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Draft Final

Feasibility Study Report
Operable Unit 1
Quanta Resources Site

Edgewater, N.J.

Submitted to

U.S. Environmental Protection Agency, Region 2

Submitted on behalf of

Respondents to Administrative Order on Consent II-CERCLA-2003-2012

July 2010

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Executive Summary

This draft final feasibility study (FS) report for Operable Unit 1 (OU1) of the Quanta Resources Superfund Site in Edgewater, New Jersey, has been prepared in accordance with CERCLA requirements pursuant to an EPA Administrative Order on Consent (AOC) and with EPA direction and input. As defined in the AOC, OU1 "shall mean the areas of the Site, including soil, debris and groundwater, westward of the Hudson River Bulkhead"; OU2 "shall mean the areas of the Site, including surface water and sediments, eastward of the Hudson River Bulkhead." OU2 is being investigated pursuant to a separate EPA AOC. The EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP) and with public input, will use the FS information to select a remedial action alternative for OU1.

The site has been characterized and is well understood for purposes of supporting OU1 remedial alternative development, evaluation, and selection. The extent of OU1 contamination for groundwater and soil is based on the data and evaluations presented in the final Remedial Investigation (RI) Report[1] and draft final Supplemental Remedial Investigation (SRI) Report[2] as shown in Figure ES-1. The primary components of the conceptual site model—including site setting and land use, geology, and hydrogeology, and nature and extent of contamination—are discussed below.

The purpose of this FS is to develop and evaluate a range of alternatives that protect human health and the environment, maintain that protection over time, and are consistent in defining and addressing risk at the site.

Site Setting and Land Use

The approximately 24-acre OU1 has been used for various purposes and has had multiple property owners. Prior to the mid-1800s, the site and surrounding areas were tidal marshlands associated with the Hudson River. Development included the systematic infilling of these marshlands with a variety of materials, some containing polycyclic aromatic hydrocarbons (PAHs) and heavy metals at concentrations exceeding present-day regulatory soil cleanup criteria and contributing to the presence of these constituents in groundwater.

Numerous entities operated at the site from the latter part of the 1800s until 1981. From approximately 1872 to 1970, a large portion of the site was used to process coal tar and to produce paving and roofing materials. From 1974 to 1981, a portion of the site was reoccupied and leased for oil recycling. Aboveground and underground storage tanks were subsequently removed, and that portion of the site has remained vacant since 1988. Operation of a former pyrite ore–sulfuric acid plant on an adjacent property generated elevated concentrations of metals (primarily arsenic) that remain in a portion of OU1,

[1] CH2M HILL. 2008. Final Remedial Investigation Report, Quanta Resources Superfund Site, Operable Unit 1. August.

[2] CH2M HILL. 2010. Final Supplemental Remedial Investigation Report, Quanta Resources Superfund Site, Operable Unit 1. June.

partially overlapping areas of former coal tar operations. A portion of this area is the subject of NJDEP and EPA Administrative Consent Orders. A number of commercial buildings and roads are currently located on portions of OU1.

Geology and Hydrogeology

OU1 soil consists predominantly of historic fill material contaminated with PAHs and metals overlying deposits of native sand and organic silt, including peat. Heterogeneous fill material contains constituents of interest (COIs) in concentrations that exceed regulatory soil cleanup criteria and contribute to the presence of constituents in groundwater that also exceed regulatory criteria. The fill material also contains boulders and large debris.

These upper stratigraphic units are underlain by a silty-clay aquitard, the top of which is approximately 7 to 80 ft below ground surface (bgs), ranging in thickness from 2 to 35 ft. It is found across most of the site with an undulating surface that dips eastward close to the existing shoreline and pinches out towards the north against a bedrock high. The surface of the silty-clay aquitard forms a natural depression in the central portion of the site. A confined, water-bearing, deep sand unit lies below portions of the aquitard and above the bedrock.

Depth to groundwater is shallow on the Quanta property (ranging from 0.5 to 6 ft bgs), and the flow direction of unconfined groundwater is predominately to the southeast. A tidally influenced mud flat/ marsh associated with the Hudson River borders OU1 immediately to the east of the wooden bulkhead.

Conceptual Site Model

The primary sources of site-related constituents are no longer present except for material that may be contained within buried piping. As a result of historical site activities, secondary sources remain at the site today in the form of non–aqueous phase liquid (NAPL); solid tar; and soil containing PAHs, non-PAH semivolatile organic compounds (SVOCs), aromatic volatile organic compounds (VOCs), and other constituents. A former sulfuric acid plant, located on an adjacent property, contributed to unburned or partially burned pyritic ore remnants in soil that represent a secondary source of inorganic constituents, particularly arsenic, in soil.

NAPL is present primarily in the form of residual and free-phase dense NAPL in six discrete discontinuous areas (NAPL zones) within and above the silty-clay confining layer or in the fill, native sand, or organic silt above bedrock to the north where the silty clay is not present. NAPL at OU1 is generally stable under current conditions. Migration is constrained by the physical properties of the NAPL (e.g., high viscosity and interfacial tension), the soil pore size, and physical barriers such as the silty clay confining unit and shallower organic silt deposits. Stratigraphic units slope downward south and north as well as east, where NAPL saturation levels are highest along the shoreline. This geologic architecture, along with the presence of some less-viscous NAPL near the shoreline, indicates that a portion of the NAPL behind and north of the bulkhead has the potential for mobility. Tar boils occur at various locations at the site during the summer months when solid tar in the shallow unsaturated zone becomes heated enough to seep upward to the ground surface through cracks in soil or pavement.

Eight separate sources of soluble arsenic to groundwater and, to a lesser extent, other inorganic constituents in groundwater were identified within the lateral extent of OU1: a high-concentration arsenic area (HCAA) and seven other arsenic sources to groundwater (arsenic areas AA-1 through AA-7). Each of the AAs has elevated soil concentrations that have a potential direct contact risk to human health. NAPL and arsenic source material are depicted in Figure ES-1.

The baseline human health risk assessment[3] evaluated potential risk at the site and identified constituents of concern (COCs) for surface soil, subsurface soil, and groundwater. These COCs consist primarily of SVOCs (predominantly PAHs), aromatic VOCs, metals, and, to a lesser extent, chlorinated VOCs, pesticides, and polychlorinated biphenyls. Of the COCs identified, arsenic, carcinogenic PAHs, and naphthalene are the primary risk drivers for most media and receptors evaluated.

Attenuation of COCs is occurring within and downgradient of OU1. The composite extent of both the organic constituents and arsenic dissolved in groundwater is not expanding beyond its current boundary; concentrations of constituents in groundwater are generally in equilibrium as a result of adsorption and degradation processes.

Principal Threat Evaluation

OU1 data were evaluated in accordance with EPA guidance to determine the locations of principal threat and low-level threat wastes. EPA guidance defines a principal threat waste as material that is considered to be highly toxic or highly mobile source material that generally cannot be reliably contained or would potentially present a significant risk should exposure occur. A low-level threat waste is source material that generally can be reliably contained and would pose only a low potential risk. EPA expects to use "treatment to address principal threats posed by a site, wherever practicable" and "engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable" (40 CFR Section 300.430(a)(1)(iii). Of the 15 OU1 areas containing source material, the following are addressed in this FS as principal threats:

- NAPL zones 1, 2, and 5
- Tar boils
- AA-1 through AA-7

NAPL zones NZ-3, NZ-4, NZ-6, and the HCAA were determined to be low-level threat wastes though they are still considered sources or potential sources of dissolved constituents to the groundwater.

Treatment of low-level threat waste in NZ-3, NZ-4, and NZ-6 (i.e., deep NAPL) would not result in a significant improvement to groundwater quality and would not improve the overall risk profile at the site. The presence of certain site-specific and contaminant-specific factors, including residual NAPL and complex hydrogeologic site conditions, render the restoration of groundwater quality technically impracticable. Although the potential benefit of treating low-level threat waste is minimal when compared to the costs, technologies that

[3] CH2M HILL. 2007. Baseline Human Health Risk Assessment, Quanta Resources Superfund Site, Operable Unit 1. November.

can provide some mass removal or treatment for portions of NZ-3, NZ-4 and NZ-6 have been considered and included in some remedial alternatives.

Applicable or Relevant and Appropriate Requirements, Remedial Action Objectives, and Preliminary Remediation Goals

Applicable or relevant and appropriate requirements (ARARs) were identified, and remedial action objectives (RAOs) and preliminary remediation goals (PRGs) were developed for OU1 in accordance with CERCLA guidance. The RAOs and PRGs help define the extent of contaminated media requiring remedial action and support development of remedial action alternatives that will protect human health and the environment and comply with ARARs.

The following RAOs were identified to mitigate the potential risks associated with the site:

Principal Threat Source Material

1. Remove, treat, or contain free product pursuant to NJAC 7:26E-6.1(d)
2. Prevent human exposure to NAPL and arsenic source material that poses a human health risk in excess of 10^{-3} ELCR or otherwise constitutes a principal threat
3. Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure
4. Prevent migration of NAPL that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable

Low-Level Threat Source Material

1. Prevent or minimize potential human exposure through contact, ingestion, dust inhalation, or vapor intrusion that presents unacceptable risk
2. Prevent or minimize potential erosional transport offsite or to OU2 of site COCs at concentrations posing unacceptable risk
3. Remove, treat, or contain free and residual product pursuant to NJAC 7:26E-6.1(d)

Groundwater

1. Prevent/minimize potential exposure by contact, ingestion, inhalation/vapor intrusion that presents unacceptable risk
2. Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors

NJAC, New Jersey Administrative Code; ELCR, excess lifetime cancer risk.

As described in the EPA's guidance for evaluating the technical impracticability of groundwater restoration,[4] site-specific and contaminant-specific factors can inhibit groundwater restoration. The site-specific and contaminant-specific factors inhibiting restoration of groundwater to drinking water quality at the site include the following:

[4] EPA. 1993. Interim-Final Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration. *Directive 9234.2-25*. September.

- Widespread presence of DNAPL and recalcitrant NAPL-related constituents.
- Long history of releases at the site
- Volume and depth of contaminated media
- Presence of arsenic in soil and groundwater, and the colocation of arsenic and NAPL
- Complex geology consisting of interbedded and undulating layers of sands, silts and clays with discontinuous peat deposits
- Heterogeneous soil conditions and the presence of low permeability materials such as silts and clays
- Highly urbanized environment with significant surficial and subsurface infrastructure

In addition, the presence of offsite sources and regional characteristics would render restoration within OU1 futile, as these sources would recontaminate the area and continue to render groundwater unusable as a potable source for reasons beyond the scope of the Quanta Resources Superfund Site. Further, conventional water resource planning practices render the potential use for the potable groundwater in the area impossible.

A technical impracticability waiver of specific ARARs is being requested for onsite groundwater. It is feasible, however, to implement a remedy at the site that achieves the RAOs for groundwater and is protective of human health and the environment. Remedial alternatives are developed in this FS that provide approaches to protect human health and the environment, maintain that protection over time, and are consistent in defining and addressing risk at the site.

Technology Screening

In a manner consistent with the RAOs and PRGs, remedial technologies were identified for free-phase NAPL, soil, and groundwater. Technologies generally fell within the categories of (1) no further action (NFA), (2) institutional controls, (3) monitored natural attenuation (MNA), (4) containment, (5) in situ treatment, and (6) physical removal and ex situ treatment or disposal. Technologies were then screened on the basis of technical implementability, effectiveness, and relative cost.

Technologies retained for free-phase NAPL remediation include the following:

- Institutional controls
- Containment
- NAPL recovery wells or trenches
- In situ solidification/stabilization
- Other in situ treatment (such as chemical oxidation)
- Excavation and offsite disposal

Technologies retained for soil and residual NAPL remediation include the following:

- Institutional controls
- Soil cover
- Soil multilayer cap

- In situ solidification/stabilization
- Other in situ treatment (such as chemical oxidation)
- Excavation followed by treatment or disposal

Those retained for groundwater remediation include the following:

- Institutional controls
- MNA
- Physical containment
- Reactive barriers
- In situ treatment (such as air sparging or contaminant sequestration)
- Extraction/treatment and disposal

Remedial Action Alternatives

The remedial technologies retained after the screening were assembled into eight active alternatives, with two HCAA process options, that use varying combinations of technologies to address principal and low-level threat source material and mitigate potential risks. As required, no further action is included as Alternative 1 for comparison to the active remedial alternatives.

All of the remedial action alternatives that are evaluated within this FS address the presence of principal threat source material and dissolved-phase COCs by eliminating exposure pathways, thereby eliminating potential risk to human health and the environment. Each of the alternatives was then evaluated against the seven criteria identified in the National Contingency Plan (NCP).

All alternatives, with the exception of the no further action alternative, include soil capping and institutional controls to prevent exposure to low-level threat waste and residual concentrations of COCs, and vapor intrusion mitigation to eliminate the exposure pathway to indoor air. Figure ES-2 depicts areas to be capped as part of all active alternatives.

Each active alternative employs a different combination of technologies to mitigate principal threats and COCs in groundwater, as summarized below and depicted in Figures ES-3 through ES-15.

- **Alternative 2—NAPL and Arsenic Containment:** NAPL, tar boils, and arsenic contaminated soils are capped; potential NAPL migration to the Hudson is mitigated by a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier); and institutional controls are applied. Constituent migration in groundwater is mitigated via the shoreline funnel-and-gate system.

- **Alternative 3—NAPL and Arsenic Containment with NAPL Recovery:** NAPL is collected via recovery wells in NZ-1, NZ-2, and NZ-5 and via directionally drilled recovery wells under the 115 River Road building; potential NAPL migration is mitigated by a barrier cutoff wall; principal threat arsenic areas and NAPL and tar boils are capped, and institutional controls applied. Constituent migration in groundwater is mitigated via the shoreline barrier cutoff wall.

- **Alternative 4a—NAPL and Arsenic In Situ Solidification/Stabilization:** Tar boils, accessible NAPL in NZ-1, NZ-2, a portion of NZ-3, NZ-5, and all defined arsenic areas[5] are solidified/stabilized in situ; institutional controls applied. NAPL is collected via existing monitoring wells within NZ-3 and NZ-4. A subaqueous reactive barrier is installed in OU2 to mitigate migration of residual COCs in groundwater prior to discharge.
- **Alternative 4a (HCAA Process Option) —NAPL and Arsenic In Situ Solidification/Stabilization with Containment of the HCAA:** Tar boils, accessible NAPL in NZ-1, NZ-2, a portion of NZ-3, NZ-5, and arsenic areas AA-1 through AA-7[5] are solidified/stabilized in situ; and institutional controls applied. NAPL is collected via existing monitoring wells within NZ-3 and NZ-4. COCs in groundwater downgradient of the HCAA would be captured by barrier cutoff wall and treated prior to discharge. A subaqueous reactive barrier is installed in OU2 to mitigate migration of residual COCs in groundwater prior to discharge.
- **Alternative 4b—NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of the 115 River Road Buildings:** Tar boils, NAPL in NZ-1, NZ-2, a portion of NZ-3, NZ-5, and all defined arsenic areas[5] are solidified/stabilized in situ; the 115 River Road buildings are demolished, providing access for in situ solidified/stabilized of NAPL beneath the buildings, and institutional controls are applied. NAPL is collected via existing monitoring wells within NZ-3 and NZ-4. A subaqueous reactive barrier is installed in OU2 to mitigate migration of residual COCs in groundwater prior to discharge.
- **Alternative 5a—NAPL In Situ Chemical Oxidation with Arsenic Stabilization:** Tar boils, NZ-1, and NZ-2 are excavated to a depth of 4 ft bgs for offsite disposal; NAPL is collected via standard recovery wells in NZ-1, NZ-2, NZ-5, and portions of NZ-3 and NZ-4, followed by in situ chemical oxidation at NZ-1, NZ-2, NZ-5, and a portion of NZ-3; potential NAPL migration to the Hudson is mitigated at NZ-2 and NZ-5 by a barrier cutoff wall; all defined arsenic areas[5] are solidified/stabilized in situ; and institutional controls applied. Constituent migration in groundwater is mitigated via the shoreline barrier cutoff wall.
- **Alternative 5a (HCAA Process Option)—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Containment of the HCAA:** Tar boils, NZ-1, and NZ-2 are excavated to a depth of 4 ft bgs for offsite disposal; NAPL is collected via standard recovery wells in NZ-1, NZ-2, NZ-5, and portions of NZ-3 and NZ-4, followed by in situ chemical oxidation at NZ-1, NZ-2, NZ-5, and a portion of NZ-3; potential NAPL migration to the Hudson is mitigated at NZ-2 and NZ-5 by a barrier cutoff wall; arsenic areas AA-1 through AA-7[5] are solidified/stabilized in situ and capped; and institutional controls are applied. COCs in groundwater downgradient of the HCAA would be captured by barrier cutoff wall and treated prior to discharge. Constituent migration in groundwater is mitigated via the shoreline barrier cutoff wall.
- **Alternative 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Demolition of the 115 River Road Buildings:** Tar boils, NZ-1, and NZ-2 are excavated

[5] AA-3 will be addressed as part of redevelopment on the Former Lever Brothers Property.

to a depth of 4 ft bgs for offsite disposal; NAPL is collected via standard recovery wells in NZ-1, NZ-2, NZ-5, and portions of NZ-3 and NZ-4, followed by in situ chemical oxidation at NZ-1, NZ-2, NZ-5, and a portion of NZ-3; potential NAPL migration to the Hudson is mitigated at NZ-2 and NZ-5 by a barrier cutoff wall; the 115 River Road buildings are demolished, providing access for removal and treatment of NAPL beneath the buildings; all defined arsenic areas are solidified/stabilized in situ; and institutional controls are applied. Constituent migration in groundwater is mitigated via the shoreline barrier cutoff wall.

- **Alternative 6a—NAPL and Arsenic Excavation:** Tar boils and accessible NAPL in NZ-1, NZ-2, NZ-5, and portions of NZ-3 are excavated for offsite disposal; potential NAPL migration to the Hudson is mitigated at NZ-2 and NZ-5 by a barrier cutoff wall; and all defined arsenic areas[6] are excavated for offsite disposal. A subaqueous reactive barrier is installed in OU2 to mitigate migration of residual COCs in groundwater prior to surface water discharge.
- **Alternative 6b—NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings:** Tar boils and NAPL in NZ-1, NZ-2, NZ-5 and portions of NZ-3 (including NAPL beneath the 115 River Road Buildings) are excavated for offsite disposal; the 115 River Road buildings are demolished, providing access for removal and treatment of NAPL beneath the buildings; and all arsenic areas[6] are excavated for offsite disposal. NAPL is collected via existing monitoring wells within NZ-3 and NZ-4. A subaqueous reactive barrier is installed in OU2 to mitigate migration of residual COCs in groundwater prior to surface water discharge.

Detailed Analysis of Alternatives

A comparative analysis of Alternatives 2 through 6 is summarized in Table ES-1, indicating how each successfully mitigates potential risk associated with principal threat waste and how each relates to other contaminant source considerations. Table ES-2 summarizes how each alternative addresses the seven NCP criteria that are applicable at this stage of the FS process. Evaluation of the alternatives against the seven NCP criteria indicate that each alternative would provide protection of human health and the environment but would require long-term maintenance of caps, institutional controls, and vapor intrusion mitigation measures. The last two criteria, community acceptance and state acceptance, will be incorporated after a public comment period. Alternatives 2 through 6 meet the two threshold criteria of overall protection of human health and the environment and compliance with ARARs, with the exception of drinking water ARARs for groundwater, as noted above.

Alternatives 2 through 6 satisfy the four "balancing" criteria of long-term effectiveness or permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; and implementability. Rough order-of-magnitude estimates are presented in Table ES-2 for each alternative for the fifth balancing criterion, cost. Estimates range from approximately $41 million for Alternative 2 (containment) to $480 million for Alternative 5b (ISCO and building demolition).

[6] AA-3 will be addressed as part of redevelopment on the Former Lever Brothers Property.

Table ES-2 summarizes how the alternatives comply with NJDEP regulations requiring the removal, treatment, or containment of product and why a technical impracticability waiver from the requirement to remediate groundwater to drinking water standards is appropriate for the site.

The following summarizes the performance of each of the alternatives with regard to the balancing criteria:

- Alternative 2 is least disruptive to the community, workers, and environment, and allows for the most rapid redevelopment of the Quanta property. However, this alternative would require the most restrictive institutional controls for future site land use due to the residual COCs that would remain onsite.
- Alternative 3 removes principal threat waste and allows for relatively rapid redevelopment. However, this alternative would also have restrictive future land use due to residual COCs that remain onsite.
- Alternative 4a permanently reduces mobility and toxicity through the solidification/stabilization of principal threat wastes (and some low-level threat waste where NZ-3 is "stacked" under NZ-1 on the Quanta property) and allows for relatively rapid redevelopment of the site. Short-term impacts can be managed. Large fill debris that could interfere with the mixing process would need to be removed prior to treatment. Treatability studies would be conducted to (1) determine the optimal reagent mix, (2) confirm corresponding cost-effectiveness under full-scale conditions, and (3) confirm compatibility with redevelopment objectives. The HCAA process option for Alternative 4 removes some implementation and treatability challenges; however, long-term operation and maintenance of the system would be required.
- Alternative 4b and its HCAA process option have the same qualities as 4a except that they require the demolition of the 115 River Road buildings, which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.
- Alternative 5a treats principal threat wastes; however, this alternative takes the longest period of time to implement, significantly delaying redevelopment. In addition, excavated contaminated soil must be transported to and disposed of at a landfill. Chemical oxidation would pose potential risks of NAPL mobilization and vapor intrusion. The HCAA process option for Alternative 5a removes some implementation and treatability challenges; however, long-term operation and maintenance of the system would be required.
- Alternative 5b and its HCAA process option have the same qualities as 5a except that they require the demolition of the 115 River Road buildings, which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.
- Alternative 6a removes the source material from the site and allows for relatively rapid redevelopment. It is also the least restrictive of future site land uses. However, it is the most disruptive to the site and community in the short term, and significant potential

risks are posed by deep excavations adjacent to buildings and roadways. In addition, large volumes of contaminated soil must be transported to and disposed of at a landfill.

- Alternative 6b has the same qualities as 6a except that it requires the demolition of the 115 River Road buildings, which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.

In addition, respondents have worked closely with the owner of the Quanta property and the 115 River Road property in the development of remedies and the construction implementation plan. Building operations have been reviewed with the owner and implementation logistics discussed in order to minimize potential impacts to tenants during construction activities.

