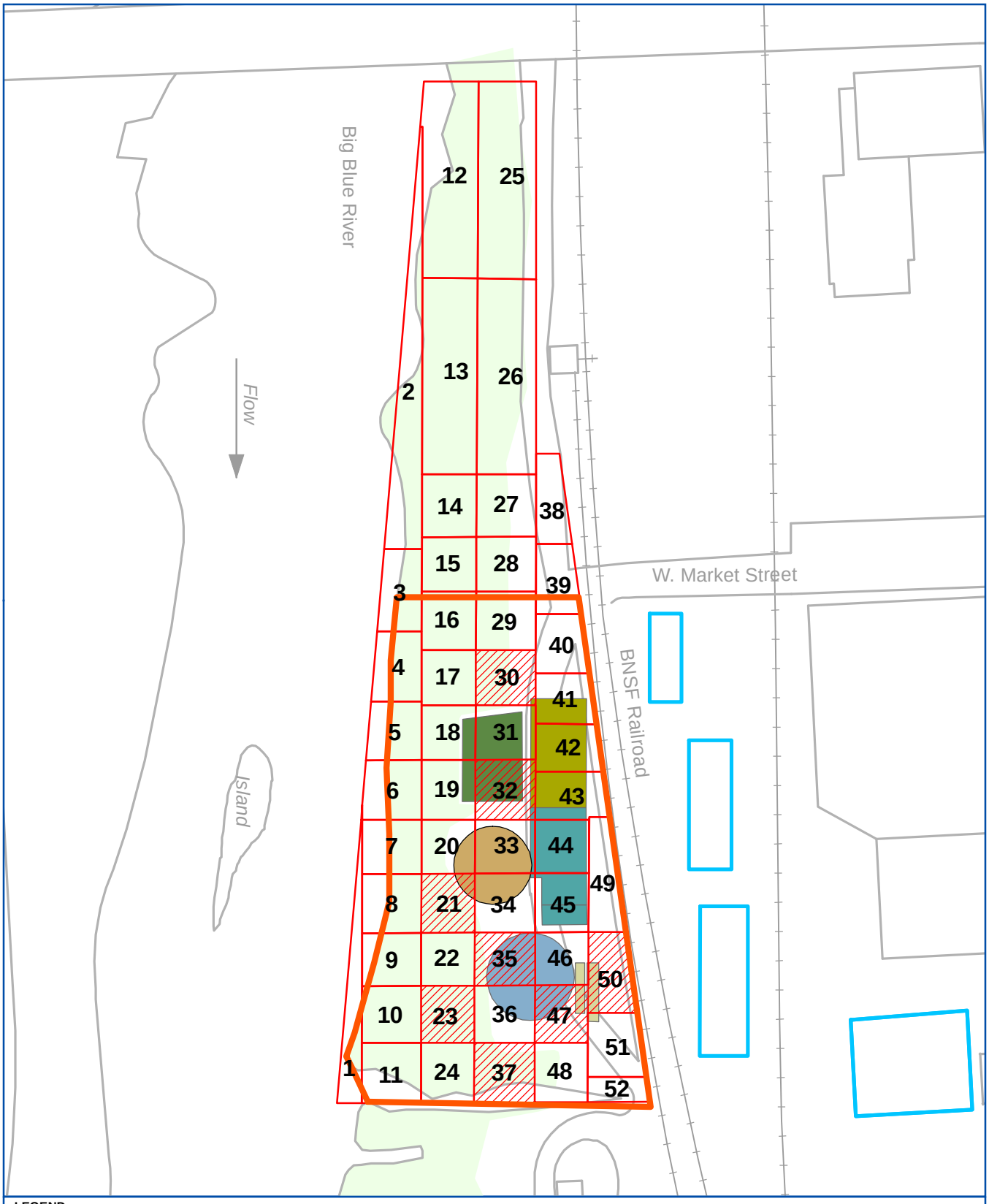

LEGEND

- SOIL SAMPLE GRIDS
- DEEP SOIL SAMPLES
- RAILROAD
- BNSF PROPERTY
- MGP SITE
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

SOURCES
BEATRICE WEST, NE DIGITAL ORTHO QUAD, 1999
TETRA TECH 2004

N
W E
S

0 100
Feet

NOTE
LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

FIGURE 2-4
HISTORICAL RSE SOIL SAMPLING GRID (2004)

EE/CA ALTERNATIVES EVALUATION REPORT

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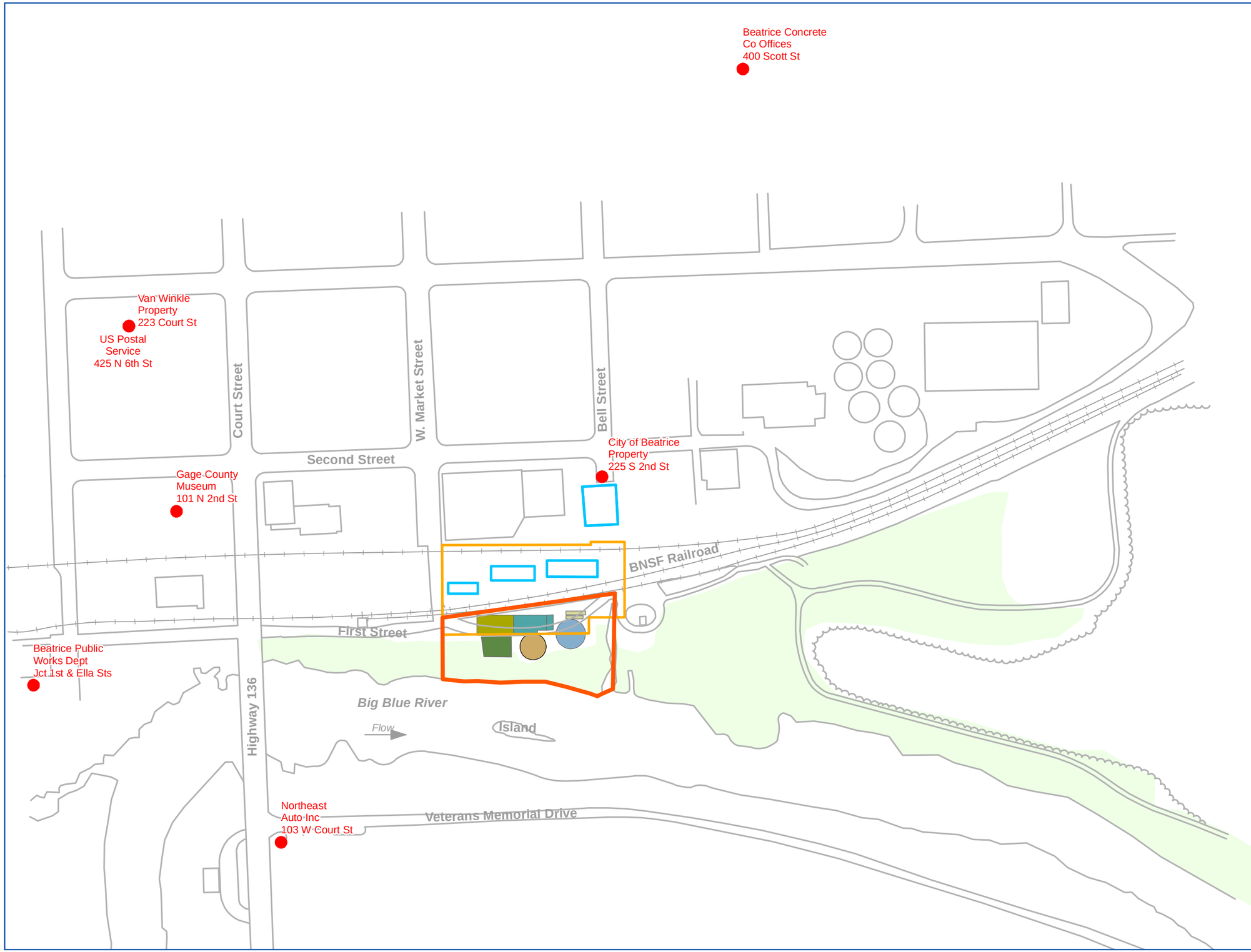

LEGEND

- LUST OR LAST LOCATION
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

NOTE

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

N E S W

0 200
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS (1913, 1923);
NDEQ 2011

FIGURE 2-5
LUST/LAST LOCATIONS WITHIN 1/4 MILE OF THE MGP SITE

EE/CA ALTERNATIVES EVALUATION REPORT

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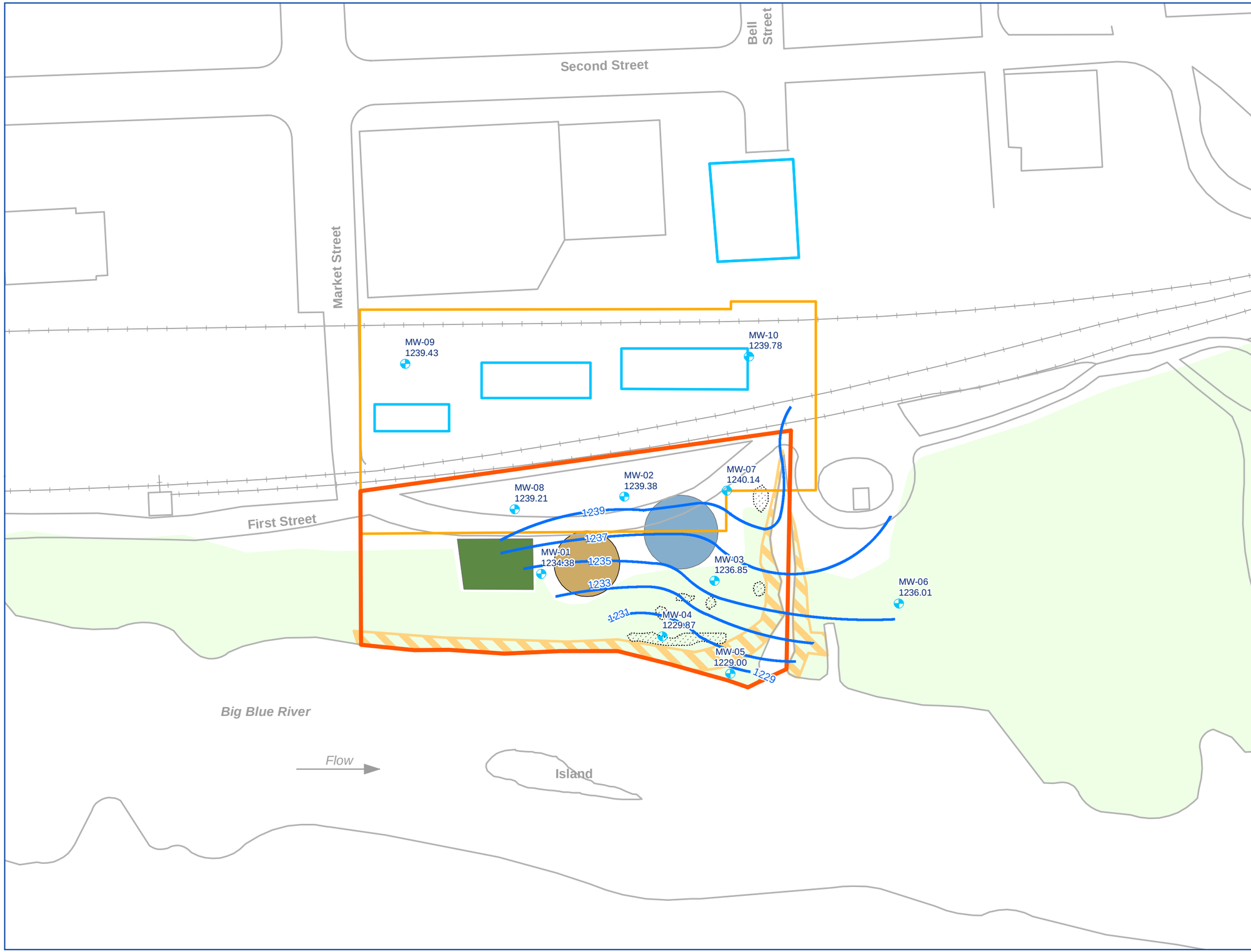

LEGEND

- MONITORING WELL
- GROUNDWATER CONTOUR
- GROUNDWATER FLOWLINE
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- STEEP TERRAIN
- RUBBLE
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- BELOWGROUND 50,000 CF GAS HOLDER
- CHEMICAL LABORATORY

NOTES

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

2. WATER LEVELS WERE MEASURED ON JULY 11, 2010.

N E S W

0 80
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS
(1913, 1923, 1948, 1953)

FIGURE 2-6
POTENTIOMETRIC SURFACE CONTOURS

EE/CA ALTERNATIVES EVALUATION REPORT

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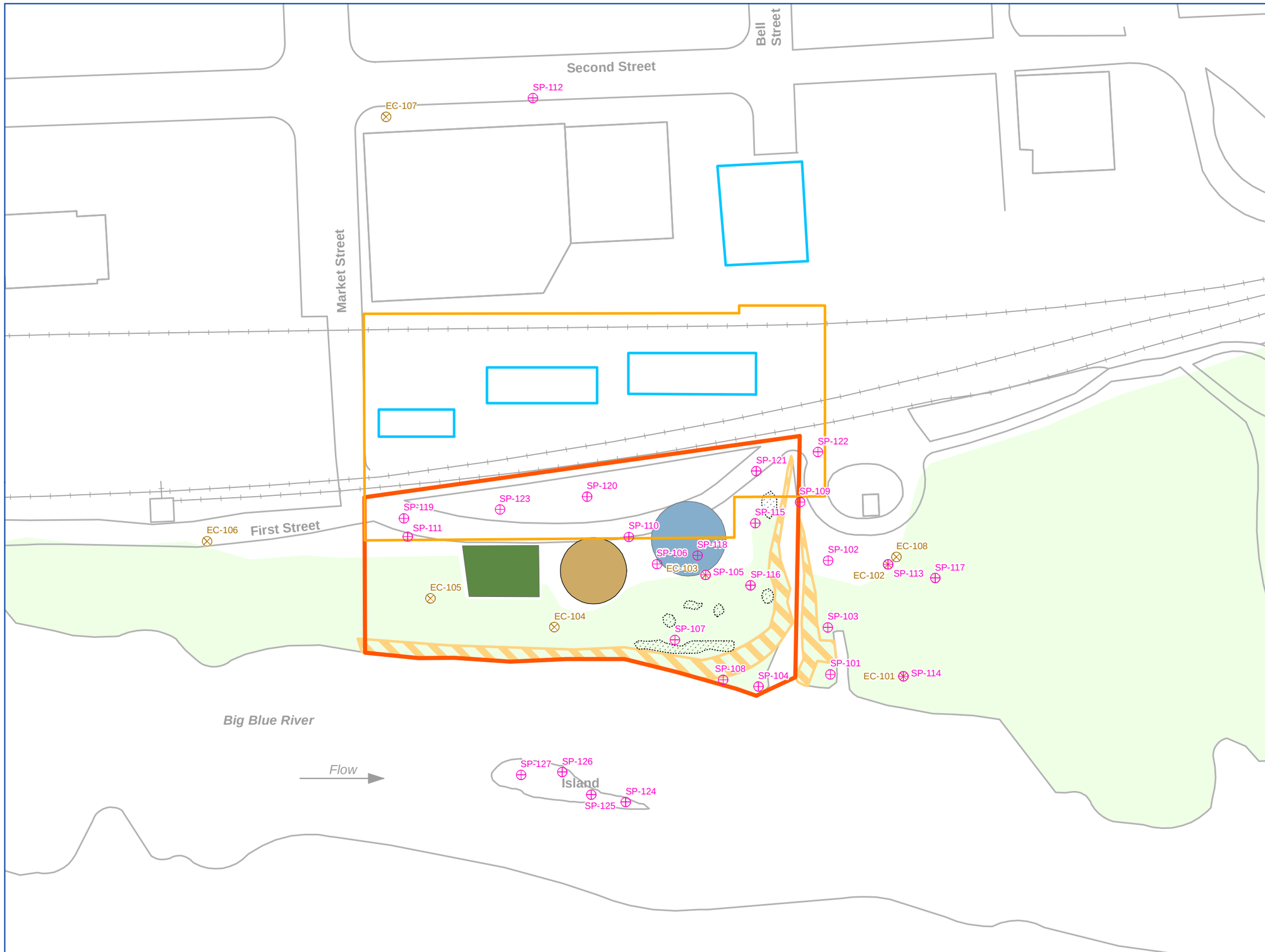
Path:\GIS01\Projects\143927.0412_Beatrice\Map_Doc\AlternativesEvaluationReportFig2-6_PotentiometricSurface | 11/6/2013 | K. McRae



LEGEND

- SOIL PROBE
- EC PROBE
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- STEEP TERRAIN
- RUBBLE
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- BELOWGROUND 50,000 CF GAS HOLDER
- CHEMICAL LABORATORY

NOTE

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

N W E S

0 80
Feet

SOURCES

USGS SEAMLESS DATA; SANBORN MAPS (1913, 1923, 1948, 1953)

FIGURE 2-7

EE/CA EC AND SOIL PROBE LOCATIONS

EE/CA ALTERNATIVES EVALUATION REPORT

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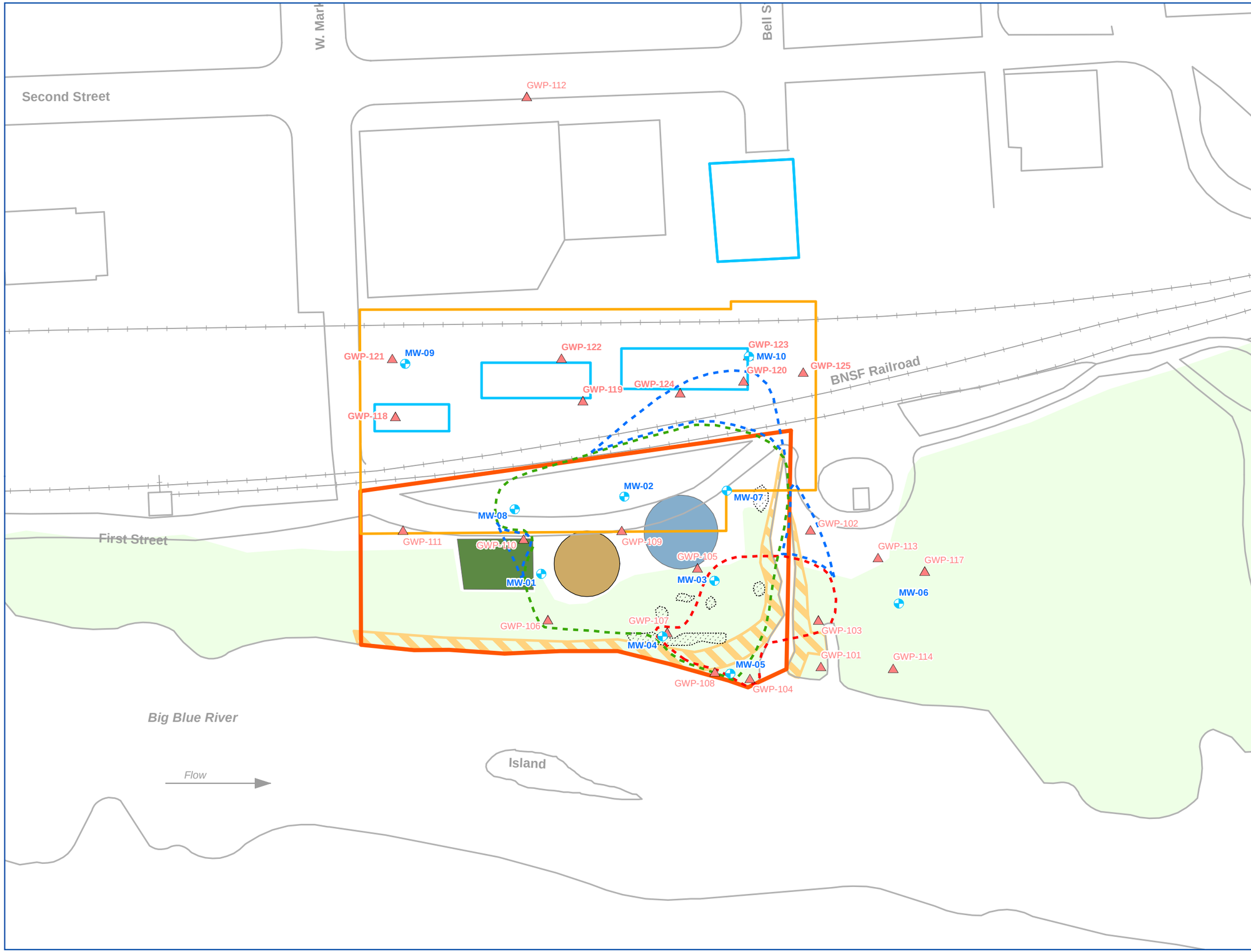
Path:\GIS01\Projects\143927.0412_Beatrice\Map_Doc\AlternativesEvaluationReportFig2-7_ProposedMonitoringWells | 11/6/2013 | K. McRae



LEGEND

- MONITORING WELL
- DNAPL
- LNAPL
- DNAPL/LNAPL MIXTURE
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- STEEP TERRAIN
- RUBBLE
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- BELOWGROUND 50,000 CF GAS HOLDER
- CHEMICAL LABORATORY

NOTE

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

N E S W

0 80
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS (1913 & 1923);

FIGURE 2-8
DNAPL AND LNAPL MEASURED/OBSERVED IN MONITORING WELLS AND GROUNDWATER PROBES

EE/CA ALTERNATIVES EVALUATION REPORT

BLACK & VEATCH
Building a world of difference.

Path:\GIS01\Projects\143927.0412_Beatrice\Map_Doc\AlternativesEvaluationReportFig2-8_DNAPLandLNAPL | 11/4/2013 | K. McRae

LEGEND

- SURFACE WATER SAMPLE LOCATION
- SEDIMENT SAMPLE LOCATION
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

NOTES

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

2. SEDIMENT AND SURFACE WATER SAMPLES ALONG THE EAST SIDE OF THE RIVER WERE COLLECTED APPROXIMATELY 6 FEET FROM THE RIVER BANK.

N E S W

0 150
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS (1913, 1923)

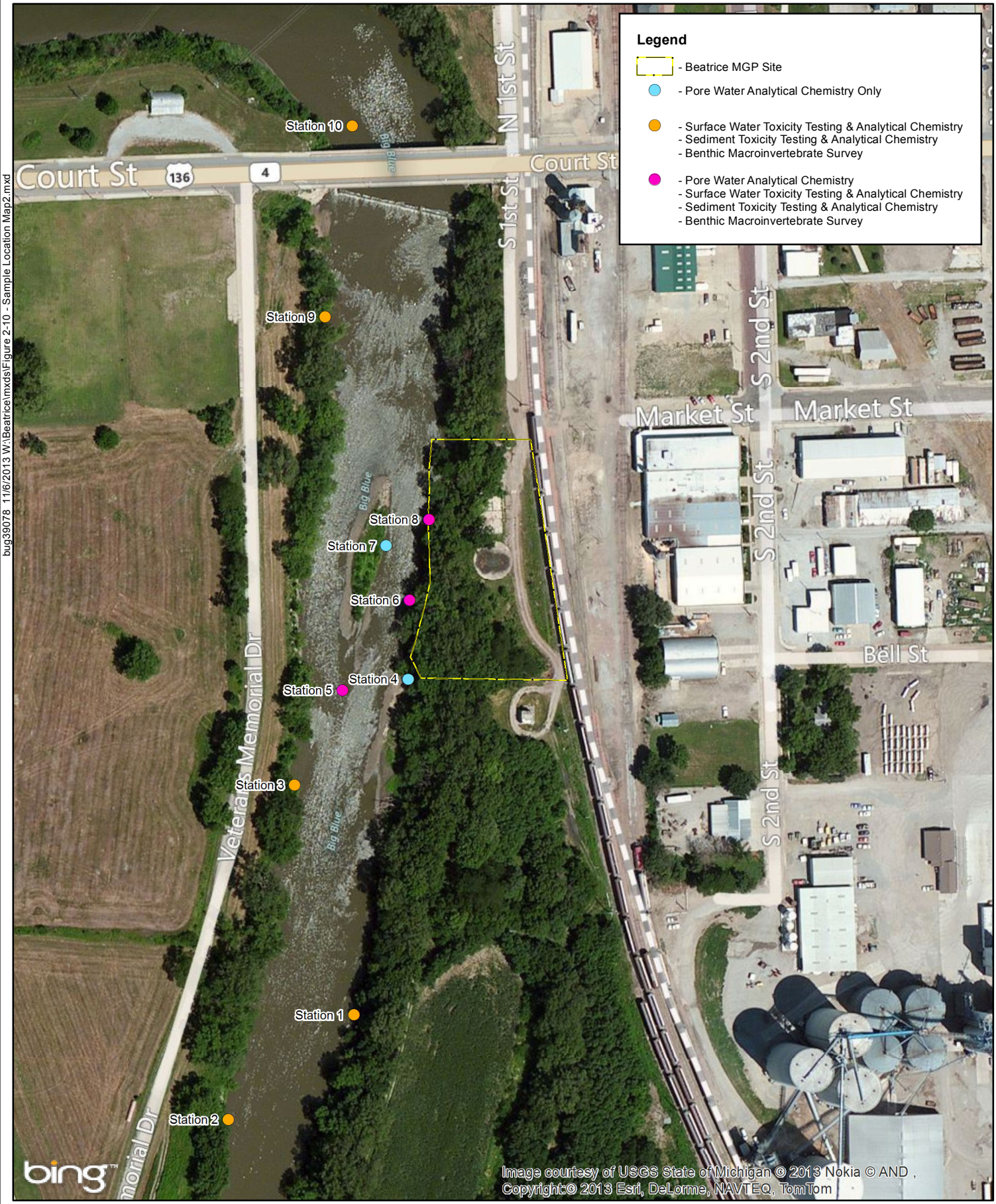
FIGURE 2-9
EE/CA SEDIMENT AND SURFACE WATER SAMPLE LOCATIONS

EE/CA ALTERNATIVES EVALUATION REPORT

BLACK & VEATCH
Building a world of difference.