This FS evaluation also considered "green"/sustainable remediation-related elements such as energy and carbon footprint reduction, waste generation reduction, timing, future land use potential, and offsite impacts. In particular, due to its prime location, there is a significant benefit to the community in returning the site to productive use as soon as possible, and the alternatives are consistent with future redevelopment. In addition, the groundwater components proposed for Alternatives 2, 4a, 4b, 6a, and 6b (either a funnel-and-gate system or subaqueous reactive barriers) are energy-efficient approaches that use passive treatment and reduce the amount of waste produced compared to other, traditional approaches. Each alternative has the opportunity to include techniques during the remedial design that could enhance the overall sustainability of the alternative.

Conclusions and Next Steps

This FS report presents a range of alternatives developed to address the site ARARs, RAOs, and PRGs and the principal threat and low-level threat wastes identified for the site. This FS is consistent with EPA's expectations for development and evaluation of remedial alternatives and provides a range of alternatives that mitigate potential risk to human health and the environment.

The FS conclusions are the following:

- A range of remedial alternatives has been developed to address the RAOs identified for the site, with a focus on treatment of principal threat wastes in accordance with EPA guidance.
- As part of the FS evaluation, it has been determined that the restoration of groundwater at the site is technically impracticable as a result of site-related factors. Although a technical impracticability waiver for specific ARARs is requested, remedial alternatives are designed to prevent further migration of the plume and human exposure to the COCs in groundwater.

Following the submission of the final FS report, EPA will make available for public comment the FS report and proposed plan outlining the remedial alternatives and preferred alternative.

TABLE ES-1
Remedial Alternative Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Alternative							
				4—NAPL and Arsenic In Situ Solidification/Stabilization		5— NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
Evaluation Criteria		**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**
Principal Threat NAPL	Alternative Description	Tar boils at the ground surface throughout the site, NAPL present in NZ-1, NZ-2 and NZ-5 would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place. A funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) would be installed to prevent potential NAPL migration to the Hudson River.	NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5 and via directionally drilled recovery wells under the 115 River Rd. Building. Capping and institutional controls would be established to document and limit use of areas with COCs remaining in place. A barrier cutoff wall with groundwater extraction and treatment would be installed to prevent potential NAPL migration to the Hudson River..	In situ solidification/stabilization of tar boils, accessible NAPL present in NZ-1, NZ-2, and NZ-5 with capping. Subsurface debris would be excavated for offsite disposal. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place. NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed.	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for offsite disposal. NAPL would be collected via standard recovery wells located in NZ-1, NZ-2, and NZ-5. NAPL collection would be followed by in situ chemical oxidation in NAPL zones NZ-1, NZ-2, and NZ-5. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed.	NAPL present in NZ-1, NZ-2, NZ-5, tar boils would be excavated from accessible areas and disposed of offsite. Water generated from dewatering activities would be treated onsite prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline. NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed.
	NAPL Mobility Addressed	Barrier cutoff wall with PRB to prevent migration of NAPL to the River	NAPL recovery and barrier cutoff wall to prevent migration of NAPL to the River	In situ solidification/stabilization mitigates potential migration of NAPL to the Hudson River.		NAPL recovery and ISCO mitigates potential migration to the Hudson River		Excavation mitigates potential migration of NAPL to the Hudson River.	
	NAPL Toxicity Addressed	Capping and ICs, including maintenance of existing surfaces, eliminates direct contact pathway. Funnel-and-gate protects ecological receptors.	Capping and ICs, including maintenance of existing surfaces, and NAPL recovery eliminates direct contact pathway. Barrier cutoff wall protects ecological receptors.	In situ solidification/stabilization of NAPL reduces accessibility and leachability (and therefore toxicity). Capping and ICs are also provided.		ISCO and NAPL recovery reduces accessibility and leachability (and therefore toxicity). Capping and ICs are also provided		Excavation eliminates direct contact exposure pathway. Capping and ICs are also provided.	
Arsenic-Contaminated Soil	Alternative Description	Arsenic-contaminated soils >390 ppm from 0-2 ft bgs and soils >1,000 ppm from 2-10 ft bgs would be capped, or existing surfaces maintained. Institutional controls would be established to document and limit use of areas with COCs remaining in place.	Arsenic-contaminated soils >390 ppm from 0-2 ft bgs and soils >1,000 ppm from 2-10 ft bgs would be capped, or existing surfaces maintained. Institutional controls would be established to document and limit use of areas with COCs remaining in place. A cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.	Principal threat arsenic on Block 93 and the Quanta property, and arsenic within the HCAA would be solidified/stabilized. **HCAA Process option:** Principal threat arsenic on Block 93 and the Quanta property would be solidified/ stabilized and cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.		Principal threat arsenic on Block 93 and the Quanta property, and arsenic within the HCAA would be solidified/stabilized. **HCAA Process option:** Principal threat arsenic on Block 93 and the Quanta property would be solidified/stabilized in situ. A cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.		Principal threat arsenic on Block 93 and the Quanta property, and arsenic within the HCAA would be excavated, and then backfilled and compacted with clean material to grade.	
	Arsenic Enabler	Despite the presence of NAPL, attenuation of arsenic through adsorption is occurring at the site	NAPL recovery would provide a potential change in redox conditions that would promote reduced arsenic solubility and increased attenuation of dissolved phase arsenic.	In situ solidification/stabilization of NAPL would reduce potential for PAHs to leach to groundwater and provides a potential change in redox conditions that would promote reduced arsenic solubility and increased attenuation of dissolved phase arsenic. Stabilization/solidification of arsenic reduces potential of arsenic to leach to groundwater. **HCAA Process Option:** Installation of cutoff wall with groundwater extraction and treatment to reduce arsenic concentrations in groundwater downgradient of HCAA.		NAPL recovery and ISCO would reduce potential for PAHs to leach to groundwater and provides a potential change in redox conditions that would promote reduced arsenic solubility and increased attenuation of dissolved phase arsenic. Stabilization/solidification of arsenic reduces potential of arsenic to leach to groundwater **HCAA Process Option:** Installation of cutoff wall with groundwater extraction and treatment to reduce arsenic concentrations in groundwater downgradient of HCAA.		Excavation would reduce potential for PAHs to leach to groundwater and provides a potential change in redox conditions that would promote reduced arsenic solubility and increased attenuation of dissolved phase arsenic. Excavation of arsenic reduces potential of arsenic to leach to groundwater.	

TABLE ES-1
Remedial Alternative Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Alternative							
				4—NAPL and Arsenic In Situ Solidification/Stabilization		5— NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
Evaluation Criteria		**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**
Arsenic-Contaminated Soil	Residual Soil	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	Same as Alternative 2	Same as Alternative 2		Same as Alternative 2		Same as Alternative 2	
Arsenic-Contaminated Soil	Vapor	A vapor intrusion mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Rd. building. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Same as Alternative 2	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted. A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd. building.	Materials under 115 River Rd. would be treated.	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted. A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd. building.	Materials under 115 River Rd. would be treated.	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted. A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd. building.	Materials under 115 River Rd. would be treated.
Groundwater/ Surface Water	Alternative Description	Site groundwater would be contained and treated with a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) before discharging to the Hudson River. Institutional controls restricting groundwater use would be established.	Site groundwater would be contained with a barrier cutoff wall and groundwater extraction and treatment prior to discharging to the Hudson River. Institutional controls restricting groundwater use would be established.	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established. **HCAA Process Option:** Site groundwater would be contained around the HCAA with a barrier cutoff wall and groundwater extraction and treatment.		Site groundwater would be contained with a barrier cutoff wall and groundwater extraction and treatment prior discharging to the Hudson River. Institutional controls restricting groundwater use would be established. **HCAA Process Option:** Site groundwater would be contained around the HCAA with a barrier cutoff wall and groundwater extraction and treatment.		A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.	
Groundwater/ Surface Water	Groundwater Source	NAPL and arsenic continue to serve as a source to groundwater.	NAPL recovery reduces sources of PAHs to groundwater, thereby promoting attenuation. Residuals in soils, especially outside of treatment areas, and historic fill material continue to serve as sources to groundwater	In situ solidification/stabilization of NAPL reduces sources of PAHs to groundwater, thereby promoting attenuation. Stabilization of arsenic or installation of barrier cutoff wall and groundwater extraction and treatment reduces sources of arsenic to groundwater, thereby promoting attenuation. Residuals in soils, especially, outside of treatment areas, and historic fill material continue to serve as sources to groundwater.		Excavation and ISCO reduces sources of PAHs to groundwater, thereby promoting attenuation. Stabilization of arsenic or installation of barrier cutoff wall and groundwater extraction and treatment reduces sources of arsenic to groundwater, thereby promoting attenuation. Residuals in soils, especially, outside of treatment areas, and historic fill material continue to serve as sources to groundwater.		Excavation reduces sources of PAHs and arsenic to groundwater, thereby promoting attenuation. Residuals in soils, especially outside of treatment areas, and historic fill material continue to serve as sources to groundwater	

TABLE ES-2
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Alternative							
			4—NAPL and Arsenic In Situ Solidification/Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
NCP Evaluation Criteria[a]	**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**
Overall protection of human health and environment	The potential for direct exposure to principal threat NAPL waste would be minimized through capping and institutional controls. The barrier cutoff wall with a funnel and gate would inhibit the potential migration of principal threat material to the Hudson River. Reactive barrier treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Existing arsenic liner, additional capping and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact of arsenic impacted soils. Infiltration would be minimized however, groundwater would continue to flow through affected soils, leaching constituents to groundwater.	The potential for direct exposure to principal threat NAPL waste would be minimized through capping and institutional controls. The barrier cutoff wall would inhibit the potential migration of principal threat material to the Hudson River. Treatment system treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Existing arsenic liner, additional capping and institutional controls would mitigate the potential risk of human exposure through direct contact with arsenic impacted soils. Infiltration would be minimized, however groundwater would continue to flow through affected soils, leaching constituents to groundwater. Extraction wells would reduce the amount of free phase NAPL in the subsurface; however, the portion of the total mass that can be removed by this method is limited. Constituents would continue to leach to groundwater.	The potential for exposure to the principal threat waste would be minimized through solidification/stabilization, and institutional controls. Constituents remain in place; however, solidification/stabilization would be designed to significantly reduce leaching of constituents from treated soils under normal groundwater geochemical conditions. Institutional controls for all properties would minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Stabilization and capping would mitigate the risk of human exposure through direct contact with arsenic impacted soils. Reactive barriers treat or adsorb groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors. **HCAA Process Option:** Contaminants associated with the HCAA would remain in place. Existing liner and institutional controls would mitigate the potential risk of human exposure through direct contact. The barrier cutoff wall with groundwater extraction and treatment would eliminate migration of arsenic in groundwater from the HCAA.		NAPL recovery, in situ treatment with ISCO, and institutional controls would reduce contaminant mass and minimize exposure to principal threat NAPL through direct contact, ingestion, and volatilization. ISCO also would reduce contaminant mass that is leaching constituents from the soils to surface water or groundwater; however, constituents that do not come in contact with oxidant would remain and continue to leach to groundwater. Same as Alternative 4 for ICs and arsenic. Treatment system treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors. **HCAA Process Option:** Contaminants associated with the HCAA would remain in place. Existing liner and institutional controls would mitigate the potential risk of human exposure through direct contact. The barrier cutoff wall and groundwater extraction and treatment system would eliminate migration of arsenic in groundwater from the HCAA.		NAPL zones (NZ-1, NZ-2, NZ-5, and portions of NZ-3), principal threat arsenic areas, the HCAA, and tar boils would be removed. Reactive barrier treats or adsorbs groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors. Institutional controls would restrict the use of the groundwater.	
			NAPL under 115 River Rd. is left in place. Current building slab provides a vapor barrier, which reduces inhalation potential.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed. Vapor intrusion monitoring would be performed in newly constructed buildings.	NAPL under 115 River Rd. is left in place. Current building slab provides a vapor barrier, which reduces inhalation potential.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed. Vapor intrusion monitoring would be performed in newly constructed buildings.	NAPL under 115 River Rd. is left in place. Current building slab provides a vapor barrier, which reduces inhalation potential.	115 River Rd. tenants are relocated, building is demolished to access NAPL areas below building footprint, and then the building is reconstructed. Vapor intrusion monitoring would be performed in newly constructed buildings.

TABLE ES-2
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

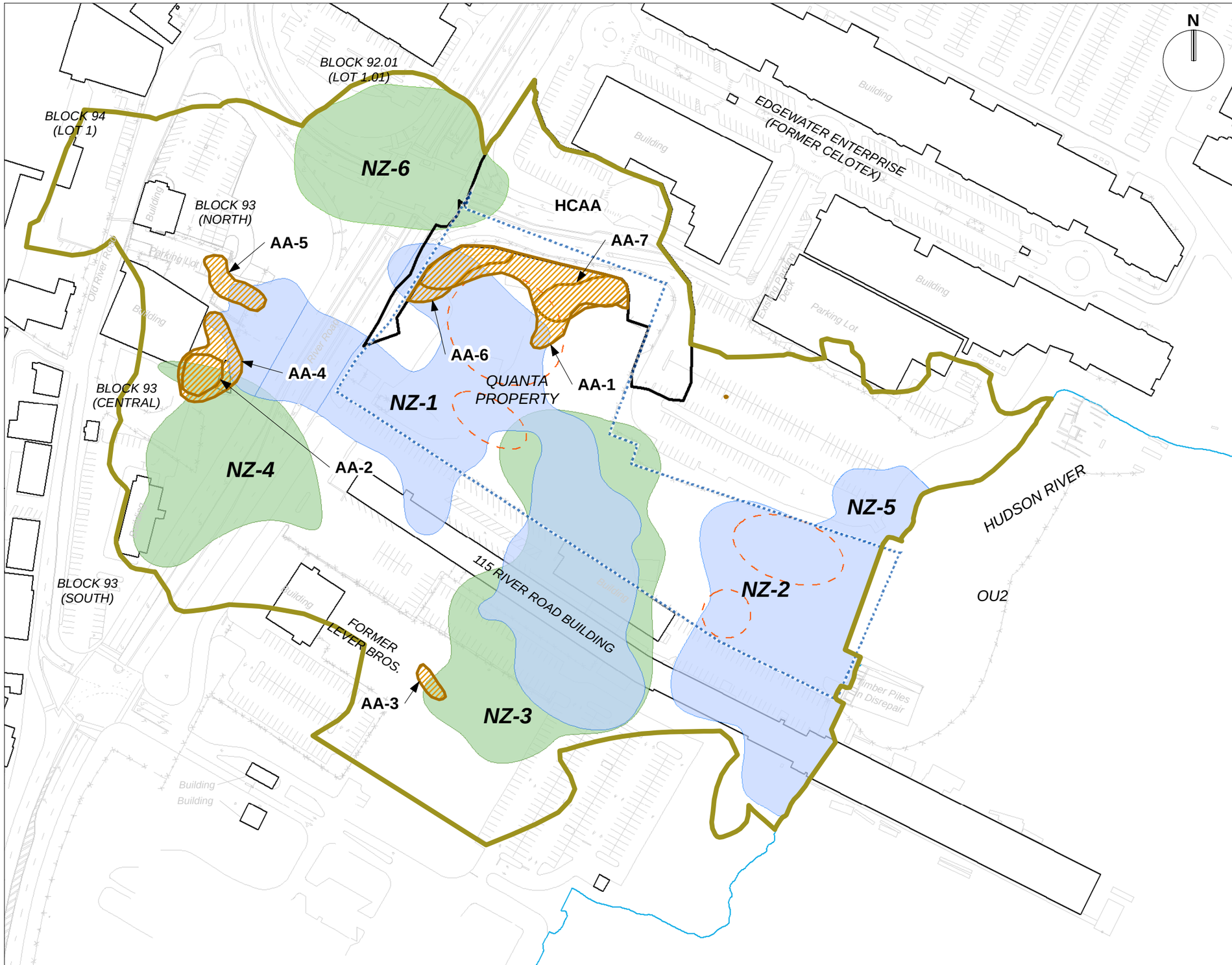
	Alternative							
			4—NAPL and Arsenic In Situ Solidification/Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
NCP Evaluation Criteria[a]	**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**
Compliance with ARARs	Would not meet soil clean-up standards, but most other ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary. The ARARs for vapor intrusion would be met. Contaminated groundwater is treated prior to being discharged to Hudson River. Achievement of drinking water ARARs in inland groundwater is not feasible, therefore ICs would be used to prevent site groundwater from being used as drinking water and a waiver of ARARs based on technical impracticability of groundwater restoration would be necessary.	Same as Alternative 2. ARARs concerned with leaching to groundwater would be met around the HCAA. Complies with the ARAR to treat, remove, or contain NAPL to the extent practicable by recovering NAPL (NJDEP 7:26E-6.1(d)).	Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization. Complies with the ARAR to treat, remove, or contain NAPL to the extent practicable by treating NAPL with solidification/stabilization. (NJDEP 7:26E-6.1(d)). ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary. The ARARs for vapor intrusion would be met. Contaminated groundwater is treated prior to being discharged to Hudson River. **HCAA Process Option:** Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization. ARARs concerned with leaching to groundwater would be met around the HCAA. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary. Achievement of drinking water ARARs in inland groundwater is not feasible, therefore ICs would be used to prevent site groundwater from being used as drinking water and a waiver of ARARs based on technical impracticability of groundwater restoration would be necessary.		Same as Alternative 4, except complies with the ARAR to treat, remove, or contain NAPL to the extent practicable (NJDEP 7:26E-6.1(d)) by recovery and chemical oxidization.		Same as Alternative 4, except complies with the ARAR to treat, remove, or contain NAPL to the extent practicable (NJDEP 7:26E-6.1(d)) by excavation and offsite disposal	
Long-Term Effectiveness and Permanence	Capping, ICs, and vapor intrusion mitigation are maintained indefinitely and provide reliable and long-term effectiveness in reducing potential risk associated with NAPL, soil, vapor, and groundwater. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely.	Same as Alternative 2, plus NAPL recovery would permanently remove some NAPL from the site. The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA.	Solidified soils, capping, ICs, reactive barriers and vapor intrusion mitigation provide reliable and long-term effectiveness in reducing potential risks associated with NAPL, soil, vapor, and groundwater. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely. **HCAA Process Option:** The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA.		Same as Alternative 4 for solidified soils, capping, ICs, and VI mitigation. ISCO is proven reliable and effective. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely. **HCAA Process Option:** The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA.		Same as Alternative 4 for capping, ICs, reactive barrier and VI mitigation. Excavation is proven reliable and effective. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely.	

TABLE ES-2
Alternative Evaluation Summary
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Alternative							
			4—NAPL and Arsenic In Situ Solidification/Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
NCP Evaluation Criteria[a]	**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**
Reduction of Toxicity, Mobility, or Volume	Toxicity and volume of NAPL would remain. Mobility of NAPL, impacted residual and arsenic impacted soils would be reduced through the installation of a barrier cutoff wall, however, leaching to groundwater would continue.	Same as Alternative 2, except NAPL recovery would reduce TMV, and groundwater constituents would be treated through a treatment system before discharging to surface water. Replacement or regeneration of system components would generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue that requires offsite disposal.	Toxicity and mobility of NAPL and arsenic would be reduced through in situ solidification/stabilization but volume would not be reduced. Some source material remains; however, capping, vapor intrusion mitigation, and ICs reduce exposure. SRB protects Hudson River. **HCAA Process Option:** Groundwater constituents associated with the HCAA would be treated through a treatment system before discharging to surface water. Replacement or regeneration of system components would generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue that requires offsite disposal.		Same as Alternative 4 for capping, VI mitigation, ICs and SRB. ISCO reduces NAPL TMV and in situ solidification/stabilization reduces arsenic TMV. Use of a barrier cutoff wall and groundwater extraction and treatment system would reduce groundwater concentrations to acceptable levels to allow for migration to the Hudson River. Replacement or regeneration of system components would generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue that requires offsite disposal. **HCAA Process Option:** Groundwater constituents associated with the HCAA would be treated through a treatment system before discharging to surface water.		Same as Alternative 4 for capping, VI mitigation, ICs and SRB. Plus excavation reduces NAPL and arsenic TMV.	
			Materials under 115 River Rd. would not be treated.	NZ-1 and NZ-2 under 115 River Rd. would be solidified/stabilized in situ with reagents.	Materials under 115 River Rd. would not be treated.	NZ-1 and NZ-2 under 115 River Rd. would be treated with ISCO.	Materials under 115 River Rd. would not be treated.	Shallow NZ-1 and NZ-2 material under 115 River Rd. would be excavated.
Short-Term Effectiveness	Potential risk to workers and the community during remedial construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust, vapors, noise, and odor control during construction activities).	Same as Alternative 2. Additionally, operations and maintenance of NAPL recovery would require periodic transport of NAPL offsite. Appropriate health and safety, storage, and handling procedures must be followed.	Same as Alternative 2. Additionally, in situ solidification/stabilization could result in the potential for additional risk to workers due to high concentrations of NAPL, arsenic, and other COCs expected. Potential risk of suspending sediment and release of NAPL during SRB construction.		Same as Alternative 3. Additionally, implementation of ISCO could result in the potential for additional risk to workers, due to handling of large quantities of chemical required for oxidants. In situ solidification/stabilization could result in the potential for additional risk to workers due to high concentrations of arsenic and other COCs expected.		Same as Alternative 2. Additionally, excavation could result in significant potential risk to workers, community and the environment during implementation. Potential risk of suspending sediment and release of NAPL during SRB construction.	
			No additional risk.	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.	No additional risk.	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.	No additional risk.	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.
Implementability	Technically and administratively feasible; however, access would be needed for cap installation and property owners would need to concur with restriction of usage for each parcel on which IC are established.	Same as Alternative 2.	Same as Alternative 2. Additionally, solidification/stabilization is technically feasible based pending the results of bench and pilot testing and if large (>12 in.) objects are excavated from the surface and subsurface. **HCAA Process Option:** Installation of cutoff wall is feasible		Same as Alternative 4. Plus ISCO would be technically feasible based on site conditions, pending the results of bench- and pilot-scale testing. **HCAA Process Option:** Installation of cutoff wall is feasible		Same as Alternative 2. However, excavation near structures and utilities would have to be evaluated and structural support provided as needed.	
Present Worth Cost	***$29,043,000 to $62,235,000***	***$44,548,000 to $95,460,000***	***4a = $50,568,000 to $108,360,000*** ***4b = $118,174,000 to $253,230,000***		***5a = $255,948,000 to $548,460,000*** ***5b = $336,182,000 to $720,390,000***		***6a = $144,144,000 to $308,880,000*** ***6b = $215,747,000 to $462,315,000***	

[a] State and community acceptance are modifying criteria that are evaluated following public comment on the proposed plan and are used to modify the selection of the recommended alterative.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
HCAA high-concentration arsenic area
IC institutional control
ISCO in situ chemical oxidation
NAPL non–aqueous phase liquid
PRB permeable reactive barrier
PRG preliminary remediation goal
RAO remedial action objective
SRB subaqueous reactive barrier
TMV toxicity, mobility, or volume
VI vapor intrusion



LEGEND

- Existing Arsenic Liner
- Principal Threat Arsenic Area
- Principal Threat NAPL Zone
- Low Level Threat NAPL Zone
- Extent of OU1
- Tar Boils

Notes:

1. Source material is defined based on criteria derived from A Guide to Principal Threat and Low Level Threat Wastes. (EPA, 1991)
2. NZ = NAPL Zone, AA = Arsenic Area
3. Depth of NAPL Zones:
   - NZ-1: 1-11 ft bgs
   - NZ-2: 4-25 ft bgs
   - NZ-3: 15-25 ft bgs
   - NZ-4: 10-32 ft bgs
   - NZ-5: 10-25 ft bgs
   - NZ-6: 10-15 ft bgs
4. Depth of Arsenic Areas:
   - AA-1: 10 ft bgs
   - AA-2: 5 ft bgs
   - AA-3: 7 ft bgs
   - AA-4: 2 ft bgs
   - AA-5: 2 ft bgs
   - AA-6: 2 ft bgs
   - AA-7: 2 ft bgs

0 70 140 ft.

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SOURCE MATERIAL

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-1**

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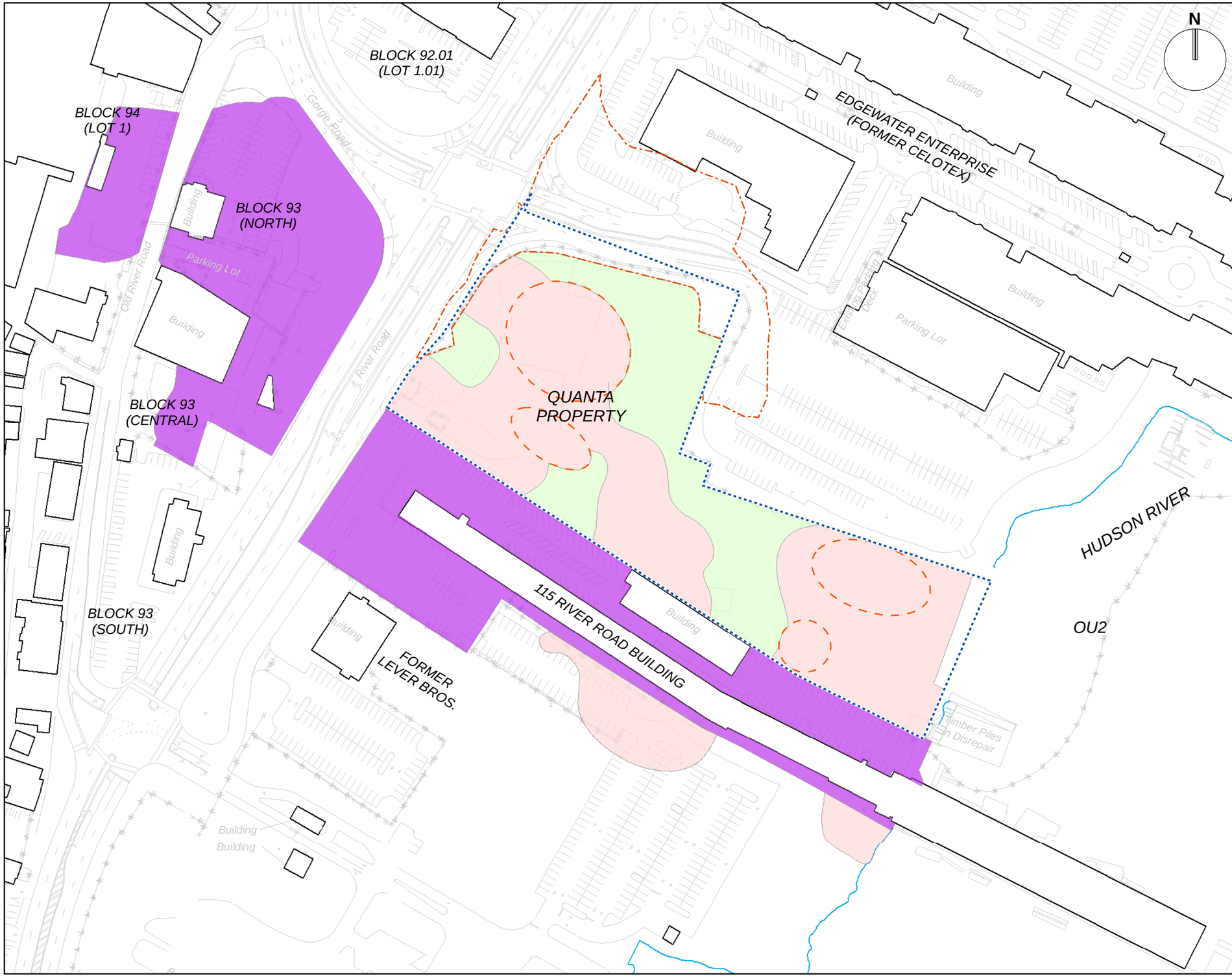

LEGEND

- Hudson River Shoreline
- Quanta Property Boundary
- Existing Arsenic Liner
- Asphalt Cap
- Engineered Cap
- Engineered Cap or Cover Selection based on technology implemented (see note 1)
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Notes:

1. Engineered cap for Alternatives 2 and 3. Soil cover for Alternatives 4, 5, and 6.
2. Existing road surfaces and on-slab grade formations will remain in place and are maintained by others.
3. Arsenic liner remains and is maintained by others.

0 70 140 ft.

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EXTENT OF CAPPING

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

Figure ES-2

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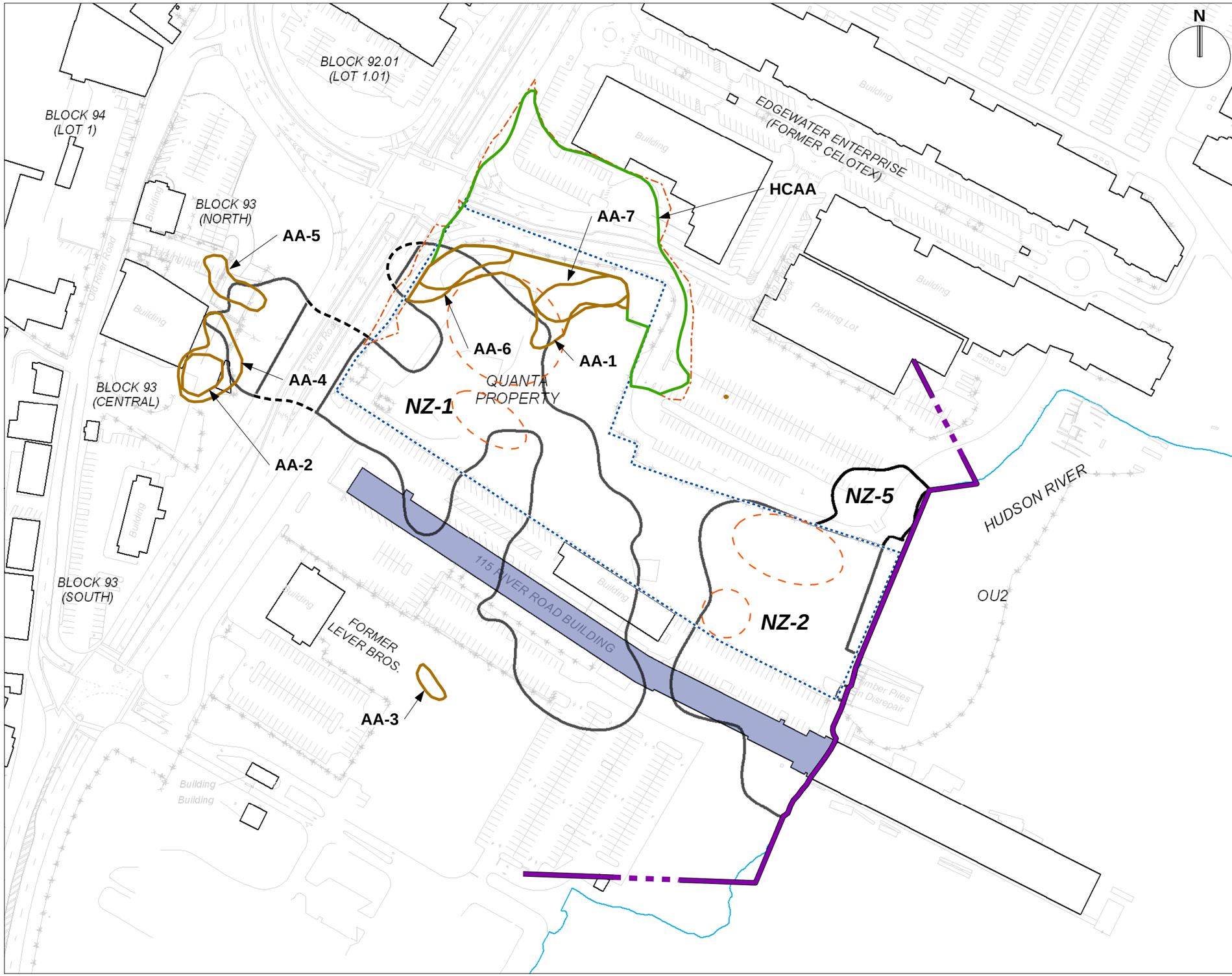

LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Vapor Intrusion Engineering Controls
- Barrier Wall
- Permeable Reactive Barrier

Notes:

1. Alternative also includes capping of residual soils.
2. The final gate size finalized during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

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ALTERNATIVE 2
NAPL AND ARSENIC CONTAINMENT

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **Figure ES-3**

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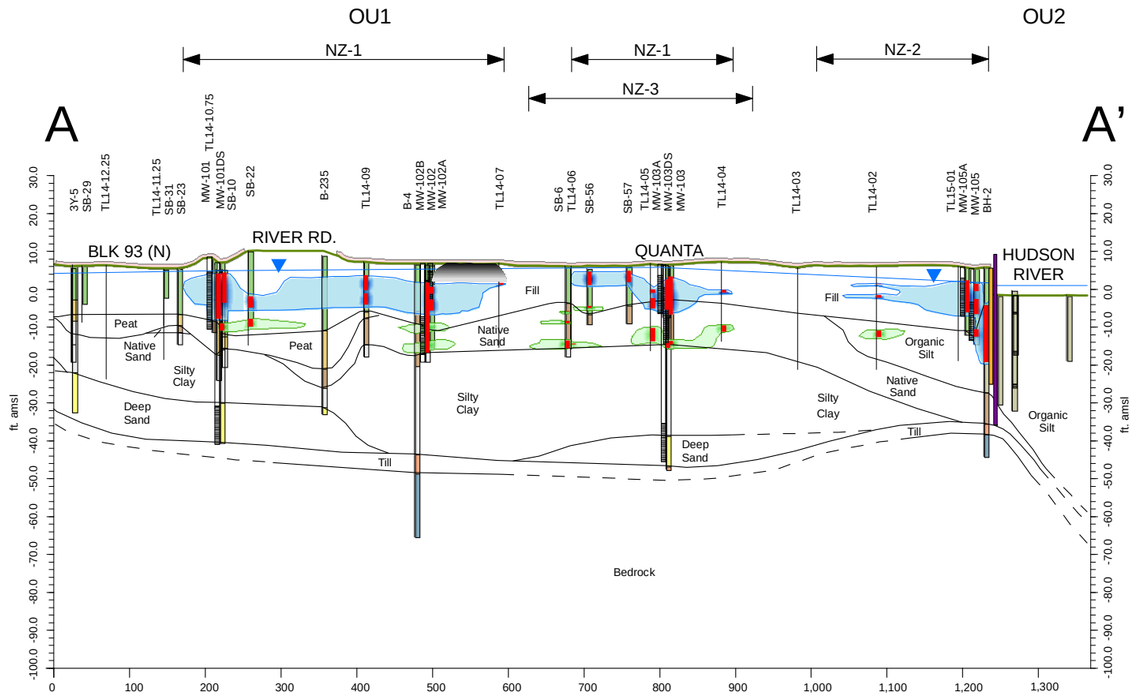
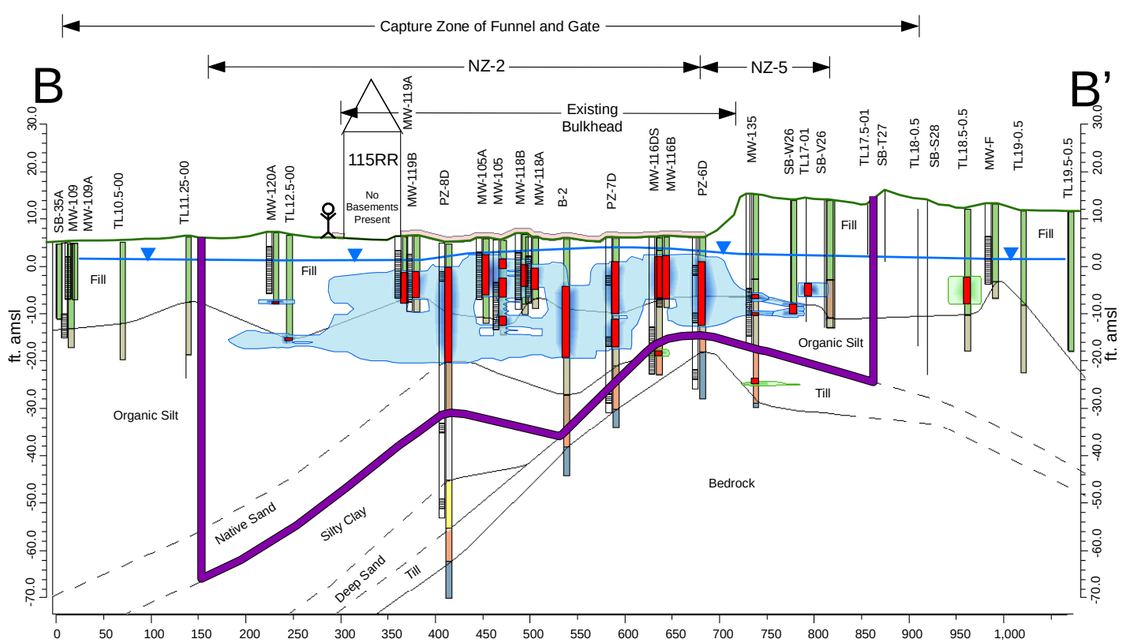
Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock



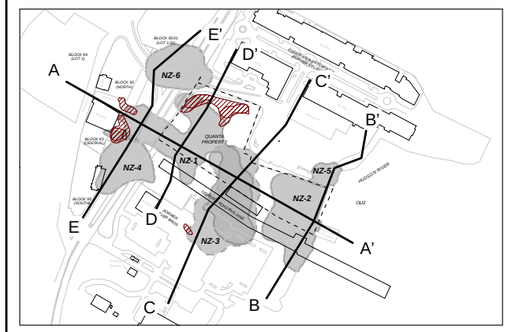
CROSS-SECTION A-A'



CROSS-SECTION B-B'

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- Engineered Cap
- Tar Boils
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
7. Barrier wall and jet grouting shown parallel to cross-section line.
8. 115 River Road dimensions are estimated.
9. Configuration of the barrier wall is approximated for visual depiction and will be determined during remedial design.
10. ft. = feet, amsl = above mean sea level

CH2MHILL

ALTERNATIVE 2 - CROSS SECTIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-4**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-04_ALTERNATIVE 2 - CROSS SECTIONS.MXD JHANSEN1 7/6/2010 12:36:24

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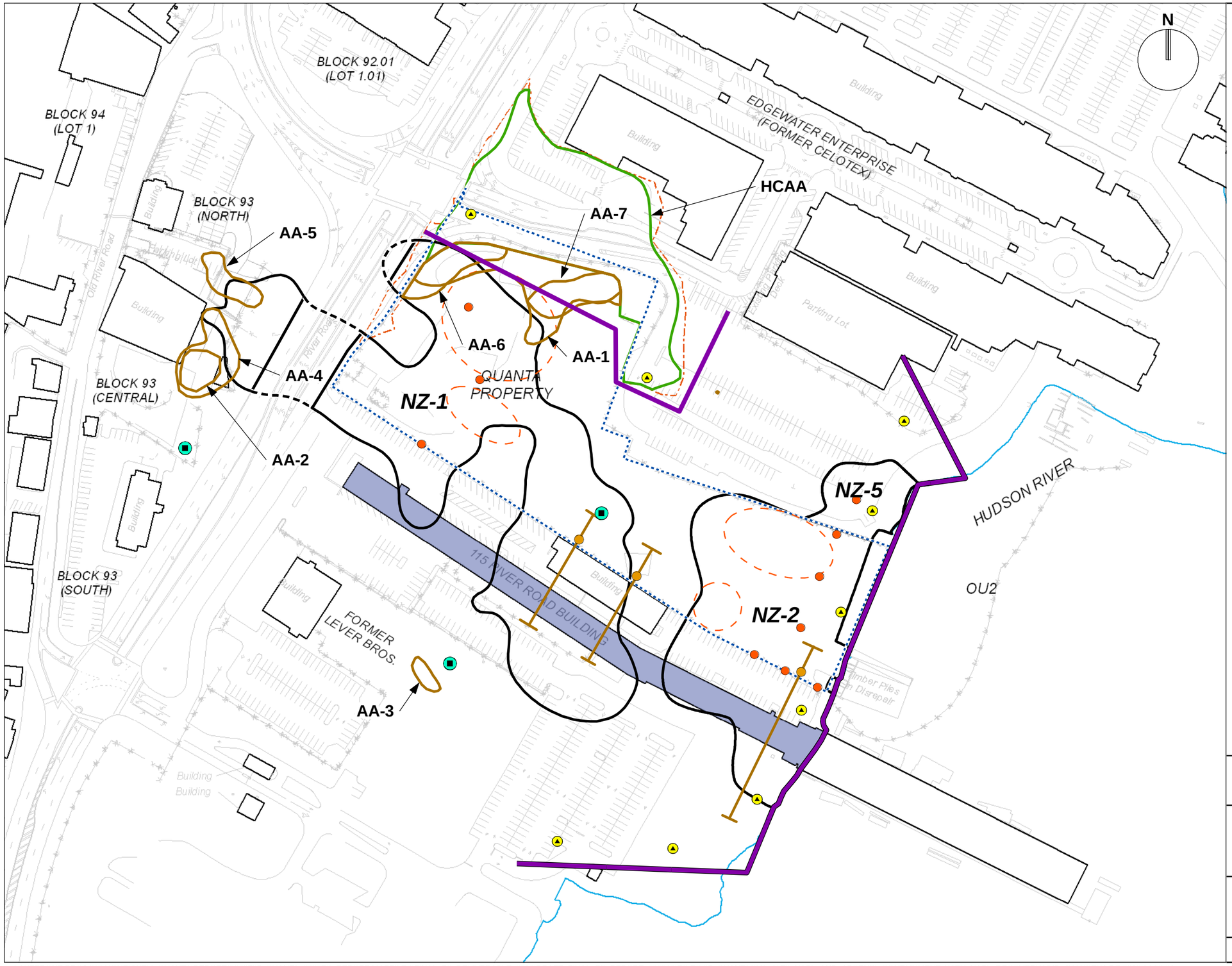


LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 Principal Threat NAPL Zone
- HCAA High Concentration Arsenic Area
- AA-7 Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Vapor Intrusion Engineering Controls
- Barrier Wall
- Horizontal NAPL Recovery Well and Sump
- Groundwater Extraction Well
- NAPL Recovery Wells
- Passive NAPL Recovery

Note:

1. Alternative also includes capping of residual soils
2. Final recovery well layout to be finalized during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 3 - NAPL AND ARSENIC CONTAINMENT WITH NAPL RECOVERY

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

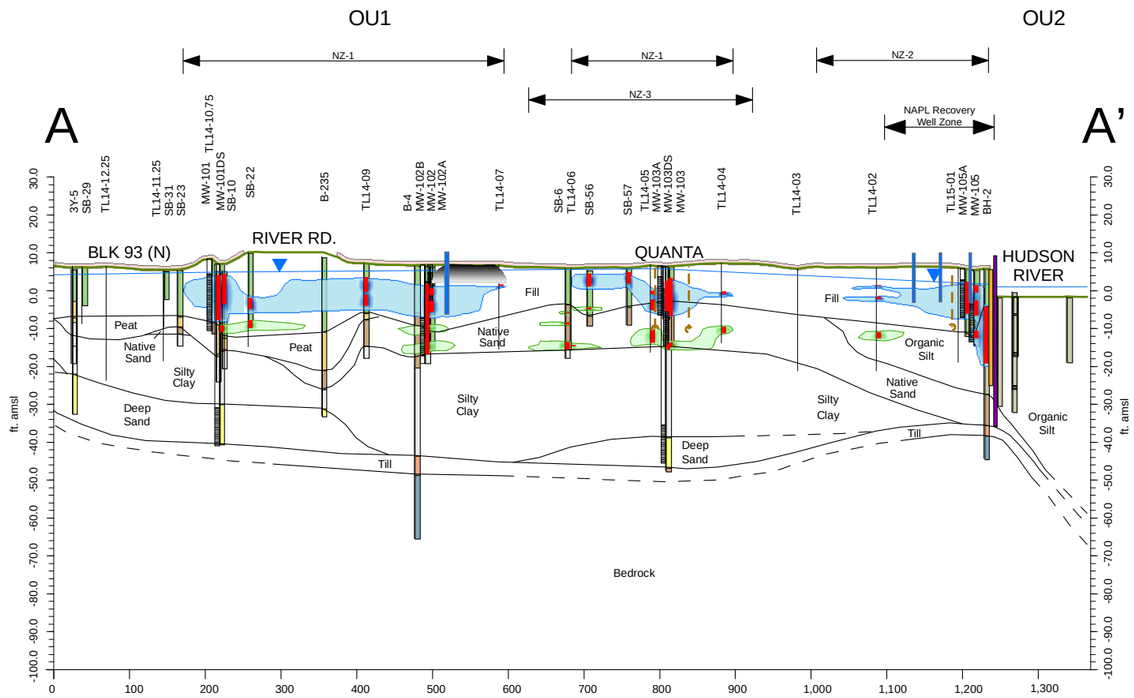
July 6, 2010 | **Figure ES-5**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-05_QUANTAOU1_ALT3_NAPL_AND_ARSENIC_CONTAINMENT_WITH_NAPL_RECOVERY.MXD JHANSEN1 7/7/2010 14:09:01