Path:\GIS01\Projects\143927.0412_Beatrice\Map_Doc\AlternativesEvaluationReportFig2-9SedimentAndSurfaceWaterSampleLocations | 11/4/2013 | K. McRae

bug39078 11/6/2013 W:\Beatrice\mxds\Figure 2-10 - Sample Location Map2.mxd



N

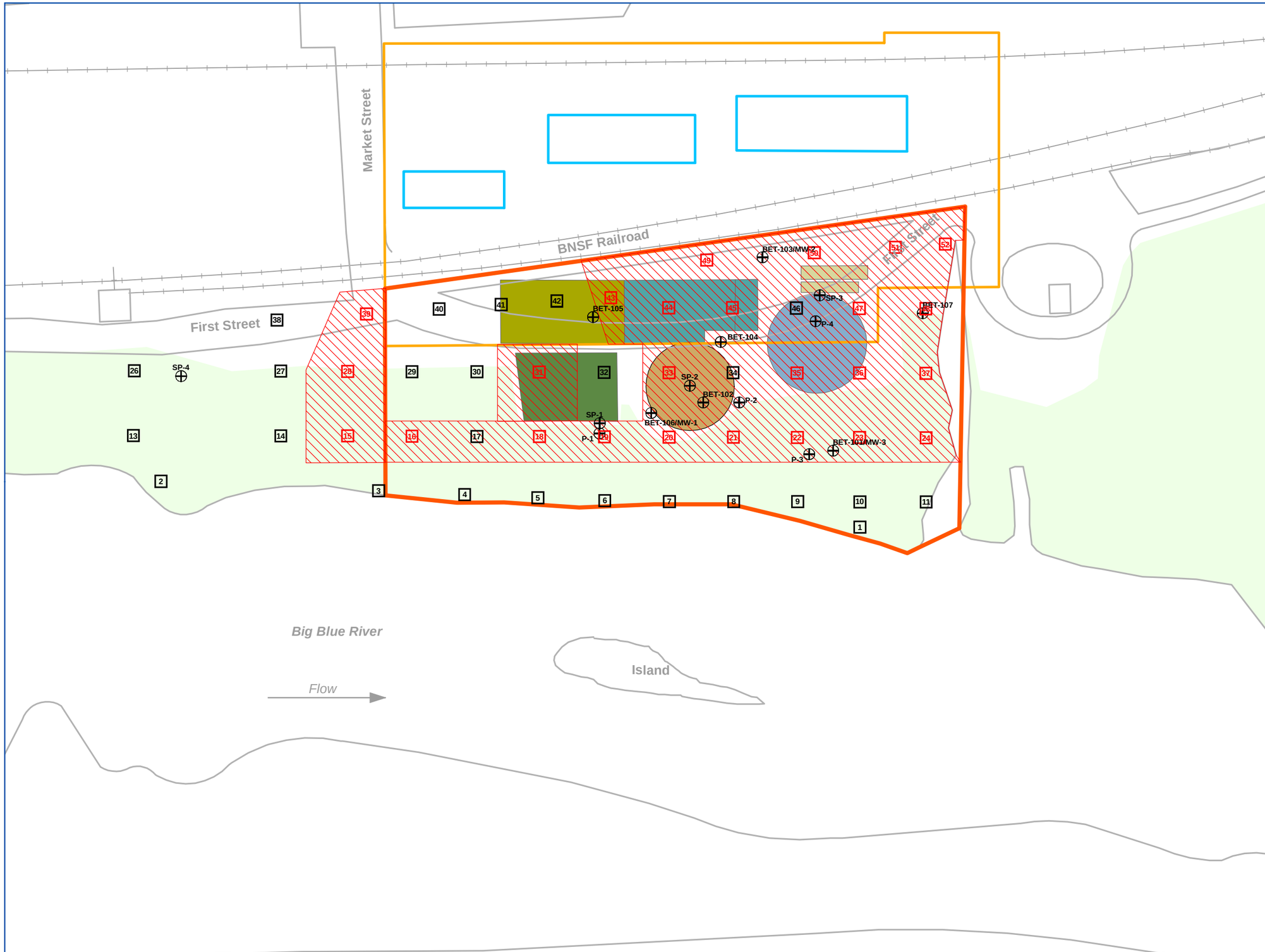
0 100 200

Feet

State Plane Nebraska (feet)

ERA Sample Station Location Map
EE/CA Alternatives Evaluation Report

Figure 2-10



LEGEND

- SHALLOW (0-2 FEET BGS) SOIL SAMPLES WITHOUT A PRG EXCEEDENCE
- SHALLOW (0-2 FEET BGS) SOIL SAMPLES WITH A PRG EXCEEDENCE
- RAILROAD
- MGP SITE
- BNSF PROPERTY
- DENSE VEGETATION
- EXISTING STRUCTURE
- ABOVEGROUND GAS HOLDER BASE
- ESTIMATED AREA OF SOIL EXCEEDING PRGS

HISTORICAL STRUCTURES

- FORMER OIL STORAGE FACILITY
- OIL TANK
- BELOWGROUND 50,000 CF GAS HOLDER
- GAS PLANT BUILDING
- COKE BIN
- CHEMICAL LABORATORY

NOTES

1. LOCATIONS OF MGP STRUCTURES DETERMINED FROM 1913 AND 1923 SANBORN MAPS, AND FROM JULY 2008 EE/CA INVESTIGATION.

2. SAMPLE LOCATIONS ARE APPROXIMATE.

3. SAMPLES LABELED WITH A NUMBER ONLY ARE FROM THE RSE INVESTIGATION. LOCATIONS SHOWN ARE LOCATED IN THE CENTER OF THE CORRESPONDING SAMPLE GRIDS SHOWN ON FIGURE 2-4.

N W E S

0 60
Feet

SOURCES
USGS SEAMLESS DATA;
SANBORN MAPS
(1913, 1923, 1948, 1953)

FIGURE 3-1
SOIL AREAS EXCEEDING PRGs

EE/CA ALTERNATIVES EVALUATION REPORT

BLACK & VEATCH
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Path:\GIS01\Projects\143927.0412_Beatrice\Map_Doc\AlternativesEvaluationReportFig5-1_ExceedingPRGs | 4/30/2014 | K. McRae

Appendix A

Data Summary Tables

TABLE 2-1
1992 SITE INVESTIGATION SOIL DATA[1]
Beatrice MGP site
EE/CA Work Plan

Boring	BET-101		BET-102			BET-103			BET-104		BET-105		BET-106		BET-107	
Depth (feet bgs)	0-2	18-20	2-4	4-6	18-20	0-2	2-4	20-22	2-4	8-10	3.5-5.5	11.5-13.5	3-5	15-17	0-2	6-8
VOCs (mg/kg)																
Carbon Disulfide	ND	ND	ND	NA	ND	ND	NA	ND	ND	0.0081	ND	ND	ND	ND	ND	NA
Ethylbenzene	ND	4.8	ND	NA	4	ND	NA	0.78	ND	ND	ND	ND	ND	ND	ND	NA
Xylenes (total)	ND	5.2	ND	NA	1.6	ND	NA	ND	ND	ND	ND	ND	ND	ND	ND	NA
SVOCs (mg/kg)																
Naphthalene	ND	69	NA	ND	210	NA	ND	13	ND	ND	ND	ND	NA	ND	NA	0.89
2-Methylnaphthalene	ND	16	NA	ND	89	NA	ND	3.9	ND	ND	ND	ND	NA	ND	NA	ND
Acenaphthylene	ND	11	NA	ND	NA	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
Acenaphthene	ND	9.6	NA	ND	49	NA	ND	9.5	ND	ND	ND	ND	NA	ND	NA	ND
Fluorene	ND	12	NA	ND	22	NA	ND	4.6	ND	ND	ND	ND	NA	ND	NA	ND
N-Nitrosodiphenylamine	ND	ND	NA	ND	9.3	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
Phenanthrene	49	38	NA	ND	74	NA	ND	16	ND	ND	ND	ND	NA	ND	NA	0.35
Anthracene	ND	10	NA	ND	23	NA	ND	4.3	ND	ND	ND	ND	NA	ND	NA	ND
Fluoranthene	98	9	NA	ND	28	NA	ND	3.6	ND	ND	ND	ND	NA	ND	NA	ND
Pyrene	130	14	NA	ND	39	NA	6.1	6.7	ND	ND	ND	ND	NA	ND	NA	ND
Benzo(a)anthracene	82	ND	NA	ND	11	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
Chrysene	100	ND	NA	ND	10	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
Benzo(b)fluoranthene	100	ND	NA	ND	9.1	NA	6.8	ND	ND	ND	ND	ND	NA	ND	NA	ND
Benzo(a)pyrene	ND	ND	NA	ND	8.8	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND
Benzo(g,h,i)perylene	79	ND	NA	ND	ND	NA	ND	ND	ND	ND	ND	ND	NA	ND	NA	ND

TABLE 2-1 (Continued)
1992 SITE INVESTIGATION SOIL DATA[1]
Beatrice MGP site
EE/CA Work Plan

Boring	BET-101		BET-102			BET-103			BET-104		BET-105		BET-106		BET-107	
Depth (feet bgs)	0-2	18-20	2-4	4-6	18-20	0-2	2-4	20-22	2-4	8-10	3.5-5.5	11.5-13.5	3-5	15-17	0-2	6-8
Inorganics (mg/kg)																
Arsenic	35.6	NA	ND	NA	NA	ND	NA	NA	ND	NA	ND	NA	ND	NA	ND	NA
Barium	83.9	NA	226	NA	NA	140	NA	NA	103	NA	143	NA	363	NA	26.1	NA
Beryllium	ND	NA	0.53	NA	NA	0.37	NA	NA	0.52	NA	0.57	NA	0.73	NA	ND	NA
Cadmium	ND	NA	ND	NA	NA	0.64	NA	NA	ND	NA	ND	NA	0.90	NA	ND	NA
Chromium	26.6	NA	12.1	NA	NA	12.1	NA	NA	6.4	NA	8.3	NA	8.3	NA	1.8	NA
Cobalt	4.4	NA	5.2	NA	NA	2.8	NA	NA	4.2	NA	4.7	NA	9.8	NA	ND	NA
Copper	49.9	NA	22.8	NA	NA	20.2	NA	NA	9.6	NA	9.4	NA	15.2	NA	2.1	NA
Lead	106	NA	18	NA	NA	116	NA	NA	103	NA	16.4	NA	16.4	NA	8.5	NA
Nickel	17.4	NA	12.8	NA	NA	10.2	NA	NA	10.7	NA	10.8	NA	22.7	NA	ND	NA
Vanadium	26.3	NA	17.6	NA	NA	13.4	NA	NA	11.4	NA	14.8	NA	17.4	NA	2.7	NA
Zinc	94.8	NA	72.4	NA	NA	104	NA	NA	64.7	NA	31.9	NA	47	NA	14.3	NA
Cyanide	14	ND	ND	NA	ND	1.9	NA	ND	ND	NA	ND	ND	ND	ND	ND	NA

Abbreviations:
bgs below ground surface
mg/kg milligrams per kilogram
NA not analyzed
ND not detected
SVOC semi-volatile organic compounds
VOC volatile organic compounds

Note:
[1] Compounds not detected in any of the samples are not presented.

TABLE 2-2
1992 SITE INVESTIGATION GROUNDWATER DATA[(1) (2)]
Beatrice MGP site
EE/CA Work Plan

Chemical Parameter	MW-101	MW-103		MW-106
		Primary	Duplicate	
VOCs (µg/L)				
Benzene (MCL = 5)	**12,000**	**920**	**980**	ND
Ethylbenzene (MCL = 700)	**2,800**	**1,300**	**1,300**	92
Toluene (MCL = 1,000)	750	75	77	ND
Xylenes (total) (MCL = 10,000)	2,400	800	800	18
PAHs (µg/L)				
Acenaphthene	380	1,200	1,000	74
Fluorene	ND	580	580	26
2-Methylnaphthalene	1,500	1,200	960	ND
Naphthalene	4,900	7,800	6,500	120
Phenanthrene	370	1,300	960	20
Inorganics (mg/L)				
Arsenic (MCL = 0.05)	0.015	0.013	0.014	0.011
Barium (MCL = 2)	0.38	0.28	0.27	0.82
Chromium (MCL = 0.1)	ND	ND	ND	0.026
Copper (MCL = 1.3)	ND	ND	ND	0.024
Lead (MCL = 0.015)	ND	0.0062	0.0062	**0.019**
Nickel	ND	ND	ND	0.055
Vanadium	ND	ND	ND	0.048
Zinc	0.059	0.068	0.055	0.14
Cyanide (MCL = 0.2)	0.17	ND	0.020	ND

Abbreviations:
ND not detected
MCL Maximum Contaminant Level
mg/L milligrams per liter
µg/L micrograms per liter

Notes:
(1) Numbers in bold are concentrations above the MCL.
(2) Compounds not detected in any of the samples are not presented.

TABLE 2-3
2002 PA/SI SOIL ANALYTICAL DATA[(1)]
Beatrice MGP Site
EE/CA Work Plan

	SP-1		SP-2		SP-3		SP-4	
Sample Depth (feet bgs)	1-2	7-8	7-8	13-15	1-2	11-12	1-2	8-10
VOCs (mg/kg)								
1,2,4–Trimethylbenzene	NA	ND	NA	ND	NA	**7.1**	NA	ND
1,3,5–Trimethylbenzene	NA	ND	NA	ND	NA	**2.1**	NA	ND
Acetone	NA	0.041	NA	**0.140**	NA	ND	NA	0.025
Ethylbenzene	NA	ND	NA	ND	NA	**5.1**	NA	ND
Isopropylbenzene	NA	ND	NA	ND	NA	**1.2**	NA	ND
Xylenes (total)	NA	ND	NA	ND	NA	**4.9**	NA	ND
n-Propylbenzene	NA	ND	NA	ND	NA	**0.930**	NA	ND
p-Isopropyltoluene	NA	ND	NA	ND	NA	0.850	NA	ND
PAHs (mg/kg)								
Acenaphthene	ND	ND	ND	ND	ND	**82**	ND	ND
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND
Anthracene	0.021	ND	0.0023	ND	0.057	**16**	0.083	0.017
Benzo(a)anthracene	0.140	0.087	0.0047	ND	0.250	**9.2**	0.390	0.061
Benzo(a)pyrene	0.190	0.130	0.011	ND	1.5	**6.6**	0.480	0.070
Benzo(b)fluoranthene	0.160	0.120	0.011	ND	0.73	**2.8**	0.280	0.063
Benzo(k)fluoranthene	0.073	0.052	0.0046	ND	**0.36**	**1.6**	0.160	0.028
Benzo(g,h,i)perylene	0.160	0.063	0.0064	ND	**3.0**	**1.1**	0.270	0.044
Chrysene	0.140	0.110	0.0074	ND	0.170	**4.1**	0.400	0.061
Dibenzo(a,h)anthracene	ND	ND	**0.023**	ND	ND	ND	ND	ND
Fluoranthene	0.270	0.230	0.029	ND	0.630	**26**	0.980	0.170
Fluorene	ND	ND	ND	ND	ND	**19**	0.026	ND
Indeno(1,2,3-cd)pyrene	0.140	ND	ND	ND	**1.9**	ND	0.270	0.039
Naphthalene	ND	ND	ND	ND	ND	190	ND	ND
Phenanthrene	0.085	0.095	0.019	ND	ND	**54**	0.550	0.110
Pyrene	0.330	0.2	ND	ND	0.930	ND	0.940	0.160
Inorganics (mg/kg)								
Arsenic	2.79	**3.99**	1.16	0.888	1.13	ND	1.7	0.947
Beryllium	0.627	0.593	0.362	0.347	0.36	0.284	0.503	0.329
Cadmium	**0.558**	**0.825**	ND	ND	ND	ND	ND	ND
Chromium	10.4	10.3	6.46	6.32	6.4	5.45	9.26	7.55
Copper	16.7	13.2	7.82	5.43	6.12	7.8	14.1	4.67
Lead	25.9	13.2	13.2	5.67	6.32	4.4	21.5	5.46
Nickel	14.4	14.5	7.03	7.58	8.16	5.05	11.3	7.34
Selenium	ND	**1.58**	ND	ND	ND	ND	2.59	ND
Zinc	118	**160**	32.4	19.7	21.9	18	50	18.9
Mercury	**0.176**	ND	ND	ND	ND	ND	ND	ND
Cyanide	ND	ND	ND	ND	ND	ND	ND	ND

Abbreviations:
bgs below ground surface
NA not analyzed
ND not detected
mg/kg milligram per kilogram
PAHs polynuclear aromatic hydrocarbons
VOCs volatile organic compounds

Note:
(1) Numbers in bold are concentrations greater than three times the background level (as reported in NDEQ 2002).

TABLE 2-4
2002 PA/SI GROUNDWATER ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

	MW-1	MW-2	MW-3
Chemical Parameter	Results		
VOCs (µg/L)			
1,2,4-Trimethylbenzene	8.2	140	120
1,3,5-Trimethylbenzene	1.3	51	40
Benzene (MCL = 5)	1	**460**	**1,100**
Ethylbenzene (MCL = 700)	2.8	360	180
Isopropylbenzene	5.1	46	38
Xylenes (total) (MCL = 10,000)	3.2	280	170
n-Propylbenzene	2.2	20	11
p-Isopropyltoluene	ND	7.7	6.9
Sec-Butylbenzene	ND	1.5	1.1
Toluene (MCL = 1,000)	ND	19	63
PAHs (µg/L)			
Acenaphthene	23	ND	ND
Acenaphthylene	ND	ND	1,200
Benzo(a)anthracene	0.029	110	44
Benzo(a)pyrene (MCL = 0.2)	0.041	**70**	**32**
Benzo(b)fluoranthene	ND	45	28
Benzo(k)fluoranthene	ND	17	ND
Fluoranthene	0.28	ND	130
Fluorene	2.4	310	110
Naphthalene	99	3,900	3,800
Phenanthrene	ND	720	ND
Pyrene	ND	300	160
Inorganics (mg/L)			
Arsenic (MCL = 0.05)	ND	ND	0.0223
Beryllium (MCL = 0.004)	ND	ND	0.00194
Chromium (MCL = 0.1)	ND	0.0188	0.0536
Copper (MCL = 1.3)	ND	0.0216	0.0953
Lead (MCL = 0.015)	ND	**0.0163**	**0.0373**
Nickel	ND	ND	0.0382
Selenium (MCL = 0.05)	ND	**0.0591**	**0.0778**
Silver	ND	ND	0.00746
Zinc	ND	ND	0.145
Cyanide (MCL = 0.2)	ND	ND	0.005

Abbreviations:
MCL Maximum Contaminant Level
mg/L milligrams per liter
ND not detected
µg/L micrograms per liter

Note:
[1] Numbers in bold are concentrations above the MCL.

TABLE 2-5
2002 PA/SI SEDIMENT ANALYTICAL DATA
Beatrice MGP Site
EE/CA Work Plan

Chemical Parameter	HA-1 (Upstream)	HA-2 (Adjacent to Site)	HA-3 (Downstream)	HA-4 (Downstream)
PAHs (mg/kg)				
Anthracene	0.0016	0.002	0.0034	ND
Benzo(a)anthracene	ND	0.0024	**0.012**	**0.0033**
Benzo(a)pyrene	0.0045	0.0053	**0.015**	0.0054
Benzo(b)fluoranthene	0.0039	0.0038	**0.013**	0.0052
Benzo(g,h,i)perylene	0.0023	0.0029	**0.0089**	0.0038
Benzo(k)fluoranthene	0.002	0.0022	**0.0067**	0.0024
Chrysene	0.0041	0.0048	**0.016**	0.0048
Fluoranthene	0.010	0.0095	**0.033**	0.011
Fluorene	ND	ND	**0.0012**	ND
Naphthalene	ND	**0.013**	ND	ND
Phenanthrene	ND	ND	**0.015**	ND
Pyrene	0.0089	ND	0.013	ND
Inorganics (mg/kg)				
Arsenic	1.47	ND	0.718	1.37
Beryllium	0.352	0.253	0.294	0.506
Chromium	6.66	4.94	5.39	9.14
Copper	6.41	4.99	5.32	9.39
Cyanide	ND	ND	ND	ND
Lead	8.30	6.88	8.15	8.27
Mercury	ND	ND	ND	ND
Nickel	7.52	5.87	5.69	10.6
Selenium	ND	ND	ND	**1.38**
Zinc	24	24.5	21.3	33.3

Abbreviations:
ND not detected
mg/kg milligrams per kilogram

Note:
(1) Numbers in bold are concentrations greater than three times the concentration detected in background sample HA-1 (NDEQ 2002).

TABLE 2-6

2004 RSE VOC SOIL ANALYTICAL DATA[1]

Beatrice MGP Site

EE/CA Work Plan

Grid Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Sample Depth (bgs)[2]	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acetone	0.29	0.12	0.22	0.19	0.15	0.13	0.13	0.22	0.12	0.22	600
Benzene	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	1.30
2-Butanone	ND	0.011	0.025	0.014	0.029	0.014	0.015	ND	0.023	0.024	NE
Carbon Disulfide	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	NE
Styrene	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	0.011	ND	ND	ND	ND	ND	ND	ND	420

Grid Number	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Sample Depth (bgs)[2]	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acetone	0.14	0.10	0.15	0.22	0.046	0.099	0.073	0.070	0.046	ND	600
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.30
2-Butanone	0.016	ND	0.020	0.020	ND	0.017	ND	ND	ND	ND	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.013	420

Grid Number	**21**				**22**	**23**				**24**	
Sample Depth (bgs)[2]	0-2	4-8	8-12	12-16	0-2	0-2	4-8	8-12	12-16	0-2	EPA PRG
Acetone	0.018	0.038	0.085	0.15	0.043	ND	0.094	0.086	0.077J	0.17	600
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.022	1.30
2-Butanone	ND	ND	ND	0.022	ND	ND	ND	ND	ND	0.027	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	420

TABLE 2-6 (Continued)
2004 RSE VOC SOIL ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**25**	**26**	**27**	**28**	**29**	**30**				**31**	
Sample Depth (bgs) [2]	0-2	0-2	0-2	0-2	0-2	0-2	0-2	4-8	8-12	12-16	EPA PRG
Acetone	0.037	0.082	0.064	0.075J	ND	0.066	0.029	ND	ND	ND	600
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.30
2-Butanone	ND	ND	0.011	0.012	ND	0.013	ND	ND	ND	ND	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	420

Grid Number	**32**				**33**	**34**	**35**				
Sample Depth (bgs) [2]	0-2	4-8	8-12	12-16	0-2	0-2	0-2	4-8	8-12	12-16	EPA PRG
Acetone	0.025	0.092	0.088	0.053U	0.073J	0.077	0.047	0.044U	ND	ND	600
Benzene	ND	ND	ND	ND	ND	ND	ND	0.16	ND	**2.50**	1.30
2-Butanone	ND	0.019	0.020	0.014	ND	0.013	ND	ND	ND	ND	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	0.034	4.40	16.0	20
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	0.015	ND	1.80	NE
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	0.026	4.00	15.0	420

Grid Number	**36**	**37**				**38**	**39**	**40**	**41**	**42**	
Sample Depth (bgs) [2]	0-2	0-2	4-8	8-12	12-16	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acetone	0.088	0.076	ND	0.021	0.013	0.075	ND	ND	0.12	ND	600
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.30
2-Butanone	0.013	ND	ND	ND	ND	ND	ND	ND	0.027	0.013	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Styrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	520
Xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	420

TABLE 2-6 (Continued)
2004 RSE VOC SOIL ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**43**	**44**	**45**	**46**	**47**				**48**	
Sample Depth (bgs) [2]	0-2	0-2	0-2	0-2	0-2	4-8	8-12	12-16	0-2	EPA PRG
Acetone	ND	0.036	ND	ND	ND	ND	ND	ND	ND	600
Benzene	ND	ND	ND	ND	ND	ND	0.28	**20.0**	ND	1.30
2-Butanone	ND	ND	ND	ND	0.013	ND	ND	ND	ND	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	0.013	ND	ND	720
Ethylbenzene	ND	0.018	ND	ND	ND	ND	0.044	**70.0**	ND	20
Isopropylbenzene	ND	0.024	ND	ND	ND	ND	ND	11.0	ND	NE
Styrene	ND	0.066	ND	ND	ND	ND	ND	1.60U	ND	170
Toluene	ND	0.017	ND	ND	ND	ND	ND	32.0	ND	520
Xylenes (total)	ND	0.018	ND	ND	ND	ND	0.019	65.0	ND	420

Grid Number	**49**	**50**				**51**	**52**	**River Bank**	**Circular Pad**	
Sample Depth (bgs) [2]	0-2	0-2	4-8	8-12	12-16	0-2	0-2	0-2	0-2	EPA PRG
Acetone	0.036	0.018	0.17J	0.17	ND	0.062	0.026	0.10	ND	600
Benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.30
2-Butanone	ND	0.049	0.042J	0.045	ND	ND	ND	ND	ND	NE
Carbon Disulfide	ND	ND	ND	ND	ND	ND	ND	ND	ND	720
Ethylbenzene	0.015	0.018	ND	ND	12.0	ND	ND	ND	ND	20
Isopropylbenzene	ND	ND	0.016J	0.012	2.3	ND	ND	ND	ND	NE
Styrene	0.062	ND	ND	ND	ND	ND	ND	ND	ND	170
Toluene	0.040	0.014	ND	ND	ND	ND	ND	ND	ND	520
Total Xylene	1.20	0.012	0.025J	ND	8.20	ND	ND	ND	ND	420

Abbreviations:
bgs below ground surface
J concentration estimated
mg/kg milligrams per kilogram
ND not detected
NE not established
PRG Preliminary Remediation Goal

Notes:
[1] All concentrations are in mg/kg. Numbers in bold are concentrations above the EPA Region 9 PRG for industrial soil.
[2] Sample depths in feet bgs except for River Bank and Circular Pad samples, which are in inches bgs.