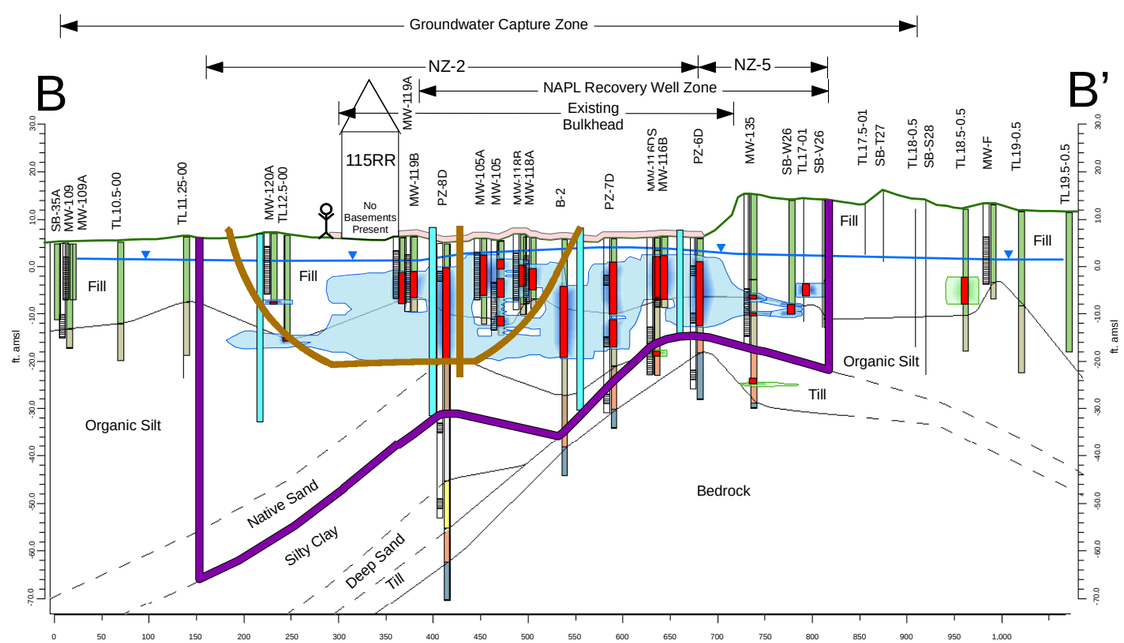
400022

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock



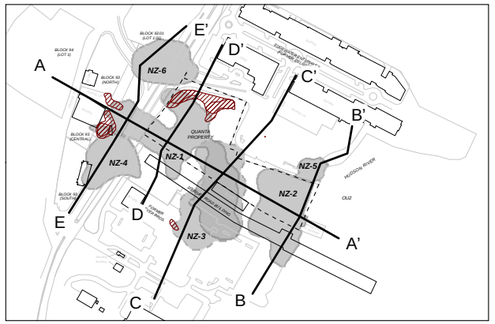
CROSS-SECTION A-A'



CROSS-SECTION B-B'

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- NAPL Recovery Well
- Recovery Sump
- Groundwater Extraction Well
- Water Table
- Engineered Cap
- Tar Boils
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Passive NAPL Recovery Wells
- Recovery Wells (Perpendicular to Cross-section)



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
8. 115 River Road dimensions are estimated.
9. Configuration of the sheet pile is approximated for visual depiction and will be determined during remedial design.
10. ft. = feet, amsl = above mean sea level

CH2MHILL

ALTERNATIVE 3 - CROSS SECTIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-6**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-06_ALTERNATIVE 3 - CROSS SECTIONS.MXD JHANSEN1 7/6/2010 12:43:09

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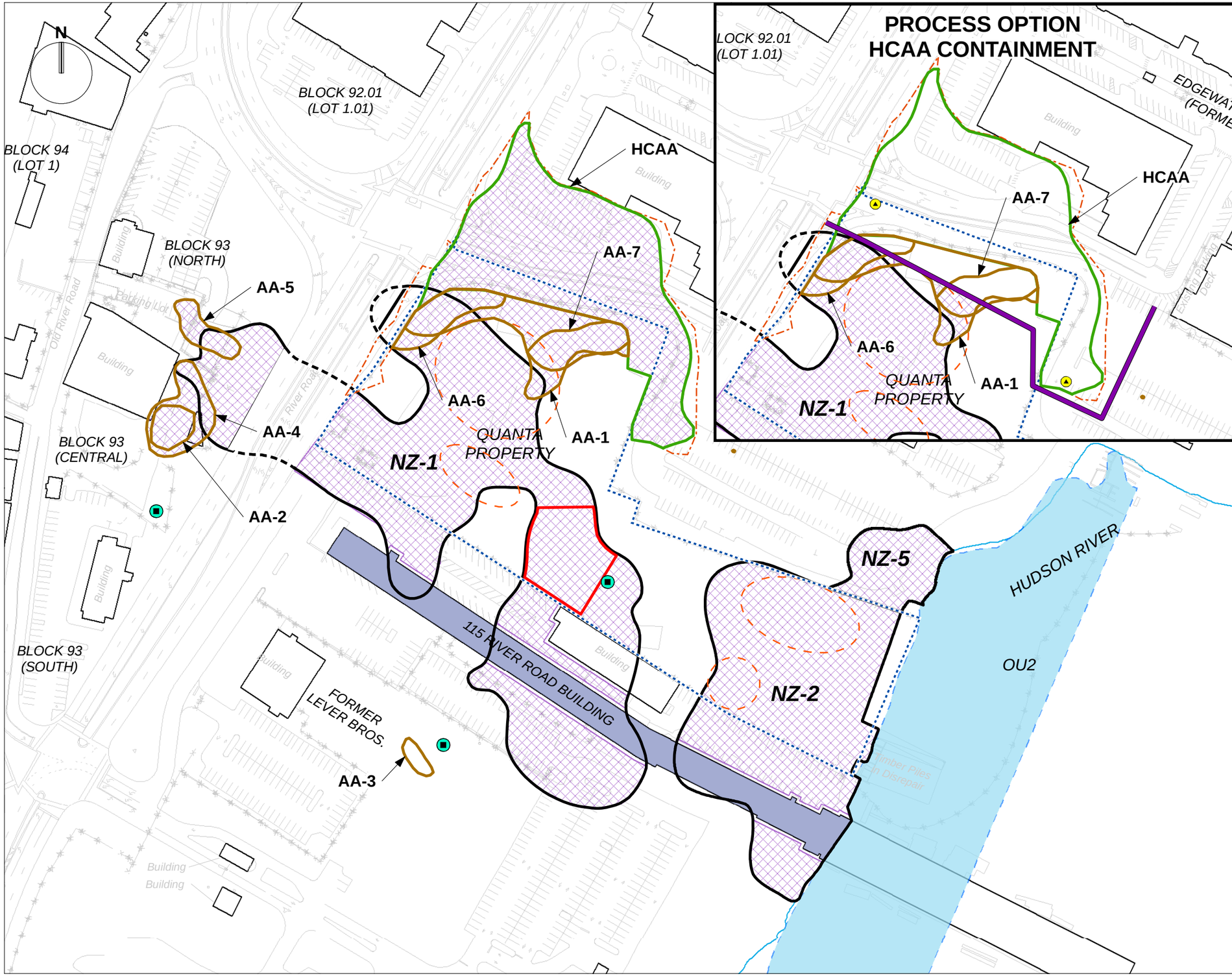
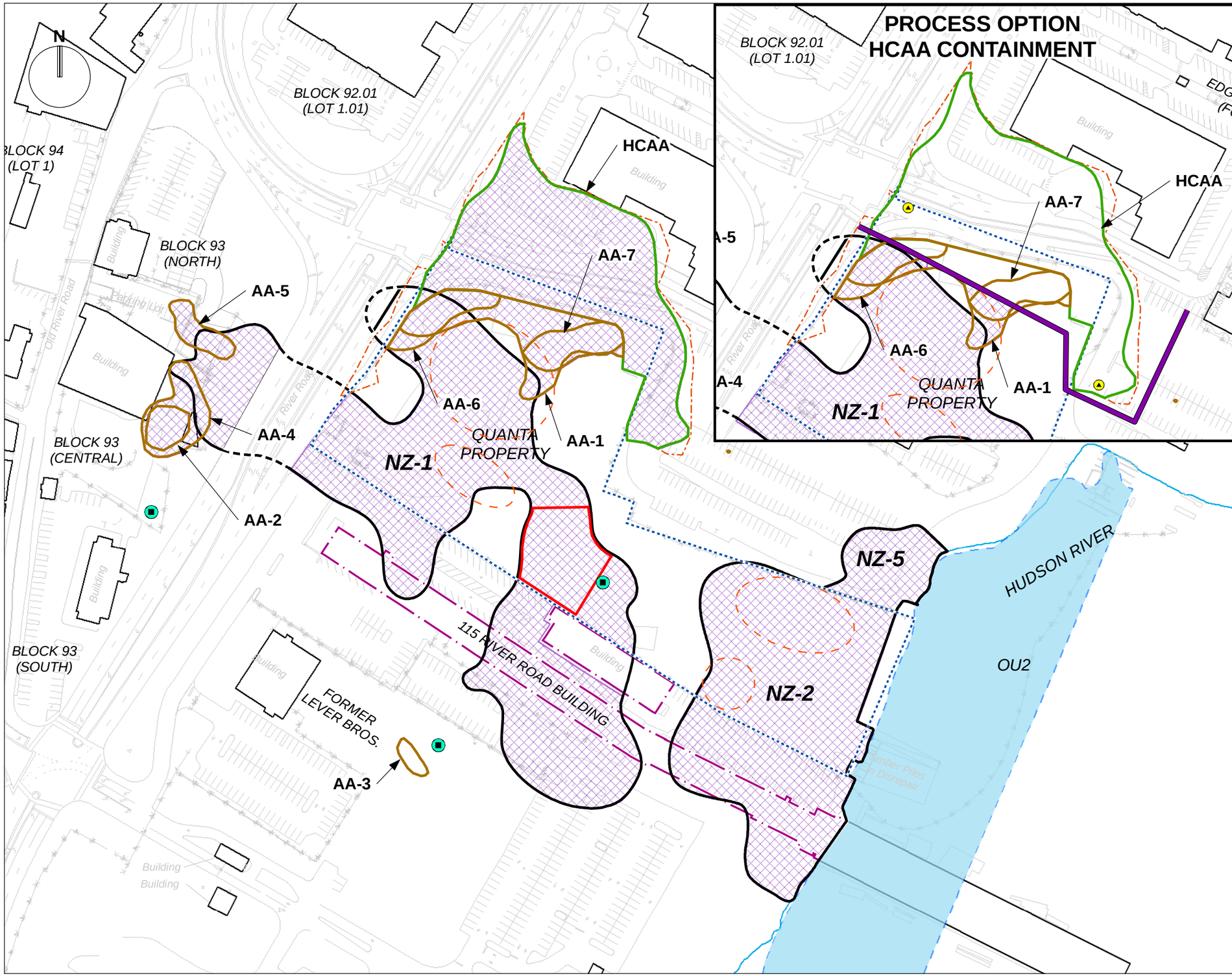

N
BLOCK 94
(LOT 1)
BLOCK 92.01
(LOT 1.01)
BLOCK 93
(NORTH)
BLOCK 93
(CENTRAL)
BLOCK 93
(SOUTH)
Old River Road
River Road
Building
Parking Lot
HCAA
AA-7
AA-5
AA-6
AA-4
AA-1
AA-2
AA-3
NZ-1
QUANTA
PROPERTY
NZ-5
NZ-2
115 RIVER ROAD BUILDING
FORMER
LEVER BROS.
HUDSON RIVER
OU2
Building
Building
Building



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Demolition
- In Situ Stabilization/Solidification
- Subaqueous Reactive Barrier (SRB)
- Barrier Wall
- Groundwater Extraction Well
- Passive NAPL Recovery

Note:

1. Alternative also includes capping of residual soils.
2. Methods and reagents for solidification and stabilization may vary for the various NAPL and arsenic areas.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 4B - NAPL AND ARSENIC SOLIDIFICATION/STABILIZATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

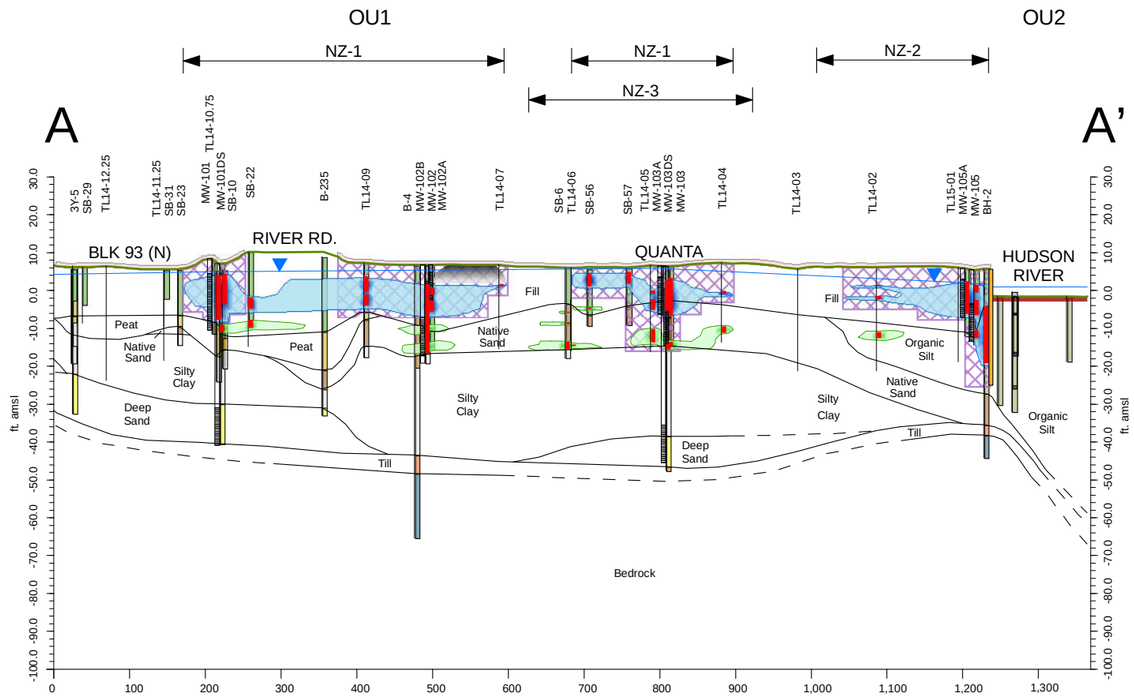
July 6, 2010 | **FIGURE ES-8**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-08_QUANTAOU1_ALT4_NAPL_AND_ARSENIC_SOLIDIFICATIONSTABILIZATION_BLDG115_DEMO_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:16:24

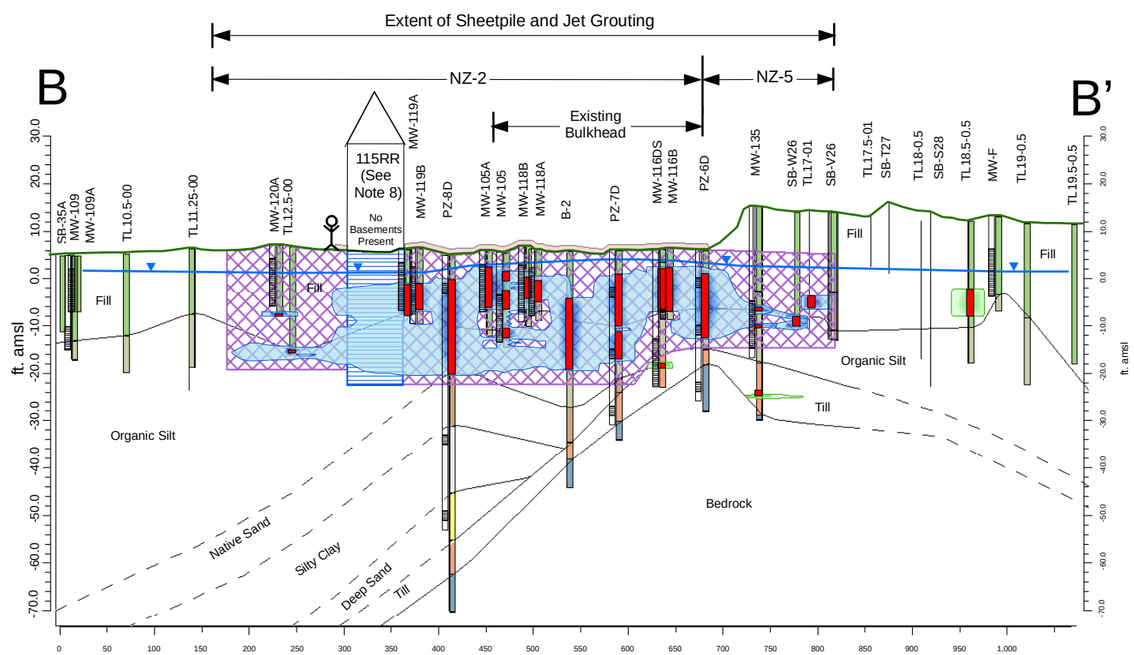
400025

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock



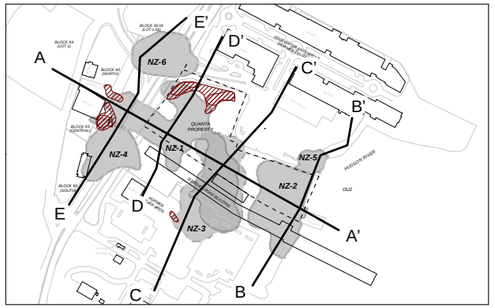
CROSS-SECTION A-A'



CROSS-SECTION B-B'

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Solidification/ Stabilization
- Tar Boils
- Barrier Wall
- Engineered Cap
- Subaqueous Reactive Barrier (SRB)



Plan view of the Quanta Resources Superfund Site

Notes:

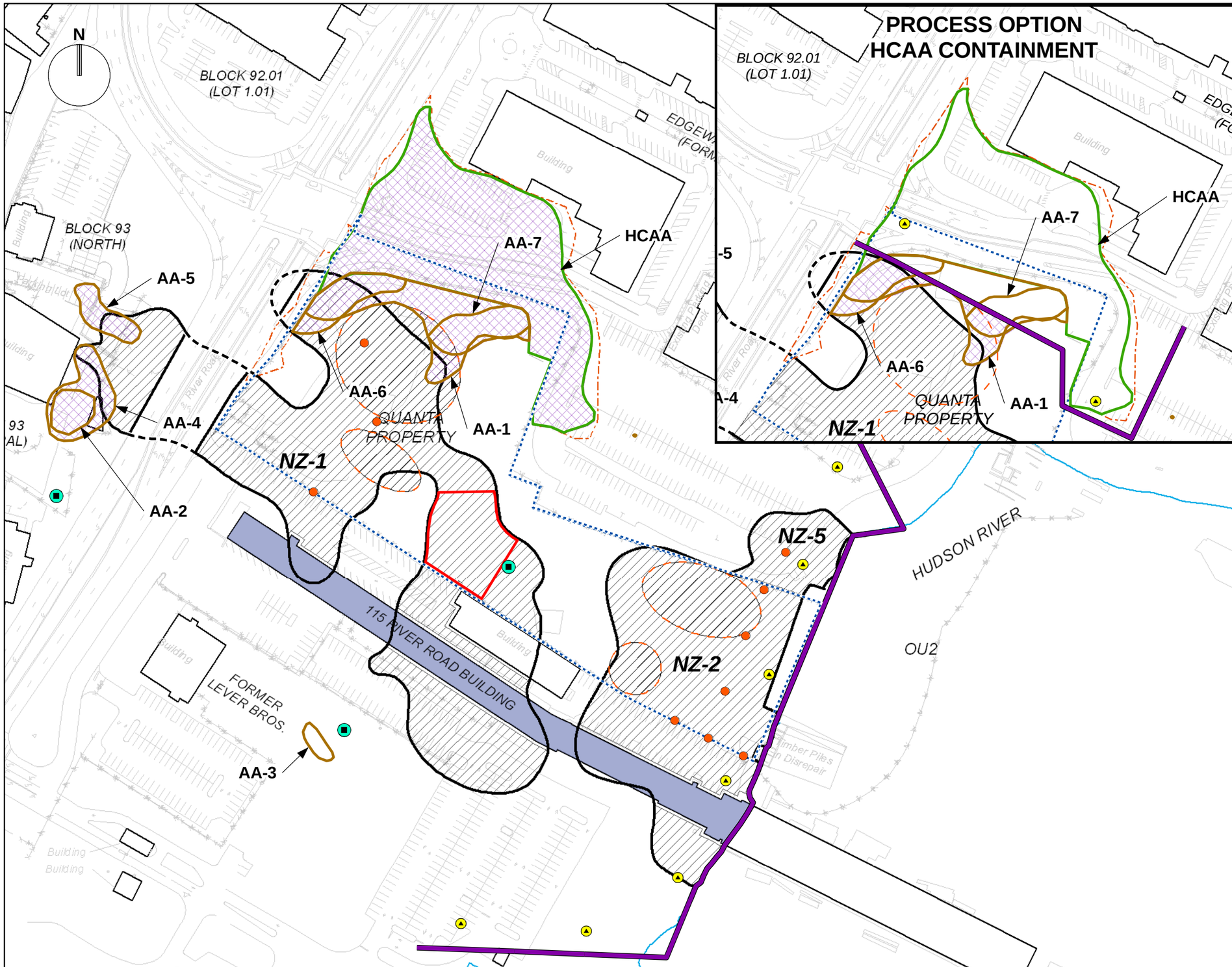
1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2
7. 115 River Road and garage dimensions are estimated.
8. ft. = feet, amsl = above mean sea level

CH2MHILL

ALTERNATIVE 4 - CROSS SECTIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-9**



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation for NAPL (0 - 4 ft bgs)/ Tar Boils and ISCO
- Stabilization
- Vapor Intrusion Engineering Controls
- Barrier Wall
- NAPL Recovery Wells
- Groundwater Extraction Well
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
3. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 5A - NAPL IN SITU CHEMICAL OXIDATION WITH ARSENIC STABILIZATION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-10**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-10_QUANTAOU1_ALT5_NAPLINSITUCHEMICALOXIDATION_WITH_ARSENIC_STABILIZATION_WITH_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:18:16

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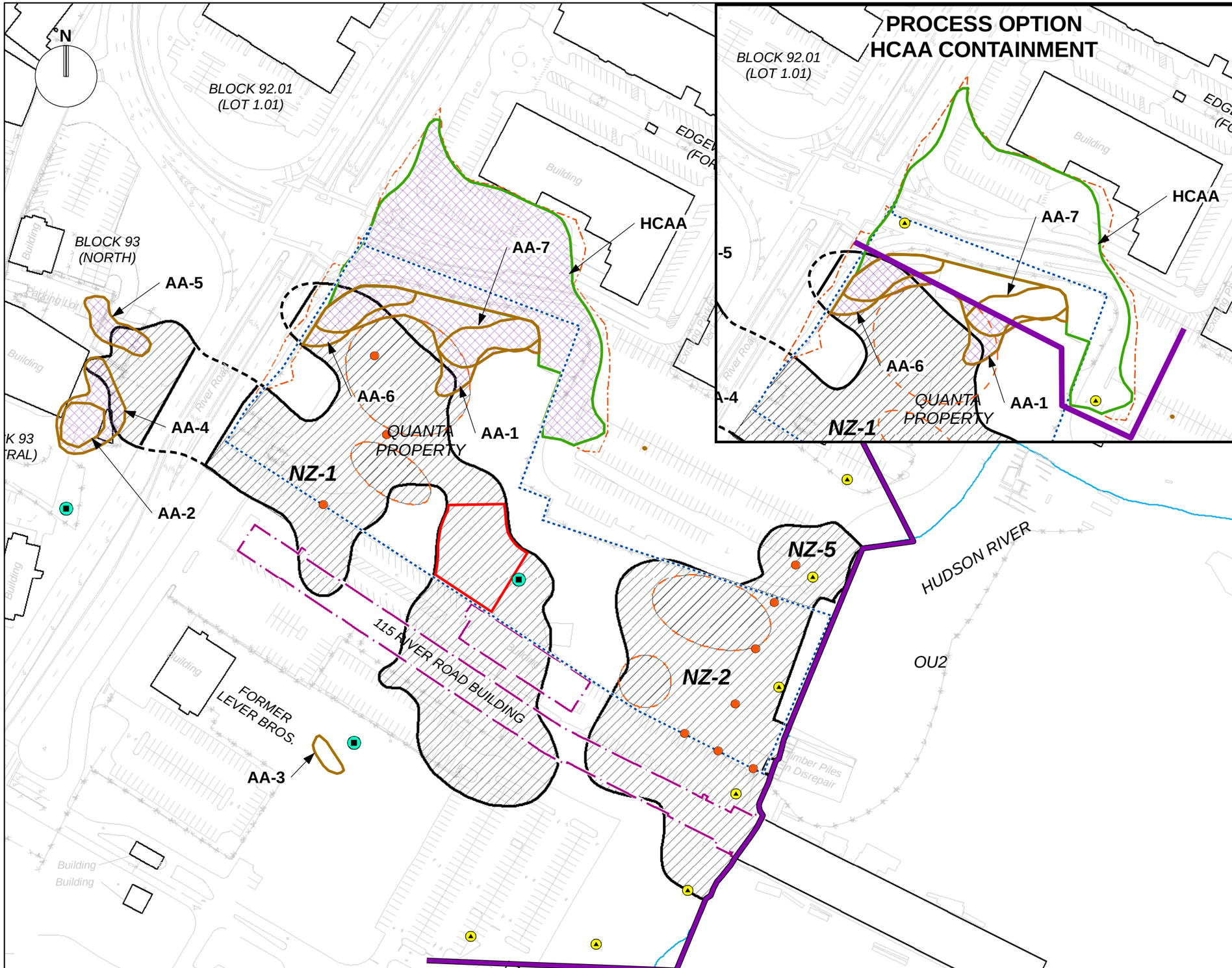


LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation for NAPL (0 - 4 ft bgs)/ Tar Boils and ISCO
- Stabilization
- Demolition
- Barrier Wall
- NAPL Recovery Wells
- Groundwater Extraction Well
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
3. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 5B - NAPL IN SITU CHEMICAL OXIDATION WITH ARSENIC STABILIZATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

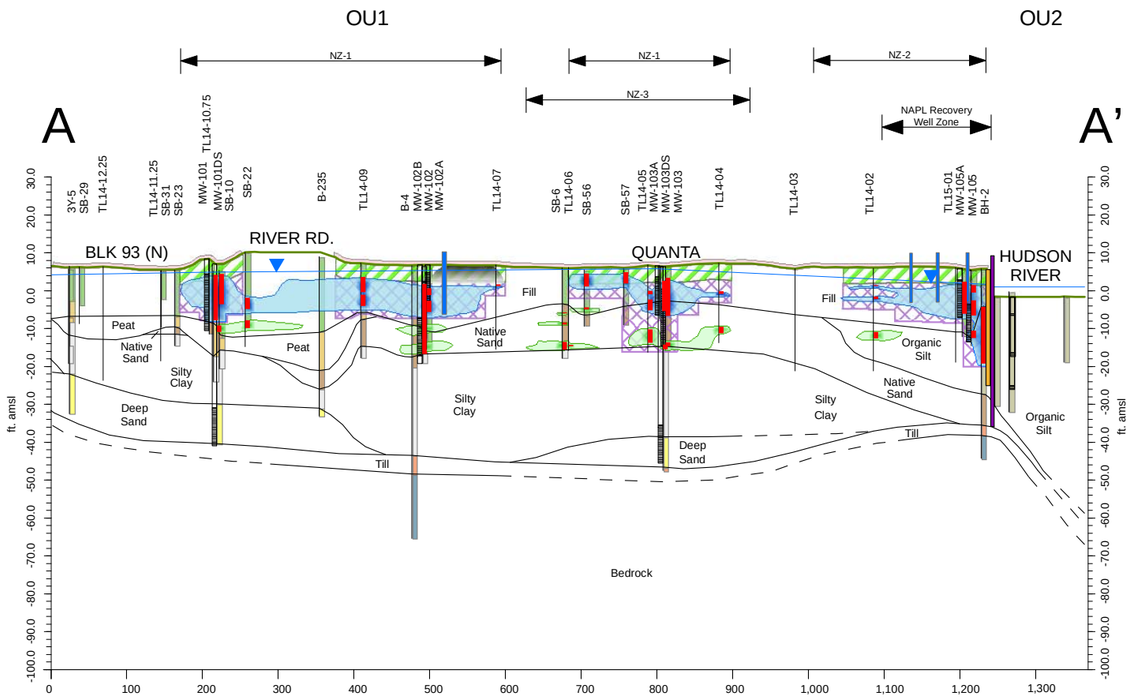
July 6, 2010 | **FIGURE ES-11**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-11_QUANTAOU1_ALT5_NAPLINSITUCHEMICALOXIDATION_WITH_ARSENIC_STABILIZATION_WITH_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:21:12

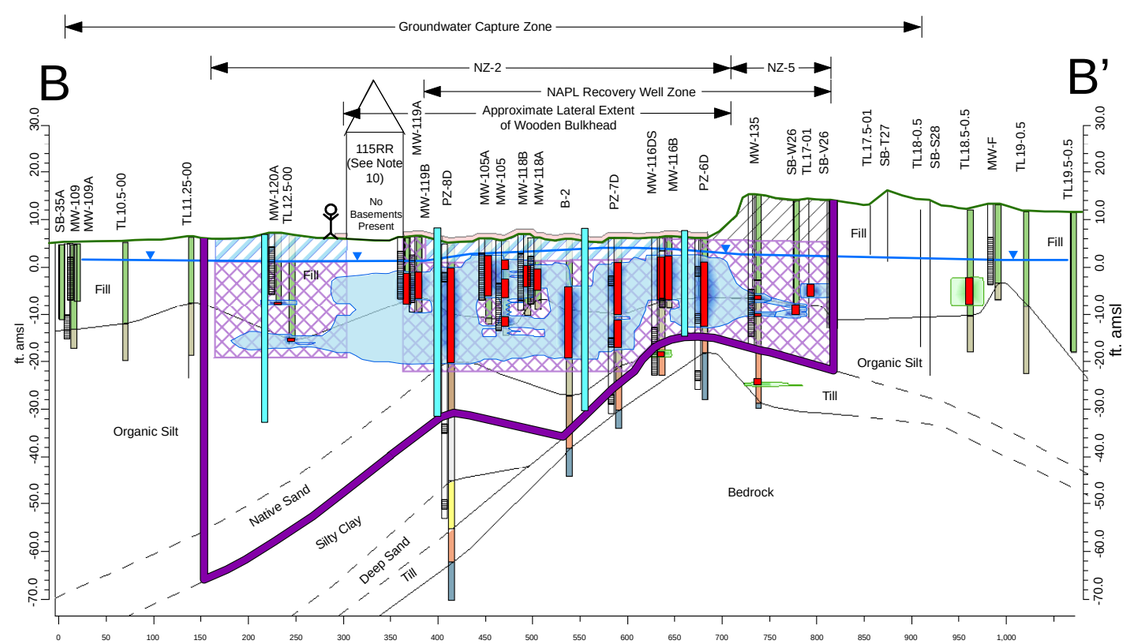
400028

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock



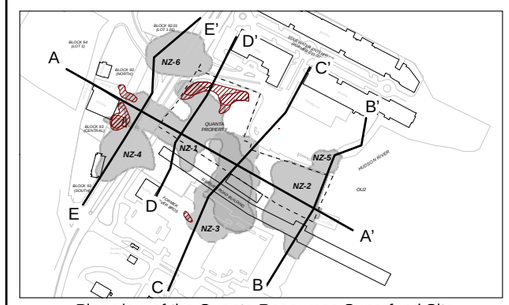
CROSS-SECTION A-A'



CROSS-SECTION B-B'

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- NAPL Recovery Well
- Groundwater Extraction Wells
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Tar Boils
- Stabilization
- Excavation
- InSitu Chemical Oxidation
- Material to be Removed Prior ISCO
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
8. 115 River Road dimensions are estimated.
9. Configuration of the sheet pile is approximated for visual depiction and will be determined during remedial design.
10. ft. = feet, amsl = above mean sea level

CH2MHILL

ALTERNATIVE 5 - CROSS SECTIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-12**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-12_ALTERNATIVE 5 - CROSS SECTIONS.MXD JHANSEN1 7/6/2010 14:04:52

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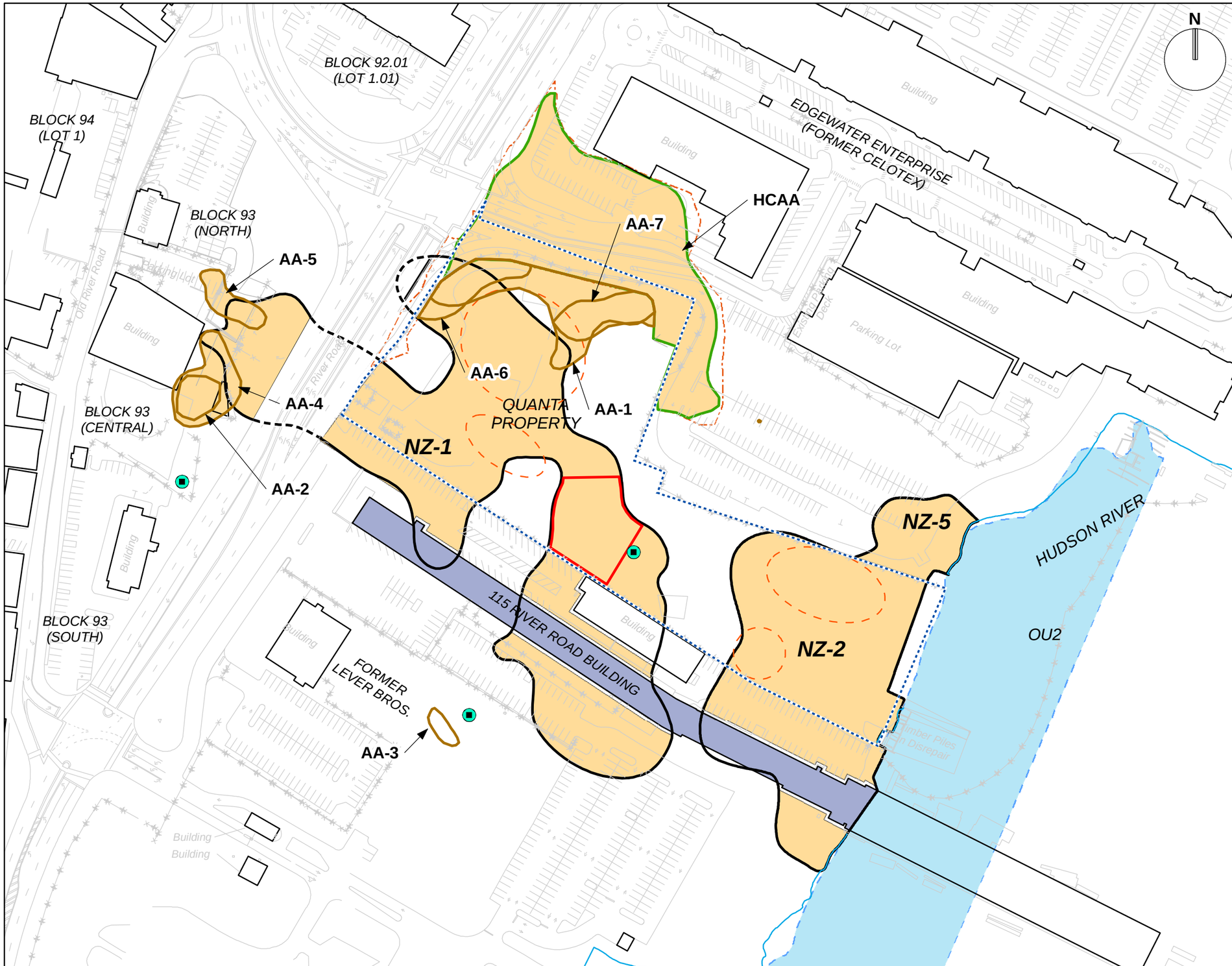

LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation
- Vapor Intrusion Engineering Controls
- Subaqueous Reactive Barrier (SRB)
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Final excavation depths will be determined during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 6A - NAPL AND ARSENIC EXCAVATION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-13**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-13_QUANTAOU1_ALT6_NAPL_AND_ARSENIC_EXCAVATION.MXD JHANSEN1 7/7/2010 14:23:24

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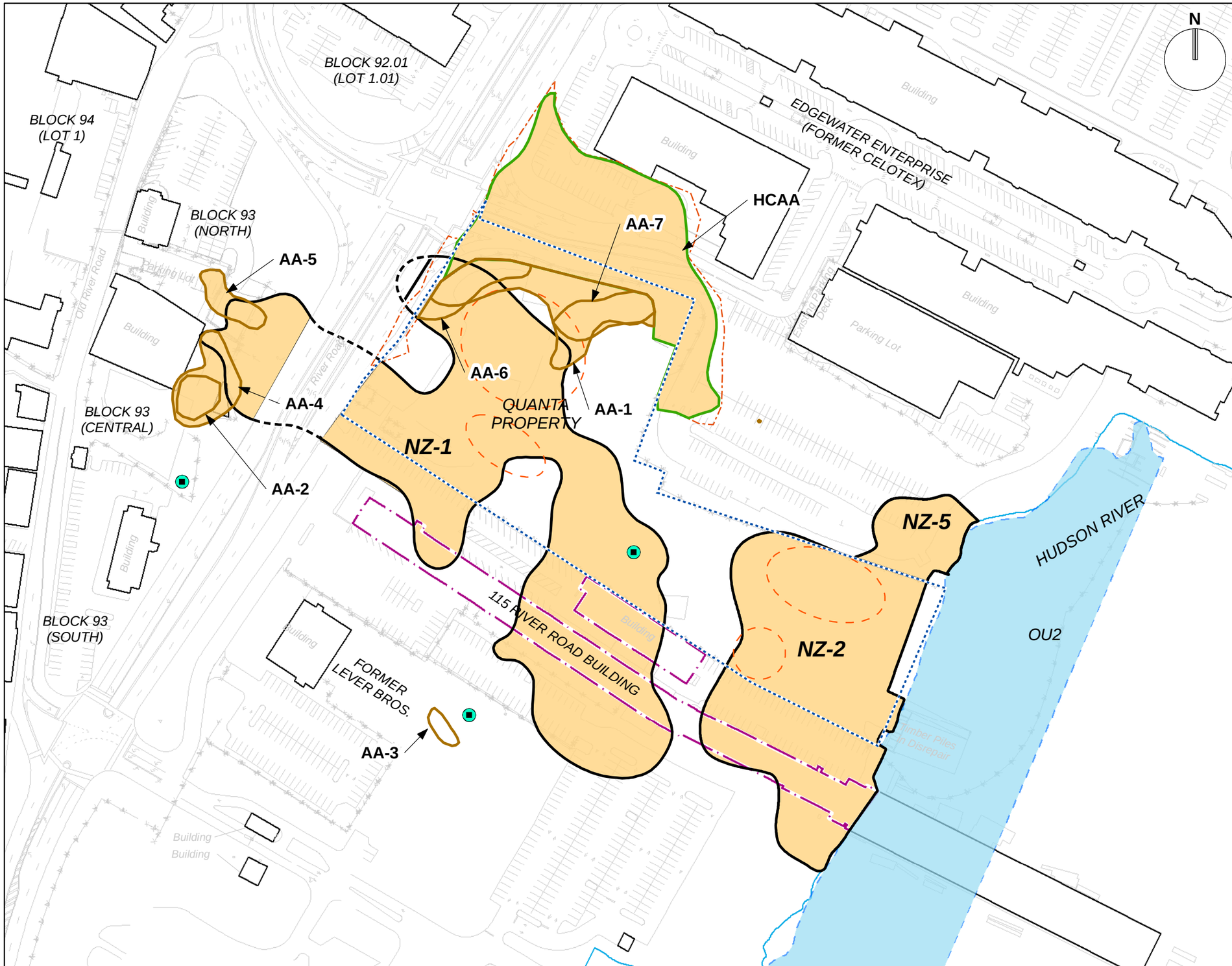


LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation
- Demolition
- Subaqueous Reactive Barrier (SRB)
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Final excavation depths will be determined during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 6B - NAPL AND ARSENIC EXCAVATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

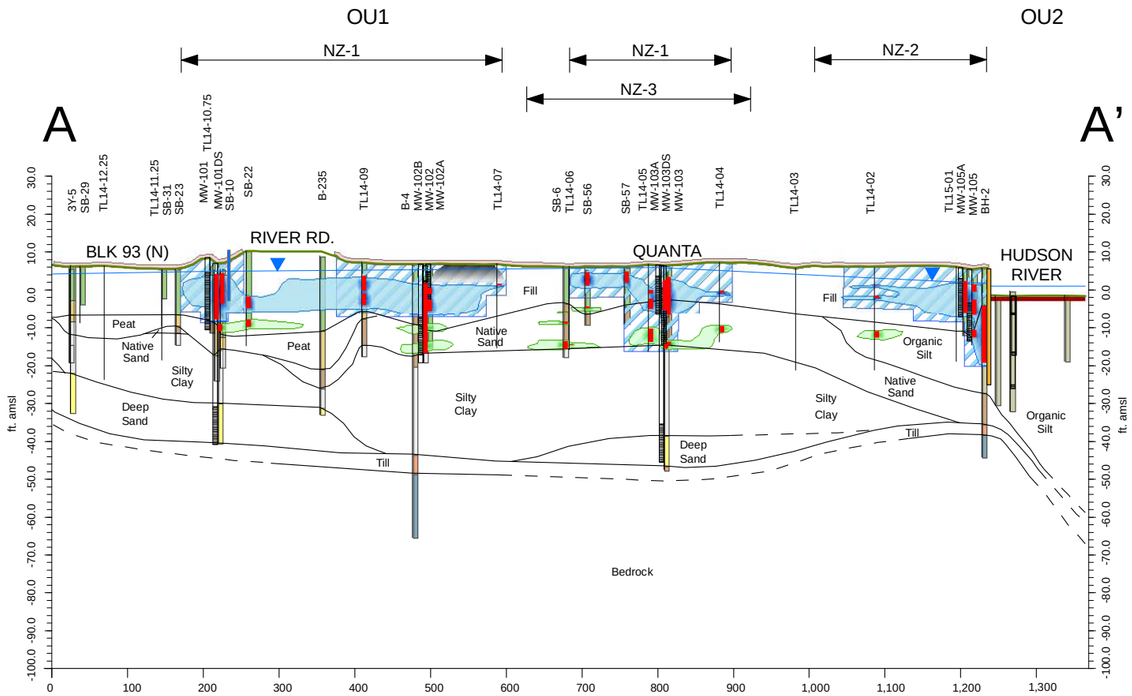
July 6, 2010 | **FIGURE ES-14**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-14_QUANTAOU1_ALT6_NAPL_AND_ARSENIC_EXCAVATION.MXD JHANSEN1 7/7/2010 14:25:10

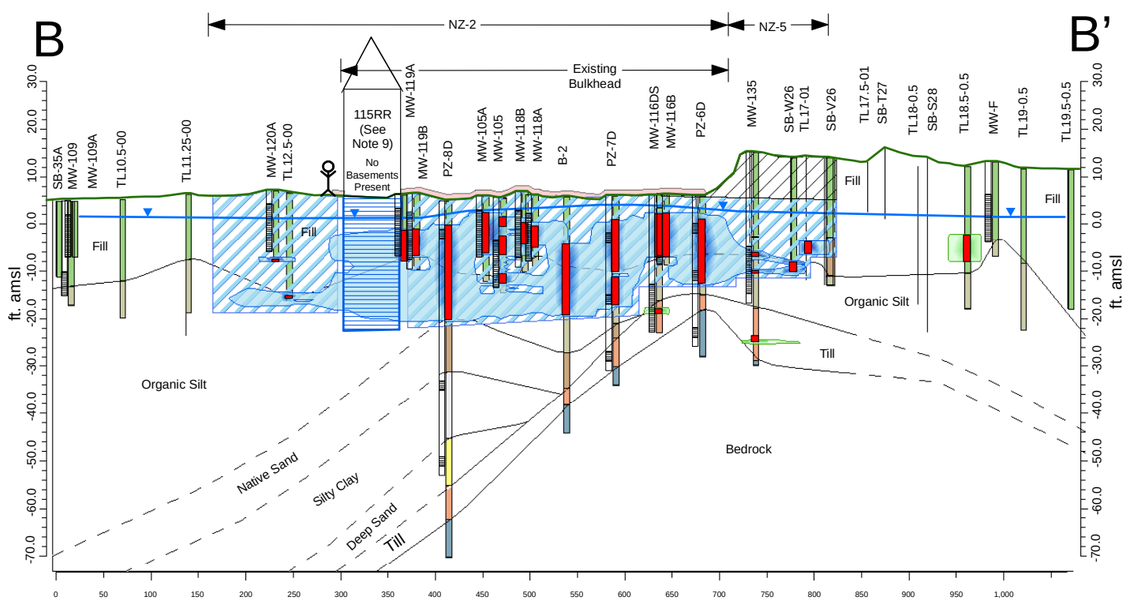
400031

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock



CROSS-SECTION A-A'