TABLE 2-7
2004 RSE PAH SOIL ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Sample Depth (bgs) [2]	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29,000
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	100,000
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.10
Benzo(a)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.21
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.10
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	21.0
Chrysene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	210
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.21
Fluoranthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	22,000
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	26,000
Indeno (1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190
Phenanthrene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Pyrene	ND	ND	0.53	ND	ND	ND	ND	ND	ND	ND	29,000

Grid Number	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	
Sample Depth (bgs) [2]	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29,000
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	1.20	0.66	NE
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	0.43	ND	100,000
Benzo(a)anthracene	ND	ND	ND	ND	0.51	ND	ND	0.88	0.76	0.74	2.10
Benzo(a)pyrene	ND	ND	ND	ND	**0.54**	**0.49**	ND	**0.96**	**1.10**	**0.83**	0.21
Benzo(b)fluoranthene	ND	ND	ND	ND	0.48	ND	ND	0.65	0.94	1.10	2.10
Benzo(g,h,i)perylene	ND	ND	ND	ND	0.40	0.44	ND	0.74	1.10	1.20	NE
Benzo(k)fluoranthene	ND	ND	ND	ND	0.46	ND	ND	0.71	0.85	0.53	21.0
Chrysene	ND	ND	ND	ND	0.58	ND	ND	0.91	0.96	0.91	210
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.21
Fluoranthene	ND	ND	ND	ND	1.00	ND	ND	1.30	1.10	1.20	22,000
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	26,000
Indeno (1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	ND	0.75	0.79	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190
Phenanthrene	ND	ND	ND	ND	0.46	ND	ND	0.37	ND	0.40	NE
Pyrene	ND	ND	ND	ND	0.93	0.55	ND	2.00	1.20	1.60	29000

TABLE 2-7 (Continued)
2004 RSE PAH SOIL ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**21**				**22**	**23**				**24**	**25**	
Sample Depth (bgs) [2]	0-2	4-8	8-12	12-16	0-2	0-2	4-8	8-12	12-16	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.70J	ND	29,000
Acenaphthylene	3.90	0.89	ND	ND	2.30	1.70	0.41	ND	ND	3.90J	ND	NE
Anthracene	1.60	0.39	ND	ND	1.10	0.79	ND	ND	ND	16.0	ND	100,000
Benzo(a)anthracene	**3.60**	ND	ND	ND	**5.50**	1.40	0.42	ND	ND	**30.0J**	ND	2.10
Benzo(a)pyrene	**2.90**	ND	ND	ND	**3.30**	**1.30**	**0.72**	ND	ND	**21.0**	ND	0.21
Benzo(b)fluoranthene	**5.90**	0.44	ND	ND	**7.70**	**2.40**	0.71	ND	ND	**28.0**	ND	2.10
Benzo(g,h,i)perylene	5.60	ND	ND	ND	8.70	1.90	1.10	ND	ND	21.0	ND	NE
Benzo(k)fluoranthene	4.60	ND	ND	ND	8.10	2.10	0.60	ND	ND	18.0	ND	21.0
Chrysene	5.30	ND	ND	ND	7.60	2.70	0.58	ND	ND	36.0J	ND	210
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	**4.10J**	ND	0.21
Fluoranthene	4.70	ND	ND	ND	5.80	1.70	0.63	ND	ND	77.0	ND	22,000
Fluorene	0.42	ND	ND	ND	ND	ND	ND	ND	ND	6.20J	ND	26,000
Indeno (1,2,3-cd)pyrene	**4.20**	0.39	ND	ND	**6.60**	1.50	0.71	ND	ND	**17.0**	ND	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.77	ND	NE
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.90	ND	190
Phenanthrene	0.61	ND	ND	ND	1.50	ND	ND	ND	ND	62.0	ND	NE
Pyrene	6.60	ND	ND	ND	8.00	2.50	1.30	ND	ND	62.0J	ND	29,000

Grid Number	**26**	**27**	**28**	**29**	**30**				**31**	**32**		
Sample Depth (bgs) [2]	0-2	0-2	0-2	0-2	0-2	4-8	8-12	12-16	0-2	0-2	4-8	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	29,000
Acenaphthylene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	0.89	ND	ND	100,000
Benzo(a)anthracene	ND	ND	0.85	ND	ND	ND	ND	ND	1.80	ND	ND	2.10
Benzo(a)pyrene	ND	ND	**0.58**	ND	ND	ND	ND	ND	**1.30**	ND	ND	0.21
Benzo(b)fluoranthene	ND	ND	0.66	ND	0.54	ND	ND	ND	2.00	ND	ND	2.10
Benzo(g,h,i)perylene	ND	ND	0.48	ND	0.49	ND	ND	ND	0.68	ND	ND	NE
Benzo(k)fluoranthene	ND	ND	0.62	ND	ND	ND	ND	ND	ND	ND	ND	21.0
Chrysene	0.39	ND	0.86	ND	ND	ND	ND	ND	1.40	ND	ND	210
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.21
Fluoranthene	0.71	0.82	1.80	ND	ND	ND	ND	ND	3.50	ND	ND	22,000
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	0.75	ND	ND	26,000
Indeno (1,2,3-cd)pyrene	ND	ND	0.45	ND	ND	ND	ND	ND	0.70	ND	ND	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NE
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	190
Phenanthrene	0.41	0.50	0.97	ND	ND	ND	ND	ND	3.60	ND	ND	NE
Pyrene	0.52	0.56	1.50	ND	0.50	ND	ND	ND	2.70	ND	ND	29,000

TABLE 2-7 (Continued)
2004 RSE PAH SOIL ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**32**		**33**	**34**	**35**				**36**	**37**	
Sample Depth (bgs) [2]	8-12	12-16	0-2	0-2	0-2	4-8	8-12	12-16	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	0.86	12.0	4.10	ND	ND	29,000
Acenaphthylene	ND	ND	3.80	ND	ND	ND	ND	ND	1.90	2.30	NE
Anthracene	ND	ND	1.40	ND	ND	ND	14.0J	2.70	0.96	1.30	100,000
Benzo(a)anthracene	ND	ND	**2.60**	ND	0.80	ND	**7.00J**	**2.30**	**2.20**	**13.0**	2.10
Benzo(a)pyrene	ND	ND	**2.70**	ND	**0.64**	ND	**4.90J**	**1.60**	**1.60**	**6.70**	0.21
Benzo(b)fluoranthene	ND	ND	**2.70**	ND	1.10	ND	**3.60J**	1.30	1.50	**18.0J**	2.10
Benzo(g,h,i)perylene	ND	ND	3.80	ND	0.75	ND	1.80	0.62	1.40	11.0	NE
Benzo(k)fluoranthene	ND	ND	2.40	ND	ND	ND	1.20	ND	1.60	5.40	21.0
Chrysene	ND	ND	2.90	ND	0.85	ND	4.70J	1.90	2.40	16.0	210
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	**0.54**	ND	ND	**1.50**	0.21
Fluoranthene	ND	ND	3.50	0.42	1.70	ND	11.0J	2.50	4.60	20.0	22,000
Fluorene	ND	ND	0.41	ND	ND	ND	13.0J	2.30	ND	ND	26,000
Indeno (1,2,3-cd)pyrene	ND	ND	**2.60**	ND	0.50	ND	1.30	0.50	1.10	**9.70**	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	0.88	34.0	11.0	ND	ND	NE
Naphthalene	ND	ND	ND	ND	ND	4.40	43.0	15.0	ND	ND	190
Phenanthrene	ND	ND	0.76	ND	0.69	0.80	17.0	9.60	2.30	7.90	NE
Pyrene	ND	ND	3.50	0.46	1.20	ND	13.0J	3.20	5.10	28.0	29,000

Grid Number	**37**			**38**	**39**	**40**	**41**	**42**	**43**	**44**	
Sample Depth (bgs) [2]	4-8	8-12	12-16	0-2	0-2	0-2	0-2	0-2	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.81	29,000
Acenaphthylene	ND	ND	ND	ND	0.76	ND	ND	ND	ND	2.40	NE
Anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.40	100,000
Benzo(a)anthracene	0.48	2.00	0.52	0.42	**2.60**	ND	ND	ND	0.52	**5.80**	2.10
Benzo(a)pyrene	ND	**0.58**	ND	ND	**2.60**	ND	ND	ND	**0.48**	**9.10**	0.21
Benzo(b)fluoranthene	ND	**2.90J**	0.91J	0.63	**3.10**	ND	0.65	ND	0.71	**6.20**	2.10
Benzo(g,h,i)perylene	ND	1.50	0.44	ND	2.80	ND	0.51	ND	0.50	6.80	NE
Benzo(k)fluoranthene	ND	0.74	ND	ND	0.79	ND	ND	ND	ND	2.30	21.0
Chrysene	0.68	2.20	0.66	0.41	2.30	ND	ND	ND	0.50	5.90	210
Dibenzo(a,h)anthracene	ND	**0.57**	ND	ND	**0.84**	ND	ND	ND	ND	**1.60**	0.21
Fluoranthene	0.88	4.10	1.20	0.67	2.20	ND	0.50	ND	0.66	8.60	22,000
Fluorene	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.70	26,000
Indeno (1,2,3-cd)pyrene	ND	1.20	ND	ND	**2.20**	ND	ND	ND	ND	**5.70**	2.10
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.60	NE
Naphthalene	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.30	190
Phenanthrene	ND	1.70	ND	ND	ND	ND	ND	ND	ND	9.60	NE
Pyrene	1.20	5.00	1.50	0.77	5.10	ND	0.89	ND	1.10	10.0	29,000

TABLE 2-7 (Continued)
2004 RSE PA/SI PAH SOIL ANALYTICAL[1]
Beatrice MGP Site
EE/CA Work Plan

Grid Number	**45**	**46**	**47**				**48**	**49**	
Sample Depth (bgs) [2]	0-2	0-2	0-2	4-8	8-12	12-16	0-2	0-2	EPA PRG
Acenaphthene	ND	ND	ND	ND	2.60	ND	ND	68.0	29,000
Acenaphthylene	1.70	ND	ND	ND	2.20	ND	4.70	24.0	NE
Anthracene	1.10	ND	ND	ND	3.20	ND	6.40	43.0	100,000
Benzo(a)anthracene	**3.70**	ND	0.93	ND	1.80	ND	**17.0**	**30.0**	2.10
Benzo(a)pyrene	**4.60**	ND	**0.82**	ND	**1.30**	ND	**13.0**	**200**	0.21
Benzo(b)fluoranthene	**4.20**	ND	1.40	ND	1.10	ND	**13.0**	**12.0**	2.10
Benzo(g,h,i)perylene	5.20	ND	1.20	ND	0.68	ND	7.50	13.0	NE
Benzo(k)Fluoranthene	1.50	ND	ND	ND	0.40	ND	8.80	12.0	21.0
Chrysene	2.80	ND	0.79	ND	1.50	ND	15.0	32.0	210
Dibenzo(a,h)Anthracene	**1.20**	ND	ND	ND	ND	ND	**3.80J**	ND	0.21
Fluoranthene	5.50	0.38	1.10	ND	3.30J	ND	26.0	65.0	22,000
Fluorene	0.73	ND	ND	ND	2.70	ND	ND	50.0	26,000
Indeno (1,2,3-cd)pyrene	**3.00**	ND	0.75	ND	0.43	ND	**7.10**	ND	2.10
2-Methylnaphthalene	0.46	ND	ND	ND	6.30	38.0	ND	54.0	NE
Naphthalene	ND	ND	ND	ND	11.0	58.0	ND	ND	190
Phenanthrene	3.90	ND	0.43	ND	9.60	18.0	11.0	180	NE
Pyrene	8.90	0.43	1.80	ND	4.10	ND	21.0	99.0	29,000

Grid Number	**50**				**51**	**52**	**River bank**	**Circular pad**	
Sample Depth (bgs) [2]	0-2	4-8	8-12	12-16	0-2	0-2	0-2	0-2	EPA PRG
Acenaphthene	ND	2.40	1.70	18.0	ND	ND	ND	ND	29,000
Acenaphthylene	0.65	ND	ND	ND	1.90	0.60	ND	3.00	NE
Anthracene	0.64	1.80	1.10	ND	0.62	ND	ND	1.10	100,000
Benzo(a)anthracene	**2.30**	1.70	0.87	ND	**5.70**	**2.20**	ND	**6.50**	2.10
Benzo(a)pyrene	**1.50**	**1.10**	**0.49**	ND	**3.30**	**1.40**	ND	**6.90**	0.21
Benzo(b)fluoranthene	**2.70**	1.20	0.43	ND	**4.60**	**2.50**	ND	**8.80J**	2.10
Benzo(g,h,i)perylene	1.60	0.55	ND	ND	8.80	2.00	ND	9.10	NE
Benzo(k)Fluoranthene	0.66	0.87	0.43	ND	1.30	0.86	ND	2.60	21.0
Chrysene	1.80	1.80	0.83	ND	7.30	2.10	ND	3.80	210
Dibenzo(a,h)Anthracene	**0.51**	ND	ND	ND	**2.20**	**0.62**	ND	**1.10**	0.21
Fluoranthene	2.90	5.10	2.30	ND	7.30	2.80	ND	5.70	22,000
Fluorene	0.45	2.60	1.60	ND	ND	ND	ND	ND	26,000
Indeno (1,2,3-cd)pyrene	1.20	0.50	ND	ND	**5.60**	1.40	ND	6.50	2.10
2-Methylnaphthalene	ND	ND	ND	0.56	ND	ND	ND	ND	NE
Naphthalene	ND	ND	0.67	2.10	25.0	ND	ND	0.44	190
Phenanthrene	1.50	2.60	7.90	2.90	24.0	2.50	ND	1.20	NE
Pyrene	4.80	5.60	6.00	3.00	ND	15.0	ND	9.80	29,000

TABLE 2-7 (continued)
2004 RSE PA/SI PAH SOIL ANALYTICAL[1]
Beatrice MGP Site
EE/CA Work Plan

Abbreviations:

bgs	below ground surface
J	concentration estimated
mg/kg	milligrams per kilogram
ND	not detected
NE	not established
PRG	Preliminary Remediation Goal

Notes:
[1] All concentrations are in mg/kg. Numbers in bold are concentrations above the EPA Region 9 PRG for industrial soil.
[2] Sample depths in feet bgs except for River Bank and Circular Pad samples, which are in inches bgs.

TABLE 2-8
2004 RSE GROUNDWATER ANALYTICAL DATA[1]
Beatrice MGP Site
EE/CA Work Plan

	MW-1	MW-2	MW-3	GW-4	GW-1	GW-2	GW-3	PRG	MCL
VOCs (µg/L)									
Acetone	ND	15.0	ND	14.0	ND	10.0	ND	5500	NE
Benzene	ND	**710**	**18000**	ND	ND	ND	**19000**	0.35	5
Ethyl Benzene	ND	**520**	**4500**	ND	ND	ND	**2800**	1300	700
Isopropyl Benzene	ND	39.0	170	ND	ND	ND	ND	NE	NE
Toluene	ND	14.0	**1500**	ND	ND	ND	**740**	720	1000
Xylenes (total)	ND	**230**	**3900**	ND	ND	ND	**2500**	210	10000
PAHs (µg/L)									
Acenaphthene	10.0	270	**2800J**	ND	ND	26.0	43.0J	370	NE
Acenaphthylene	ND	ND	625J	ND	ND	ND	14.0J	NE	NE
Anthracene	ND	ND	1200J	ND	ND	ND	6.10J	1800	NE
Benzo(a)anthracene	ND	ND	**480J**	ND	ND	ND	ND	0.092	NE
Benzo(a)pyrene	ND	ND	**460J**	ND	ND	ND	ND	0.0092	0.20
Benzo(b)fluoranthene	ND	ND	ND	ND	ND	ND	ND	0.092	NE
Benzo(g,h,i)perylene	ND	ND	ND	ND	ND	ND	ND	NE	NE
Benzo(k)fluoranthene	ND	ND	ND	ND	ND	ND	ND	0.92	NE
Chloronaphthalene	ND	ND	ND	ND	ND	ND	ND	NE	NE
Chrysene	ND	ND	**570J**	ND	ND	ND	ND	9.2	NE
Dibenzo(a,h)anthracene	ND	ND	ND	ND	ND	ND	ND	0.0092	NE
Fluoranthene	ND	ND	1100J	ND	ND	ND	4.00J	1500	NE
Fluorene	ND	ND	**1500J**	ND	11.0	ND	18.0J	240	NE
Indeno(1,2,3-cd)pyrene	ND	ND	ND	ND	ND	ND	ND	0.092	NE
2-Methylnaphthalene	ND	89.0	8000J	ND	ND	ND	210J	NE	NE
Naphthalene	**23.0J**	**1800**	**18000J**	ND	ND	ND	**5716J**	6.20	NE
Phenanthrene	ND	85.0	4000J	ND	ND	ND	28.0J	NE	NE
Pyrene	ND	ND	**1600J**	ND	ND	ND	5.70J	180	NE
Cyanide (mg/L)	0.003	0.116	**0.075**	ND	0.004	0.004	0.143	0.73	0.2

Abbreviations:
J concentration estimated
MCL Maximum Contaminant Level
mg/L milligram per liter
ND not detected
NE not established
PAHs polynuclear aromatic hydrocarbons
PRG Preliminary Remediation Goal
µg/L microgram per liter
VOCs volatile organic compounds

Note:
[1] Numbers in bold are concentrations above the MCL or EPA Region 9 tap water PRGs.

TABLE 2-2
GROUNDWATER MONITORING WELL DEPTH AND SCREENED INTERVAL

Monitoring Well	Total Depth (feet bgs)	Ground Elevation (feet above msl)	Screened Interval	
			(feet bgs)	(feet above msl)
MW-01	27.2	1253.58	17.2-27.2	1226.38-1236.38
MW-02	24	1251.68	13.7-23.7	1227.98-1237.82
MW-03	27.5	1250.22	16.9-26.9	1223.32-1233.32
MW-04	22	1247.70	12.4-22	1225.70-1235.30
MW-05	15	1238.31	5.4-15	1223.31-1232.91
MW-06	20.5	1247.58	10.4-20	1227.58-1237.18
MW-07	24	1251.24	9.5-24	1227.24-1241.74
MW-08	20	1250.98	10.4-20	1230.98-1240.58
MW-09	20	1252.07	7-20	1232.07-1245.07
MW-10	17	1250.73	7.4-17	1233.73-1243.33

Abbreviation:
msl mean sea level

TABLE 3-1
GROUNDWATER DEPTHS AND ELEVATIONS

Monitoring Well	TOC Elevation (ft amsl)	Date	Depth to water (ft btoc)	Ground Water Elevation[1] (ft amsl)	LNAPL Thickness (ft)	DNAPL Thickness (ft)	Comments
MW-01	1253.59	7/11/10	19.21	1234.38	<0.01	0	None
		9/10/10	19.93	1237.68	0.01	0	None
		1/18/11	20.22	1233.37	0	0	None
MW-02	1251.25	7/11/10	11.87	1239.38	<0.01	0	None
		9/10/10	12.82	1238.44	0.01	0	None
		1/18/11	13.53	1237.72	<0.01	0	None
MW-03	1253.18	7/11/10	19.54	1236.44	3.5	1.33	0.01' LNAPL measured with oil/water indicator probe; 3.5' LNAPL staining on probe upon withdrawal
		9/10/10	20.55	1233.05	0.53	1.42	0.01' LNAPL measured with oil/water indicator probe; 0.53' LNAPL staining on probe upon withdrawal
		1/18/11	20.74	1232.44	<0.01	1.88	None
MW-04	1249.89	7/11/10	20.02	1229.87	<0.01	0	None
		9/10/10	21.51	1229.12	0.93	1.17 (smears)	0.02' LNAPL measured with oil/water indicator probe; 0.93' of LNAPL on probe upon withdrawal
		1/18/11	21.54	1228.37	0.02	0.83	None
MW-05	1241.13	7/11/10	12.13	1229.00	0	0.33 (smears)	None
		9/10/10	13.53	1227.62	0.03	0	0.03' LNAPL measured with oil/water indicator probe; 0.01' of LNAPL staining on probe upon withdrawal
		1/18/11	13.39	1227.74	0	0.25 (smears)	None
MW-06	1250.46	7/11/10	14.45	1236.01	0	0	None
		9/10/10	16.14	1234.32	0	0	None
		1/18/11	15.46	1235.00	0	0	None
MW-07	1250.82	7/11/10	10.68	1240.14	<0.01	0	None
		9/10/10	11.69	1239.14	0.01	0	None
		1/18/11	12.59	1238.23	0	0	None
MW-08	1250.40	7/11/10	11.32	1241.21	0.17	0	None
		9/10/10	11.91	1238.52	0.04	0	0.01' LNAPL measured with oil/water indicator probe; 0.04' of LNAPL staining on probe upon withdrawal
		1/18/11	12.63	1237.77	0	0	None
MW-09	1251.48	7/11/10	12.05	1239.43	0	0	None
		9/10/10	12.58	1238.90	0	0	None
		1/18/11	13.30	1238.18	0	0	None

TABLE 3-1 (Continued)
GROUNDWATER DEPTHS AND ELEVATIONS

Monitoring Well	TOC Elevation (ft amsl)	Date	Depth to water (ft btoc)	Ground Water Elevation[1] (ft amsl)	LNAPL Thickness (ft)	DNAPL Thickness (ft)	Comments
MW-10	1250.15	7/11/10	10.37	1239.78	0	0	None
		9/10/10	10.87	1239.28	0	0	None
		1/18/11	11.49	1238.66	0	0	None

Abbreviations:

amsl above mean sea level
btoc below top of casing

Note:
[1] To account for LNAPL where present, the groundwater elevation was calculated by multiplying the LNAPL thickness by 0.8 and subtracting this value from the measured depth to water.

TABLE 4-1
SOIL OBSERVATIONS

Probe	Total Depth (ft bgs)	PID readings (ppm)	Observations/Odors
SP-101	17	0	Tar sheen from 15.5 to 17 ft bgs.
SP-102	17.5	0	Tar odor from 7.2 to 17.5 ft bgs. Tar sheen from 15 to 17.5 ft bgs.
SP-103	17	Ranged from 0 to 12.3 with the highest at 5 ft bgs.	Tar odor from 6.5 to 15 ft bgs. Tar sheen from 15 to 17 ft bgs.
SP-104	15	Ranged from 0 to 18.1 with the highest at 14.5 ft bgs.	Tar sheen from 7 to 15 ft bgs.
SP-105	25	Ranged from 0.5 to 641 with highest at 18 ft bgs.	Tar seams/sheen from 17.8 to 23 ft bgs. Tar odor from 17.8 to 25 ft bgs.
SP-106	24	Ranged from 0 to 450 with the highest at 20 ft bgs.	Tar odor from 9 to 24 ft bgs. Tar seams from 21 to 22.5 ft bgs. Tar smearing from 20 to 21 and 22.5 to 23.5 ft bgs.
SP-107	23	0	Tar smearing from 20 to 23 ft bgs.
SP-108	16	PID readings ranged from 0 to 62.8 ppm with peak reading at 12 ft bgs.	Tar odor from 10 to 16 ft bgs. Rainbow sheen from 10 to 12 ft bgs. Tar sheen from 12 to 13.5 feet bgs.
SP-109	17.5	0	No contamination evident.
SP-110	24	Ranged from 0.8 to 146 with highest at 17 ft bgs.	Tar odor from 11 to 17.5 ft bgs. Tar sheen from 17.5 to 21.5 ft bgs. Tar odor from 23 to 24 ft bgs.
SP-111	19	Ranged from 0 to 1.8.	No contamination evident.
SP-112	23	Ranged from 0 to 1089 with the highest at 22 ft bgs.	Petroleum/diesel odor from 19.5 to 23 ft bgs.
SP-113	18	Ranged from 0 to 1.8.	No contamination evident.
SP-114	15	0	No contamination evident.
SP-115	24	Ranged from 0 to 62.5 with the highest at 16 ft bgs.	Rainbow sheen from 6.5 to 6.8 ft bgs. Petroleum odor from 6.8 to 12 ft bgs. Tar seams from 12 to 22.5 ft bgs. Tar odor from 22.5 to 23 ft bgs.
SP-116	24	Ranged from 0 to 33.5 with the highest at 23 ft bgs.	Rainbow sheen from 16 to 23 ft bgs. Tar saturated from 23 to 23.5 ft bgs.
SP-117	20	0	No contamination evident.
SP-118	21	Ranged from 0 to 197 with the highest at 7.5 ft bgs.	Rainbow sheen/Tar odor from 4 to 21 ft bgs.
SP-119	19	0	No contamination evident.
SP-120	17	Range from 0 to 220 with the highest at 4 ft bgs.	Tar odor from 3 to 16.6 ft bgs. Tar coated from 5.5 to 10 ft bgs. Tar saturated from 12.2 to 15.6 ft bgs. Trace tar from 15.6 to 16.6 ft bgs.

TABLE 4-1 (Continued)
SOIL OBSERVATIONS

Probe	Total Depth (ft bgs)	PID readings (ppm)	Observations/Odors
SP-121	18	Not measured due to equipment malfunction.	Tar coated/stringers from 4.5 to 16.6 ft bgs. Tar saturated from 16.6 to 16.9 ft bgs.
SP-122	15	Not measured due to equipment malfunction.	No contamination evident.
SP-123	20	Not measured due to equipment malfunction.	Petroleum odor from 14.1 to 19.3 ft bgs.
GWP-121	20	Not measured due to equipment malfunction.	No PID readings were collected.
MW-09	19.9	0	No contamination evident.
MW-10	16.7	0	No contamination evident.
SP-124	7.5	0	No contamination evident.
SP-125	10	0	No contamination evident.
SP-126	9	0	No contamination evident.
SP-127	7	0	No contamination evident.

Abbreviation:
ppm part per million

TABLE 4-2

SOIL BTEX AND PAH ANALYTICAL DATA SUMMARY[1]

Probe	Sample Date	Laboratory	Sample Depth (feet bgs)	Benzene	Toluene	Ethylbenzene	Total Xylenes[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
SP-101	7/15/08	ECCS	2-3	<0.022	0.03	<0.022	<0.0166	<0.01	<0.01	0.011	<0.01	0.019	<0.01	0.018	<0.01	0.028	<0.01	0.027	<0.01	<0.01	<0.01	<0.01	0.03
		ECCS	6-7	<0.02	0.03	<0.02	<0.0151	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086	<0.0086
SP-102	7/15/08	ECCS	3-3.5	<0.026	0.027	0.081	0.042	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089	<0.0089
		ECCS	9-10	<0.024	0.043	<0.024	<0.0181	<0.0079	0.015	<0.0079	<0.0079	0.041	<0.0079	0.052	<0.0079	0.061	<0.0079	0.031	<0.0079	<0.0079	<0.0079	<0.0079	0.059
		ECCS	13-13.5	<0.023	0.032	<0.023	<0.0178	2.2	1.2	1.6	1.4	0.79	0.91	0.37	0.38	0.96	0.073	2.2	0.55	0.24	0.15	9.3	3
SP-103	7/15/08	ECCS	5-6	<0.027	0.041	<0.027	<0.0197	<0.0085	<0.0085	<0.0085	<0.0085	0.089	<0.0085	0.1	<0.0085	0.035	<0.0085	0.03	<0.0085	0.025	<0.0085	<0.0085	0.03
		ECCS	9-10	<0.026	0.036	<0.026	0.041	0.6	0.086	0.54	0.23	0.35	0.29	0.16	0.26	0.31	0.029	0.37	0.41	0.091	1.4	0.92	0.58
		ECCS	14-15	<0.026	0.041	<0.026	0.022	0.67	0.12	0.085	<0.0096	<0.0096	<0.0096	0.021	<0.0096	0.062	<0.0096	0.055	0.28	<0.0096	0.25	0.35	0.11
SP-103 (Duplicate)	7/15/08	ECCS	14-15	<0.24	0.32	<0.24	<0.18	0.2	0.068	0.034	<0.0083	<0.0083	<0.0083	<0.0083	<0.0083	<0.0083	<0.0083	<0.0083	0.12	<0.0083	0.11	0.22	0.0085
SP-104	7/16/08	ECCS	2-3	<0.024	0.05	<0.024	0.0098	<0.0078	<0.0078	0.0099	<0.0078	<0.0078	<0.0078	0.0083	<0.0078	<0.0078	<0.0078	<0.0078	0.11	<0.0078	0.092	0.18	0.011
		Pace	6-7	<0.0013	<0.0015	<0.0019	<0.0022	0.024	0.0028	0.0115	0.0053	0.0036	0.0047	0.0013	<0.00088	0.0057	<0.00063	0.0146	0.0121	<0.00076	0.019	0.0414	0.0213
SP-107	7/16/08	ECCS	2-3	<0.023	<0.023	<0.023	<0.0178	<0.0086	0.036	0.05	0.08	0.095	0.57	0.23	0.095	0.24	0.01	0.25	<0.0086	0.12	0.1	0.22	0.38
		ECCS	11-12	<0.024	0.035	<0.024	<0.018	0.014	0.083	0.052	0.14	0.17	0.66	0.27	0.13	0.3	0.043	0.24	0.13	0.16	0.13	0.27	0.4
		ECCS	21-22	11J	1.6J	54J	70J	130	12	58	40	27	13	14	13	26	6.6	65	55	13	230	150	21
		Pace	21-22	1.29	0.647	28	17.6	23.1	2.46J	12.3	7.3	5.81J	5.34J	1.57J	2.1J	6.65J	0.512J	13.7	12.5	1.16J	88.2J	26.8	22.6
SP-107 (Duplicate)	7/16/08	ECCS	21-22	1.6	0.64	320	188	540	260	320	330	200	49	200	41	180	220	310	370	200	730	<0.098	300
		Pace	21-22	1.82	0.935	37	24.2	97.9	10.4J	60.4J	24.7J	23.7J	18.7J	8.04J	7.69J	21.9J	2.29J	51.9J	45.3	5.61J	282J	148J	101J
SP-108	7/15/08	ECCS	3-4	<0.028	0.042	<0.028	<0.0209	<0.01	<0.01	0.014	<0.01	<0.01	<0.01	0.021	<0.01	0.027	<0.01	0.048	<0.01	<0.01	<0.01	<0.01	0.043
		Pace	3-4	<0.0013	<0.0015	<0.0019	<0.0021	0.0452	0.0046	0.0263	0.0138	0.0134	0.015	0.0058	<0.00089	0.0169	<0.00064	0.0301	0.0202	0.0047	<0.001	0.0767	0.0512
		ECCS	11-12	0.23	0.036	0.39	0.15	0.45	0.012	0.092	<0.0078	0.011	<0.0078	0.012	<0.0078	0.023	<0.0078	0.031	0.22	<0.0078	0.66	0.32	0.045
		Pace	11-12	<0.0013	<0.0016	0.0079	0.0099	0.892	0.0246	0.0802	0.0163	0.0126	0.0158	0.0071	0.0044	0.0177	<0.00066	0.0484	0.358	0.0058	1.21	0.463	0.063
SP-109	7/19/08	ECCS	2-3	<0.49	0.8	<0.49	<0.36	<5	<5	<5	44	79	180	28	120	54	<5	41	<5	10	<5	<5	54
SP-110	7/16/08	ECCS	2-3	<0.026J	<0.026J	<0.026J	<0.0194J	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	0.013	<0.0096	<0.0096	<0.0096	<0.0096	0.13	<0.0096	0.11	0.21	0.0098
		ECCS	11-12	<0.5J	<0.5J	6.2J	6.7J	95	21	45	57	30	24	20	18	36	14	65	59	19	330	150	95
		ECCS	17-18	0.61	0.89J	32	26	55	15	31	37	21	24	15	10	23	10	41	36	17	160	79	57
SP-111	7/18/08	ECCS	2-3	<0.024	0.058	0.11	0.074	<0.01	0.015J	<0.01	0.038J	0.05J	<0.01	0.1J	0.058J	0.043J	<0.01	0.039J	<0.01	0.013J	0.084J	0.045J	0.064J
		Pace	2-3	<0.0013	<0.0015	0.0023	<0.0021	0.0434	0.142	0.27	0.671	0.604	0.825	0.183	0.341	0.789	0.0674J	1.49	0.144	0.193J	0.272	1.54	1.58
		ECCS	8-9	<0.023	0.038	<0.023	<0.0167	<0.0089	0.014	0.029	0.049	0.058	0.19	0.086	0.046	0.065	<0.0089	0.091	<0.0089	0.011	0.066	0.081	0.12
		ECCS	14-15	<0.023	0.027	<0.023	<0.0178	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082	<0.0082
SP-112	7/18/08	ECCS	2-3	<0.024	0.044	<0.024	<0.0181	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096
		ECCS	8-9	<0.025J	<0.025J	<0.025J	<0.0193J	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
		ECCS	14-15	<0.21	0.38	<0.21	<0.063	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093	<0.0093
SP-113	7/16/08	ECCS	3-4	<0.024	0.036	<0.024	<0.0179	0.27	0.059	0.99	0.95	0.82	1.2	0.63	0.35	0.93	0.62	2.2	0.33	0.56	0.22	1.5	2
		ECCS	6-7	<0.025	0.032	<0.025	<0.0182	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	0.22	<0.0094
SP-114	7/17/08	ECCS	2-3	<0.024	<0.024	<0.024	<0.0179	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081	<0.0081
		ECCS	6-7	<0.025	0.031	<0.025	<0.0193	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098	<0.0098
SP-115	7/19/08	ECCS	7-8	<0.5J	0.61J	2.3J	5.7J	100	14	120	49	24	<2.4	6.6	<2.4	12	<2.4	47	57	<2.4	250	140	77
SP-116	7/19/08	ECCS	9-10	<0.51	0.51	<0.51	0.43	<0.091	4.6	<0.091	4.2	6.4	7.7	5.3	4.8	3.1	1.2	1.1	0.95	4	2	<0.091	2.9
		ECCS	12-13	<0.025	0.028	<0.025	<0.0181	<0.093	3.8	<0.093	8.7	5.1	9.1	4.6	4.9	<0.093	1.9	0.22	0.62	2.7	1.6	<0.093	4.3
SP-117	7/19/08	ECCS	2-3	<0.024J	<0.024J	<0.024J	0.0196J	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094	<0.0094
		ECCS	7-8	<0.024J	<0.024J	<0.024J	<0.0181J	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096	<0.0096
SP-118	7/19/08	ECCS	7-8	1.76	1.28	15.4	15.1	24.3	4.15	11.3	5.75	4.63	4.21	1.57	1.24	5.92	0.468	9.91	12.6	1.15	127	28.4	21.5
SP-119	9/22/09	Pace	2.5-3.5	<0.0011	<0.0014	<0.0017	<0.0019J	0.0122	0.0165	0.0326	0.106	0.0925	0.236	0.0840	<0.00079	0.153	0.0142	0.255	0.0231	0.0701	0.196	0.459	0.278
		Pace	8-9	<0.0011	<0.0013	<0.0017	<0.0019J	0.0024	0.00042	0.00079	0.00069	0.00077	0.0015	0.00097	<0.0007	0.0018	<0.00053	0.0015	0.0029	0.00050	0.0041	0.0081	0.0017
		Pace	12-13	<0.0009	<0.0011	<0.0013	<0.0015J	0.0011	<0.00035	<0.00039	<0.0005	<0.00043	<0.00041	<0.00046	<0.00065	0.00068	<0.00048	<0.0005	0.0014	<0.00041	0.0026	0.0026	<0.00058

TABLE 4-2(Continued)

SOIL BTEX AND PAH ANALYTICAL DATA SUMMARY[1]

Probe	Sample Date	Laboratory	Sample Depth (feet bgs)	Benzene	Toluene	Ethylbenzene	Total Xylenes[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene
SP-120	9/22/09	Pace	5-6	0.0603	0.103	1.53J	1.54J	35.8	3.55	18	9.01	7.58	10	3.27	<0.42	8.66	0.656	22.2	19.9	2.61	213	57.4	30
		Pace	9-10	0.279	1.89J	48.9	49.7	106	15.3	61.6	36.1	31.5	38.8	13.5	<0.766	32.4	2.45	75.7	64.7	10.0	575	193	110
SP-121	9/22/09	Pace	4.5-5.5	0.409	1.33J	4.02	6.38	117	15.6	53.1	26.6	21.5	25.3	10.0	<0.785	25.4	2.09	49.4	65.2	7.22	325	170	73.1
		Pace	9-10	0.964	2.45J	17.8	18.4	134	15	58.9	29	19.8	22.6	8.12	<0.796	26.9	1.72	52.4	76.7	5.87	396	192	77.5
		Pace	16-17	0.362	<0.285J	8.32	8.95	48.8	6.12	26.3	12.9	9.46	11.4	4.05	<0.435	13.1	0.779	28.3	31.2	2.92	166	95.4	40.6
SP-121 (Duplicate)	9/22/09	Pace	4.5-5.5	0.441	1.53J	4.48	7.52	110	17.4	52.6	29.7	23.5	32.1	12.8	<0.783	30.4	2.2	52.6	63.2	9.02	303	168	79.9
SP-122	9/22/09	Pace	4-5	<0.0012	<0.0014	0.0021	<0.002J	0.0162	0.0844	0.0469	0.147	0.194	0.334	0.179	<0.00076	0.166	0.0281	0.183	0.0247	0.135	0.0603	0.138	0.26
		Pace	6.5-7.5	<0.001	<0.0012	<0.0015	<0.0017J	0.0043	0.0062	0.0052	0.0083	0.0079	0.0166	0.0074	<0.00069	0.0115	0.0013	0.0148	0.0052	0.0056	0.0065	0.0166	0.0298
SP-123	9/22/09	Pace	4-5	<0.0013	<0.0016	<0.002	<0.0022J	0.0123	0.0029	0.0092	0.0056	0.0048	0.0108	0.0038	<0.00081	0.0077	0.00070	0.0122	0.0127	0.0032	0.0122	0.0437	0.0172
		Pace	9-10	<0.0011	<0.0014J	<0.0017	0.0044	0.0019	0.00079	0.0012	0.00096	0.00095	0.0029	0.00066	<0.00075	0.0023	<0.00056	0.0028	0.0023	0.00053	0.0028	0.0061	0.0030

Abbreviations:

< Analyte was not detected at or above the method detection limit presented.

J Concentration was qualified as estimated based on data evaluation/validation.

Notes:

(1) Concentrations are in mg/kg.

(2) ECCS reported xylenes as o-xylene and m&p-xylenes while Pace reported total xylenes. For ease of comparison, ECCS concentrations/detection limits were summed to present a total xylene concentration.

TABLE 4-3
SOIL METALS AND CYANIDE ANALYTICAL DATA SUMMARY[1]

Probe	Sample Date	Sample Depth (ft bgs)	Arsenic	Barium	Cadmium	Chromium	Lead	Cyanide
SP-101	7/15/08	2-3	2.5J	123J	0.14	7.4J	8.6J	0.43J
		6-7	3.2J	109J	0.069	6.5J	24.2J	0.17J
SP-102	7/15/08	3-3.5	2.1J	127J	<0.013	10.2J	6.8J	0.25J
		9-10	2.6J	127J	0.041	10.3J	7.8J	<0.039J
		13-13.5	1.4J	98.4J	<0.013	7.1J	5.8J	0.24J
SP-103	7/15/08	5-6	12.8J	348J	14.5	19.6J	956J	1.2J
		8-10	3.8J	175J	0.2	12.7J	14.2J	<0.043J
		14-15	3J	107J	0.0089	7.4J	6.4J	<0.039J
SP-103 (Duplicate)	7/15/08	14-15	2J	122J	0.12	8.7J	7.4J	0.13J
SP-104	7/16/08	2-3	3J	151J	0.084	10.1J	9.6J	1.2J
		6-7	2.8J	138J	0.029	8.5J	7.6J	0.73J
SP-107	7/16/08	2-3	7.7J	222J	0.2	16.2	27.5J	0.51J
		11-12	3.6J	145J	0.088	10.4	18.8J	0.17J
		21-22	4.9J	73.8J	0.053	7.1	24.3J	0.33J
SP-107 (Duplicate)	7/16/08	21-22	4.8J	125J	0.19	8.6	21.2J	3.2J
SP-108	7/15/08	3-4	3.5J	160J	0.069	10.6	10J	1.9J
		11-12	3.4J	147J	0.46	10.5	11.6J	<0.041J
SP-109	7/19/08	2-3	2.8J	143J	0.045	8.3J	7.2J	2.1J
SP-110	7/16/08	2-3	3.8J	166J	0.14	9.7	11.4J	0.48J
		11-12	2.7J	188J	0.019	9.2	6.9J	0.3J
		17-18	2.3J	118J	<0.011	9.4	6.2J	0.06J
SP-111	7/18/08	8-9	3.5J	130J	0.0026	11.5J	29.6J	0.46J
		14-15	0.69J	8.3J	<0.013	1.9J	1.3J	0.82J
		2-3	6J	177J	0.64	14.4J	33.6J	0.28J
SP-112	7/18/08	2-3	7.1J	169J	0.1	16.9J	15.6J	0.14J
		8-9	4.2J	154J	<0.014	15.9J	8.3J	<0.04J
		14-15	1.2J	10.3J	<0.012	3.2J	2.8J	0.069J
SP-113	7/16/08	3-4	4J	214J	0.5	12.8	48.8J	0.18J
		6-7	2.2J	137J	<0.013	11.3	7.4J	0.3J
SP-114	7/17/08	2-3	3.2J	162J	0.092	11.4J	10.1J	0.65J
		6-7	3.3J	161J	0.048	9.9J	10J	0.94J
SP-115	7/19/08	2-3	5.5J	95.8J	0.38	13.3	16.2J	0.12J
		7-8	4.6J	223J	0.21	15.4	27.5J	0.33J
		16-17	2.7J	116J	0.0035	9.3	5.6J	0.0073J
SP-116	7/19/08	2-3	5.4J	210J	<0.013	28.4	45.4J	4.6J
		9-10	1.4J	113J	0.21	6.8	6J	7.1J
		12-13	2.3J	140J	<0.012	9.9	7.4J	1.8J
SP-117	7/19/08	2-3	2.7J	125J	0.0076	9.3	6.7J	0.78J
		7-8	2.6J	208J	0.011	11.6	8.8J	0.065J

TABLE 4-3 (Continued)
SOIL METALS AND CYANIDE ANALYTICAL DATA SUMMARY[1]

Probe	Sample Date	Sample Depth (ft bgs)	Arsenic	Barium	Cadmium	Chromium	Lead	Cyanide
SP-119	9/22/09	2.5-3.5	8.9J	204J	0.49	15.6J	74.8J	0.83
		8-9	1.4J	46.7J	0.020	5.1J	3.5J	0.73
		12-13	0.74J	16.1J	<0.01	1.5J	1.3J	0.56
SP-120	9/22/09	5-6	4.3J	173J	0.28	10.9J	15.4J	1.5
		9-10	3.2J	158J	0.044	8.6J	6.4J	1.4
SP-121	9/22/09	4.5-5.5	2.5J	166J	0.12	9.8J	7.1J	0.70
		9-10	2.4J	156J	0.14	9.2J	7.6J	1.1
		16-17	15.7J	139J	0.53	16.4J	8.2J	0.62
SP-121 (Duplicate)	9/22/09	4.5-5.5	11.3J	159J	0.25	9.1J	17.8J	0.94
SP-122	9/22/09	4-5	6.4J	151J	0.31	12.0J	19.6J	0.92J
		6.5-7.5	2.8J	26.8J	0.021	2.1J	1.9J	1.1J
SP-123	9/22/09	4-5	5.8J	153J	0.50	12.8J	29.8J	0.55J
		9-10	2.5J	116J	0.067	7.4J	5.5J	1.1J

Abbreviations:

< Analyte was not detected at or above the method detection limit presented.

J Concentration was qualified as estimated based on data validation.

Note:

[1] Concentrations are in mg/kg.

TABLE 4-4
GROUNDWATER PROBE OBSERVATIONS

Probe	Total Depth (feet bgs)	Water Level (feet bgs)	Visible Contamination Thickness (feet)
GWP-101	16	13.34	None
GWP-102	19	13.35	Sheen on purge water
GWP-103	15	9.45	~2 (tar on tubing removed after sampling)
GWP-104	13	9.43	~0.5 (tar on tubing removed after sampling)
GWP-105	25	17.55	None
GWP-106	23	18.64	~1 (LNAPL on tubing removed after sampling)
GWP-107	23	19.6	None
GWP-108	15	Not recorded	None
GWP-109	24	17.31	~2.78 (LNAPL measured with oil/water interface probe)
GWP-110	24	17.65	Up to 7.5 (Undifferentiated tar/LNAPL measured with oil/water interface probe)
GWP-111	19	14.2	None
GWP-112	23	19.22	None
GWP-113	18	9.75	None
GWP-114	15	~7	None
GWP-117	19	~12	None
GWP-118	17	~13.5	None
GWP-119	18	~14	None
GWP-120	18	~14	~4 (Tar on tubing removed after sampling); Tar sheen on purge water(1)
GWP-121	17.5	~13.5	None
GWP-122	17	~12.8	None
GWP-123	17	~12.8	None
GWP-124	17	~13.5	Tar/sheen on purge water(1)
GWP-125	17	~13	None

Note:
(1) In the field, the observations at these locations were logged as tar because the contamination encountered resembled typical MGP-related impacts. However, based on distance from the MGP source structures, groundwater flow direction, and geology showing the bedrock trending upward to the east, this contamination is not likely MGP-related. It is likely associated with the former bulk oil facilities in this area.

TABLE 4-5

GROUNDWATER PROBE AND EXISTING MONITORING WELL BTEX AND PAH ANALYTICAL DATA SUMMARY[1]

Groundwater Probe/Well	Sample Date	Laboratory	Sample Depth (ft bgs)	Benzene	Toluene	Ethylbenzene	Xylene (total)[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a) anthracene	Benzo(a) pyrene	benzo(b) fluoranthene	Benzo(ghi) perylene	Benzo(k) fluoranthene	Chrysene	Dibenzo(a,h) anthracene	Fluoranthene	Fluorene	Indeno (1,2,3-c,d) pyrene	Naphthalene	Phenanthrene	Pyrene
GWP-101	7/15/08	ECCS	8-12	<0.50	<1.0	<1.0	0.14	1.7J	<0.25	0.47	<0.25	<0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	6.1J	4.0J	0.29
	7/15/08	ECCS	12-16	<0.50	<1.0	<1.0	0.1	46J	0.65	2.2	<0.25	0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	0.46J	6.1	<0.25	2.3J	5.7J	0.49
GWP-102	7/15/08	ECCS	11-15	400J	100J	380	410	76J	24	37	<0.25	<0.25	<0.25J	<0.25	0.84	2.4	<0.25	24J	95	<0.25	6100J	160J	30
	7/15/08	ECCS	15-19	52J	23J	150	95	200J	15	25	<0.25	<0.25	<0.25J	<0.25	<0.25	0.80	<0.25	10J	59	<0.25	2700J	74J	13
GWP-103	7/15/08	ECCS	7.5-11.5	8.2J	<1.0	20	108	120J	19	15	<0.25	<0.25	<0.25J	<0.25	<0.25	1.4	<0.25	6.1J	43	<0.25	3300J	47J	9.3
	7/15/08	ECCS	11-15	28J	56	100	370	660J	32	280	170	28	<12J	31	72	39	<12	150J	250	<12	8300J	690J	230
GWP-104	7/16/08	ECCS	9-13	2400J	92J	1100	560	420J	42	100	67	34	26J	16	9.9	47	3.9J	140J	170	12J	4900J	280J	190
GWP-105	7/16/08	ECCS	17-21	790J	50J	63	59	6200J	1300	3300	3100	1600	970J	970	1000	2500	580J	4500J	4000	860J	48000J	3700J	6500
	7/16/08	ECCS	21-25	770J	49J	74	43	8300J	3800J	7200J	7300J	6900J	7200J	6100J	7500J	6800J	4800J	9800J	6600J	6700J	33000J	9800J	12000J
GWP-106	7/17/08	ECCS	15-19	1.4J	<1.0J	13	2.75	50	2.2	22J	8.3	5.2	11	3.3	<0.25	8.2	<0.25	26	21	2.3	180	53	35
	7/17/08	ECCS	19-23	92J	3.6J	330	67	210	3.8	39J	14	7.1	14	6.1	4.6	14J	0.65	41	87	3.7	3400	200	55
GWP-106 (Duplicate)	7/17/08	ECCS	19-23	77J	2.8J	330	74	2600J	53J	960J	310J	320J	470J	160J	200J	400J	<12J	1100J	1100J	<12J	6500J	3400J	1600J
GWP-107	7/17/08	ECCS	19-23	2000J	170J	1900	1130	21000J	4800J	13000J	13000J	12000J	8700J	6300J	5500J	9200J	5300J	18000J	12000J	7900J	76000J	26000J	25000J
GWP-108	7/16/08	ECCS	6-10	220J	88J	49	510	190J	18	16	<0.25	<0.25	<0.25J	<0.25	<0.25	0.56	<0.25	4.4J	50	<0.25	4200J	44J	6.1
	7/16/08	ECCS	11-15	5900J	7.2J	1300	39	170J	23	25	0.98	1.7	<0.25J	0.79	0.38	3.0	<0.25	9.3J	63	<0.25	5800J	70J	14
GWP-108 (Duplicate)	7/16/08	ECCS	11-15	7100J	500J	9200	5200	260J	34	46	15	8.7	8.9J	3.8	5.2	17	0.36J	38J	98	2.1J	6700J	150J	54
GWP-109	7/17/08	ECCS	16-20	4.8J	1.1J	7.7	4.3	5500J	450J	2600J	770J	780J	1100J	410J	460J	1100J	170J	1900J	2800J	360J	25000J	7700J	3100J
	7/17/08	ECCS	20-24	860J	78J	1200	790	200J	15J	27J	8.0J	5.5J	9.0J	2.9J	3.3J	8.3J	0.36J	19J	75J	1.5J	3300J	120J	26J
GWP-110	7/17/08	ECCS	16-20	<0.50	<1.0	9.3	3.98	190J	9.8	36	60	33	26J	15	11	30	3.9J	100J	83	12J	46J	140J	140
	7/17/08	ECCS	20-24	<5.0	<10	27	11.1	950J	360	580	820	770	930J	660	800	690	480J	1200J	660	660J	370J	840J	1300
	7/17/08	Pace	20-24	0.58	0.34	16.1	6.6	157	9.8	28.6	27	20.1	18.1	6.3	7.8	24.5	2.1	61.8	71.6	5	74.7	107	83.8
GWP-110 (Duplicate)	7/17/08	Pace	20-24	0.58	0.35	15	6.1	229	17.2	57.7	65.9	51.6	46.4	15.8	20.5	58	5.8	131	119	13.1	109	203	165
GWP-111	7/17/08	ECCS	11-15	<0.50	<1.0J	<1.0	<0.30	1.1	<0.25	6.0J	<0.25	<0.25	<0.25	<0.25	<0.25	0.89J	<0.25	2.4	<0.25	<0.25	<0.25	<0.25	3.6
	7/17/08	ECCS	15-19	<0.50	<1.0J	<1.0	<0.30	8.7	<0.25	13J	<0.25	<0.25	<0.25	<0.25	<0.25	1.2J	<0.25	4.8	<0.25	<0.25	<0.25	27	6.6
GWP-112	7/17/08	ECCS	19-23	0.54J	1.0J	<1.0	<0.41	0.26	<0.25	2.1J	<0.25	<0.25	<0.25	<0.25	<0.25	0.70J	<0.25	0.88	<0.25	<0.25	19	<0.25	1.4
	7/18/08	Pace	19-23	<0.05	0.45	2.9	61.9	1.4	0.23	0.65	0.67	0.44	0.39	0.3	0.16	0.59	<0.02	1.6	0.8	0.11	7.7	2.6	2.2
GWP-113	7/15/08	ECCS	9-13	<0.50	<1.0	<1.0	<0.30	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	4.6J	<0.25	<0.25
	7/15/08	ECCS	14-18	<0.50	<1.0	<1.0	<0.30	0.65J	<0.25	<0.25	<0.25	<0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	0.26J	<0.25	<0.25	3.3J	<0.25	0.27
GWP-114	7/17/08	ECCS	7-11	<0.50	<1.0	<1.0	<0.30	2.3J	<0.25	0.98	<0.25	<0.25	<0.25J	<0.25	<0.25	0.27	<0.25	<0.25	2.6	<0.25	7.4J	4.4J	0.33
	7/17/08	ECCS	11-15	0.91J	<1.0	<1.0	0.44	28J	<0.25	8.4	<0.25	<0.25	<0.25J	<0.25	<0.25	0.59	<0.25	2.3J	11	<0.25	72J	17J	3.3
GWP-117	7/19/08	ECCS	11-15	<0.50	<1.0	<1.0	<0.30	3.5	<0.25J	<0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	1.4	<0.25	2.7	7.3	0.67
	7/19/08	ECCS	15-19	<0.50	<1.0	<1.0	0.23	2.7J	<0.25J	<0.25	<0.25J	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	0.99J	0.89J	<0.25	7.6J	6.7J	1.8J
GWP-118	9/22/09	Pace	13-17	<0.05	<0.18	<0.11	<0.47	<0.021	<0.053	<0.021	<0.011	0.32	0.76	0.36	<0.021	<0.011	0.056	1.8	<0.021	0.25	<0.27	<0.27	<0.021
GWP-119	9/22/09	Pace	14-18	<0.05	<0.18	<0.11	<0.47	<0.022	<0.054	<0.022	<0.011	<0.022	<0.022	<0.054	<0.022	<0.011	<0.011	<0.022	<0.022	<0.022	<0.27	<0.27	<0.022
GWP-120	9/22/09	Pace	14-18	<0.07	<0.064	4.2	12.3	467J	37.8J	139J	67.1J	40.8J	48.6J	12.8J	<0.5J	66.5J	3.3J	120J	178J	10.8J	46.4J	563J	179J
GWP-120 (Duplicate)	9/22/09	Pace	14-18	<0.07	<0.064	3.7	13.8	558J	61.3J	235J	120J	68.7J	91.4J	25.1J	<5.2J	118J	6.4J	222J	321J	19.4J	33.4J	810J	313J
GWP-121	9/21/09	Pace	13.5-17.5	<0.05	<0.18	<0.11	<0.47	<0.017	<0.042	<0.017	<0.0085	<0.017	<0.017	<0.042	<0.017	<0.0085	<0.0085	<0.017	<0.017	<0.017	<0.21	<0.21	<0.017
GWP-122	9/21/09	Pace	13-17	<0.07	<0.08	<0.11	<0.33	<0.019	<0.047	<0.019	<0.0094	<0.019	<0.019	<0.047	<0.019	<0.0094	<0.0094	<0.019	<0.019	<0.019	<0.24	<0.24	<0.019
GWP-123	9/21/09	Pace	13-17	<0.07	<0.064	<0.078	<0.15	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02
GWP-124	9/21/09	Pace	13-17	<0.04	6.0	104	70.0	202J	20.9J	51.9	24.5J	15.1J	17.8J	4.7J	<0.53J	23.1J	1.1J	48.5J	95.7J	4.0J	80.4J	173J	72.7J
GWP-125	9/21/09	Pace	13-17	<0.05	<0.18	<0.11	<0.47	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052	<0.052

TABLE 4-5 (Continued)

GROUNDWATER PROBE AND EXISTING MONITORING WELL BTEX AND PAH ANALYTICAL DATA SUMMARY[1]

Groundwater Probe/Well	Sample Date	Laboratory	Sample Depth (ft bgs)	Benzene	Toluene	Ethylbenzene	Xylene (total)[2]	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a) anthracene	Benzo(a) pyrene	benzo(b) fluoranthene	Benzo(ghi) perylene	Benzo(k) fluoranthene	Chrysene	Dibenzo(a,h) anthracene	Fluoranthene	Fluorene	Indeno (1,2,3-c,d) pyrene	Naphthalene	Phenanthrene	Pyrene
MW-01	7/17/08	ECCS	NA	2.8J	<1.0J	2.2	1.79	31	<0.25	3.9J	<0.25	0.33	<0.25	<0.25	<0.25	0.31J	<0.25	0.42	<0.25	<0.25	<0.25	7.1	0.48
	7/17/08	Pace	NA	0.68	0.32	1.4	1.9	22.5J	<0.02	0.93J	<0.01	<0.02	<0.01	<0.02	<0.02	<0.02	<0.02	0.32J	6.9J	<0.01	3.8J	2.6J	0.26J
MW-03	7/18/08	Pace	NA	8090	423	1450	1320	57.2J	18.1J	19.7J	7J	5.8J	4.2J	1.5J	1.2J	6.8J	0.79J	13.8J	12.6J	1.1J	6.6J	44.9J	18.5J
	7/17/08	ECCS	NA	11000	5.6J	15	13.8	140	29	31J	14	6.9	12	3.9	<0.25	17J	0.94	28	59	2.3	3900	96	45

Abbreviations:

< Analyte was not detected at or above the method detection limit presented.

J Concentration was qualified as estimated based on data evaluation/validation.

Notes:

(1) Concentrations are in µg/L.

(2) ECCS reported xylenes as o-xylene and m&p-xylenes while Pace reported total xylenes. For ease of comparison, ECCS concentrations/detection limits were summed to present a total xylene concentration.

TABLE 4-6

GROUNDWATER ANALYTICAL DATA SUMMARY (JULY 2010 MONITORING WELL SAMPLING)[1]

Monitoring Well	Sample Date	Benzene	Ethylbenzene	Toluene	Xylene (total)	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-c,d)pyrene	Naphthalene	Phenanthrene	Pyrene	Arsenic	Barium	Cadmium	Chromium	Lead	Cyanide
MW-01	7/11/10	0.62	1.3	<0.1	<0.3	27.4	0.73	1.4	0.043	<0.022	0.013	<0.011	<0.022	0.041	<0.022	0.64	7.2	<0.022	12.5	4.5	0.53	5.6	384	<0.33	1.5	<2	5.6
MW-02	7/11/10	419	498	<2	163	169	8.0	10.7	<0.8	<0.75	<0.7	<0.8	<0.85	<0.85	<0.7	<0.85	51.5	<0.6	904	55.3	3.6	12.2	555	<0.33	2.0	<2	250
MW-03	7/11/10	16500	7690	1080	6620	14000	3360	6890	3120	2070	2110	745	<91.4	2850	189	6010	7770	493	82600	21500	9010	17.5	431	<0.33	2.3	<2	98
MW-04	7/11/10	1610	1610	160	946	90.7	13.9	8.0	<1.8	<1.7	<1.6	<1.8	<1.9	<1.9	<1.6	<1.9	26.4	<1.3	1840	<2	5.1	9.6	246	<0.33	2.6	<2	760
MW-05	7/11/10	1890	1050	116	744	144	18.7	10.7	<3.4	<3.2	<3	<3.4	<3.7	<3.7	<3	<3.7	40.7	<2.6	3410	<3.9	5.5	14.7	293	<0.33	1.1	<2	1200
MW-05 (Duplicate)	7/11/10	2070	1160	130	829	145	18.8	12.2	<3.2	<3	<2.8	<3.2	<3.4	<3.4	<2.8	<3.4	40.5	<2.4	3400	<3.6	7.9	13.7	294	<0.33	0.73	<2	1400
MW-06	7/11/10	0.11	0.19	<0.1	<0.3	0.043	0.030	0.032	<0.022	<0.022	<0.011	<0.011	<0.022	<0.022	<0.022	<0.022	0.060	<0.022	0.47	<0.11	<0.033	11.2	145	<0.33	0.54	<2	<1
MW-07	7/11/10	589	349	28.5	474	116	75.8	15.2	<8.5	<8	<7.4	<8.5	<9	<9	<7.4	<9	77.1	<6.4	4840	<9.6	<8.5	31.4	186	<0.33	2.7	<2	320
MW-08	7/11/10	0.13	0.44	0.19	1.3	63.3	3.1	10.4	3.2	2.1	2.9	0.94	<0.022	2.7	0.15	9.9	31.4	0.71	5.1	40.6	10.8	6.2	199	<0.33	0.61	<2	13
MW-09	7/12/10	<0.04	<0.1	<0.1	<0.3	0.36	0.033	0.20	0.036	<0.02	<0.01	<0.01	<0.02	0.027	<0.02	0.28	0.12	<0.02	<0.1	<0.1	0.32	<4.8	87.7	<0.33	1.5	<2	6.0
MW-10	7/12/10	<0.04	<0.1	<0.1	<0.3	3.3	0.62	0.48	0.19	0.021	0.031	<0.016	<0.017	0.19	<0.014	1.4	1.6	<0.012	0.064	7.8	1.8	<4.8	47.7	<0.33	<0.51	<2	11

Abbreviation:

< Analyte was not detected at or above the method detection limit presented.