CROSS-SECTION B-B'

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Engineered Cap
- Subaqueous Reactive Barrier (SRB)
- Excavation
- Tar Boils
- Material is Removed but not Disposed
- Barrier Wall

Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
7. 115 River Road dimensions are estimated.
8. Configuration of the sheet pile is approximated for visual depiction and will be determined during remedial design.
9. ft. = feet, amsl = above mean sea level

CH2MHILL

ALTERNATIVE 6 - CROSS SECTIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE ES-15**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ES\ES-15_ALTERNATIVE 6 - CROSS SECTIONS.MXD JHANSEN1 7/6/2010 14:09:15

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Abbreviations and Acronyms

µg/L	micrograms per liter
AA	arsenic area
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirement
ASA	arsenic source area
BERA	baseline ecological risk assessment
bgs	below ground surface
BHHRA	baseline human health risk assessment
CEA	Classification Exception Area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CHP	catalyzed hydrogen peroxide
COC	constituent of concern
COI	constituent of interest
cSt	centistoke
DNAPL	dense non–aqueous phase liquid
ELCR	excess lifetime cancer risk
EPA	U.S. Environmental Protection Agency
FS	feasibility study
GAC	granular activated carbon
gpm	gallons per minute
GWQS	groundwater quality standard
HCAA	high-concentration arsenic area
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
IC	institutional control
ISCO	in situ chemical oxidation
LNAPL	light non–aqueous phase liquid
MCL	maximum contaminant level
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
NAPL	non–aqueous phase liquid

NCP	National Contingency Plan
NFA	no further action
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJPDES	New Jersey Pollutant Discharge Elimination System
NJSA	New Jersey Statutes Annotated
NZ	NAPL zone
O&M	operations and maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	operable unit
PAB	permeable absorptive barrier
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POTW	publicly owned treatment works
PPE	personal protective equipment
PRB	permeable reactive barrier
PRG	preliminary remediation goal
psf	pounds per square foot
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act
RI	remedial investigation
ROD	record of decision
S-ISCO™	Surfactant-Enhanced In Situ Chemical Oxidation
SLERA	screening-level ecological risk assessment
SRB	subaqueous reactive barrier
SRI	supplemental remedial investigation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TarGOST®	Tar-Specific, Green Optical Screening Tool (Dakota Technologies, Inc.)
TBC	to be considered
TCLP	Toxicity Characteristic Leaching Procedure
TI	technical impracticability
TMV	toxicity, mobility, or volume
UST	underground storage tank
VI	vapor intrusion
VOC	volatile organic compound

SECTION 1

Introduction

This draft final feasibility study (FS) report for Operable Unit (OU) 1 of the Quanta Resources Superfund Site[1] (Site), located in Edgewater, New Jersey (Figure 1-1), has been prepared in accordance with the requirements of the U.S. Environmental Protection Agency (EPA) Administrative Order on Consent (AOC) II–Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)–2003-2012 for the Uplands Area, OU1 (EPA, 2003). The Site is adjacent to the Hudson River, in Bergen County, in northeastern New Jersey. Surface water and sediment in the Hudson River are considered OU2 and are being investigated pursuant to a separate EPA AOC.

The Site was listed on the National Priorities List on September 9, 2002. In a manner consistent with the OU1 AOC, the site characterization, remedial evaluation, and selection process are being conducted pursuant to the EPA National Oil and Hazardous Substances Pollution Contingency Plan (40 Code of Federal Regulations [CFR] 300), "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (EPA, 1988a), and other relevant guidance stated in this report and listed in Section 6 of EPA (2003).

1.1 Purpose

This report documents the development and evaluation of remedial action alternatives for OU1. The EPA, in consultation with the New Jersey Department of Environmental Protection (NJDEP) and with public input, will use the information in this report to select a remedial action for its record of decision (ROD), in accordance with 40 CFR 300.

The criteria for remedy selections under CERCLA are the following:

- Protect human health and the environment
- Comply with applicable or relevant and appropriate requirements (ARARs) of federal and state environmental laws within a reasonable timeframe
- Be cost-effective
- Use permanent solutions and alternative treatment technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces contaminant toxicity, mobility, or volume (TMV)

The goal of the remedy selection process, as stated in 40 CFR 300.430(a)(1)(i), is to select remedies that protect human health and the environment, maintain protection over time, and minimize untreated waste. The National Contingency Plan (NCP) describes EPA's six

[1] As defined in the Administrative Order on Consent (AOC) II-CERCLA-2003-2012, the Quanta Resources Superfund Site includes the former Quanta Resources property, located on River Road in Edgewater, New Jersey, and any areas where contamination from the property has come to be located. The current Quanta property refers to Block 95, Lot 1, as defined on the Borough of Edgewater, New Jersey, tax map.

expectations for development of remedial alternatives consistent with 40 CFR 300.430(a)(1)(iii)(A–F):

- Use treatment to address the principal threats[2] posed by a site, wherever practicable
- Use engineering controls, such as containment, for waste that poses a relatively low long-term threat or where treatment is impracticable
- Use a combination of methods, as appropriate, to achieve protection of human health and the environment
- Use institutional controls, such as water use and deed restrictions, to supplement engineering controls as appropriate, for short- and long-term management to prevent or limit exposure to hazardous substances, pollutants, or contaminants
- Consider using innovative technology when such technology offers the potential for comparable or superior treatment performance or implementability, fewer or lesser adverse impacts than other available approaches, or lower costs for similar levels of performance, than demonstrated technologies
- Return usable groundwaters to their beneficial uses wherever practicable and within a timeframe that is reasonable given the particular circumstances of the Site

The Office of Solid Waste and Emergency Response (OSWER) Directive No. 9355.7-04 (EPA, 1995) provides additional information for considering current and future land uses during development and selection of remedial alternatives. In addition, EPA has developed nine criteria for evaluating remedial alternatives to ensure that all important considerations are factored into remedy selection decisions. The nine-criterion analysis comprises two steps: (1) individually evaluating each alternative with respect to each criterion and (2) comparing options to determine the relative performance of the alternatives through an evaluation of relative advantages and disadvantages. This analysis is provided in Section 5.

As described in EPA (1988a) guidance and in 40 CFR 300, the FS consists of the development and screening of remedial alternatives and the detailed analysis of selected alternatives. The following steps were used in developing the remedial alternatives for OU1:

1. Identify ARARs
2. Develop remedial action objectives (RAOs)
3. Define remedial action goals, including the following:
   - Developing quantitative preliminary remediation goals (PRGs) using chemical-specific ARARs and human health–based and ecological-based risk levels
   - Identifying areas of constituents exceeding PRGs
4. Develop general response actions
5. Identify and screen technologies (including innovative technologies)
6. Identify and evaluate technology process options
7. Assemble remaining process options into remedial alternatives
8. Evaluate the remedial alternatives in accordance with 40 CFR 300

[2] Defined as described in *A Guide to Principal Threat and Low Level Threat Wastes* (EPA, 1991).

1.2 Report Organization

This report consists of six sections. Section 1 introduces the FS; summarizes background information, such as site physical description, site geology and hydrogeology, nature and extent of contamination, fate and transport of contaminants, and human health and ecological risks; and presents an overall conceptual site model for OU1.

The ARARs, RAOs, and PRGs that are intended to adequately protect human health and the environment are discussed in Section 2. Chemical-specific PRGs were developed for soil and groundwater based on the potential risk associated with the various concentrations of constituents in those media, and ARARs.

Section 3 presents the developed general response actions that address the remedial action goals and introduces the identification and screening of the technology types and process options. Remedial technologies were screened to reduce the number of technologies considered in the detailed alternatives.

Section 4 assembles the remaining technologies into remedial action alternatives that achieve some or all of the remedial action goals and provides a range of levels of remediation and a corresponding range of costs.

A detailed analysis of the remedial alternatives retained after the initial screening is presented in Section 5.

Section 6 includes references used during the preparation of this FS report.

1.3 Definitions

Definitions used throughout this document include the following:

Quanta Property. The land portion of Block 95, Lot 1, in Edgewater, New Jersey.

Former Quanta Resources Property. The land portion of Block 95, Lot 1, and Block 93, Lot 1, as well as the portion of River Road between these lots.

Quanta Resources Superfund Site. As defined in the AOC II-CERCLA-2003-2012, the Quanta Resources Superfund Site includes "the former Quanta Resources Site and any areas where contamination from the Site has come to be located." The Site consists of two operable units, OU1 and OU2. The boundary of OU1 was updated as part of the Supplemental Remedial Investigation (SRI) report (CH2M HILL, 2010a).

Former Barrett Property. The maximum extent of Barrett Manufacturing Company operations as depicted on historical Sanborn® fire insurance maps included in the OU1 Remedial Investigation Report (CH2M HILL, 2008).

Former Celotex Property. The land portion of Block 91, Lot 1 (north of the Quanta property).

Former Acid Plant. A chemical plant that produced acids, alums, sodium compounds, and sulfuric acid (Parsons, 2005) at the former Celotex property and the northwest portion of the current Quanta property from at least 1900 until 1957.

115 River Road Property. The land portion of Block 96, Lot 3.01 (south of the Quanta property).

Former Lever Brothers Property. The land portion of Block 99, Lots 1, 3, and 4 (south of the 115 River Road property).

Block 93. Three separate properties west of River Road:

- Block 93 North, which consists of Lot 1, the northern portion of Lot 2, and Lot 3
- Block 93 Central, which consists of Lots 1.01, 3.03, and 3.04, and the southern portion of Lot 2
- Block 93 South, which consists of Lots 1.02 and 4

Block 94. Block 94, Lot 1, which is west of Block 93 and Old River Road.

NAPL. Non–aqueous phase liquid, or "product." NAPL can exist as a single chemical component or as a mixture of several, and it can exist in soils in free-phase or residual states. Free-phase NAPL moves under the force of gravity and hydraulic forces. Residual NAPL is defined as being immobile when soil capillary forces are greater than gravity and hydraulic forces (Cohen and Mercer, 1993). In this report, the term "NAPL" refers to both free-phase and residual states, unless otherwise noted.

LNAPL. Light non–aqueous phase liquid. LNAPL has a density less than 1.0.

DNAPL. Dense non–aqueous phase liquid. DNAPL has a density greater than 1.0.

Coal Tar. Material characterized by a complex and variable mixture of compounds, typically complex high-molecular-weight hydrocarbons and other byproducts from former manufactured-gas plant operations (Hayes et al., 1996; EPA, 2000). At the Site, coal tar was delivered to the former Barrett property for use by the Barrett Company Shadyside[3] Plant for production of roofing paper and other materials.

Tar "Boils." Solid, black, soft-to-stiff, semiplastic-to-plastic tar in the near-surface vadose zone that has been observed to seep upward to the ground surface through cracks in soil or pavement on very hot days (around 90°F). Once the tar reaches the surface, it either forms a bubble or spreads out laterally in thin layers within the preexisting, hardened tar (from past heating events).

COI. Constituent of interest.[4] A constituent present at concentrations exceeding one or more state or federal screening criteria.

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[3] The Town of Edgewater was formerly known as Shadyside, New Jersey.

[4] COIs were identified in the RI Report (CH2M HILL, 2008) by screening analytical results against the lowest available soil and groundwater screening criteria from among the EPA (2004) Region 9 PRGs (residential soil, industrial soil, and groundwater), proposed New Jersey soil cleanup criteria (residential, nonresidential, and impact-to-groundwater) (New Jersey Administrative Code [NJAC] 7-26D), and promulgated New Jersey groundwater quality criteria (or interim generic values (NJAC 7:9-6). In the follow-up SRI Report (CH2M HILL, 2010a), COIs were identified as above, with the exception that replaced or revised screening criteria were used where appropriate. Specifically, NJDEP promulgated residential and nonresidential soil cleanup criteria and eliminated the impact-to-groundwater soil-cleanup criteria in June 2008. For several constituents, the promulgated residential or nonresidential standard had been revised from the value presented in the draft criteria. The 2004 EPA Region 9 Preliminary Remediation Goals were replaced in September 2008 by the EPA Regional Screening Levels for Chemical

COC. Constituent of concern. Constituent present at concentrations exceeding calculated acceptable risk ranges in the Ecological and Human Health Risk Assessments.

Source Material. Material that includes or contains hazardous substances, pollutants, or contaminants that act as a reservoir for migration of constituents to groundwater, to surface water, or to air, or act as a source for direct exposure (EPA, 1991).

High-Concentration Arsenic Area. The high-concentration arsenic area (HCAA) is defined by the extent of the impermeable arsenic liner on the former Celotex property, which was originally designed and built to cover concentrations of arsenic in soil in excess of 1,000 milligrams per kilogram (mg/kg).

Principal Threat Waste. Source material considered highly toxic or highly mobile that generally cannot be reliably contained and that would present a significant potential risk to human health or the environment should exposure occur (EPA, 1991). "Highly mobile" refers to source material that is not reliably contained and has a significant potential to migrate to surface water, to sediments, or to air or to act as a source for direct exposure. Highly toxic source material represents a significant potential risk based on the characteristics of the material and based on the exposure potential of the material (e.g., greater than 10^{-3} excess lifetime cancer risk, or ELCR).

Low-Level Threat Waste. Source material that generally can be reliably contained and that would present only a low-level potential risk in the event of release. It includes source materials that exhibit low toxicity or low mobility in the environment, or are near health-based levels.[5]

Residual Soil. Soil within the boundary of OU1 that contains constituents at concentrations exceeding one or more PRGs but not considered principal threat waste or source material.

1.4 Site Setting and Background

OU1 consists of the current Quanta property (Block 95, Lot 1), the 115 River Road property to the south, and the following additional areas:

- The former Celotex property to the north
- The former Lever Brothers property to the south
- River, Old River, and Gorge Roads to the west
- Blocks 93 North, Central, and South to the west
- Block 94 to the west
- Block 92.01 to the northwest

Figure 1-2 shows the extent of OU1. The total land area of OU1 encompasses approximately 24 acres. OU1 includes the observed extent of Site-related NAPL and constituents detected in soil and groundwater related to former operations, plus the HCAA. A tidally influenced mud flat–marsh associated with the Hudson River borders OU1 immediately to the east of the wooden bulkhead. These river sediments, which consist of silt to clayey silt greater than 50 ft

Contaminants at Superfund Sites. SRI groundwater data was also screened against EPA Maximum Contaminant Levels (MCLs) for drinking water (EPA, 2002).

[5] OSWER Directive 9380.3-06FS.

thick, and the surface water compose OU2 and are being evaluated and addressed under a separate AOC.

Prior to the mid-1800s, the Site and surrounding areas were tidal marshlands associated with the Hudson River. Development of rail lines and industry along the banks of the Hudson River prompted the systematic filling in of these marshlands. Fill material during this timeframe is known to have contained coal, coal ash, wood ash, cinder, and slag. This fill material contains varying concentrations of polycyclic aromatic hydrocarbons (PAHs) and heavy metals in concentrations that often exceed regulatory soil cleanup criteria and contribute to the presence of constituents in groundwater.

From approximately 1872 to 1971, a large portion of the Site was used to process coal tar and to produce paving and roofing materials.

The former Celotex property, to the north, has been the site of a chemical plant, a gypsum company, a vacuum truck company, and a metal reclaiming/refinishing plant. The chemical plant, General Chemical Company, operated on the southern portion of the property from at least 1900 until 1957. The chemical plant was used to produce acids, alums, sodium compounds, and sulfuric acid (Parsons, 2005). In 1974, a portion of the Site was reoccupied and leased for oil recycling, which continued until NJDEP stopped all activities in 1981 when it discovered that storage tanks contained waste oil contaminated with polychlorinated biphenyls (PCBs). Afterward, aboveground and underground storage tanks were removed, and the site has remained vacant since.

1.5 Site Geology, Hydrogeology, and Hydrology

1.5.1 Geology

Soil impacted by former Site operations consists predominantly of fill material and deposits of native sand, peat, and organic silt in contact with shallow groundwater. With the exception of areas to the north, where a bedrock high is present, these units are underlain by a silty-clay confining layer at a depth of approximately 7 to 80 ft below ground surface (bgs), ranging in thickness from 2 to 35 ft. South of the bedrock high, a confined, water-bearing "deep sand" unit lies between the aquitard (confining unit) and the bedrock or glacial till surfaces. This deeper sand unit is approximately 7 to 32 ft thick and slopes downward to the south and east away from the bedrock high.

1.5.2 Hydrogeology

Although historical groundwater flow paths may have differed from those observed during the remedial investigation (RI) and the SRI, the direction of the shallow unconfined groundwater flow is generally to the east and south, with an area of radial flow on the Quanta property. Evaluation of groundwater elevation data indicates that the direction of the shallow groundwater is predominately to the southeast, under an average hydraulic gradient of 0.0068 ft/ft during low-tide conditions and 0.0066 ft/ft during high-tide conditions. Flow direction remains consistent between daily tidal events (low and high tides); however, the hydraulic gradient is slightly steeper during low-tide conditions.

A tidal response has been observed in monitoring wells adjacent to the Hudson River north and south of the area of the wooden bulkhead, which impedes groundwater flow on the

Quanta property. Leakage has been observed across the bulkhead during low tide. In addition, lower hydraulic heads at select wells adjacent to the bulkhead and indications of groundwater upwelling in sediments suggest groundwater leakage may be occurring across the structure. However, a geophysical survey has indicated that, below the water table and mean surface water level, the bulkhead's boards are relatively competent.

Most groundwater at the shoreline flanks the bulkhead to the north and south before moving into the sediments at OU2 and eventually upwelling to the surface water at OU2 in zones of preferential discharge identified during the SRI. Tidal influences on the shallow and deep sand hydrostratigraphic units decrease westward from the Hudson River.

The radial groundwater flow pattern in shallow unconfined groundwater is the result of localized recharge associated with low-lying unpaved areas in the central portion of the Quanta property, where less-permeable peat deposits slow the percolation of rainwater. The wooden bulkhead impedes groundwater flow to the Hudson River from OU1, along with the bedrock high at the former Celotex property, driving a southerly component to flow.

South of the Site, an area of groundwater convergence has been observed consistently near the central to northern portion of the former Lever Brothers property, which is believed to be the result of remnant stream channels that were shaped by the bedrock topography. At this location, shallow unconfined groundwater from the central portions of the former Lever Brothers flows to the northeast and converges with groundwater flowing from the Quanta property and from Block 93. This interpretation has been confirmed by data collected as part of environmental investigations at the former Lever Brothers property (GZA, 2008).

Groundwater within the deep sand hydrostratigraphic unit flows uniformly east-southeast, and the hydraulic heads measured within this unit are more readily influenced by tidal conditions than are those in the shallow hydrostratigraphic unit. Hydraulic heads in the deep sand unit are consistently higher than those observed in collocated wells screened at the base of the unconfined shallow groundwater zone. The vertical hydraulic gradients measured between the unconfined and deep sand units remain upward during high- and low-tide conditions and confirm that the two units are not connected hydraulically. The reported hydraulic conductivity values for samples collected from the silty clay interval between the two sand units ranged from 4.06×10^{-7} cm/s to 8.19×10^{-8} cm/s. The low-permeability values of these undisturbed samples support the classification of the silty-clay interval as an aquitard, preventing Site-related constituents from permeating through the unit to the deep sand.

1.5.3 Hydrology

Although OU2 is being investigated pursuant to a separate AOC, mitigating any risk posed by potential constituent flux from groundwater (OU1) to surface water (OU2) is a critical element of remedial goal development for OU1. The presence of a wooden bulkhead along the shoreline largely affects groundwater flow to OU2. This structure impedes groundwater flow, causing groundwater flowing eastward to flow north and south once it reaches the shoreline. However, flow does occur across it to some degree, particularly in the southern end and at discrete areas along its length. Once groundwater moves from OU1 to OU2, it is driven upward through the sediments and discharges to surface water at OU2. Areas of potential groundwater upwelling have been identified in OU2 north of and immediately east of the bulkhead along the shoreline. Further south, beyond the bulkhead, upward

forces of groundwater flow are not as pronounced. In this area, vertical gradients are more subdued and generally flat, and groundwater discharge occurs slightly farther offshore.

1.6 Conceptual Site Model

1.6.1 Sources

Sources of Site-related constituents were identified and characterized during the OU1 RI (CH2M HILL, 2008). The primary sources of these constituents are no longer present except for material that may be contained within piping buried on the Quanta property. Historical operations with which the sources were associated include coal-tar-processing operations and, subsequently, oil-recycling operations. A former acid plant, located on the northern portion of the Quanta property and the southern portion of the former Celotex property, contributed to the presence of unburned or partially burned pyritic ore remnants in soil that represent a secondary source of inorganic constituents in soil, particularly arsenic.

As a result of historical Site activities, secondary sources remain at the Site today in the form of NAPL; solid tar; and soil containing PAHs, non-PAH semivolatile organic compounds (SVOCs), aromatic volatile organic compounds (VOCs), and other constituents. Additional secondary sources of NAPL and sediments containing similar compounds exist within the nearshore sediments at OU2. Although pipes of various sizes and construction materials exist in the subsurface at OU1, none of the pipes investigated are acting as preferential pathways for the offsite migration of NAPL or other COCs beyond OU1 (CH2M HILL, 2008, 2010a).

Before 1985, when initial removal actions were proposed, the property had 61 aboveground storage tanks, an unknown number of underground storage tanks, and underground piping. The total storage capacity of the tanks was over 9 million gallons of "oil, tar, asphalt, sludge, process water, and other unknown liquids" (EPA, 2003).

Additional secondary sources of groundwater and soil constituents unrelated to historical operations associated with OU1 or the former acid plant operations but within OU1's lateral extent[6] include the following:

- LNAPL and petroleum impacts in the northeast corner of the former Lever Brothers property
- A small area of pyritic material with elevated concentrations of arsenic, iron, sulfate, and other inorganics within the fill in the northern portion of the former Lever Brothers property
- An unidentified upgradient source of chlorinated solvents to shallow upgradient groundwater and deep sand groundwater beneath the Site
- PCBs in soil on adjacent properties

[6] COIs present within the extent of OU1 as a result of these non-site-related sources are not specifically targeted by the remedial alternatives evaluated in this FS but may be mitigated by proposed actions if they are implemented in the same location.