Note:

(1) Concentrations are in µg/L.

TABLE 4-7

COMPARISON OF LMW to HMW PAHs DETECTED IN JULY 2010 MONITORING WELL SAMPLES AND SEPTEMBER 2009 GROUNDWATER PROBES GWP-120 AND GWP-124

Monitoring Well	MW-01 (north edge of gas holder base		MW-02 (northeast of below ground gas holder)		MW-03 (southwest of belowground gas holder)		MW-04 (west of belowground gas holder near river)		MW-05 (west-southwest of belowground gas holder near river)		MW-05D (west-southwest of belowground gas holder near river)	
Total PAH Concentration	55		1,202		159,220		1,984		3,680		3,625	
Concentration LMW PAH/% of Total(2)	53.7	98%	1,199	99.7%	136,120	85.5%	1,979	99.7%	3,675	99.9%	3,617	99.8%
Concentration HMW PAH/% of Total(3)	1.3	2.36%	3.60	0.30%	23,100	14.5%	5.10	0.26%	5.50	0.15%	7.90	0.22%

Monitoring Well	MW-06 (south of MGP Site)		MW-07 (southeast of belowground gas holder)		MW-08 (northeast of gas holder base)		MW-09 (east of MGP Site in area of historical oil storage facilities)		MW-10 (east of MGP Site in area of historical oil storage facilities)		GWP-120 (east of MGP Site in area of historical oil storage facilities)		GWP-120D (east of MGP Site in area of historical oil storage facilities)		GWP-124 (east of MGP Site in area of historical oil storage facilities)	
Total PAH Concentration	0.64		5,215		185		1.37		17.5		1,980		3,003		835	
Concentration LMW PAH/% of Total(2)	0.64	100%	5,215	100%	153.9	83%	0.71	51.8%	13.9	79%	1,431	72.3%	2,019	67.2%	624	74.7%
Concentration HMW PAH/% of Total(3)	0	0%	0	0%	31.3	17%	0.66	48%	3.63	21%	549	27.7%	984	32.8%	211	25.3%

Notes:

(1) Concentrations are in µg/L.

(2) LMW PAHs (2-3 benzene rings) are acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene.

(3) HMW PAHs (4-6 benzene rings) are benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-c,d)pyrene, and pyrene.

TABLE 4-8

SURFACE WATER SAMPLE ANALYTICAL DATA SUMMARY[1]

Location	Sample Date	Water Column Thickness (feet)[2]	Benzene	Toluene	Ethylbenzene	Xylene (total)	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total Arsenic	Total Barium	Total Cadmium	Total Chromium	Total Lead	Total Cyanide
SW-101	9/20/09	1.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	13.8J	219	0.38	6.0J	9.2J	37
SW-102	9/20/09	1.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	0.019	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	13.6J	219	0.39	6.3J	9.2J	<1
SW-103	9/20/09	0.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	0.013	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	0.042	<0.02	<0.02	<0.25	<0.25	0.031	12.6J	211	0.41	6.2J	8.8J	<1
SW-104	9/20/09	2.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	13.0J	223	0.30	6.4J	10.3J	<1
SW-105	9/20/09	1.5	<0.07J	<0.08	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	11.9J	209	<0.28	5.2J	7.8J	<1
SW-106	9/20/09	0.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	14.7J	267	0.30	8.6J	13.6J	<1
SW-107	9/20/09	1.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	0.011	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	13.5J	206	0.34	5.4J	7.5J	<1
SW-107 (Duplicate)	9/20/09	1.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	12.2J	212	<0.28	5.7J	8.8J	<1
SW-108	9/20/09	1.0	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	12.8J	218	0.32	6.0J	9.9J	<1
SW-109	9/20/09	1.0	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	11.9J	211	0.43	5.0J	8.1J	<1
SW-110	9/20/09	0.5	<0.07	<0.08J	<0.11	<0.33	<0.02	<0.05	<0.02	<0.01	<0.02	<0.02	<0.05	<0.02	<0.01	<0.01	<0.02	<0.02	<0.02	<0.25	<0.25	<0.02	12.5J	218	0.29	6.0J	9.4J	<1
SW-111	9/23/09	5.0	<0.07J	<0.08	<0.11	<0.33	<0.021	<0.052	<0.021	<0.01	<0.021	<0.021	<0.052	<0.021	<0.01	<0.01	0.040	<0.021	<0.021	<0.26	<0.26	<0.021	10.7J	211	0.31	4.2J	7.8J	23
SW-112	9/23/09	4.0	<0.07	<0.064	<0.078	<0.15	<0.021	<0.053	<0.021	<0.011	<0.021	<0.021	<0.053	<0.021	<0.011	<0.011	<0.021	<0.021	<0.021	<0.27	<0.27	<0.021	10.7J	214	<0.28	3.7J	7.4J	20

Notes:

(1) Concentrations are in µg/L.

(2) Samples were collected during low-flow conditions from a point as close to the sediment surface as possible without disturbing the sediment.

TABLE 4-9

SEDIMENT SAMPLE ANALYTICAL DATA SUMMARY[1]

Location	Sample Date	Sample Depth (feet)	Benzene	Toluene	Ethylbenzene	Xylene (total)	Acenaphthene	Acenaphthylene	Anthracene	Benzo(a)anthracene	Benzo(a)pyrene	Benzo(b)fluoranthene	Benzo(ghi)perylene	Benzo(k)fluoranthene	Chrysene	Dibenzo(a,h)anthracene	Fluoranthene	Fluorene	Indeno(1,2,3-cd)pyrene	Naphthalene	Phenanthrene	Pyrene	Total Arsenic	Total Barium	Total Cadmium	Total Chromium	Total Lead	Total Cyanide
SD-101	9/20/09	0-0.3	<0.0017J	<0.002J	<0.0025J	<0.0029J	0.0026	0.0014	0.0015	0.0026	0.0024	0.0060	0.0020	<0.0011	0.0047	<0.00085	0.0094	0.0045	0.0014	0.0078	0.0122	0.0078	5.2J	207J	0.33	13.9J	10.5J	3.2
SD-103	9/20/09	0-0.3	<0.0011J	<0.0013J	<0.0017J	<0.0019J	0.0046	0.0068	0.0076	0.0256	0.0268	0.0527	0.0210	<0.00082	0.0293	0.0027	0.0500	0.0042	0.0156	0.0119	0.0289	0.0571	2.3J	119J	0.18	6.5J	7.4J	2.5
SD-105	9/20/09	0-0.3	<0.001	<0.0012J	<0.0016	0.0034	0.0098	0.0027	0.0361	0.0049	0.0022	0.0041	0.0014	<0.00069	0.0057	<0.00052	0.0492	0.0089	0.00097	0.0324	0.0581	0.0783	2.0J	74.9J	0.064	2.5J	4.7J	1.5
SD-106	9/23/09	0-0.7	<0.00098	<0.0012	<0.0015J	<0.0017	0.0028	<0.00037	0.00045	<0.00054	<0.00046	0.00077	<0.00049	<0.00069	0.0010	<0.00051	0.0013	0.0014	<0.00044	0.0037	0.0038	0.0012	0.98J	25.2J	0.066	1.3J	2.0J	2.3
SD-107	9/23/09	0-0.8	0.0067	0.0044	0.865J	0.47	28.4	2.58	14.7	7.75	6.76	7.76	3.01	<0.155	7.03	0.405	19.5	14.5	2.16	68.3	47.4	25.4	2.3J	26.8J	0.070	2.8J	3.4J	1.5
SD-108	9/23/09	0-0.7	<0.001	<0.0013	<0.0016J	<0.0018	0.0034	<0.00038	0.00065	<0.00055	<0.00047	<0.00045	<0.0005	<0.0007	0.00092	<0.00052	0.00085	0.0014	<0.00045	0.0055	0.0036	0.0010	1.5J	19.1J	0.033	1.7J	2.5J	2.0
SD-109	9/23/09	0-0.5	<0.00097	<0.0012	<0.0015J	<0.0016	0.0024	0.0014	0.0046	0.0375	0.0244	0.104	0.0147	<0.0007	0.0443	0.0033	0.0454	0.0033	0.0161	0.0084	0.0329	0.0434	4.6J	40.2J	0.33	5.0J	92.1J	2.1
SD-110	9/23/09	0-0.7	<0.001	<0.0012	<0.0016J	<0.0018	0.00077	<0.00039	0.00061	<0.00056	<0.00048	<0.00046	<0.00052	<0.00072	0.00079	<0.00054	<0.00056	0.0011	<0.00046	0.0020	0.0026	<0.00064	1.6J	23.2J	0.037	1.9J	3.1J	1.4
SD-111	9/23/09	0-0.7	<0.0014J	<0.0017J	<0.0021J	<0.0024J	0.0027	0.00065	0.0048	0.0120	0.0103	0.0239	0.0069	<0.00088	0.0133	0.0011	0.0329	0.0043	0.0058	0.0045	0.0253	0.0256	3.4J	160J	0.20	9.7J	10.2J	3.3
SD-113	9/23/09	0-0.8	0.0200	0.0123	4.74J	1.88J	26.2	2.29	12.6	6.72	5.83	6.66	2.54	<0.159	5.8	<0.119	15.3	12.8	1.72	102	40.3	21.1	2.3J	53.9J	0.050	1.9J	2.0J	1.9
SD-113 (Duplicate)	9/23/09	0-0.5	0.0800	0.0291	7.38J	3.64J	15.3	1.45	7.45	3.8	3.21	3.67	1.31	<0.164	3.23	<0.122	8.54	7.14	0.932	52.7	23	12	2.9J	51.1J	0.068	2.6J	2.6J	1.5

Note:

[1] Concentrations are in mg/kg.

Table 3-1
Surface Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS01SW			BEESS02SW		
		12/10/2012	12/12/2012	12/14/2012	12/10/2012	12/12/2012	12/14/2012
ICP Total Metals							
Aluminum	ug/L	88.3	191	276	290	1460	456
Antimony	ug/L	3.1 U	3.1 U	3.1 U	10 U	3.1 U	3.1 U
Arsenic	ug/L	7.8 J	6.3 J	7.2 J	5.9 J	7.2 J	7 J
Barium	ug/L	134 J	139 J	148 J	139 J	164 J	149 J
Beryllium	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium	ug/L	5 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium	ug/L	82000 J	79700 J	79200 J	81600 J	81700 J	78800 J
Chromium	ug/L	0.84 J	5 U	0.98 J	0.99 J	5 U	1.3 J
Cobalt	ug/L	0.76 U	0.87 J	0.78 J	0.92 J	1.3 J	0.76 U
Copper	ug/L	1.9 J	1.6 J	1.9 J	2.1 J	2.3 J	1.5 J
Iron	ug/L	199	249	349	307	1370	494
Lead	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	3.9 J	2.4 U
Magnesium	ug/L	17000 J	15100 J	16100 J	17200 J	16600 J	16300 J
Manganese	ug/L	266 J	322 J	345 J	284 J	491 J	361 J
Nickel	ug/L	2.1 J	2.1 J	2.3 J	2.6 J	3.5 J	2.7 J
Potassium	ug/L	9770 J	9280 J	9200 J	9840 J	9890 J	9100 J
Selenium	ug/L	3.5 J	3.7 J	3.3 J	4.7 J	3.1 J	3.2 J
Silver	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium	ug/L	83600 J	85300 J	93700 J	84100 J	86200 J	93000 J
Thallium	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Total Hardness by 2340B	ug/L	275000 J	261000 J	264000 J	275000 J	272000 J	264000 J
Vanadium	ug/L	4.9 J	4 J	3.9 J	4.4 J	6.7 J	4.2 J
Zinc	ug/L	7.4 J	7.3 U	7.3 U	7.3 U	8.9 J	7.3 U
Mercury	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
Total Cyanide	mg/L	0.0033 J	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0026 J
ICP Dissolved Metals							
Aluminum, Dissolved	ug/L	75 U	25 U	28.7 J	75 U	26.4 J	25 U
Antimony, Dissolved	ug/L	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic, Dissolved	ug/L	4.6 U	6.4 J	6.4 J	4.6 U	6.6 J	6.8 J
Barium, Dissolved	ug/L	117 J	125 J	136 J	121 J	121 J	134 J
Beryllium, Dissolved	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium, Dissolved	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium, Dissolved	ug/L	73900 J	81600 J	80800 J	77800 J	75600 J	81200 J
Chromium, Dissolved	ug/L	1.1 J	0.69 U	0.69 U	1 J	0.69 U	0.69 U
Cobalt, Dissolved	ug/L	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U
Copper, Dissolved	ug/L	0.99 U	1.2 J	1.4 J	1.1 J	1.5 J	2 J
Iron, Dissolved	ug/L	17.2 U	17.2 U	17.2 U	17.2 U	17.2 U	17.2 U
Lead, Dissolved	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	5 U
Magnesium, Dissolved	ug/L	15000 J	16900 J	16700 J	15800 J	15700 J	17000 J
Manganese, Dissolved	ug/L	149 J	0.7 J	0.77 J	145 J	0.77 J	0.76 J
Nickel, Dissolved	ug/L	1.7 J	1.8 J	2.7 J	1.7 J	1.8 J	2.2 J
Potassium, Dissolved	ug/L	9040 J	9600 J	9360 J	9580 J	8940 J	9340 J
Selenium, Dissolved	ug/L	4.3 J	2.7 U	5.5 J	4.5 J	2.7 U	3.8 J
Silver, Dissolved	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium, Dissolved	ug/L	86800 J	88000 J	96300 J	81800 J	81800 J	96900 J
Thallium, Dissolved	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Vanadium, Dissolved	ug/L	4 J	3.6 J	3.6 J	4.4 J	3.5 J	2.9 J
Zinc, Dissolved	ug/L	8.5 J	7.3 U	50 U	7.3 U	50 U	7.3 U
Mercury, Dissolved	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
PAHs							
Acenaphthene	ug/L	0.027 U	0.027 UJ	0.027 U	0.027 U	0.027 UJ	0.027 U
Acenaphthylene	ug/L	0.019 U	0.1 U	0.019 U	0.019 U	0.019 UJ	0.019 U
Anthracene	ug/L	0.027 U	0.027 UJ	0.027 U	0.027 U	0.027 UJ	0.027 U
Benzo(a)anthracene	ug/L	0.023 U	0.023 UJ	0.023 U	0.023 U	0.023 UJ	0.023 U
Benzo(a)pyrene	ug/L	0.017 U	0.017 UJ	0.017 U	0.017 U	0.017 UJ	0.017 U
Benzo(b)fluoranthene	ug/L	0.015 U	0.015 UJ	0.015 U	0.015 U	0.015 UJ	0.015 U
Benzo(g,h,i)perylene	ug/L	0.021 U	0.1 U	0.11	0.021 U	0.021 UJ	0.021 U
Benzo(k)fluoranthene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.022 U
Chrysene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.022 U
Dibenzo(a,h)anthracene	ug/L	0.1 U	0.02 UJ	0.12	0.02 U	0.02 UJ	0.02 U
Fluoranthene	ug/L	0.031 U	0.031 UJ	0.031 U	0.031 U	0.031 UJ	0.031 U
Fluorene	ug/L	0.02 U	0.02 UJ	0.02 U	0.02 U	0.02 UJ	0.02 U
Indeno(1,2,3-cd)pyrene	ug/L	0.019 U	0.1 U	0.087 J	0.019 U	0.019 UJ	0.019 U
Naphthalene	ug/L	0.5 U	0.094 J	0.5 U	0.5 U	0.5 U	0.5 U
Phenanthrene	ug/L	0.091 J	0.5 UJ	0.07 U	0.086 J	0.5 U	0.5 U
Pyrene	ug/L	0.028 U	0.028 UJ	0.028 U	0.028 U	0.028 UJ	0.028 U

Table 3-1
Surface Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS03SW			BEESS05SW			
		12/10/2012	12/12/2012	12/14/2012	12/10/2012	12/12/2012	12/12/2012 (DUP	12/14/2012
ICP Total Metals								
Aluminum	ug/L	1030	196	329	125	185	179	260
Antimony	ug/L	3.1 U	3.1 U	3.1 U	10 U	3.1 U	3.1 U	3.1 U
Arsenic	ug/L	6.5 J	6 J	6.6 J	8.8 J	5.8 J	5.8 J	5.5 J
Barium	ug/L	158 J	140 J	150 J	139 J	141 J	141 J	150 J
Beryllium	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium	ug/L	87100 J	80600 J	80800 J	83800 J	79800 J	81500 J	81000 J
Chromium	ug/L	1.6 J	5 U	0.92 J	0.69 U	5 U	0.71 J	0.69 U
Cobalt	ug/L	1.3 J	0.76 U	0.91 J	0.76 U	0.76 U	0.79 J	0.82 J
Copper	ug/L	2.3 J	1.4 J	2.2 J	1.5 J	1.2 J	1.7 J	1.8 J
Iron	ug/L	1120 J	255	382	212	247	244	342
Lead	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
Magnesium	ug/L	18100 J	16400 J	16700 J	17300 J	16200 J	17000 J	16600 J
Manganese	ug/L	392 J	353 J	352 J	282 J	351 J	366 J	349 J
Nickel	ug/L	3 J	2.4 J	2.7 J	2 J	2.5 J	2.4 J	2.7 J
Potassium	ug/L	10400 J	9580 J	9340 J	9700 J	9360 J	9620 J	9340 J
Selenium	ug/L	2.8 J	2.7 U	3.7 J	3 J	2.7 U	4.2 J	3.2 J
Silver	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium	ug/L	87200 J	87200 J	95400 J	83600 J	85700 J	87600 J	96300 J
Thallium	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Total Hardness by 2340B	ug/L	292000 J	269000 J	270000 J	281000 J	266000 J	273000 J	270000 J
Vanadium	ug/L	6.7 J	4.3 J	4.9 J	4.4 J	4.2 J	4.6 J	4.2 J
Zinc	ug/L	9.5 J	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U
Mercury	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
Total Cyanide	mg/L	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U
ICP Dissolved Metals								
Aluminum, Dissolved	ug/L	75 U	25 U	25 U	75 U	25 U	25 U	25 U
Antimony, Dissolved	ug/L	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic, Dissolved	ug/L	4.6 U	6 J	6.9 J	4.6 U	7.9 J	7.5 J	4.9 J
Barium, Dissolved	ug/L	121 J	121 J	136 J	124 J	128 J	123 J	133 J
Beryllium, Dissolved	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium, Dissolved	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium, Dissolved	ug/L	76900 J	77700 J	81200 J	76600 J	79500 J	78800 J	78900 J
Chromium, Dissolved	ug/L	1.5 J	0.69 U	0.69 U	1.1 J	0.69 U	0.69 U	0.69 U
Cobalt, Dissolved	ug/L	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U
Copper, Dissolved	ug/L	0.99 U	1.4 J	1.5 J	0.99 U	1.2 J	1.3 J	1.4 J
Iron, Dissolved	ug/L	17.2 U	17.2 U	17.2 U	17.2 U	17.2 U	17.2 U	17.2 U
Lead, Dissolved	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
Magnesium, Dissolved	ug/L	15500 J	16300 J	16800 J	15400 J	16700 J	16600 J	16100 J
Manganese, Dissolved	ug/L	130 J	0.62 J	0.6 U	174 J	0.77 J	0.81 J	0.74 J
Nickel, Dissolved	ug/L	1.9 J	1.6 J	2.4 J	1.5 J	2 J	1.9 J	2.2 J
Potassium, Dissolved	ug/L	9480 J	9170 J	9310 J	9420 J	9390 J	9350 J	9180 J
Selenium, Dissolved	ug/L	2.7 U	2.7 U	3.1 J	3.7 J	2.9 J	2.7 U	3.2 J
Silver, Dissolved	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium, Dissolved	ug/L	79600 J	84000 J	97400 J	80800 J	86200 J	84900 J	94600 J
Thallium, Dissolved	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Vanadium, Dissolved	ug/L	4.6 J	3.5 J	3.9 J	4.1 J	3.8 J	3.5 J	3.3 J
Zinc, Dissolved	ug/L	7.3 U	7.3 U	50 U	7.3 U	50 U	7.3 U	50 U
Mercury, Dissolved	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
PAHs								
Acenaphthene	ug/L	0.027 U	0.08 J	0.027 U	0.027 U	0.1 U	0.027 UJ	0.027 U
Acenaphthylene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 UJ	0.019 UJ	0.019 U
Anthracene	ug/L	0.027 U	0.1 UJ	0.027 U	0.027 U	0.1 UJ	0.027 UJ	0.027 U
Benzo(a)anthracene	ug/L	0.023 U	0.023 UJ	0.023 U	0.023 U	0.023 UJ	0.1 U	0.023 U
Benzo(a)pyrene	ug/L	0.017 U	0.017 UJ	0.017 U	0.017 U	0.017 UJ	0.1 U	0.017 U
Benzo(b)fluoranthene	ug/L	0.015 U	0.015 UJ	0.015 U	0.015 U	0.1 U	0.1 U	0.015 U
Benzo(g,h,i)perylene	ug/L	0.021 U	0.021 UJ	0.021 U	0.021 U	0.021 UJ	0.021 UJ	0.021 U
Benzo(k)fluoranthene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.022 UJ	0.022 U
Chrysene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.1 UJ	0.022 U
Dibenzo(a,h)anthracene	ug/L	0.02 U	0.02 UJ	0.02 U	0.02 U	0.02 UJ	0.02 UJ	0.02 U
Fluoranthene	ug/L	0.031 U	0.031 UJ	0.031 U	0.031 U	0.1 U	0.031 UJ	0.031 U
Fluorene	ug/L	0.02 U	0.1 UJ	0.02 U	0.02 U	0.1 U	0.02 UJ	0.02 U
Indeno(1,2,3-cd)pyrene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 UJ	0.019 UJ	0.019 U
Naphthalene	ug/L	0.5 U	0.32 J	0.5 U	0.5 U	0.5 U	0.057 UJ	0.5 U
Phenanthrene	ug/L	0.073 J	0.5 U	0.07 U	0.071 J	0.5 U	0.5 UJ	0.5 U
Pyrene	ug/L	0.028 U	0.1 U	0.028 U	0.028 U	0.028 UJ	0.028 UJ	0.053 J

Table 3-1
Surface Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS06SW				BEESS08SW		
		12/10/2012	12/12/2012	12/14/2012	12/14/2012 (DUP)	12/10/2012	12/12/2012	12/14/2012
ICP Total Metals								
Aluminum	ug/L	160	186	265	277	120	184	268
Antimony	ug/L	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic	ug/L	4.6 U	5.9 J	6.5 J	6.2 J	4.6 U	6.6 J	5.4 J
Barium	ug/L	142 J	142 J	149 J	146 J	142 J	142 J	146 J
Beryllium	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium	ug/L	85400 J	81200 J	80400 J	78100 J	86500 J	81700 J	78900 J
Chromium	ug/L	0.97 J	0.69 U	0.92 J	1.3 J	0.69 U	0.69 U	0.89 J
Cobalt	ug/L	1.4 J	0.82 J	0.76 U	0.76 U	1.4 J	0.79 J	0.76 U
Copper	ug/L	1.2 J	1.4 J	1.5 J	1.6 J	1.5 J	1.2 J	1.5 J
Iron	ug/L	268	250	351	340	220	251	338
Lead	ug/L	2.4 U	2.4 U	2.6 J	2.4 U	2.4 U	2.4 U	2.4 U
Magnesium	ug/L	17800 J	16600 J	16500 J	16100 J	18100 J	16900 J	16100 J
Manganese	ug/L	297 J	362 J	348 J	339 J	289 J	365 J	342 J
Nickel	ug/L	2.8 J	2.2 J	2.5 J	2.4 J	3.5 J	2.1 J	2.3 J
Potassium	ug/L	9800 J	9610 J	9280 J	9040 J	10300 J	9650 J	9180 J
Selenium	ug/L	6.8 J	3.7 J	4.4 J	3.3 J	7.6 J	4.6 J	2.8 J
Silver	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium	ug/L	84700 J	87200 J	94600 J	92000 J	87600 J	87300 J	93300 J
Thallium	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Total Hardness by 2340B	ug/L	286000 J	271000 J	269000 J	261000 J	290000 J	274000 J	263000 J
Vanadium	ug/L	5.2 J	4.4 J	3.9 J	4.4 J	5.5 J	4.2 J	4.1 J
Zinc	ug/L	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U
Mercury	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
Total Cyanide	mg/L	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0021 U
ICP Dissolved Metals								
Aluminum, Dissolved	ug/L	75 U	25 U	25 U	25 U	75 U	25 U	25 U
Antimony, Dissolved	ug/L	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic, Dissolved	ug/L	4.6 U	5.7 J	4.7 J	7 J	4.6 U	5.6 J	6.3 J
Barium, Dissolved	ug/L	122 J	127 J	136 J	134 J	124 J	121 J	138 J
Beryllium, Dissolved	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium, Dissolved	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium, Dissolved	ug/L	76500 J	80900 J	81500 J	80000 J	77000 J	77200 J	82200 J
Chromium, Dissolved	ug/L	0.98 J	0.72 J	0.69 U	0.69 U	0.78 J	0.69 U	0.69 U
Cobalt, Dissolved	ug/L	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U	0.76 U
Copper, Dissolved	ug/L	1.1 J	1.3 J	1.6 J	12.5	0.99 U	1.2 J	1.9 J
Iron, Dissolved	ug/L	17.2 U	17.2 U	21.5 J	17.2 U	17.2 U	17.2 U	17.2 U
Lead, Dissolved	ug/L	2.4 U	2.4 U	5 U	5 U	2.4 U	2.4 U	2.4 U
Magnesium, Dissolved	ug/L	15600 J	17000 J	17000 J	16500 J	15500 J	16300 J	17300 J
Manganese, Dissolved	ug/L	168 J	0.76 J	0.88 J	0.6 U	177 J	0.6 U	0.6 U
Nickel, Dissolved	ug/L	2 J	1.8 J	3.8 J	2.4 J	1.6 J	1.7 J	2.1 J
Potassium, Dissolved	ug/L	9420 J	9530 J	9430 J	9220 J	9520 J	9090 J	9530 J
Selenium, Dissolved	ug/L	4.1 J	3.1 J	2.7 J	3.5 J	3.1 J	2.7 J	3.1 J
Silver, Dissolved	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium, Dissolved	ug/L	78600 J	87400 J	97600 J	95600 J	79800 J	83400 J	99200 J
Thallium, Dissolved	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Vanadium, Dissolved	ug/L	4.2 J	3.7 J	3.6 J	3.2 J	4.1 J	4 J	3.3 J
Zinc, Dissolved	ug/L	7.3 U	7.3 U	50 U	50 U	7.3 U	50 U	7.3 U
Mercury, Dissolved	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
PAHs								
Acenaphthene	ug/L	0.027 U	0.1 U	0.088 J	0.027 U	0.027 U	0.027 UJ	0.027 U
Acenaphthylene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 U	0.019 UJ	0.019 U
Anthracene	ug/L	0.027 U	0.027 UJ	0.027 U	0.027 U	0.027 U	0.1 U	0.027 U
Benzo(a)anthracene	ug/L	0.023 U	0.023 UJ	0.023 U	0.023 U	0.023 U	0.023 UJ	0.023 U
Benzo(a)pyrene	ug/L	0.017 U	0.017 UJ	0.017 U	0.017 U	0.017 U	0.017 UJ	0.017 U
Benzo(b)fluoranthene	ug/L	0.015 U	0.015 UJ	0.015 U	0.015 U	0.015 U	0.015 UJ	0.015 U
Benzo(g,h,i)perylene	ug/L	0.021 U	0.021 UJ	0.021 U	0.021 U	0.021 U	0.021 UJ	0.021 U
Benzo(k)fluoranthene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 U	0.022 UJ	0.022 U
Chrysene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 U	0.022 UJ	0.022 U
Dibenzo(a,h)anthracene	ug/L	0.02 U	0.02 UJ	0.02 U	0.02 U	0.02 U	0.02 UJ	0.02 U
Fluoranthene	ug/L	0.031 U	0.1 U	0.031 U	0.031 U	0.031 U	0.1 U	0.031 U
Fluorene	ug/L	0.02 U	0.02 UJ	0.051 J	0.02 U	0.02 U	0.1 U	0.02 U
Indeno(1,2,3-cd)pyrene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 U	0.019 UJ	0.019 U
Naphthalene	ug/L	0.5 U	0.5 U	0.95	0.5 U	0.5 U	0.5 U	0.5 U
Phenanthrene	ug/L	0.07 U	0.5 U	0.07 U	0.07 U	0.085 J	0.5 U	0.07 U
Pyrene	ug/L	0.028 U	0.028 UJ	0.028 U	0.028 U	0.028 U	0.1 U	0.028 U