1.6.2 Nature and Extent

To develop a comprehensive understanding of the nature and extent of Site-related constituents and to define the boundaries of OU1, the RI report (CH2M HILL, 2008) and final SRI report (CH2M HILL, 2010a) compiled data from approximately 3,980 soil analyses, 72 groundwater-monitoring locations, NAPL fingerprinting and physical characteristics analyses, TarGOST® (Tar-Specific, Green Optical Screening Tool; Dakota Technologies, Inc.) coal tar delineation (Figure 1-3), soil vapor analyses, indoor/outdoor air analyses, and building surveys.

Additional data were also collected at and downgradient of the shoreline to determine the role of the wooden bulkhead and the movement and distribution of Site-related constituents relative to OU2. Specifically, a groundwater–surface water interaction study was conducted at OU2 that involved the identification of preferential upwelling zones and subsequent sampling of pore water and surface water. Geophysical survey data were collected to determine the depth and breadth of the wooden bulkhead, and five sets of nested piezometers were installed for the collection of hydraulic head data and additional deeper pore water sampling.

The extent of NAPL was defined on the basis of the comprehensive RI and SRI data sets, and specific COIs were identified for soil and groundwater by screening analytical results against the lowest available soil- and groundwater-screening criteria from EPA and NJDEP. The location, nature, and extent of free and residual NAPL at OU1 have been characterized, and appropriate data evaluations have been performed to support remedy decisions.

Nature and Extent of NAPL and Solid Tar

The location, nature, and extent of free and residual NAPL at OU1 have been characterized using analytical data and field observations and refined through TarGOST®. The extent of solid tar has been defined through field observations. Residual and free-phase NAPL occur in shallow soils in discrete areas above the silty-clay confining layer that generally correspond with locations of former primary sources (e.g., historic tank farms). Impacts extend beyond the lateral extent of NAPL in the form of staining or odors, as shown in Figure 1-2, and as adsorbed and dissolved-phase aromatic VOCs and SVOCs (predominantly PAHs) in soil and groundwater. A detailed description of these impacts is included in the final SRI report (CH2M HILL, 2010a).

NAPL is present primarily in the form of residual and free-phase DNAPL, which is denser than water. Depictions of NAPL show that it is consistent with the locations of former tanks depicted in historical maps (CH2M HILL, 2010a). NAPL is present in shallow soils in discrete discontinuous areas within and above the silty-clay confining layer overlying the deep sand unit or in the fill, native sand, or organic silt above the bedrock high to the north where the silty clay is not present. NAPL has accumulated in natural depressions in the surface of the silty clay confining unit or the surface of the shallower peat deposits to the west, except in those areas where it remains hung up around the water table due to elevated viscosities and interfacial tensions preventing further downward migration.

Physical Properties of NAPL. With the exception of LNAPL at MW-7 on the former Lever Brothers property,[7] NAPL samples collected were identified through chemical analysis as consisting, at least partially, of coal tar. Variances in the physical properties of the NAPL samples suggest that they have varying degrees of mobility in the subsurface under current conditions. With the exception of the NAPL detected to the south at monitoring well MW-107 and to the north along the shoreline at MW-135, the NAPL at OU1 has relatively elevated measured viscosity and interfacial tension, indicating a lower propensity to migrate. These data support observations that indicated that NAPL at select monitoring wells was "thick" and difficult to penetrate with sampling and measurement devices.

Solid tar has been observed in several soil borings at the Site, most frequently in the form of a black, soft to stiff, semiplastic to plastic material.

Extent of NAPL. Extensive characterization has revealed that most NAPL at the Site is present in one of six discrete NAPL zones (NZs). The NAPL zones are depicted in Figure 1-4. Although the NAPL in each of these zones is composed primarily of coal tar, each zone's NAPL has distinct physical characteristics. NAPL also exists outside these defined zones but is generally characterized by the presence of residual NAPL only, or thin, discontinuous pockets of free-phase NAPL that are not contiguous with the defined NAPL zones.

NAPL is found within the lateral extent of the current Quanta property and extends west across River Road and onto the eastern portions of Block 92.01 and Blocks 93 North, Central, and South. Site-related NAPL also extends southward into the northern and central portions of the former Lever Brothers property. To the east, on the Quanta property, NAPL is found in significant thicknesses adjacent to the wooden bulkhead, from which it appears to have moved laterally to the south and north along this feature in deeper and thinner lenses. South of 115 River Road, along the shoreline, Site-related NAPL appears to be residual only and is close to non-site-related NAPL and constituents in soil associated with historical operations at the former Lever Brothers property. To the north, free-phase NAPL along the shoreline has been found to accumulate within monitoring well MW-135. Most occurrences of solid tar have been observed in the fill deposits at the Quanta property and to the west, at Block 93 North. Solid tar was found within fill material in only one boring on Block 94, confirming that Site-related NAPL does not extend to Block 94. Based on field investigations conducted to date at the Site, surficial tar boils typically occur in areas that coincide with solid tar.

NAPL Zone 1. NZ-1 is present in the southern portion of the Quanta property and west beneath River Road into the eastern portions of Blocks 93 North and Central. It extends south into the 115 River Road property and into a limited area along the northern boundary of the former Lever Brothers property. In NZ-1, high viscosity and interfacial tension and the presence of less-permeable meadow mat deposits have generally limited the downward vertical migration of NAPL, confining it to within the fill layer near the water table. Most of NZ-1 is at a depth of approximately 11 ft bgs, with NAPL between 3 and 11 ft east of River Road, and between 1 and 12 ft bgs beneath Blocks 93 North and Central. NAPL is present between 6.5 and 20 ft bgs beneath River Road. In an isolated area (the vicinity of MW-102B and SB-9), NAPL has migrated to the depth of the silty-clay confining unit, approximately

[7] As discussed in the RI Report (CH2M HILL, 2008), LNAPL from MW-7 is considerably different than the NAPL samples in the remaining monitoring wells.

23.5 ft bgs, which corresponds to the location of a former coal tar underground storage tank (UST) and a localized area of thicker fill deposits.

NAPL Zone 2. NAPL in NZ-2 is present along the Site shoreline, from the northern Quanta property boundary southward, beneath the 115 River Road building, and into portions of the northeast corner of the former Lever Brothers property. It extends approximately 250 ft inland westward and is bound at the east by the shoreline. NAPL at NZ-2 is not homogeneous; it has been found to have varying physical characteristics, which indicates portions of the NAPL have limited potential for migration. NAPL in this zone extends throughout the fill unit and into the upper portions of the organic silt deposits with sporadic occurrences within the underlying till to the north. Its migration has been limited to between approximately 4 and 25 ft bgs; however, the bulk of the NAPL at NZ-2 is above a depth of approximately 15 ft bgs. The wooden bulkhead along the shoreline has impeded the flow of NAPL to OU2, causing it to seep laterally north and south beyond the extents of the bulkhead.

NAPL Zone 3. NZ-3, extending from the central portion of the Quanta property south into the former Lever Brothers property, is beneath NZ-1; it extends laterally beyond the extent of this shallower NAPL zone from a depth of approximately 15 ft bgs to a few feet into the top of the silty-clay confining unit at approximately 22 to 25 ft bgs. Due to its lower interfacial tension (8.2 dynes/cm^2) and viscosity (3.49 centistokes (cSt)), NAPL in NZ-3 is has migrated downward and laterally to a natural depression in the top of the undulating silty-clay confining unit, which is limiting further migration. Its presence as thin, discontinuous lenses southeastward indicates that under current conditions, NAPL at NZ-3 is not migrating beyond the natural depression in the top of the silty-clay confining unit.

NAPL Zone 4. NZ-4 consists of NAPL beneath the northwestern portion of the former Lever Brothers property and across River Road into Blocks 93 Central and South. NAPL in NZ-4 is present in two separate layers, one between approximately 10 and 15 ft bgs and the other between approximately 20 and 32 ft bgs. The first lens occurs mostly in the fill layer or into the top few feet of the peat unit. The second lens penetrates the peat near MW-123 but is sporadic and discontinuous. Interfacial tension (16.65 dynes/cm^2) and viscosity (13.1 cSt at 122°F) of this NAPL are similar to that of NAPL in NZ-2 at MW-116B. NAPL saturation in the vicinity of MW-123 is likely elevated, based on the presence of 14.2 ft of NAPL in this well. In all directions along the periphery of NZ-4 a consistent rise in the elevation of the peat and silty clay is present preventing further lateral migration.

NAPL Zone 5. NAPL at NZ-5 is adjacent to the Hudson River in the southeastern portion of the former Celotex property, from the shoreline up to 130 ft inland to the west and 120 ft north of the Quanta/former Celotex property boundary. It is present at depths of up to 40 ft bgs, with the majority residing between 20 and 25 ft bgs, at the interface between the fill and soft organic silt units. The interfacial tension and viscosity of a NAPL sample collected from MW-135 is the lowest for all NAPL samples from the Site, with the exception NAPL at MW-107 in NZ-3 indicating that it has the potential for mobility. NAPL zones NZ-2 and NZ-5 are connected, with NZ-5 being present as thinner deposits and at a lower saturation levels than NAPL behind the bulkhead at NZ-2 to the south. NAPL zones NZ-2 and NZ-5 are at the same elevation; although NZ-5 has had approximately 10 ft of fill material and asphalt placed over it during redevelopment of the former Celotex property.

NAPL Zone 6. NAPL Zone 6 comprises NAPL observed at the intersection of Gorge and River Roads, from the northeast corner of Block 93 North, the southwest corner of the former Celotex property, the northwest corner of the Quanta property, and the southeast corner of Block 92.01. It is present at depths ranging from 8.4 to 15 ft bgs just beneath the water table. NAPL observed at a depth of 8.4 ft bgs in a single monitoring well (MW-N1) represents an isolated occurrence not representative of the elevation of the majority of the NAPL found in this zone. Most NAPL in this zone is found at 10 ft bgs. The NAPL remains at least 10 ft above the surface of the silty-clay between the fill and underlying native sand or peat. Its failure to accumulate in MW-126, which is screened within the most NAPL-impacted interval observed within NZ-6, suggests that NAPL saturation levels in this area are lower than in other NAPL zones. A natural depression in the silty clay surface in this portion of the Site underlies NZ-6.

Solid Tar and Tar Boils. Solid tar has been observed in several soil borings at the Site, most frequently in the form of a black, soft-to-stiff, semiplastic-to-plastic material at discrete depth intervals, with a thickness ranging from 0.3 ft to approximately 6 ft. Most solid tar has been observed in the fill deposits at the Quanta property and to the west, at Block 93 North. Solid tar was found within fill material in only one boring on Block 94, confirming that Site-related NAPL does not extend to Block 94. Based on field investigations conducted to date at the Site, surficial tar boils, as depicted in Figure 1-4, typically occur in areas that coincide with solid tar.

Nature and Extent of COIs in Soil

COIs detected in soil include aromatic VOCs, SVOCs (predominantly PAHs), and metals (principally arsenic and lead). COIs identified less frequently include chlorinated VOCs, pesticides, and PCBs.

VOCs and SVOCs. Soil-sampling events conducted in and around the Site have indicated the presence of PAHs in unsaturated and saturated soil. PAHs were not detected above screening criteria in soil samples collected from the deep sand unit beneath the silty-clay aquitard. Exceedances of aromatic VOCs, particularly benzene, in unsaturated soils appear to lie within the extent of the historical Site operations, whereas the extent of benzene in saturated soil extends slightly farther south, outside the footprint of former operations, in the direction of groundwater flow.

In general, the distribution of PAHs, aromatic VOCs, and other NAPL-related constituents (e.g., select non-PAH SVOCs) was observed to be coincident with the presence of NAPL. However, concentrations of PAHs unrelated to former Site operations have also been observed consistently above screening criteria outside these areas. These concentrations are due to the presence of ubiquitous fill material throughout the area and south of OU1 and as a result of historical operations at the former Lever Brothers property.

Chlorinated VOCs were detected intermittently in soil samples—predominantly in saturated soil samples—across the Site during RI and SRI investigation activities. Chlorinated VOCs were detected less frequently in soil at the Quanta property than at the adjacent properties, with the majority of the detections in soils at the former Lever Brothers and former Celotex properties. The infrequent and low-level detections along with the irregular distribution of chlorinated solvents in soil suggest that no known, ongoing, Site-related source of these constituents exists.

Inorganics. The distribution of metals is consistent with areas of former pyrite roasting associated with the former acid plant. However, concentrations of metals unrelated to operations associated with the former acid plant have been observed consistently above screening criteria outside these areas because of the ubiquitous heterogeneous fill containing coal, cinders, and slag.

The extent of elevated arsenic concentrations in soil near the site of the former acid plant has been defined and does not extend beyond the southern portion of the former Celotex property and the northwestern corner of the Quanta property. During the SRI, a separate and much smaller source of elevated metals concentrations exhibiting a pyritic-material signature was identified in the shallow fill in the north-central portion of the former Lever Brothers property. Elevated arsenic concentrations in soil outside these two pyritic source zones—with the possible exception of an isolated area of elevated arsenic concentrations adjacent to the Hudson River in the southern part of the former Celotex property that may have resulted from the historic transport of arsenic from the HCAA in groundwater and its subsequent readsorption to soils downgradient—are associated with isolated hotspots in the heterogeneous anthropogenic fill material. These fill materials also contain concentrations of PAHs above screening criteria.

Beyond the pyritic source zones, the extent and distribution of lead in soil has been defined and is different than that of arsenic (Figures 1-5 and 1-6). The distribution of lead is more widespread at the former Celotex property.

Pesticides and PCBs. Pesticides in soil within OU1 represent isolated, noncontiguous release scenarios that are the likely result of the historical use of pesticides. Detected concentrations of PCBs in soil above the EPA Regional Screening Level of 0.22 mg/kg occur in contiguous areas on the western portion of OU1. The detected PCB concentrations above the screening criteria occur primarily in the vadose zone; detected PCB concentrations exceeding applicable screening criteria in the saturated zone deeper soils are limited and are present in five sample locations in four isolated areas.

Nature and Extent of COIs in Groundwater

COIs identified in groundwater consist primarily of SVOCs (predominantly PAHs), aromatic VOCs, metals (e.g., arsenic, lead, iron), ammonia, and, to a lesser extent, chlorinated VOCs, pesticides, and PCBs. The extent of Site-related constituents in groundwater includes areas on the Quanta property; 115 River Road; the former Lever Brothers property; the former Celotex property; Blocks 93 North, Central, and South; Block 94; and Block 92.01 (Figures 1-7 through 1-10). Additional, non-site-related constituents in groundwater that include PAHs, VOCs, and metals are present beyond OU1, in the northeast corner of the former Lever Brothers property and farther south beyond the zone of groundwater convergence. At the convergence zone, shallow unconfined groundwater from the central portions of the former Lever Brothers flows to the northeast and converges with groundwater from the Quanta property. This area of convergence coincides with a pair of west-to-east-trending storm drain lines that outfall to the Hudson River near the area where the convergence feature typically is observed.

VOCs and SVOCs. Naphthalene and benzo(a)pyrene were selected as representative PAHs at OU1. Naphthalene in groundwater extends farther downgradient from known areas of NAPL than does benzo(a)pyrene. In general, naphthalene in groundwater covers an area similar in

shape and slightly greater than the portion of the OU1 in which evidence of NAPL has been identified (except where offsite sources of naphthalene are present). Similarly, the extent of dissolved-phase benzo(a)pyrene is limited to within the total lateral extent of NAPL—again, with the exception of areas where offsite sources are present.

With the exception of naphthalene, the presence of dissolved-phase PAHs exceeding applicable screening criteria was not found in monitoring wells screened in the deep sand unit, indicating that most dissolved-phase PAHs are confined to the shallow fill and native sand deposits above the silty-clay aquitard.

The extent of non-PAH SVOCs at OU1 are similar to the extent of PAHs. Non-PAH SVOCs at OU1 consist primarily of phenolics (e.g., phenol and 2,4-dimethylphenol), dibenzofuran, and carbazole. Non-PAH SVOCs exceeded the applicable groundwater-screening criteria in a lower percentage of RI and SRI groundwater samples than PAHs and are found primarily in the central portions of the Site. Non-PAH SVOCs do not extend beyond the footprint of the naphthalene plume.

The distribution in groundwater of benzene, a representative aromatic VOC, is consistent with the known distribution of Site-related NAPL. However, with a greater solubility in groundwater and a lower screening criterion, benzene exceedances in groundwater extend farther hydraulically downgradient of NAPL source material than naphthalene. The footprints of other Site-related VOCs in groundwater at OU1 are located within the lateral extent of benzene.

Chlorinated VOCs were detected at their highest concentrations in the deep sand groundwater and in shallow groundwater upgradient of Site-related constituents in groundwater (e.g., aromatic VOCs, PAHs, and non-PAH SVOCs) at the foot of the Palisades. The lateral and vertical distribution of these compounds throughout the Site, as well as the relationship of hydraulic heads between the shallow unconfined and deep sand units, indicates that the source of these chlorinated VOCs is not the result of a release or releases related to Site-specific historical operations.

Inorganics. Inorganic constituents are present throughout the Site, with arsenic being the most widespread. Due to the presence of arsenic in soil and groundwater across the Site and at adjacent properties, above the applicable soil standards as a result of the ubiquitous presence of historic fill, the SRI focused on identifying soils that represented sources of arsenic to groundwater. Based on comprehensive evaluation of geochemistry and arsenic phase associations four areas were identified in the final SRI report (CH2M HILL, 2010a) as ongoing sources to groundwater (arsenic source area (ASA)-1, ASA-2, ASA-3, and the HCAA).

Due to differences in the nature and extent of the pyritic sources versus those of the regional fill material, and because lead, unlike arsenic, is not redox sensitive and is expected to be relatively immobile at the Site, the distribution of dissolved lead in groundwater is distinctly different than that of arsenic and iron. Thus, the portions of the Site where lead concentrations are greater than the N.J. Groundwater Quality Standard (GWQS) of 5 µg/L are almost exclusively within the footprint the former acid plant (Figure 1-10). This is due to the specific geochemical environment found here because of the acid generation caused by

the leaching of the pyritic material and the relative strength of the source material in the HCAA compared to other areas.

Ammonia, a byproduct of coal-tar distillation, was stored at the Site during historical coal-tar operations, but its distribution systems (i.e., piping systems) and potential use in manufacturing are not known. Ammonia concentrations above the lowest screening criterion cover most of the Site, as described in the final RI report (CH2M HILL, 2008). However, exceedances do not extend downgradient as far as the Hudson River. The distribution of ammonia concentrations observed in groundwater is consistent with the location of previous storage areas as identified in historical maps, suggesting the source of these detected constituents is related to the former coal tar operations.

Pesticides and PCBs. Groundwater-sampling results indicate that low concentrations of pesticides were detected within the interior portions of the Quanta property. These concentrations represent isolated, noncontiguous groundwater concentrations that are the result of the historical use of pesticides. The PCB Aroclor-1260 was detected at one location in the central portion of the former Celotex property (monitoring well MW-J) during RI groundwater-sampling activities. Because PCBs adsorb strongly to soils and have not been detected in groundwater between the Quanta property and MW-J, this observed concentration is not considered related to Site operations.

1.6.3 Fate and Transport

Relevant fate and transport processes controlling the migration of constituents at the Site have been evaluated and are understood sufficiently to allow the development of remedial alternatives.

Fate and Transport of NAPL

The potential for NAPL migration varies among the six defined discrete NAPL zones on the basis of the varying physical characteristics (e.g., viscosities, densities, and interfacial tensions) of NAPL samples collected across these areas as well as the physical characteristics of the subsurface. NAPL migration under current conditions has been evaluated for each of six NAPL zones (shown in Figure 1-4):

NAPL Zone 1. High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to a depth of 11 ft bgs. At an isolated area (the vicinity of MW-102B and SB-9), NAPL has migrated to the depth of the silty-clay confining unit, approximately 23.5 ft bgs. Historical Sanborn maps and a greater thickness of fill indicate that disturbances of subsurface soils likely occurred here during the installation and/or removal of a former UST, which resulted in the presence of localized deeper NAPL here. Further migration of NAPL in this zone is not predicted to occur, based on the physical characteristics of the NAPL and the likely age of the release(s) that resulted in the presence of NAPL here. In the vicinity of MW-102B and SB-9, further migration is prevented by the presence of the silty-clay confining unit.

NAPL Zone 2. NAPL viscosities span a wide range, and thicknesses measured in several wells indicate elevated NAPL saturation levels. These factors, along with the dip of stratigraphic units eastward, suggest that at least a portion of the NAPL at NZ-2 is characteristically mobile. The bulkhead along the shoreline extends below the base of all

observed NAPL at NZ-2 and is a significant impediment to NAPL migration; however, it is not a complete barrier. The presence of NAPL in nearshore sediment and at similar elevations in OU1 and OU2 are evidence that NAPL has moved and may continue to move from OU1 to OU2. NAPL has also flanked the bulkhead toward the north and south, with more mobile forms migrating toward NZ-5 in the north, where heavy sheening is observed along the shoreline. To the south, NZ-2 NAPL is currently immobile, as indicated by the absence of measurable thickness in wells screened across NZ-2 in this area. Downgradient of the Site, additional secondary sources of NAPL exist within the nearshore sediments at OU2 as a result of the migration of NAPL and NAPL constituents from OU1 as well as from historical releases that occurred directly to OU2. The remedial alternative development, evaluation, and selection presented in this FS address the potential for migration to occur at NZ-2. The remedy will be designed to account for the present and future uncertainty surrounding nearshore processes.

NAPL Zone 3. This NAPL zone consists of deeper NAPL in the central portion of the Quanta property and extending across the 115 River Road property onto the northern portion of the former Lever Brothers property. NAPL in NZ-3 has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 ft bgs. Gravitational forces and the impermeability of the confining layer significantly limit the lateral migration of the limited quantity of NAPL in this zone. Historic geotechnical borings completed in the northern portion of the former Lever Brothers property indicate that the silty-clay unit dips south and east beyond where NAPL is present as thin and discontinuous lenses.

NAPL Zone 4. NZ-4 consists of deeper NAPL beneath Blocks 93 Central and South, River Road, and the northwestern portion of the former Lever Brothers property. NAPL in NZ-4 is present in two separate layers, one between approximately 10 and 15 ft bgs and the other between approximately 20 and 32 ft bgs. Potential migration of NAPL in NZ-4 is unlikely due to elevated viscosity and interfacial tension. The peat and depression in the silty-clay surfaces in the area provide a barrier to further vertical and lateral migration.