Table 3-1
Surface Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS09SW			BEESS10SW		
		12/10/2012	12/12/2012	12/14/2012	12/10/2012	12/12/2012	12/14/2012
ICP Total Metals							
Aluminum	ug/L	4280	5440	2600 J	410	207	285
Antimony	ug/L	10 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic	ug/L	10.2	10	6.2 J	4.6 U	6.4 J	7.5 J
Barium	ug/L	222 J	248 J	192 J	146 J	140 J	148 J
Beryllium	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium	ug/L	89800 J	89900 J	81400 J	84800 J	81500 J	79100 J
Chromium	ug/L	4.9 J	5.4	3.2 J	1.2 J	5 U	0.75 J
Cobalt	ug/L	2.7 J	3.1 J	1.8 J	0.86 J	0.76 U	0.85 J
Copper	ug/L	4.1 J	4.8 J	3.3 J	1.6 J	1.1 J	2.4 J
Iron	ug/L	4510	4990	2430 J	489	271	356
Lead	ug/L	2.8 J	7.6	5.2	2.4 U	2.4 U	2.4 U
Magnesium	ug/L	19000 J	18000 J	16500 J	17500 J	16800 J	16300 J
Manganese	ug/L	826 J	1000 J	584 J	307 J	362 J	343 J
Nickel	ug/L	6.6	6.9	4.5 J	3.1 J	2.6 J	2.7 J
Potassium	ug/L	11100 J	11200 J	9560 J	10200 J	9680 J	9250 J
Selenium	ug/L	6.9 J	3.6 J	3.4 J	2.7 U	4.4 J	3.3 J
Silver	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium	ug/L	86700 J	88400 J	93300 J	86800 J	86900 J	94400 J
Thallium	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Total Hardness by 2340B	ug/L	302000 J	299000 J	271000 J	284000 J	273000 J	264000 J
Vanadium	ug/L	12.4	12.7	8 J	5.5 J	4.5 J	4.2 J
Zinc	ug/L	21 J	22.5 J	12.2 J	7.3 U	7.3 U	7.3 U
Mercury	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
Total Cyanide	mg/L	0.0021 U	0.0021 U	0.0021 U	0.0021 U	0.0037 J	0.0021 U
ICP Dissolved Metals							
Aluminum, Dissolved	ug/L	75 U	25 U	25 U	75 U	25 U	28.2 J
Antimony, Dissolved	ug/L	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U	3.1 U
Arsenic, Dissolved	ug/L	4.6 U	6.4 J	7.7 J	4.7 J	5.6 J	7.1 J
Barium, Dissolved	ug/L	122 J	125 J	134 J	124 J	123 J	139 J
Beryllium, Dissolved	ug/L	0.5 U	0.5 U	1.2	0.5 U	0.5 U	0.5 U
Cadmium, Dissolved	ug/L	0.39 U	0.39 U	5 U	0.39 U	0.39 U	0.39 U
Calcium, Dissolved	ug/L	78300 J	82000 J	80200 J	77300 J	78400 J	81400 J
Chromium, Dissolved	ug/L	1.3 J	0.69 U	5 U	1.3 J	0.69 U	0.69 U
Cobalt, Dissolved	ug/L	0.76 U	0.76 U	1.4 J	0.76 U	0.76 U	0.76 U
Copper, Dissolved	ug/L	0.99 U	1.2 J	2.7 J	0.99 U	1.2 J	2 J
Iron, Dissolved	ug/L	17.2 U	17.2 U	50 U	17.2 U	17.2 U	17.2 U
Lead, Dissolved	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U	5 U
Magnesium, Dissolved	ug/L	16300 J	17300 J	16400 J	15800 J	16400 J	16900 J
Manganese, Dissolved	ug/L	93.2 J	0.76 J	0.91 J	174 J	0.77 J	0.6 U
Nickel, Dissolved	ug/L	1.6 J	1.8 J	5 U	1.5 J	1.8 J	1.8 J
Potassium, Dissolved	ug/L	9940 J	9710 J	9140 J	9620 J	9260 J	9450 J
Selenium, Dissolved	ug/L	2.7 U	2.7 U	5.7 J	4.3 J	3.2 J	4.6 J
Silver, Dissolved	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium, Dissolved	ug/L	81000 J	87800 J	99100 J	77600 J	85300 J	98000 J
Thallium, Dissolved	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Vanadium, Dissolved	ug/L	4.1 J	3.8 J	4.5 J	4.1 J	3.9 J	3.4 J
Zinc, Dissolved	ug/L	7.3 U	7.3 U	7.3 U	7.3 U	7.3 U	50 U
Mercury, Dissolved	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
PAHs							
Acenaphthene	ug/L	0.027 U	0.1 U	0.027 U	0.027 U	0.027 UJ	0.027 U
Acenaphthylene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 UJ	0.019 U
Anthracene	ug/L	0.027 U	0.027 UJ	0.027 U	0.027 U	0.027 UJ	0.027 U
Benzo(a)anthracene	ug/L	0.023 U	0.023 UJ	0.023 U	0.023 U	0.023 UJ	0.023 U
Benzo(a)pyrene	ug/L	0.017 U	0.017 UJ	0.017 U	0.017 U	0.017 UJ	0.017 U
Benzo(b)fluoranthene	ug/L	0.015 U	0.015 UJ	0.015 U	0.015 U	0.015 UJ	0.015 U
Benzo(g,h,i)perylene	ug/L	0.021 U	0.021 UJ	0.021 U	0.021 U	0.021 UJ	0.021 U
Benzo(k)fluoranthene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.022 U
Chrysene	ug/L	0.022 U	0.022 UJ	0.022 U	0.022 U	0.022 UJ	0.022 U
Dibenzo(a,h)anthracene	ug/L	0.02 U	0.02 UJ	0.02 U	0.02 U	0.02 UJ	0.02 U
Fluoranthene	ug/L	0.031 U	0.031 UJ	0.031 U	0.031 U	0.031 UJ	0.031 U
Fluorene	ug/L	0.02 U	0.02 UJ	0.02 U	0.02 U	0.02 UJ	0.02 U
Indeno(1,2,3-cd)pyrene	ug/L	0.019 U	0.019 UJ	0.019 U	0.019 U	0.019 UJ	0.019 U
Naphthalene	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Phenanthrene	ug/L	0.072 J	0.5 U	0.07 U	0.07 U	0.5 UJ	0.5 U
Pyrene	ug/L	0.028 U	0.028 UJ	0.08 J	0.028 U	0.028 UJ	0.028 U

Table 3-2
Water Quality Field Measurements
Ecological Risk Assessment
Beatrice MGP EE/CA

Water Quality Parameters [1]							
Location	**Date**	**Temperature (°C)**	**Conductivity (µs/cm)**	**DO (%)**	**pH**	**ORP (mV)**	**Turbidity (NTU)**
Station 1	12/10/2012	1.75	781	61.00	8.23	154.80	6.10
	12/12/2012	0.03	828	34.70	8.38	128.10	7.50
	12/14/2012	0.31	860	14.60	8.37	248.80	9.50
Station 2	12/10/2012	1.85	733	48.90	8.60	154.00	7.00
	12/12/2012	-0.04	825	45.60	8.32	136.50	13.20
	12/14/2012	0.43	860	35.00	8.20	244.80	9.30
Station 3	12/10/2012	1.55	776	48.20	8.62	158.80	8.30
	12/12/2012	0.06	830	30.00	8.45	134.10	7.70
	12/14/2012	0.26	860	14.80	8.40	244.20	9.70
Station 5	12/10/2012	0.95	778	50.50	8.52	162.70	7.10
	12/12/2012	0.06	826	24.40	8.94	137.60	7.70
	12/14/2012	0.30	857	17.10	8.40	250.10	8.80
Station 6	12/10/2012	0.87	778	55.20	8.56	175.50	7.20
	12/12/2012	0.12	791	30.10	8.44	140.00	9.60
	12/14/2012	0.23	865	17.30	8.40	243.70	8.80
Station 8	12/10/2012	0.92	778	57.60	8.56	176.60	8.20
	12/12/2012	0.14	827	32.00	8.45	143.50	7.10
	12/14/2012	0.23	865	18.50	8.36	241.70	8.70
Station 9	12/10/2012	2.90	786	76.80	8.68	170.70	31.70
	12/12/2012	0.91	845	39.60	8.45	146.10	36.20
	12/14/2012	0.59	852	25.30	8.44	233.30	44.40
Station 10	12/10/2012	0.81	784	75.20	8.64	171.70	8.80
	12/12/2012	0.43	829	45.10	8.47	148.20	11.10
	12/14/2012	0.34	867	69.80	8.43	231.80	10.60

Abbreviations:
°C degrees Celsius
µs/cm microsiemens per centimeter
mV millivolts
NTU Nephelometric Turbidity Unit

Note:
(1) Water quality parameters collected congruently with surface water analytical samples.

Table 3-3
Sediment Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS01SD	BEESS02SD	BEESS03SD	BEESS05SD	BEESS06SD	
		12/11/2012	12/11/2012	12/11/2012	12/11/2012	12/13/2012	12/13/2012 (DUP)
PAHs							
Acenaphthene	ug/kg	2 U	1.9 U	2 U	1.9 U	2310	2150
Acenaphthylene	ug/kg	2 U	1.9 U	2 U	1.9 U	232	217
Anthracene	ug/kg	2 U	1.9 U	2 U	1.9 U	1140	864
Benzo(a)anthracene	ug/kg	2 U	1.9 U	5	1.9 U	369	364
Benzo(a)pyrene	ug/kg	2 U	1.9 U	5.9	1.9 U	282	281
Benzo(b)fluoranthene	ug/kg	2 U	1.9 U	14.9	1.9 U	327	332
Benzo(g,h,i)perylene	ug/kg	2 U	1.9 U	3.2 J	1.9 U	154	142
Benzo(k)fluoranthene	ug/kg	2 U	1.9 U	2 U	1.9 U	46.6 U	40.5 U
Chrysene	ug/kg	2 U	1.9 U	6	1.9 U	332	347
Dibenzo(a,h)anthracene	ug/kg	2 U	1.9 U	2 U	1.9 U	46.6 U	40.5 U
Fluoranthene	ug/kg	2 U	1.9 U	6.7	1.9 U	1430	982
Fluorene	ug/kg	2 U	1.9 U	2 U	1.9 U	855	1180
Indeno(1,2,3-cd)pyrene	ug/kg	2 U	1.9 U	3 J	1.9 U	94.9	103
Naphthalene	ug/kg	2.1 J	3.2 J	2 U	1.9 U	5000	3590
Phenanthrene	ug/kg	2 U	1.9 U	3.2 J	1.9 U	4120	3100
Pyrene	ug/kg	2 U	1.9 U	7.7	1.9 U	1620	1180
Percent Moisture							
Percent Moisture	%	19.2	14.5	16.5	14.8	11.9	10.6
Total Organic Carbon (TOC)							
TOC Result 1	mg/kg	5620	1580	805	699	2410	3890
TOC Result 2	mg/kg	3900	1880	1050	731	2780	2670
Mean TOC	mg/kg	4760	1730	928	715	2590	3280
Relative Percent Difference	%	36.1	17.1	26.7	4.5	14.2	37.2
Grain Size							
Clay	%	0.0	0.0	0.0	0.0	1.1	0.4
Silt	%	0.8	0.2	0.1	0.2	1.6	0.6
Fine Sand	%	10.5	1.3	1.4	1.0	7.4	3.1
Medium Sand	%	8.4	5.6	2.6	7.6	7.9	3.9
Coarse Sand	%	35.2	84.6	68.6	82.2	20.6	37.3
Gravel	%	45.1	8.3	27.3	9.0	61.4	54.7
USCS Classification	ASTM D2487	SP Poorly graded sand with	SP Poorly graded sand	SP Poorly graded sand with	SP Poorly graded sand	GP Poorly graded gravel with	GP Poorly graded gravel with

Table 3-3
Sediment Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS08SD	BEESS09SD	BEESS10SD
		12/13/2012	12/13/2012	12/13/2012
PAHs				
Acenaphthene	ug/kg	5	1.8 U	1.9 U
Acenaphthylene	ug/kg	2.7 J	1.8 U	1.9 U
Anthracene	ug/kg	6.1	2 J	1.9 U
Benzo(a)anthracene	ug/kg	9.7	1.8 U	1.9 U
Benzo(a)pyrene	ug/kg	6.3	1.8 U	1.9 U
Benzo(b)fluoranthene	ug/kg	10.9	1.8 U	1.9 U
Benzo(g,h,i)perylene	ug/kg	7.5	1.8 U	1.9 U
Benzo(k)fluoranthene	ug/kg	1.9 U	1.8 U	1.9 U
Chrysene	ug/kg	16.4	1.8 U	1.9 U
Dibenzo(a,h)anthracene	ug/kg	1.9 J	1.8 U	1.9 U
Fluoranthene	ug/kg	15.6	6.6	1.9 U
Fluorene	ug/kg	1.9 U	1.8 U	1.9 U
Indeno(1,2,3-cd)pyrene	ug/kg	3.6 J	1.8 U	1.9 U
Naphthalene	ug/kg	7.6	1.8 U	1.9 U
Phenanthrene	ug/kg	28.8	5.4	1.9 U
Pyrene	ug/kg	22.5	4.6	1.9 U
Percent Moisture				
Percent Moisture	%	13.0	10.0	14.6
Total Organic Carbon (TOC)				
TOC Result 1	mg/kg	6880	347	1040
TOC Result 2	mg/kg	5710	427	1180
Mean TOC	mg/kg	6290	387	1110
Relative Percent Difference	%	18.5	20.7	13.3
Grain Size				
Clay	%	0.0	0.0	0.0
Silt	%	0.2	0.1	0.1
Fine Sand	%	1.7	0.0	0.2
Medium Sand	%	2.1	2.5	2.9
Coarse Sand	%	39.0	76.1	59.6
Gravel	%	57.0	21.3	37.2
USCS Classification	ASTM D2487	GP	SP	SP
		Poorly graded gravel with	Poorly graded sand with	Poorly graded sand with

Table 3-4
Bathymetric Measurements [1]
Ecological Risk Assessment
Beatrice MGP EE/CA

Location	Northing	Westing	Elevation (ft)	Stream depth (cm)	Stream flow (ft/sec)	Sediment depth (cm)	Macroinvertebrate Sample Area [2] (m^2)
Station 1	40.26245	-96.75463	1239	8	0.8	2	1.3
Station 2	40.26194	-96.75498	1220	17	0.1	12	1.3
Station 3	40.26337	-96.7548	1239	38.5	0.1	8	1.3
Station 4	40.26377	-96.75412	1219	NA	NA	NA	NA
Station 5	40.26373	-96.75455	1230	30	1.3	6	1.3
Station 6	40.26413	-96.75423	1251	48.5	0.8	7	1.3
Station 7	40.2641	-96.7536	1226	NA	NA	NA	NA
Station 8	40.2644	-96.75414	1230	25	2	2	1.3
Station 9	40.26526	-96.75452	1267	25	0	21	1.3
Station10	40.26608	-96.75435	1254	56	0	60	1.3

Abbreviations:
ft feet
cm centimeter
ft/sec feet per second
m˘ square meter

Notes:
[1]Stream data collected 12/14/12
[2]Macro invertebrate sample area was combined from Hester Dendy Samples (0.3 m^2) and grab samples collected from a 1 m^2 area with a kick net.

Table 3-5
Pore Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS04PW	BEESS05PW	BEESS06PW	BEESS07PW	BEESS08PW
		12/11/2012	12/11/2012	12/11/2012	12/11/2012	12/11/2012
ICP Total Metals						
Aluminum	ug/L	25 UJ	27.3 J	40.7 J	26.4 J	33.3 J
Antimony	ug/L	3.1 UJ	3.1 UJ	10 UJ	3.1 UJ	3.1 UJ
Arsenic	ug/L	4.6 UJ	7.7 J	4.6 UJ	4.6 UJ	4.6 UJ
Barium	ug/L	244 J	1460 J	742 J	579 J	426 J
Beryllium	ug/L	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ	0.5 UJ
Cadmium	ug/L	0.39 UJ	0.39 UJ	0.39 UJ	0.39 UJ	0.39 UJ
Calcium	ug/L	96800 J	111000 J	157000 J	89400 J	194000 J
Chromium	ug/L	0.76 J	1 J	1 J	0.69 UJ	0.73 J
Cobalt	ug/L	1.5 J	1 J	2 J	0.76 UJ	0.76 UJ
Copper	ug/L	1.7 J	3.2 J	0.99 UJ	1.8 J	1.3 J
Iron	ug/L	125	18.3 J	14100	17.2 U	1240
Lead	ug/L	2.4 UJ	2.4 UJ	2.4 UJ	2.4 UJ	2.4 UJ
Magnesium	ug/L	17600 J	26000 J	45800 J	22400 J	52500 J
Manganese	ug/L	2060 J	4590 J	5000 J	204 J	2650 J
Nickel	ug/L	3.2 J	3.3 J	5.4 UJ	1.5 J	2.5 J
Potassium	ug/L	12300 J	14400 J	9520 J	12700 J	9460 J
Selenium	ug/L	2.7 UJ	2.7 UJ	2.7 UJ	3.5 J	2.7 UJ
Silver	ug/L	7 UJ	7 UJ	7 UJ	1.3 UJ	7 UJ
Sodium	ug/L	97000 J	104000 J	144000 J	98700 J	85900 J
Thallium	ug/L	4.3 UJ	4.3 UJ	4.3 UJ	4.3 UJ	4.3 UJ
Total Hardness by 2340B	ug/L	314000 J	385000 J	580000 J	315000 J	700000 J
Vanadium	ug/L	1.2 UJ	5 J	1.2 UJ	2.8 J	1.2 UJ
Zinc	ug/L	11.1 J	399 J	122 J	61 J	62.5 J
Mercury	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U
Total Cyanide	mg/L	0.0061	0.0059	0.075	0.0047 J	0.021
ICP Dissolved Metals						
Aluminum, Dissolved	ug/L	25 U	28.4 J	39.6 J	25 U	33.5 J
Antimony, Dissolved	ug/L	3.1 U	3.1 U	3.1 U	4 J	3.1 U
Arsenic, Dissolved	ug/L	4.9 J	9.4 J	8 J	5.6 J	4.6 U
Barium, Dissolved	ug/L	305 J	616 J	471 J	555 J	276 J
Beryllium, Dissolved	ug/L	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Cadmium, Dissolved	ug/L	0.39 U	0.39 U	0.39 U	0.39 U	0.39 U
Calcium, Dissolved	ug/L	92800	103000	151000	83000	179000
Chromium, Dissolved	ug/L	0.69 U	0.98 J	0.69 U	0.69 U	0.69 U
Cobalt, Dissolved	ug/L	1.1 J	1.4 J	1.9 J	0.76 U	0.76 U
Copper, Dissolved	ug/L	1.5 J	1.3 J	0.99 U	0.99 U	0.99 U
Iron, Dissolved	ug/L	17.2 U	17.2 U	57.7	17.2 U	50 UJ
Lead, Dissolved	ug/L	2.4 U	2.4 U	2.4 U	2.4 U	3.1 J
Magnesium, Dissolved	ug/L	16700 J	23100 J	43000 J	20000 J	46900 J
Manganese, Dissolved	ug/L	1920 J	6040 J	4570 J	652 J	2360 J
Nickel, Dissolved	ug/L	3.7 J	3.4 J	4.7 J	1.6 J	3 J
Potassium, Dissolved	ug/L	11600 J	13800 J	9120 J	12400 J	8660 J
Selenium, Dissolved	ug/L	3.7 J	2.7 U	2.7 U	2.7 U	6 J
Silver, Dissolved	ug/L	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
Sodium, Dissolved	ug/L	94200 J	93900 J	140000 J	93800 J	80400 J
Thallium, Dissolved	ug/L	4.3 U	4.3 U	4.3 U	4.3 U	4.3 U
Vanadium, Dissolved	ug/L	1.2 U	4 J	1.2 U	1.2 U	1.2 U
Zinc, Dissolved	ug/L	80.4	85.4	21.4 J	61.6	10.9 J
Mercury, Dissolved	ug/L	0.053 U	0.053 U	0.053 U	0.053 U	0.053 U

Table 3-5
Pore Water Sample Analytical Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Parameters	Units	BEESS04PW	BEESS05PW	BEESS06PW	BEESS07PW	BEESS08PW
		12/11/2012	12/11/2012	12/11/2012	12/11/2012	12/11/2012
PAHs						
Acenaphthene	ug/L	0.24	0.027 U	15.1	0.48	40.2
Acenaphthylene	ug/L	0.088 J	0.019 U	0.65	0.019 U	1.6
Anthracene	ug/L	0.027 U	0.027 U	0.63	0.027 U	1.2
Benzo(a)anthracene	ug/L	0.13	0.023 U	0.023 U	0.023 U	0.094 J
Benzo(a)pyrene	ug/L	0.15	0.017 U	0.017 U	0.017 U	0.1
Benzo(b)fluoranthene	ug/L	0.39	0.015 U	0.015 U	0.015 U	0.14
Benzo(g,h,i)perylene	ug/L	0.19	0.021 U	0.021 U	0.021 U	0.055 J
Benzo(k)fluoranthene	ug/L	0.022 U	0.022 U	0.022 U	0.022 U	0.022 U
Chrysene	ug/L	0.21	0.022 U	0.022 U	0.022 U	0.14
Dibenzo(a,h)anthracene	ug/L	0.091 J	0.02 U	0.02 U	0.02 U	0.02 U
Fluoranthene	ug/L	0.1	0.031 U	0.19	0.031 U	1
Fluorene	ug/L	0.02 U	0.02 U	3.6	0.02 U	8.9
Indeno(1,2,3-cd)pyrene	ug/L	0.14	0.019 U	0.019 U	0.019 U	0.019 U
Naphthalene	ug/L	0.068 J	0.057 U	33.8	0.083 J	4.2
Phenanthrene	ug/L	0.5 U	0.5 U	3.5	0.5 U	8.5
Pyrene	ug/L	0.2	0.028 U	0.17	0.028 U	0.78
VOCs						
Benzene	ug/L	0.12 U	0.12 U	19.5	0.12 U	1
Ethylbenzene	ug/L	1 U	1 U	30	1 U	2.1
Toluene	ug/L	0.1 J	0.18 J	0.86 J	0.098 J	0.17 J
Xylene (Total)	ug/L	0.67 U	0.67 U	16.1	0.67 U	5.8

Table 3-6
Summary of Macroinvertebrate Community Survey Results
Ecological Risk Assessment
Beatrice MGP EE/CA

Sample ID	Number of Taxa	Number of Individuals/m^2	Mean Number of Individuals/m^2 per taxa	Shannon-Weaver Index	% Contribution Dominant Taxa	Number of Pollution Sensitive Taxa	Hilsenhoff Biotic Index	Pielou's Evenness Index
BEESSM-01	7	234	33	3.29	50	0	6.1	1.69
BEESSM-02	4	42	11	2.27	60	1	5.6	1.64
BEESSM-03	7	418	60	3.01	63	0	6.3	1.55
BEESSM-05	10	427	43	3.78	42	3	5.7	1.64
BEESSM-06	9	506	56	2.48	72	3	6.0	1.13
BEESSM-08	6	196	33	3.53	42	1	5.8	1.97
BEESSM-09 (Reference)	6	265	44	2.57	52	0	6.1	1.44
BEESSM-10 (Reference)	3	450	150	1.71	78	0	6.0	1.56

Table 3-7
Summary of Results for *P. promelas* and *C. dubia* 7-Day Chronic Toxicity Tests
Ecological Risk Assessment
Beatrice MGP EE/CA

Sample ID	Test Concentration (%)	*P. promelas*		*C. dubia*	
		Mean Survival (%)	Mean Growth (mg/fish)	Mean Survival (%)	Reproduction (Mean # Young/Adult)
BEESS01	100	97.5	0.533	100	22.2
BEESS02	100	97.5	0.567	100	20.3
BEESS03	100	100	0.577	100	20.5
BEESS05	100	97.5	0.559	100	21.8
BEESS06	100	100	0.572	100	21.5
BEESS08	100	97.5	0.547	100	20.1
BEESS09 (Reference)	100	100	0.573	100	20.9
BEESS10 (Reference)	100	97.5	0.556	100	18.6
Lab Control	Synthetic Water	97.5	0.511	100	18.9

The No Observed Effect Concentration (NOEC) for *Pimephales promelas* was 100% for survival and 100% for growth on all eight test samples. The NOEC for *Ceriodaphnia dubia* was 100% for Survival and 100% for Reproduction on all eight test samples. There were no significant differences between the site and reference or control samples for either test species.

Table 3-8
Summary of Results for *H. azteca* 10-Day Chronic Toxicity Test
Ecological Risk Assessment
Beatrice MGP EE/CA

Sample ID	Test Concentration (%)	*H. azteca*		
		Mean Survival (%)	Mean Dry Weight (mg/organism)	Mean Biomass (mg/organism)
BEESS01	100	92.5	0.146	0.135
BEESS02	100	91.25	0.14	0.129
BEESS03	100	92.5	0.131	0.122
BEESS05	100	90	0.149	0.135
BEESS06	100	4 *	0.06	0.006 *
BEESS08	100	86.25	0.08 *	0.07 **
BEESS09 (Reference)	100	76.25	0.106	0.083
BEESS10 (Reference)	100	88.75	0.108	0.096
Lab Control (Artificial Sediment)	NA	80	0.132	0.111

Dry weight was calculated by taking the mean dry weight obtained for a replicate and dividing it by the number of surviving organisms. Dry biomass was calculated by taking the mean dry weight obtained for a replicate and dividing it by the number of organisms exposed at the start of the assay.

* Statistically significant difference compared to laboratory control and reference samples BEESS09 and BEESS10.
** Statistically significant difference compared to laboratory control and reference sample BEESS10.

Appendix B

Summary of Potential ARARs and TBCs/Potential Removal Action Technologies

SUMMARY OF POTENTIAL ARARs AND TBCs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Type of ARAR	Comment
Federal ARARs				
Safe Drinking Water Act (40 USC Section 300)				
National Primary Drinking Water Standards	40 CFR Part 141	Establishes health-based standards for public water systems (maximum contaminant levels, or MCLs).	Chemical	Potential ARAR that may be relevant and appropriate.
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes welfare-based standards for public water systems (secondary MCLs).	Chemical	Potential ARAR that may be relevant and appropriate.
Maximum Contaminant Level Goals (MSLGs)	Public Law No. 99-339, 100 Statute 642, 1986	Establishes drinking water quality goals set at levels of known or anticipated adverse health effects, with an adequate margin of safety.	Chemical	Not an ARAR; no non-zero MCLGs identified as more stringent than MCLs.
Clean Water Act (33 USC Section 1251-1376)				
National Pollutant Discharge Elimination System	40 CFR Parts 122, 125	Establishes treatment requirements, permit issuance guidelines, compliance variances, and alternative effluent limitations. Requires permits to discharge pollutants from any point source into U.S. waters.	Chemical/Action	Not an ARAR because there would be no discharge to surface water.
EPA Guidelines Establishing Test Procedures for the Analysis of Pollutants	40 CFR Part 136	Establishes EPA regulations on test procedures for the analysis of pollutants.	Chemical	Potential ARAR that may be relevant and appropriate.
Disposal of Dredged Materials/Navigable Waters Permitting Requirements	40 CFR Part 230-231, 33 CFR Parts 320-330	Requirements that involve the disposal of dredge and fill materials including their disposal into navigable water bodies and wetlands.	Location/Action	Not an ARAR because no materials would be disposed into navigable water bodies or wetlands.
National Pretreatment Standards	40 CFR Part 403	Sets standards to control pollutants that pass through or interfere with treatment at wastewater treatment plants.	Chemical/Action	Potential ARAR if alternative involved discharge to a sanitary sewer.
Toxic Pollutant Effluent Standards	40 CFR Part 129	Establishes effluent standards or prohibitions for toxic pollutants, such as aldrin/dieldrin, DDT, endrin, toxaphene, benzidine, and PCBs.	Chemical/Action	Not an ARAR because these pollutants are not associated with the Site.

SUMMARY OF POTENTIAL ARARs AND TBCs

Clean Air Act (42 USC Section 7401-7642)				
National Emission Standards for Hazardous Air Pollutants	40 CFR Part 61	Establishes emission standards for specific hazardous contaminants, including asbestos.	Chemical/Action	Potential ARAR if alternative involves certain atmospheric emissions.
Resource Conservation and Recovery Act (RCRA) (42 USC 6901-6987)				
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria to determine which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health, and thereby constitute prohibited open dumps. Provides for protection of groundwater at disposal facilities.	Chemical/Action	Not an ARAR because onsite disposal of solid waste would not be performed under any alternative.
Hazardous Waste Management Systems	40 CFR Part 260	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Parts 260-265 and 268.	Action	Potential ARAR that may be relevant and appropriate.
Identification and Listing of Hazardous Wastes	40 CFR Part 261	Defines those solid wastes that are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Chemical/Action	Potential ARAR because regulation may be applicable in identifying whether a substance at the Site is defined as a hazardous waste.
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste.	Action	Potential ARAR if alternative involved disposal and treatment of hazardous wastes.
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S. if the transportation requires a manifest under 40 CFR Part 262.	Action	Potential ARAR if alternative involved transportation of hazardous wastes.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264, 265	Establishes minimum standards that define acceptable management of hazardous waste for owners and operators of treatment, storage, or disposal facilities. Provides for groundwater protection standards, monitoring requirements, and technical requirements. Provides requirements for RCRA listed or characteristic wastes or constructing a facility within 100-year flood plain.	Chemical/Action/ Location	Potential ARAR; Subparts B through O may be applicable or relevant and appropriate to onsite removal actions involving treatment, storage or disposal of hazardous waste on Site.

Land Disposal Restrictions	40 CFR Part 268	Establishes a timetable for restriction of land disposal of wastes and other hazardous materials.	Chemical/Action	Potential ARAR if alternative involves land disposal of any restricted wastes.
Hazardous Waste Permit Program	40 CFR Part 270	Establishes provisions covering basis of EPA permitting requirements.	Action	Not an ARAR because a permit is not required for onsite CERCLA response actions. Substantive requirements are addressed in 40 CFR Part 264.
CERCLA (42 USC 9605), as amended by SARA (Pub. L. 99-499)				
Worker Protection	40 CFR Part 311	Regulates worker health and safety.	Action	ARAR.
CERCLA Section 121(d)(3) and the Offsite Rule				
Offsite Disposal	40 CFR 300.440b	Before shipping any hazardous waste, hazardous substances, pollutants, or contaminants from the Site to a Subtitle C facility, Respondents shall obtain from the proposed receiving facility and submit to EPA a written certification that the proposed receiving facility is operating in compliance with these requirements.	Action	ARAR; specified in the Consent Order.
Other Federal Programs				
Occupational Safety and Health Act	29 USC Section 651-678	Regulates worker health and safety.	Action	ARAR; under 40 CFR Section 300.38, requirements of the Act apply to all response activities under the National Contingency Plan (NCP).
National Historic Preservation Act	16 CFR Part 470, et seq.	Requires federal agencies to take into account the effect of any federally-assisted undertaking or licensing on any district, site, building, structure, or object that is included in or eligible for inclusion in the National Register of Historic Places.	Location	Not an ARAR because available information indicates no areas of scientific, pre-historical, historical, or archaeological significance in Site area.
Archaeological and Historic Preservation Act	16 USC Section 469, 36 CFR Part 65	Establishes procedures to preserve historical and archeological data that might be destroyed through alteration of terrain as a result of a federal construction project or a federally-licensed activity or program.	Location	Not an ARAR because available information indicates no areas of scientific, pre-historical, historical, or archaeological significance in Site area.

Historic Sites, Buildings, and Antiquities Act	16 USC Section 461-467, 40 CFR Section 6.301(a)	Requires consideration of the existence and location of landmarks on the National Registry of Natural Landmarks to avoid undesirable impacts on such landmarks.	Location	Not an ARAR because the Site does not contain any items listed on the National Registry of Natural Landmarks.
Fish and Wildlife Coordination Act	16 USC Section 661-666	Requires consultation when stream or other water body modification is proposed and adequate provision for protection of fish and wildlife resources is required.	Location	Potential ARAR if alternative involves the modification of the shoreline.
Endangered Species Act	16 USC 1531 et seq., 50 CFR Part 200, 50 CFR Part 402	Requires action to conserve endangered species within critical habitats upon which endangered species depend.	Location	Potentially an ARAR. Although not observed at the Site, the endangered Massasauga Rattlesnake may be present in the area.
Archaeological Resources Recovery Act of 1979	43 CFR Part 7	Requirements for steps that protect archaeological resources and sites on public land.	Location	Not an ARAR because available information indicates no areas of scientific, pre-historical, historical, or archaeological significance in Site area.
Fish and Wildlife Service List of Endangered Species and Threatened Wildlife and Plants	50 CFR Section 17.11	Provides a list of endangered species and threatened wildlife and plants.	Location	Potentially an ARAR. Although not observed at the Site, the endangered Massasauga Rattlesnake may be present in the area.
National Wildlife Refuge System	16 USC 668 50 CFR 27	Restricts activities within a National Wildlife Refuge.	Location	Not an ARAR because the Site is not located within a National Wildlife Refuge.
Wild and Scenic Rivers Act	16 USC 1271 40 CFR	Prohibits actions that will have direct adverse effects on a scenic river.	Location	Not an ARAR because the Site is not on or near a scenic river.
State of Nebraska ARARs				
NDEQ Voluntary Cleanup Program Standards	NDEQ 2006	Standards for soil and groundwater established by the NDEQ Voluntary Cleanup Program (VCP)	Chemical/Action	Not an ARAR, site is not enrolled in the state VCP.
Nebraska Air Regulations	Title 129	Establishes regulations/standards for emission of air pollutants and odors, incinerators, and air pollution prevention. Establishes standards for protecting ambient air quality, general emissions, particulate matter, organic compounds, and odor.	Chemical/Action	Potential ARAR for treatment processes with atmospheric emissions, if threshold emission values are met.

Nebraska Hazardous Waste Regulations	Title 128	Establishes rules regarding the generation, transportation, treatment, disposal, and storage of hazardous waste and materials, including waste burned in boilers, industrial furnaces, and incinerators, to protect Nebraska's natural resources, including public land.	Location/Action	Potential ARAR; the substantive requirements of this regulation are applicable to the treatment, storage, or disposal of hazardous waste.
Nebraska Water Quality Regulations	Titles 117, 118, 119, 120, and 121	Establishes regulations regarding the discharge of wastes into state water bodies and the protection of state water quality.	Chemical/Action	Potential ARAR since it has been established that there has been contact between contaminated groundwater and the river.
Nebraska Health and Human Services System Regulations	Title 178, Water Well Standards and Contractors' Licensing Act	Establishes well construction requirements, sampling personnel qualifications, and well abandonment requirements.	Action	Potential ARAR; substantial requirements may be applicable to any water well (monitoring or extraction) constructed during the removal action.
Nebraska Ground Water Protection	Title 118	Establishes regulations for protection of ground water.	Action	Potential ARAR; Nebraska MCLs may be relevant and appropriate if they are more stringent than the Federal MCLs.
Nebraska Nongame and Endangered Species Act	Title 163	Requires consultation with the Nebraska Game and Parks Commission regarding actions which may affect threatened or endangered species and their critical habitat.	Location	Potentially an ARAR. Although not observed at the site, the endangered Massasauga Rattlesnake may be present in the area.
Nebraska Safe Drinking Water Standards	Title 179	Establishes regulations for protection of public water supply systems.	Chemical/Action	Not an ARAR because no waste would be discharged into a public water supply.
Rules and Regulations for Design, Operation and Maintenance of Wastewater Treatment Works	Title 123	Establishes regulations for wastewater treatment works.	Action	Not an ARAR because wastewater treatment works are not included in this project.
Regulations for Underground Injections and Mineral Production Wells	Title 122	Establishes regulations for injection of air, treated groundwater, and chemicals during remediation of contaminated groundwater.	Action	Potential ARAR for in situ chemical oxidation.

Integrated Solid Waste Management Regulations	Title 132	Establishes regulations for non-hazardous wastes that may be defined as a special waste.	Action	Potential ARAR for the disposal of any non-hazardous waste generated during removal activities.
Rules Governing Flood Plain Management	Title 258	Establishes regulations governing certain activities occurring in flood plains.	Location	Potential ARAR for any removal activities that occur within a flood plain.
Uniform Environmental Covenants Act	Neb. Rev. State 76-2601 to 76-2603	Establishes regulations for placing an environmental covenant on a property.	Action	ARAR.

POTENTIAL REMOVAL ACTION TECHNOLOGIES

Operable Unit	Technology	Contaminant Removal	Exposure Reduction		Pros	Cons	Applicability to the Site
			Short-term	Long-term			
Soil	Institutional Controls	No	Yes	Possibly	Previously accepted by EPA; relatively inexpensive.	Does not remove contaminants. Limits the potential reuse of the property. Long-term involvement of owner for overseeing any construction or future use of the Site.	May not be necessary if shallow soil is removed/treated. Owner is amenable to the idea of restricted use of the property.
	Excavation with Offsite Thermal Desorption	Yes	Yes	Yes	Previously accepted by EPA; results in contaminant removal and treatment; commonly used at MGP sites; treated soil could be reused as fill material.	Volume of soil to be removed is a relatively small amount; would not be cost effective if TDU is mobilized/used only for the Beatrice Site.	Would require offsite location for TDU. Removal of dense vegetation would be required in certain areas.
	Excavation with Offsite Disposal	Yes	Yes	Yes	Previously accepted by EPA; results in contaminant removal; commonly used at MGP sites; easily implemented; relatively inexpensive compared to other technologies.	Does not treat contaminants, but indirectly reduces their mobility; additional transportation costs to an approved disposal facility.	Disposal fees at other Nebraska MGP removal sites have been cost effective, and facilities have accepted contaminated material. Removal of dense vegetation would be required in certain areas.
	In Situ Thermal Desorption	Yes	No	Yes	Results in contaminant treatment; accepted by EPA.	Not as effective on semi-volatile contaminants or contaminants below the water table. Potential longer time period for completion (typically 6 - 9 months). Power costs may be significant. Used in conjunction with another system to treat volatilized water and organics.	Relatively deep groundwater table (10 to 14 feet bgs) is advantage. No existing power source suitable for this technology near the Site. Removal of dense vegetation would be required in certain areas.
	In Situ Chemical Oxidation	Yes	Yes	Possibly	Results in contaminant reduction; previously accepted by EPA.	Requires effective contact with impacted soil, which is more difficult in vadose zone; some products could migrate to groundwater. Would require treatability studies to evaluate the effectiveness. Multiple applications may be necessary to achieve PRGs. Runoff of oxidation materials may have a potential adverse impact on surface water/sediments of the Big Blue River.	May evaluate mixing shallow soil with an ISCO product; geology is favorable at the Site. Removal of dense vegetation would be required in certain areas.
	Capping	No	Yes	Possibly	Previously accepted by EPA; easily implemented.	Does not remove contaminants; long-term O&M requirement. Restricts future use of the Site; future use may impact integrity of cap. Long-term involvement of Site owner overseeing any construction or future use of the Site.	Source material extends into the groundwater; a cap would only serve to prevent exposure to shallow soil. Capping material would be limited based on potential future use of the property as a green space and biking/walking trail.
	In Situ Stabilization (within gas holder structure)	No	Yes	Possibly	Previously accepted by EPA; would immobilize contaminants and prevent further migration.	Creates a subsurface monolith; does not remove contaminants. May be difficult to implement with rubble material in the structure.	May be used in conjunction with excavating shallow soil to prevent further migration of source material. Based on borings, structure likely has a competent base. Could potentially dewater structure and large rubble prior to injecting/mixing the stabilizing agent.
	Bioremediation	Yes	No	Yes	If heat-enhanced used, electric heat resistance heating could increase the solubility and bio-availability of contaminants. If oxygen or nutrient-enhanced used, only requires application of oxygen and inorganic nutrients (N, P, K, and trace metals).	Could accelerate contaminant migration if improperly contained; results can be sporadic. Would require treatability studies to evaluate effectiveness.	Lack of water in shallow soil would not provide an appropriate environment for organisms to effectively degrade contaminants.
	In Situ Air Sparging/Soil Vapor Extraction	Yes	No	Yes	Previously accepted by EPA.	O&M required; may not treat heavier contaminants. Would require a power source.	Would not be applicable as a shallow soil treatment alternative.
	Ex Situ Soil Washing	Yes	Yes	Yes	Results in contaminant removal/reduction. Treated soil could be reused as fill material.	High degree of O&M required. Treatment train is extensive. More complex process.	More conventional technologies are available. Removal of dense vegetation would be required in certain areas. May require an offsite location for treatment.
	Soil Flushing	Yes	No	Yes	Results in contaminant removal/reduction.	Could accelerate migration if improperly contained. High degree of O&M required.	More conventional technologies are available. Would not be applicable as a shallow soil treatment alternative.

POTENTIAL REMOVAL ACTION TECHNOLOGIES

Operable Unit	Technology	Contaminant Removal	Exposure Reduction		Pros	Cons	Applicability to the Site
			Short-term	Long-term			
Groundwater/ NAPL	Institutional Controls	No	Yes	Possibly	Previously accepted by EPA; relatively inexpensive.	Does not remove contaminants; future migration of and exposure to contaminants is possible.	Will likely be required based on the presence of dissolved phase contamination and NAPL at the Site. Proposed future use of the Site does not include use of/exposure to groundwater.
	Groundwater Monitoring	No	No	Possibly	Previously accepted by EPA.	Does not remove/immobilize contaminants. Long-term O&M required.	May be appropriate in conjunction with sediment and surface water monitoring to ensure that contaminant migration to the river is not increasing.
	In Situ Chemical Oxidation	Yes	Yes	Yes	Previously accepted by EPA. May result in contaminant reduction, including NAPL. May require a relatively short time to completion.	Requires effective contact with impacted material; can potentially cause NAPL to mobilize. Would require treatability studies to evaluate effectiveness. Injection points near river are a concern that chemicals could come into contact with the river sediments/surface water and adversely affect the ecology.	Site conditions may cause difficulty in effectively surrounding the DNAPL mass. Layout/topography of the Site may limit placement of effective injection points.
	Permeable Reactive Barrier	Yes	No	Yes	Previously accepted by EPA. May result in dissolved phase contaminant reduction. Would prevent exposure of contaminants/NAPL to river sediments.	Long-term monitoring and maintenance required. Life span of media may be impacted based on presence of NAPL. Installation of PRB in the preferred location (close to the river) may be impractical due to constructability. May require treatability studies to evaluate effectiveness.	May not be as effective depending on influence of river flow on the reactive media portion of the PRB. Would not be effective in treating contamination between the PRB and the river. There is dense vegetation and steep terrain in the preferred area where the PRB would be installed.
	Extraction and Treatment	Yes	No	Yes	Previously accepted by EPA. Would result in contaminant reduction.	Long-term O&M. Would require power source. Would require multiple extraction points. Would require an onsite treatment building. High capital costs. Pump and treat shown to be ineffective for NAPL	Treatment volume would be substantial based on river proximity; may capture non-MGP contaminant plumes.
	Barrier System	No	No	Possibly	Prevent further downgradient migration of NAPL and dissolved phase plumes.	Long-term O&M/monitoring would be required. Does not remove or reduce contaminants. Installation of barrier in the preferred location (close to the river) may be impractical due to constructability.	Could require hydraulic containment/ extraction to prevent migration around the barrier wall. Would not prevent exposure of contaminants between the barrier and the river. There is dense vegetation and steep terrain in the preferred area where the barrier wall would be installed.
	STAR Treatment of NAPL	Yes	Yes	Yes	Would result in NAPL-contaminant destruction. May r3equire a relatively short time to completion. Decrease source of dissolved phase contamination to groundwater.	Requires effective contact with NAPL material. Would require treatability studies to evaluate applicability and effectiveness.	Would be applicable for treatment/destruction of NAPL above and below the water table. Would not likely require numerous heat/air injection points to provide effective NAPL treatment.
	Direct Recovery of NAPL	Yes	No	Yes	May prevent further migration of NAPL toward the river. Decrease source of dissolved phase contamination to groundwater.	Long-term O&M. Multiple extraction wells or deep trenches would be required to impact the volume of NAPL. Underground piping and a possible maintenance structure may be required to access the product removed for routine O&M.	Based on extent of contamination, direct recovery may not be able to adequately address remedial goals without being used in conjunction with other technologies. NAPL recovery may be limited based on Site geology.
	Deep Excavation with Offsite Disposal	Yes	Yes	Yes	Previously accepted by EPA. Would result in contaminant removal/reduction.	NAPL has migrated to groundwater; would not be able to remove all source material. Significant dewatering may be required.	There is dense vegetation and steep slopes in the vicinity of where NAPL has been observed. Would not be able to remove all NAPL material based on excavation depth limits and Site constraints.
	In Situ Air Sparging/Vapor Extraction	Yes	No	Yes	Previously accepted by EPA.	O&M may be significant; may not be suitable for treatment of heavier PAH contaminants.	More applicable as a polishing treatment step for lighter phase contaminants.

POTENTIAL REMOVAL ACTION TECHNOLOGIES

Operable Unit	Technology	Contaminant Removal	Exposure Reduction		Pros	Cons	Applicability to the Site
			Short-term	Long-term			
Sediment	Sediment Monitoring	No	No	Possibly	Relatively inexpensive way to monitor effectiveness of Site remedy.	does not provide barrier to existing river bank sediments. Long-term O&M required.	Will be required to monitor effectiveness of Site remedy over the long-term.
	Non-Reactive Capping	No	Yes	Yes	Easy to implement while achieving remedial goals. Can quickly reduce exposure to sediment contaminants. Less costly and quicker than dredging.	Contaminants in sediment could be exposed if cap material is significantly disturbed.	Stage of the river is typically low, which may require limitation on type of capping material. Some removal of cobbles/debris in sediment may be required to get a uniform layer installed.
	Reactive Capping	Yes	Yes	Yes	May require less material than non-reactive barriers. May provide some treatment of contaminants in contact with the cap. Can quickly reduce exposure to sediment contaminants. Less costly and quicker than dredging.	Contaminants in sediment could be exposed if cap material is significantly disturbed. May require more O&M than non-reactive capping if reactive material needs replacing.	Some removal of cobbles/debris in sediment may be required to get a uniform layer installed.
	Excavation/Dredging	Yes	No	Yes	Results in contaminant reduction; previously accepted by EPA.	The accuracy of mass removal techniques is questionable. There may be a degrading effect on downstream areas due to contaminants being released during sediment removal.	Site constraints would limit staging/access of conventional excavating/dredging equipment on the river bank; excavating/dredging from the river may be possible.

Note: Shaded cells denote technologies that were initially considered but eliminated from further evaluation due to low probability of achieving remedial goals.

Appendix C

Cost Estimate Tables

TABLE C-1.1
SOIL VOLUME CALCULATIONS

	Surface Soil (0 - 2 feet) TOTALS	Area in NE corner of site that does not require soil removal but which would be covered by capping material under the full-scale capping alternative
Area =	37789 sq feet	9200 sq feet
Depth =	2 feet	2 feet
Volume =	75578 cu feet	18400 cu feet
Volume =	2799 cu yards	681 cu yards
Quantity =	4199 tons	1022 tons
	Gas Holder (2-21 feet)	Native soil material needed over top of GH following ISS (assume depth of 12")
Diameter	60 feet	
Area =	2827 sq feet	2827 cu feet
Depth =	19 feet	105 cu yards
Volume =	53721 cu feet	157 tons
Volume =	1990 cu yards	
	2985 tons	

Capping Material - full-scale capping alternative:

CY	3481	24" layer of unclassified, clean fill soil
SF	46989	geotextile fabric drainage netting, heat-bonded two sides
CY	1740	12" sand layer
SF	46989	80-mil, very low density polyethylene
CY	3481	24" layer of clay material

Excavation Cover Material - to cover 2-foot depth excavation areas with low-permeability clay-rich soil material:

CY	2799	24" layer of clay-rich soil material
SF	37789	seeding

TABLE C-2.1
SOIL ALTERNATIVE C1 - SHALLOW SOIL EXCAVATION AND OFFSITE DISPOSAL
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Mobilization/demobilization/site prep (1)	LS	1	$ 46,400	$ 46,400
Clearing/grubbing	LS	1	$ 2,000	$ 2,000
Contaminated material excavation, handling, stockpiling (1) (2)	Ton	4199	$ 13.70	$ 57,524
Debris excavation, handling, transport, disposal (1)	Ton	50	$ 43.20	$ 2,160
Confirmation soil sampling (3)	Sample	31	$ 300	$ 10,000
Air monitoring (4)	LS	1	$ 41,000	$ 41,000
Transportation of contaminated material to G&P Landfill (1)	Ton	4199	$ 26.20	$ 110,100
Disposal of contaminated material at G&P Landfill (5)	Ton	4199	$ 17.50	$ 73,500
Cover material - vegetative cover (6)	Acre	1	$ 22,485	$ 22,500
Cover material - clay-rich soil layer (2) (6)	CY	2799	$ 30.40	$ 85,100
Herbicide application (6)	Acre	1	$ 450	$ 500
Dewatering, transportation, water treatment, and discharge to a POTW (1)	Gallon	5000	$ 2.30	$ 11,500
CONSTRUCTION SUBTOTAL				**$ 463,000**
Bid Contingency	15%			$ 70,000
Scope Contingency	15%			$ 70,000
CONSTRUCTION TOTAL				**$ 603,000**
Permitting and Legal	5%			$ 31,000
Construction Services	10%			$ 60,300
TOTAL IMPLEMENTATION COST				**$ 695,000**
Engineering Design	8%			$ 56,000
TOTAL CAPITAL COST:				**$ 750,000**

Notes:
(1) Average of estimates for Columbus MGP Site removal action + inflation.
(2) See Table C-1.1 for calculations of contaminated soil and backfill areas and volumes.
(3) Sample analyses includes BTEXs and PAHs, assumes one sample per 100 SF for excavation walls. No samples would be collected from excavation floor. Unit cost assumes Pace Analytical, Level 4 data, and data validation.
(4) Based on AirLogics system used for two months + TO-15 analyses for confirmation sampling.
(5) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.
(6) Cost from RS Means Environmental Remediation Cost Data - Assemblies, 7th Annual Edition, and adjusted for inflation.

TABLE C-2.2
SOIL ALTERNATIVE C2 - SHALLOW SOIL and GAS HOLDER EXCAVATION AND OFFSITE DISPOSAL
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Mobilization/demobilization/site prep (1)	LS	1	$ 46,400	$ 46,400
Clearing/grubbing	LS	1	$ 2,000	$ 2,000
Contaminated material excavation, handling, stockpiling (1) (2)	Ton	7183	$ 13.70	$ 98,411
Debris excavation, handling, transport, disposal (1)	Ton	100	$ 43.20	$ 4,320
Confirmation soil sampling (3)	Sample	31	$ 300	$ 10,000
Air monitoring (4)	LS	1	$ 41,000	$ 41,000
Transportation of contaminated material to G&P Landfill (1)	Ton	7183	$ 26.20	$ 188,300
Disposal of contaminated material at G&P Landfill (5)	Ton	7183	$ 17.50	$ 125,800
Provide, place, and compact backfill material in gas holder (1)	Ton	3581	$ 14.20	$ 51,000
Cover material - vegetative cover (6)	Acre	1	$ 22,485	$ 22,500
Cover material - clay-rich soil layer (2) (6)	CY	2799	$ 30.40	$ 85,100
Herbicide application (6)	Acre	1	$ 450	$ 500
Dewatering, transportation, water treatment, and discharge to a POTW (1)	Gallon	5000	$ 2.30	$ 11,500
CONSTRUCTION SUBTOTAL				**$ 687,000**
Bid Contingency	15%			$ 104,000
Scope Contingency	15%			$ 104,000
CONSTRUCTION TOTAL				**$ 895,000**
Permitting and Legal	5%			$ 45,000
Construction Services	10%			$ 89,500
TOTAL IMPLEMENTATION COST				**$ 1,030,000**
Engineering Design	8%			$ 83,000
TOTAL CAPITAL COST:				**$ 1,110,000**

Notes:
(1) Average of estimates for Columbus MGP Site removal action + inflation.
(2) See Table C-1.1 for calculations of contaminated soil and backfill areas and volumes.
(3) Sample analyses includes BTEXs and PAHs, assumes one sample per 100 SF for excavation walls. No samples would be collected from excavation floor. Unit cost assumes Pace Analytical, Level 4 data, and data validation.
(4) Based on AirLogics system used for two months + TO-15 analyses for confirmation sampling.
(5) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.
(6) Cost from RS Means Environmental Remediation Cost Data - Assemblies, 7th Annual Edition, and adjusted for inflation.

TABLE C-2.3
SOIL ALTERNATIVE D - CAPPING
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Mobilization/demobilization/site prep (1)	LS	1	$ 46,400	$ 46,400
Clearing/grubbing	LS	1	$ 2,000	$ 2,000
Capping material - vegetative cover (2)	Acre	1	$ 22,485	$ 22,500
Capping material - soil cover (2) (3)	CY	3481	$ 12.80	$ 44,600
Capping material - drainage netting (2) (3)	SF	46989	$ 0.70	$ 32,900
Capping material - sand (2) (3)	CY	1740	$ 16.50	$ 28,800
Capping material - impervious liner (2) (3)	SF	46989	$ 4.20	$ 197,400
Capping material - clay layer (2) (3)	CY	3481	$ 30.40	$ 105,900
Herbicide application (2)	Acre	1	$ 450	$ 500
Transportation of excess cleared/grubbed material to G&P Landfill (1)	Ton	100	$ 26.20	$ 2,700
Disposal of material at G&P Landfill (4)	Ton	100	$ 17.50	$ 1,800
O&M and inspection of cap	YR	20	$ 5,000	$ 100,000
CONSTRUCTION SUBTOTAL				**$ 586,000**
Bid Contingency	15%			$ 88,000
Scope Contingency	15%			$ 88,000
CONSTRUCTION TOTAL				**$ 762,000**
Permitting and Legal	5%			$ 39,000
Construction Services	10%			$ 76,200
TOTAL IMPLEMENTATION COST				**$ 878,000**
Engineering Design	8%			$ 71,000
TOTAL CAPITAL COST:				**$ 950,000**

Notes:
(1) Average of estimates for Columbus MGP Site removal action + inflation.
(2) Cost from RS Means Environmental Remediation Cost Data - Assemblies, 7th Annual Edition, and adjusted for inflation.
(3) See Table C-1.1 for calculations of contaminated soil and backfill areas and volumes.
(4) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.

TABLE C-2.4
SOIL ALTERNATIVE E - IN SITU SOLIDIFICATION/STABILIZATION OF GAS HOLDER MATERIAL
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Preliminary mobilization/investigation and mix design (1) (2)	LS	1	$ 23,680	$ 23,700
Mobilization/demobilization (3)	LS	1	$ 325,000	$ 325,000
In situ stabilization w/ Portland cement (3)	yd^3	1,990	$ 45	$ 89,600
Backhoe/concrete breaker (4)	day	10	$ 3,000	$ 30,000
Transport of spoils (cement and soil cuttings) (4) (5)	ton	1,500	$ 26.20	$ 39,300
Disposal of spoils at G&P Landfill (6)	ton	1,500	$ 17.50	$ 26,300
Provide, place, and compact native soil surfacing material, including delivery (4)	ton	157	$ 14.20	$ 2,300
Air monitoring (7)	sample	39	$ 220	$ 8,600
CONSTRUCTION SUBTOTAL				**$ 544,800**
Bid Contingency	15%			$ 81,800
Scope Contingency	15%			$ 81,800
CONSTRUCTION TOTAL				**$ 708,400**
Permitting and Legal	5%			$ 35,500
Construction Services	10%			$ 70,900
TOTAL IMPLEMENTATION COST				**$ 814,800**
Engineering Design	8%			$ 65,200
TOTAL CAPITAL COST:				**$ 880,000**

Notes:
(1) Site visit to obtain soil volume for treatability study.
(2) Envirocon, Omaha, NE (6/30/08), increased for inflation.
(3) ENTACT 10/18/13 estimate.
(4) Costs based on average of estimates for Columbus MGP Site removal action + inflation and experience at other sites.
(5) Assumes a spoils volume equal to 40% of the soil volume to be treated for unsaturated soil and density of 1.89 ton/yd3.
(6) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.
(7) Assume additional TO-15 analyses only in addition to AirLogics air monitoring used for shallow soil excavation.

TABLE C-3.1
SEDIMENT ALTERNATIVE B - ANNUAL MONITORING FOR 10 YEARS
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
O&M COSTS				
Annual sample collection with annual reporting (1)	LS	10	$ 18,100	$ 181,000
Annual chemical analysis & data review of PAHs at 5 locations(2)	LS	10	$ 3,000	$ 30,000
10-YEAR PROBABLE COST SUBTOTAL				**$ 211,000**
O & M Design Period	year	10		
ANNUAL PROBABLE COST SUBTOTAL				**$ 21,100**
Contingency	20%			$ 4,220
ANNUAL PROBABLE COST TOTAL				**$ 26,000**

Notes:
(1) Cost to mobilize to the site on an annual basis to sample sediment, then evaluate and summarize the data collected in an annual report. Combined with groundwater sampling events.
(2) Analysis of PAHs only.

TABLE C-3.2
SEDIMENT ALTERNATIVE C - NON-REACTIVE CAPPING MATERIAL
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Mobilization/demobilization/site prep (1)	LS	1	$ 58,000	$ 58,000
Temporary cofferdam (2)	LS	1	$ 40,000	$ 40,000
Debris excavation, handling, transport, disposal (1)	Ton	200	$ 54	$ 10,800
Provide AquaBlok material (3)	Ton	270	$ 340	$ 92,000
Place material	SF	18000	$ 5	$ 90,000
Provide, place 12" sand/gravel cover over AquaBlok (4)	CY	667	$ 16.50	$ 11,000
Provide, place layer of cobbles/rip-rap over sand/gravel	CY	667	$ 33.30	$ 23,000
Provide, place 2" thick shotcrete over rip-rap	SF	18000	$ 5.50	$ 99,000
Annual sediment sampling w/annual reporting	LS	10	$ 18,100	$ 181,000
Annual chemical analysis & data review of PAHs at 5 locations	LS	10	$ 1,500	$ 15,000
Annual cap inspection/maintenance	LS	10	$ 2,000	$ 20,000
CONSTRUCTION SUBTOTAL				**$ 640,000**
Bid Contingency	15%			$ 96,000
Scope Contingency	15%			$ 96,000
CONSTRUCTION TOTAL				**$ 832,000**
Permitting and Legal	5%			$ 42,000
Construction Services	10%			$ 83,200
TOTAL IMPLEMENTATION COST				**$ 958,000**
Engineering Design	8%			$ 77,000
TOTAL CAPITAL COST:				**$ 1,040,000**

Notes:
(1) Average of estimates for Columbus MGP Site removal action + inflation. Additional 25% added for working in the river.
(2) Budgetary quote from Dam-It Dams, 10/16/13.
(3) Budgetary quote from AquaBlok, 10/15/13.
(4) Cost from RS Means Environmental Remediation Cost Data - Assemblies, 7th Annual Edition, and adjusted for inflation.

TABLE C-3.3
SEDIMENT ALTERNATIVE D - REACTIVE CAPPING MATERIAL FOR SELECTED PORTION
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
Mobilization/demobilization/site prep (1)	LS	1	$ 58,000	$ 58,000
Temporary cofferdam (2)	LS	1	$ 40,000	$ 40,000
Debris excavation, handling, transport, disposal (1)	Ton	200	$ 54	$ 10,800
Provide AquaGate+Organoclay material (3)	SF	6000	$ 15.90	$ 96,000
Place material	SF	6000	$ 6	$ 36,000
Provide, place 12" sand/gravel cover over AquaGate (4)	CY	222	$ 16.50	$ 4,000
Provide, place layer of cobbles/rip-rap	CY	296	$ 33.30	$ 10,000
Provide, place 2" thick shotcrete over rip-rap	SF	8000	$ 5.50	$ 44,000
Annual sediment sampling w/annual reporting	LS	10	$ 18,100	$ 181,000
Annual chemical analysis & data review of PAHs at 5 locations	LS	10	$ 1,500	$ 15,000
Annual cap inspection/maintenance	LS	10	$ 1,500	$ 15,000
CONSTRUCTION SUBTOTAL				**$ 510,000**
Bid Contingency	15%			$ 77,000
Scope Contingency	15%			$ 77,000
CONSTRUCTION TOTAL				**$ 664,000**
Permitting and Legal	5%			$ 34,000
Construction Services	10%			$ 66,400
TOTAL IMPLEMENTATION COST				**$ 765,000**
Engineering Design	8%			$ 62,000
TOTAL CAPITAL COST:				**$ 830,000**

Notes:
(1) Average of estimates for Columbus MGP Site removal action + inflation. Additional 25% added for working in the river.
(2) Budgetary quote from Dam-It Dams, 10/16/13.
(3) Budgetary quote from AquaBlok, 10/15/13.
(4) Cost from RS Means Environmental Remediation Cost Data - Assemblies, 7th Annual Edition, and adjusted for inflation.

TABLE C-4.1
GROUNDWATER ALTERNATIVE B - GROUNDWATER MONITORING
COST ESTIMATE

Item	Unit	Quantity	Unit Price	Item Total
O&M COSTS				
Quarterly sample collection with annual reporting (1)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (2)	event	8	$ 4,800	$ 38,400
Wells to be sampled for COCs	well	10		
Annual sample collection with annual reporting (3)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (2)	event	8	$ 5,600	$ 44,800
Wells to be sampled for COCs	well	10		
Engineering Services	LS			$ 49,000
10-YEAR PROBABLE COST SUBTOTAL				**$ 539,000**
O & M Design Period	year	10		
ANNUAL PROBABLE COST SUBTOTAL				**$ 53,900**
Contingency	20%			$ 10,780
ANNUAL PROBABLE COST TOTAL				**$ 65,000**

Notes:
(1) Cost to mobilize to the site on a quarterly basis to sample wells, then evaluate and summarize the data collected in an annual report.
(2) Analysis of COCs includes VOCs and PAHs.
(3) Cost to mobilize to the site on an annual basis to sample wells, then evaluate and summarize the data collected in an annual report.

TABLE C-4.2
GROUNDWATER ALTERNATIVE C1 - IN SITU CHEMICAL OXIDATION (full scale treatment)
COST ESTIMATE

Item	Unit	Quantity	Unit Cost	Item Total
One-Year Treatment				
System design, installation, startup, and report preparation (1)	LS	1	$ 413,960	$ 413,960
System operation and maintenance (1)	Quarter	4	$ 138,608	$ 554,433
System decommissioning (1)	LS	1	$ 41,818	$ 41,818
Pre-injection groundwater sampling (2)	Each	1	$ 48,400	$ 48,400
Groundwater monitoring during system operation (3)	Quarter	4	$ 18,000	$ 72,000
Quarterly post-injection groundwater monitoring (4)	Quarter	8	$ 28,900	$ 231,200
Annual reporting of quarterly groundwater monitoring (5)	Each	8	$ 25,000	$ 200,000
Annual post-injection groundwater monitoring and reporting (6)	Each	8	$ 58,000	$ 464,000
CONSTRUCTION SUBTOTAL				$ 2,025,900
Bid Contingency	15%			$ 303,900
Scope Contingency	10%			$ 202,600
TOTAL PROBABLE CONSTRUCTION COST				$ 2,532,400
Permitting and Legal	5%			$ 126,700
Construction Services	10%			$ 253,300
TOTAL IMPLEMENTATION COST				$ 2,912,400
Engineering Design	8%			$ 233,000
TOTAL PROBABLE CAPITAL COST				**$ 3,150,000**
Two-Year Treatment				
System design, installation, startup, and report preparation (1)	LS	1	$ 413,960	$ 413,960
System operation and maintenance (1)	Quarter	8	$ 138,608	$ 1,108,866
System decommissioning (1)	LS	1	$ 41,818	$ 41,818
Pre-injection groundwater sampling (2)	Each	1	$ 48,400	$ 48,400
Groundwater monitoring during system operation (3)	Quarter	8	$ 18,000	$ 144,000
Quarterly post-injection groundwater monitoring (4)	Quarter	8	$ 28,900	$ 231,200
Annual reporting of quarterly groundwater monitoring (5)	Each	8	$ 25,000	$ 200,000
Annual post-injection groundwater monitoring and reporting (6)	Each	8	$ 58,000	$ 464,000
CONSTRUCTION SUBTOTAL				$ 2,652,300
Bid Contingency (7)	15%			$ 397,845
Scope Contingency (8)	10%			$ 202,600
TOTAL PROBABLE CONSTRUCTION COST				$ 3,252,745
Permitting and Legal	5%			$ 162,700
Construction Services	10%			$ 325,300
TOTAL IMPLEMENTATION COST				$ 3,740,745
Engineering Design	8%			$ 300,000
TOTAL PROBABLE CAPITAL COST				**$ 4,050,000**

Notes:
(1) Hydrogen peroxide and ozone injection with soil vapor extraction.
(2) One round of sampling of 10 monitoring wells and 30 injection wells.
(3) Two years of quarterly sampling of 10 monitoring wells and 30 injection wells.
(4) Two years of quarterly sampling of 10 monitoring wells.
(5) One report per year summarizing results for four quarters of sampling data.
(6) Eight years of annual sampling of 10 monitoring wells and one summary report per year.
(7) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(8) Scope Contingency addresses potential design modifications.

TABLE C-4.3
GROUNDWATER ALTERNATIVE C1 - IN SITU CHEMICAL OXIDATION (partial treatment)
COST ESTIMATE

Item	Unit	Quantity	Unit Cost	Item Total
One-Year Treatment				
Engineering Design	8%			$ 158,000
System design, installation, startup, and report preparation (1)	LS	1	$ 168,584	$ 168,584
System operation and maintenance (1)	Quarter	4	$ 58,443	$ 233,773
System decommissioning (1)	LS	1	$ 19,727	$ 19,727
Pre-injection groundwater sampling (2)	Each	1	$ 25,500	$ 25,500
Groundwater monitoring during system operation (3)	Quarter	4	$ 13,000	$ 52,000
Quarterly post-injection groundwater monitoring (4)	Quarter	8	$ 26,200	$ 209,600
Annual reporting of quarterly groundwater monitoring (5)	Each	8	$ 25,000	$ 200,000
Annual post-injection groundwater monitoring and reporting (6)	Each	8	$ 58,000	$ 464,000
CONSTRUCTION SUBTOTAL				$ 1,373,200
Bid Contingency (7)	15%			$ 206,000
Scope Contingency (8)	10%			$ 137,400
TOTAL PROBABLE CONSTRUCTION COST				$ 1,716,600
Permitting and Legal	5%			$ 85,900
Construction Services	10%			$ 171,700
TOTAL IMPLEMENTATION COST				$ 1,974,200
TOTAL PROBABLE CAPITAL COST				**$ 2,140,000**
Two-Year Treatment				
Engineering Design	8%			$ 189,000
System design, installation, startup, and report preparation (1)	LS	1	$ 168,584	$ 168,584
System operation and maintenance (1)	Quarter	8	$ 58,443	$ 467,547
System decommissioning (1)	LS	1	$ 19,727	$ 19,727
Pre-injection groundwater sampling (2)	Each	1	$ 25,500	$ 25,500
Groundwater monitoring during system operation (3)	Quarter	8	$ 13,000	$ 104,000
Quarterly post-injection groundwater monitoring (4)	Quarter	8	$ 26,200	$ 209,600
Annual reporting of quarterly groundwater monitoring (5)	Each	8	$ 25,000	$ 200,000
Annual post-injection groundwater monitoring and reporting (6)	Each	8	$ 58,000	$ 464,000
CONSTRUCTION SUBTOTAL				$ 1,659,000
Bid Contingency (7)	15%			$ 248,850
Scope Contingency (8)	10%			$ 137,400
TOTAL PROBABLE CONSTRUCTION COST				$ 2,045,250
Permitting and Legal	5%			$ 102,300
Construction Services	10%			$ 204,600
TOTAL IMPLEMENTATION COST				$ 2,352,150
TOTAL PROBABLE CAPITAL COST				**$ 2,550,000**

Notes:
(1) Hydrogen peroxide and ozone injection with soil vapor extraction.
(2) One round of sampling of 10 monitoring wells and 12 injection wells.
(3) Two years of quarterly sampling of 10 monitoring wells and 30 injection wells.
(4) Two years of quarterly sampling of 10 monitoring wells.
(5) One report per year summarizing results for four quarters of sampling data.
(6) Eight years of annual sampling of 10 monitoring wells and one summary report per year.
(7) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(8) Scope Contingency addresses potential design modifications.

TABLE C-4.4
GROUNDWATER ALTERNATIVE C2 - ISGS TREATMENT OF DNAPL-IMPACTED AREA ONLY
COST ESTIMATE

Item	Unit	Quantity	Unit Cost	Total
Sitework				
Mobilization	5%			$ 17,000
ISGS bench scale testing (1)	LS	1	$ 17,561	$ 18,000
ISGS pilot scale - probing (1)	LS	1	$ 21,094	$ 22,000
ISGS pilot scale - material/support/etc. from FMC (1)	LS	1	$ 32,854	$ 33,000
ISGS of DNAPL impacted area - probing (1)	LS	1	$ 140,769	$ 141,000
ISGS of DNAPL impacted area - FMC costs (1)	LS	1	$ 187,248	$ 188,000
Total Sitework				$ 420,000
Quarterly sample collection with annual reporting (2)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (2)	event	8	$ 4,800	$ 38,400
Annual sample collection with annual reporting (2)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (2)	event	8	$ 5,600	$ 44,800
Total Post Construction Site Control				$ 490,000
CONSTRUCTION SUBTOTAL				**$ 910,000**
Bid Contingency (3)	15%			$ 137,000
Scope Contingency (4)	10%			$ 91,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 1,138,000**
Permitting/Legal	5%			$ 57,000
Construction Phase Services	10%			$ 114,000
TOTAL IMPLEMENTATION COST				**$ 1,309,000**
Engineering Design	8%			$ 105,000
TOTAL PROBABLE CAPITAL COST				**$ 1,420,000**

Notes:
(1) Costs from Jan. 2012 proposals for Burlington MGP site, adjusted for inflation.
(2) Groundwater monitoring assumes quarterly sampling for the first two years then annual sampling for an additional eight
(3) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(4) Scope Contingency addresses potential design modifications.

TABLE C-4.5
GROUNDWATER ALTERNATIVE D - PERMEABLE REACTIVE BARRIER (trenching)
COST ESTIMATE

Item	Unit	Quantity	Unit Cost(1)	Total
Sitework				
Mobilization	5%			$ 18,000
Slurry wall excavation	CY	489	$ 4	$ 2,000
Soil/bentonite backfill	CY	489	$ 8	$ 4,000
PRB gate excavation	CY	244	$ 8	$ 2,000
PRB gate material - GAC	CY	122	$ 1,411	$ 173,000
PRB gate material - Peat moss	CY	122	$ 125	$ 16,000
Transport of excess soil (2)	Ton	1,100	$ 26	$ 28,820
Disposal of excess soil (3)	Ton	1,100	$ 18	$ 19,250
Dewatering/water treatment (2)	Gallon	45,000	$ 2	$ 104,000
Topsoil cover for wall	CY	67	$ 40	$ 3,000
Seeding over top of wall	LS	1	$ 1,000	$ 1,000
Total Sitework				$ 380,000
Quarterly sample collection with annual reporting (4)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (4)	event	8	$ 4,800	$ 38,400
Annual sample collection with annual reporting (4)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (4)	event	8	$ 5,600	$ 44,800
Post Construction O&M (5)	LS	2	$ 379,000	$ 758,000
Total Post Construction Site Control				$ 1,250,000
CONSTRUCTION SUBTOTAL				**$ 1,630,000**
Bid Contingency (6)	15%			$ 245,000
Scope Contingency (7)	10%			$ 163,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 2,038,000**
Permitting/Legal	5%			$ 102,000
Construction Phase Services	10%			$ 204,000
TOTAL IMPLEMENTATION COST				**$ 2,344,000**
Engineering Design	8%			$ 188,000
TOTAL PROBABLE CAPITAL COST				**$ 2,540,000**

Notes:
(1) Unless otherwise noted, unit costs were obtained from RS Means Environmental Remediation Cost Data Assemblies, 7th
(2) Average of estimates for Columbus MGP Site removal action + inflation.
(3) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.
(4) Groundwater monitoring assumes quarterly sampling for the first two years then annual sampling for an additional eight
(5) Includes PRB gate treatment media replacement every five years. Costs are for two media replacement events at five and ten
(6) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(7) Scope Contingency addresses potential design modifications.

TABLE C-4.6
GROUNDWATER ALTERNATIVE D - PERMEABLE REACTIVE BARRIER (ISCO injection points)
COST ESTIMATE

Item	Unit	Quantity	Unit Cost (1)	Total
Sitework				
Mobilization				$ 18,000
Slurry wall excavation	CY	489	$ 4	$ 2,000
Soil/bentonite backfill	CY	489	$ 8	$ 4,000
Transport of excess soil (2)	Ton	733	$ 26	$ 19,213
Disposal of excess soil (3)	Ton	733	$ 18	$ 12,833
Topsoil cover for wall	CY	44	$ 40	$ 2,000
Seeding over top of wall	LS	1	$ 1,000	$ 1,000
ISCO				
System design, installation, startup, and report preparation (4)	LS	1	$ 98,341	$ 98,341
System operation and maintenance (4)	Quarter	8	$ 34,092	$ 272,735
System decommissioning (4)	LS	1	$ 11,508	$ 11,508
Pre-injection groundwater sampling (5)	Each	1	$ 14,875	$ 14,875
Groundwater monitoring during system operation (6)	Quarter	8	$ 7,583	$ 60,667
Quarterly post-injection groundwater monitoring (7)	Quarter	8	$ 15,283	$ 122,267
Annual reporting of quarterly groundwater monitoring (8)	Each	8	$ 14,583	$ 116,667
Annual post-injection groundwater monitoring and reporting (9)	Each	8	$ 33,833	$ 270,667
CONSTRUCTION SUBTOTAL				$ 1,026,800
Bid Contingency (10)	15%			$ 155,000
Scope Contingency (11)	10%			$ 103,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 1,285,000**
Permitting/Legal	5%			$ 65,000
Construction Phase Services	10%			$ 129,000
TOTAL IMPLEMENTATION COST				**$ 1,479,000**
Engineering Design	8%			$ 119,000
TOTAL PROBABLE CAPITAL COST				**$ 1,600,000**

Notes:
(1) Unless otherwise noted, unit costs were obtained from RS Means Environmental Remediation Cost Data Assemblies, 7th Annual Edition (2001) and adjusted for inflation.
(2) Average of estimates for Columbus MGP Site removal action + inflation.
(3) Quote from Waste Connections (operator of the G&P Landfill), 10/03/2013.
(4) Hydrogen peroxide and ozone injection with soil vapor extraction.
(5) One round of sampling of 10 monitoring wells and 7 injection wells.
(6) Two years of quarterly sampling of 10 monitoring wells and 7 injection wells.
(7) Five years of quarterly sampling of 10 monitoring wells.
(8) One report per year summarizing results for four quarters of sampling data.
(9) Five years of annual sampling of 10 monitoring wells and one summary report per year.
(10) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(11) Scope Contingency addresses potential design modifications.

TABLE C-4.7
GROUNDWATER ALTERNATIVE E - STAR TREATMENT OF DNAPL-IMPACTED AREA ONLY
COST ESTIMATE

Item	Unit	Quantity	Unit Cost(1)	Total
Sitework				
STAR treatability testing (1)	LS	1	$ 20,000	$ 20,000
STAR treatment of DNAPL impacted area (1)	LS	1	$ 800,000	$ 800,000
Total Sitework				$ 820,000
Quarterly sample collection with annual reporting (2)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (2)	event	8	$ 4,800	$ 38,400
Annual sample collection with annual reporting (2)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (2)	event	8	$ 5,600	$ 44,800
Total Post Construction Site Control				$ 490,000
CONSTRUCTION SUBTOTAL				**$ 1,310,000**
Bid Contingency (3)	15%			$ 197,000
Scope Contingency (4)	10%			$ 131,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 1,638,000**
Permitting/Legal	5%			$ 82,000
Construction Phase Services	10%			$ 164,000
TOTAL IMPLEMENTATION COST				**$ 1,884,000**
Engineering Design	8%			$ 151,000
TOTAL PROBABLE CAPITAL COST				**$ 2,040,000**

Notes:
(1) Budgetary costs obtained from STAR, 10/15/13.
(2) Groundwater monitoring assumes quarterly sampling for the first two years then annual sampling for an additional eight
(3) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(4) Scope Contingency addresses potential design modifications.

TABLE C-4.8
GROUNDWATER ALTERNATIVE F - DNAPL RECOVERY
COST ESTIMATE

Item	Unit	Quantity	Unit Cost(1)	Total
Sitework				
Mobilization	5%			$ 10,000
Containment bldg.	EA	1	$ 15,000	$ 15,000
mob/demob of drill rig and supplies	MI	280	$ 6	$ 1,680
drilling w/sampling	FT	120	$ 16	$ 1,920
grouting	FT	100	$ 4	$ 400
riser pipe (4")	FT	80	$ 15	$ 1,200
screen (4")	FT	40	$ 21	$ 840
drums (provide, fill, stage)	EA	15	$ 140	$ 2,100
well completion	EA	4	$ 250	$ 1,000
decon	HR	8	$ 60	$ 480
per diem (2 people)	DAY	10	$ 270	$ 2,700
piping/pump/controller/electrical/misc.	EA	4	$ 20,000	$ 80,000
well abandonment/pump disposal	EA	4	$ 10,000	$ 40,000
B&V personnel, expenses	trip	15	$ 2,500	$ 37,500
Total Sitework				$ 200,000
Quarterly sample collection with annual reporting (2)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (2)	event	8	$ 4,800	$ 38,400
Annual sample collection with annual reporting (2)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (2)	event	8	$ 5,600	$ 44,800
NAPL system O&M	year	10	$ 14,200	$ 142,000
Total Post Construction Site Control				$ 640,000
CONSTRUCTION SUBTOTAL				**$ 840,000**
Bid Contingency (3)	15%			$ 126,000
Scope Contingency (4)	10%			$ 84,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 1,050,000**
Permitting/Legal	5%			$ 53,000
Construction Phase Services	10%			$ 105,000
TOTAL IMPLEMENTATION COST				**$ 1,208,000**
Engineering Design	8%			$ 97,000
TOTAL PROBABLE CAPITAL COST				**$ 1,310,000**

Notes:
(1) Unless otherwise noted, unit costs were obtained from RS Means Environmental Remediation Cost Data Assemblies, 7th
(2) Groundwater monitoring assumes quarterly sampling for the first two years then annual sampling for an additional eight
(3) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(4) Scope Contingency addresses potential design modifications.

TABLE C-4.9
GROUNDWATER ALTERNATIVE G - BARRIER SYSTEM (ISGS)
COST ESTIMATE

Item	Unit	Quantity	Unit Cost	Total
Sitework				
Mobilization	5%			$ 43,000
ISGS bench scale testing (1)	LS	1	$ 17,561	$ 18,000
ISGS pilot scale - probing (1)	LS	1	$ 21,094	$ 22,000
ISGS pilot scale - material/support/etc. from FMC (1)	LS	1	$ 32,854	$ 33,000
ISGS full scale containment boundary - probing (1)	LS	1	$ 336,864	$ 337,000
ISGS full scale containment boundary - FMC costs (1)	LS	1	$ 520,901	$ 521,000
Total Sitework				$ 980,000
Quarterly sample collection with annual reporting (2)	year	2	$ 63,000	$ 126,000
Quarterly chemical analysis & data review of COCs (2)	event	8	$ 4,800	$ 38,400
Annual sample collection with annual reporting (2)	year	8	$ 35,000	$ 280,000
Annual chemical analysis & data review of COCs (2)	event	8	$ 5,600	$ 44,800
Total Post Construction Site Control				$ 490,000
CONSTRUCTION SUBTOTAL				**$ 1,470,000**
Bid Contingency (3)	15%			$ 221,000
Scope Contingency (4)	10%			$ 147,000
TOTAL PROBABLE CONSTRUCTION COST				**$ 1,838,000**
Permitting/Legal	5%			$ 92,000
Construction Phase Services	10%			$ 184,000
TOTAL IMPLEMENTATION COST				**$ 2,114,000**
Engineering Design	8%			$ 170,000
TOTAL PROBABLE CAPITAL COST				**$ 2,290,000**

Notes:
(1) Costs from Jan. 2012 proposals for Burlington MGP site, adjusted for inflation.
(2) Groundwater monitoring assumes quarterly sampling for the first two years then annual sampling for an additional eight
(3) Bid contingency based on potential obstructions, relocating utilities, excessive dewatering, weather delays, etc.
(4) Scope Contingency addresses potential design modifications.