NAPL Zone 5. NZ-5 is adjacent to the Hudson River at depths of up to 40 ft bgs, with the majority residing between 20 and 25 ft bgs, at the interface between the fill and soft organic silt units. Although it is present in reduced thicknesses compared to the NAPL at NZ-2 to the south, it has been found to accumulate in monitoring well MW-135. The downward-sloping contact between the fill material and the underlying organic silt as well as the physical properties of NAPL suggest that portions of NZ-5 NAPL are characteristically mobile. The absence of the wooden bulkhead and the presence of NAPL at similar elevations in sediment at adjacent nearshore areas of OU2, in addition to the consistent presence of sheens in these areas, also suggest that NZ-5 NAPL should be considered mobile. Downgradient of the Site additional secondary sources of NAPL exist within the nearshore sediments at OU2 as a result of the migration of NAPL and NAPL constituents from OU1 as well as from historical releases that occurred directly to OU2. The remedial alternative development, evaluation, and selection presented in this FS address the potential for migration to occur at NZ-5. The remedy will be designed to account for the present and future uncertainty surrounding nearshore processes.

NAPL Zone 6. NAPL was observed in borings completed within the intersection of Gorge and River Roads just below the water table at depths ranging from 8.4 to 15 ft bgs. Its inability to accumulate in MW-126 and MW-N-2 has not allowed for a determination of its physical characteristics but suggests that NAPL saturation levels here are lower than those observed at other NAPL zones. Thin "stringers" of NAPL may connect NZ-6 to portions of NZ-1 in the northwest corner of the Quanta property, but due to the raised elevation of River Road and Block 92.01, NZ-6 resides at a greater depth below grade, and the lateral extent is limited to the footprint of the former tank farm in this area; therefore NZ-6 and NZ-1are being considered separately. The vertical extent of NZ-6 is limited to the interface of the fill and underlying native sand and peat deposits. If further vertical migration of NZ-6 were to occur, it would be physically contained by natural depressions in the silty-clay surface.

Tar Boils. Tar boils occur during the summer months when solid, taffylike tar in the near subsurface vadose zone is heated by the sun and/or ambient air temperatures, and seeps through surface cracks in soil or pavement. A visual "boil," or bubbling, of the material has been observed only on very hot days (at or around 90°F) at the Site. Once the tar reaches the surface, it either forms a bubble or spreads out laterally in thin layers within the preexisting, hardened tar (from past heating events). The lateral extent of the boils is generally less than 10 ft along their longest axis and less than 1 inch thick. The tar boils observed at the Site represent a localized mechanism for upward transport of NAPL onto the surface. Beyond localized surface exposure, the boils do not measurably contribute to the overall lateral or vertical movement of Site constituents in either soil or groundwater at the Site.

The potential for altering subsurface conditions that play a role in NAPL mobility is an important consideration for the Site. The effects of future development activities, such as excavating or placing fill material, placing subsurface structures, or pumping groundwater should be considered when specific development plans have been defined.

Fate and Transport of Constituents of Interest in Soil

Two major mechanisms exist for the transport of constituents in soil at the Site: leaching and volatilization. Erosion, degradation, and bioaccumulation play less significant roles in the transport of COIs in soil at the Site.

Although SVOCs (including PAHs) at OU1 generally adsorb strongly to soil particles and do not leach significantly, characteristics of the sources (i.e., NAPL) in the subsurface and the length of time they have been present have resulted in the dissolution of SVOCs into groundwater at the Site at levels exceeding applicable screening criteria. Since Site-related constituents have been in place for approximately 25 to 130 years, it is assumed that potential volatilization of these constituents has already occurred, and thus significant volatilization of SVOCs from surface soil is not likely unless surface soil is disturbed.

Aromatic VOCs at the Site, such as benzene, have leached from the soil to the groundwater. Benzene has a low affinity for adsorption; therefore, leaching has resulted in the presence of a large area of benzene in the saturated zone, compared to a relatively small area of benzene in the unsaturated zone (CH2M HILL, 2010a). The potential for constituents to volatilize from both soil and groundwater and enter into the indoor air of structures has been evaluated extensively and is discussed in the baseline human health risk assessment

(BHHRA) portion of the RI report (CH2M HILL, 2008) and subsequent updates, which have been included in the final SRI report (CH2M HILL, 2010a).

Four distinct areas of elevated metals in soil were defined at the Site (Figure 1-11). Two of these areas (the HCAA and ASA-1) exhibit a pyritic waste signature. A third area (ASA-3), although physically separate from the HCAA, may have resulted from the historic transport of arsenic in groundwater from the HCAA and subsequent repartitioning to soil. The remaining arsenic source area (ASA-2) represents a hot spot within the heterogeneous and ubiquitous fill that was used to initially raise the topographic elevation along the banks of the Hudson River. Mobilization of dissolved arsenic from pyritic source zones is due to the leaching of these acid wastes, whereas reductive dissolution resulting from the increased presence of dissolved organics, including coal tar, and native organics has led to soluble arsenic near hot spots within the saturated fill.

The oxidation of these pyritic wastes, because of their exposure to oxygenated rainwater and groundwater, produce reddish iron oxide minerals and elevated concentrations of iron and sulfate along with metal impurities of the ore, such as arsenic, lead, copper, antimony, and thallium. In the slag-rich fill, the transport of metals in unsaturated soils is controlled by the adsorption and desorption of these metals to and from soil during the infiltration of rainwater.

Within the saturated zone, desorption of arsenic in hot-spot areas is promoted by the organic sources, including NAPL, organic-rich fill, and the native peat and organic silt deposits. This organic material is creating redox conditions that cause the reductive dissolution of iron oxyhydroxides which serve as adsorption sites for arsenic.

Pesticides and PCBs are present in limited areas of OU1 and adsorb strongly to soil particles, limiting their downward migration and transport in groundwater.

Significant additional migration of constituents in soil at OU1 is not expected to occur. Dissolved phase constituents are at equilibrium with all of the sources, including NAPL. Limited infiltration and surface improvements prevent volatilization, erosion, leaching, or degradation from becoming significant transport mechanisms for constituents in unsaturated soil.

Fate and Transport of Constituents of Interest in Groundwater

Adsorption and degradation reactions are the most dominant attenuation factors for the fate of groundwater constituents at the Site.

Several primary lines of evidence suggest that the attenuation of both the organic constituents and arsenic is occurring within and downgradient of OU1. In general, time versus concentration plots and Mann-Kendall statistical trend analyses show that the composite extent of both the organic constituents and arsenic in groundwater is not currently expanding beyond their current boundaries. The more mobile dissolved-phase constituents in groundwater (benzene and naphthalene) have not migrated hydraulically downgradient beyond approximately 175 ft of the defined extents of Site-related NAPL. Mann-Kendall trend tests performed on arsenic time-series data indicate that no statistically significant upwards trends in arsenic concentrations are occurring at OU1 with the exception of one area at the former Celotex property that showed an increasing trend in two wells since sampling began in 2003. These increases are likely the result of filling and paving

that occurred across this area in 2003 that has cut off the flux of atmospheric oxygen to the subsurface there. Similarly, seasonal changes in redox conditions and the kinetics of redox reactions involving arsenic can result in short-term fluctuations in arsenic concentrations measured at each well. These ephemeral changes do not indicate that arsenic is being advectively transported in groundwater but emphasize the importance of a balanced statistical approach to evaluating arsenic plume stability.

Specialty soil and groundwater analyses and further characterization of the geochemical context have resulted in lines of evidence that support a detailed understanding of the mechanisms affecting the behavior of arsenic in groundwater at the Site. The solubility of arsenic is controlled by a combination of variables, including pH, redox conditions (as measured by Eh), iron oxide state and content, cation exchange capacity, major ion chemistry, and the organic content of the soil. Redox conditions at the Site are controlled by the Site-wide sources of organics—including organic-rich fill, native peat, organic silt, and NAPL—and locally by oxidizing pyrite. Levels of arsenic measured in groundwater are directly proportional to concentrations of total phosphorous, indicating that orthophosphates in groundwater are playing a significant role in limiting arsenic attenuation because they compete with arsenic for adsorption sites, causing arsenic to remain in solution. Despite the presence of orthophosphate and the dominance of the more mobile arsenite species in areas of elevated arsenic concentrations, an evaluation of these data along key groundwater flow transects support that the attenuation of arsenic through adsorption is occurring at the Site.

With the potential exception of an area of groundwater adjacent to the shoreline at the former Celotex property, dissolved arsenic is attenuating and generally in steady state. Soluble arsenic associated with a separate and much smaller area of pyritic material at the former Lever Brothers property unrelated to the former acid plant (ASA-1) attenuates before reaching the Hudson River. Additional sources of arsenic related to fill in highly reducing groundwater conditions have contributed to the presence of dissolved-phase arsenic concentrations adjacent to the Hudson River south of the Quanta property beyond the boundary of OU1. At the southeast corner of the former Celotex property, reductive dissolution of arsenic from the fill at ASA-3 as a result of coal tar and the presence organic-rich silt deposits has resulted in elevated concentration in nearshore groundwater here. Based on its being hydraulically downgradient of the HCAA, arsenic associated with ASA-3 may have originated from the HCAA and is present as a source today as the result of its subsequent repartitioning to soil here. Groundwater and hydraulic head data suggest that NAPL adjacent to and north and south of the bulkhead is a source of dissolved phase organics to the pore water at OU2; however, additional sources of Site-related NAPL constituents and arsenic are present within the sediments at OU2.

Groundwater migration from OU1 toward OU2 is impeded by the bulkhead along the shoreline, but groundwater eventually moves into OU2 as it flows to the north and south around the bulkhead and, to a lesser extent, through areas of observed leakage in the bulkhead. Preferential discharge zones for groundwater have been identified at OU2 through a Trident probe study. Despite the presence of additional nearshore sources, concentrations of dissolved-phase PAHs in shallow pore water and surface water at these zones of preferential upwelling zones are significantly reduced because of attenuation. With the exception of groundwater upwelling zone sampled north of the bulkhead, the SRI data

suggest that concentrations of arsenic observed in pore water are a function of the arsenic within the sediment and redox conditions in proximity to nearshore NAPL sources at OU2. Upgradient groundwater data, in conjunction with hydraulic data, indicate that the low-level concentrations of arsenic in the pore water north of the bulkhead may in part be the result of the advective transport of soluble arsenic in nearshore groundwater that is two orders of magnitude higher and that is the result of the reductive dissolution of arsenic associated with ASA-3. The area affected by potential contaminant discharge from groundwater to surface water is limited to nearshore areas adjacent to and flanking the wooden bulkhead.

In general, lead is strongly adsorbed under a wide range of pH and redox (Eh) conditions and would not be transported readily in groundwater. Due to the relative immobility of lead, elevated concentrations of dissolved lead associated with the former acid plant do not persist in groundwater downgradient to the south or east of the source because lead is adsorbed to organics or hydroxide minerals, or it is precipitated. Lead associated with the former acid plant attenuates in groundwater through adsorption and precipitation and does not migrate to the Hudson River.

The random and isolated occurrences of pesticides in groundwater, as well as their chemical characteristics, indicate that pesticides are not mobile in groundwater at the Site. PCBs were detected in groundwater in one location outside the extent of OU1 at the central portion of the former Celotex property, and are unrelated to former Site operations. As with pesticides, the characteristics of PCBs and the isolated occurrence in groundwater indicate that PCBs are not transported in groundwater.

Ammonia in OU1 groundwater does not discharge to the Hudson River. Although concentrations of ammonia above screening levels are present, adsorption and microbial activity are attenuating factors, resulting in concentrations below screening criteria adjacent to the Hudson River.

1.6.4 Potential Pathways and Receptors

As a result of the sources and transport mechanisms described, Site-related constituents at OU1 are contained in various media, including surface and subsurface soil, groundwater, and soil vapor. Sediment and surface water in the Hudson River are being evaluated as part of the RI for OU2. When exposed to these media, the constituents present can potentially pose a risk to certain human and/or ecological receptor populations. However, if no receptors are present, the exposure pathway is incomplete, and therefore no potential risk is posed by the constituents. The following subsections summarize the potential pathways and receptors present at the Site and evaluated as part of the BHHRA portion of the RI report (CH2M HILL, 2008) and subsequent updates, which have been included in the final SRI report (CH2M HILL, 2010a).

Human Health Risk Pathways and Receptors

For the properties evaluated in the BHHRA (Quanta, former Celotex, 115 River Road, former Lever Brothers, and Block 93 North), a total of five human receptor types were identified with the potential for exposure to one or more media at OU1 that may contain Site-related constituents under current and future Site use scenarios. Trespassers/visitors, commercial workers, and day care children could be exposed to constituents in surface soil

under current-use conditions through dermal absorption or ingestion or to constituents in ambient air through inhalation.

For potential future land use (i.e., commercial, recreational, or restricted residential), potential receptors considered include construction/utility workers, commercial workers, daycare children, trespassers, and residents. These receptors have the potential to be exposed to constituents in groundwater or surface soil through either ingestion or dermal absorption, and to constituents in ambient and indoor air through inhalation. Construction and utility workers could be exposed to constituents in groundwater through dermal absorption, to constituents in ambient air via inhalation, or to constituents in subsurface soil through ingestion or dermal absorption, under both current and future use scenarios. Constituents in groundwater can contribute to unacceptable indoor air concentrations that may pose a risk to building occupants.

For Block 93 Central and South, evaluated in a separate risk assessment following completion of the SRI (and included in the final SRI report), four human receptor types were identified. Construction/utility workers, commercial workers, residents, and adult and adolescent trespassers were evaluated for potential exposure pathways for the Block 93 Central and South properties.

Ecological Risk Pathways and Receptors

A screening-level ecological risk assessment (SLERA) has been completed for OU1. This SLERA evaluated potential risk to terrestrial receptors from exposure to compounds detected in surface soil on the 5.5-acre Quanta property. This SLERA evaluated potential ecological risk from direct exposure to soil and via the food-chain exposure pathway. Using conservative exposure scenarios and assumptions, this SLERA indicated potential risk to plant and invertebrate receptors via direct exposure and to higher-order receptors exposed to contamination through the food chain. The SLERA was refined using Site-specific input parameters, which reduced the number of compounds indicating potential risk from direct exposure and limited the higher-order receptors at potential risk to small-mammal species. Based on the location of the Site—in an urban area with limited and poor-quality habitat available for receptor populations—future inhabitation of OU1 by these receptors is unlikely (CH2M HILL, 2006). In its July 7, 2006, comments on the SLERA, EPA concurred with the overall conclusion that additional characterization of ecological risk at OU1 was not necessary. However, receptors are present in the adjacent Hudson River (OU2), and Site groundwater discharges to the river. Ecological risk in OU2 will be addressed as part of the Baseline Ecological Risk Assessment (BERA) for OU2.

1.6.5 Human Health Risk Assessment

The BHHRA conducted for most of OU1 (with the exception of River and Gorge Roads, Block 94, and Block 92.01) identified COCs for three media:

- Surface soil (0 to 2 ft bgs)
- Subsurface soil (0 to 10 ft bgs)
- Groundwater (above and below the silty-clay confining layer)

Risks above acceptable levels for one or more existing or future receptors as a result of exposure to soil or groundwater were calculated on all properties evaluated. Primary risk drivers include naphthalene, arsenic, and carcinogenic PAHs. Along with these primary risk

drivers, tar boils identified during the RI will be addressed during future remedial actions, because direct contact with this material is expected to exceed acceptable risk levels (CH2M HILL, 2008).

Identification of COCs and Risk Drivers

If a cumulative ELCR level of 1×10^{-4} is exceeded for a given medium, the constituents that pose an individual ELCR greater than 1×10^{-6} for a potential receptor–property combination were identified as COCs. If a target-organ-specific hazard index (HI) exceeds 1.0, the constituents that pose an individual hazard quotient (HQ) greater than 0.10 were identified as COCs. Table 1-1 presents the COCs identified for surface soil, subsurface soil, and shallow groundwater.

Risk-based PRGs were calculated for COCs in surface soil (0 to 2 ft bgs), subsurface soil (0 to 10 ft bgs), and shallow groundwater (within 10 ft of the surface). PRG development is presented in Section 2.3 of this FS.

The BHHRA identified arsenic and PAHs (primarily benzo(a)pyrene, dibenz(a,h) anthracene, benzo(b)floranthene, and benzo(a)anthracene and naphthalene) as the primary risk drivers for most media and receptors evaluated. Table 1-2 presents the relative risk contributions for each of these constituents. On the basis of the BHHRA conclusions, the remedial alternatives will target these primary risk drivers, as well as NAPL (a source of PAHs and aromatic VOCs). Although the complete list of COCs will be considered, it is believed that if the primary risk drivers and NAPL are adequately addressed, RAOs will be achieved.

Studies of potential vapor intrusion pathways have been conducted at buildings at 115 River Road, Block 93 North (former Jono's Restaurant), Block 93 South (Medical Arts Building), and the former Lever Brothers property (Building 9). These studies have included shallow groundwater, subslab, and indoor air sampling, physical observations of the buildings, and measuring air pressure within buildings. The results from these studies have indicated that vapor intrusion pathways are unlikely to be present or are of a sufficiently small magnitude that they do not pose an unacceptable risk to the health of occupants of these buildings under current conditions.

Despite the fact that there is currently no risk to occupants, prudent measures have been taken in order to address the potential for conditions to change. These measures include the installation and monitoring of engineering controls at 115 River Road. Ventilation fans in the basement of the 115 River Road building are operating at all times and floor drains and sumps have been sealed. An additional ventilation system providing 15 air exchanges per hour has been installed in the basements of Buildings 7 and 8 of the 115 River Road building. Ongoing monitoring is being performed at the 115 River Road and 163 Old River Road buildings to confirm that indoor concentrations remain below the risk-based screening levels in indoor air, or to confirm that any concentrations of regulated constituents observed in indoor air are not related to vapor intrusion (VI). Because only one round of subslab soil gas sampling has been performed to date at the Medical Arts building, further investigation has been recommended. Future changes in Site conditions (e.g., land use, condition of the building) would require a reevaluation of the vapor intrusion pathway. Remedial alternatives evaluated in this FS will address the risk of potential VI both at current buildings and potential future buildings within OU1.

1.6.6 Summary of Conceptual Site Model

Coal tar processing and subsequent oil-recycling operations contributed to existing secondary sources of contamination at the Site, including NAPL, pitch, soil impacted with PAHs, and other constituents. A former acid plant on the northern portion of the Quanta property and southern portion of the former Celotex property contributed to the presence of oxidizing pyrite ore remnants in soil. Primary sources are no longer present, with the exception of buried piping on the Quanta property. Additional secondary sources contributing to soil and groundwater contamination unrelated to former operations (such as regional fill material and former operations on adjacent properties) are present within the extent of OU1. Site-related secondary sources of PAHs, aromatic VOCs, and other constituents—including NAPL, pitch, and impacted soil—have been identified, characterized, and fully delineated.

Most free-phase and residual NAPL is present in discrete areas (or zones) above and within the top few feet of the silty clay confining layer. Free-phase NAPL may be recoverable in some areas but appears to be substantially immobile and unable to affect sensitive receptors, with the exception of NAPL in the zones adjacent to the Hudson River, which may be affecting surface water and sediments in nearshore areas. NAPL distribution near the bulkhead suggests that it has accumulated behind the bulkhead and has flanked it to the north and south beyond its extents. Solid tar has been observed in the form of a black, soft-to-stiff, semiplastic-to-plastic material up to 6 ft bgs mostly within the central portions of the Site. Tar boils have also been observed at the ground surface within or near some of the solid-tar areas.

A BHHRA was conducted as part of the RI and SRI for most of OU1 (with the exception of River and Gorge Roads, Block 92.01, and Block 94), and has identified COCs for surface soil, subsurface soil, and groundwater. The primary risk drivers at the Site are carcinogenic PAHs, naphthalene, and arsenic. Along with these primary risk drivers, surficial tar boils are presumed to pose an unacceptable risk.

In general, the concentrations of COCs in groundwater have remained stable or are decreasing over time and concentrations are not increasing along flow paths with distance from sources. Except for arsenic associated with ASA-3 on the southeastern corner of the former Celotex property, the footprint of the composite extent of COCs in groundwater is not expanding; concentrations of constituents in groundwater are generally in equilibrium as a result of adsorption and degradation processes. A complete conceptual site model and the detailed information on which the model is based can be found in the final SRI report (CH2M HILL, 2010a).

1.7 Principal Threat Evaluation

EPA guidance on principal threat and low-level threat waste was applied to help "streamline and focus the RI/FS on appropriate waste management options" (EPA, 1991). This guidance states that principal threat wastes are "those source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained or would present a significant risk to human health or the environment should exposure occur" (p. 2). Low-level threat wastes are those source materials that generally can be reliably contained and that would pose only a low risk in the event of exposure. EPA expects to use "treatment

to address the principal threats posed by a site, wherever practicable" and "engineering controls, such as containment, for waste that poses a relatively low long-term threat" (p. 1).

As part of the FS, arsenic in soil was evaluated further based on its risk potential to residents and construction workers. For the residential exposure scenario (0–2 ft bgs), a risk of 10^{-3} corresponds to a soil concentration of 390 mg/kg of arsenic. For the construction worker scenario (0–10 ft bgs), a risk of 10^{-3} corresponds to a soil concentration of 13,000 mg/kg of arsenic. Despite the calculated 10^{-3} risk concentration for construction worker soils, in an effort to maintain consistency with the definition of the HCAA on the former Celotex property as established by prior work performed at that property under oversight from the NJDEP a concentration of 1,000 mg/kg was used define the areas within the 2-to-10-ft-bgs interval to be considered during the FS. Based on these thresholds, seven separate areas of elevated arsenic concentrations, AA-1 through AA-7 (Figure 1-12), were identified. Although the HCAA is located below 10 ft bgs, this area was also included as a source area to be evaluated.

EPA (1991) guidance was used to help evaluate areas of NAPL and elevated arsenic concentrations within OU1. Fifteen areas within OU1 (NZ-1 through NZ-6, the tar boils, HCAA, and AA-1 through -7) were evaluated using the criteria outlined in Table 1-3, and all were found to represent source material as defined in the guidance. Each of the 15 areas was then evaluated to determine on the basis of toxicity and mobility potential whether the material constituted a low-level threat waste or a principal threat waste. A determination was made as to whether each area's potential to exhibit toxicity and/or mobility was low, moderate, or high.

On the basis of the evaluation presented in the following subsections, which is consistent with EPA guidance, 11 of these areas were positively identified as containing principal threat wastes. The remedial alternatives outlined in Section 4 include treatment options such as solidification/stabilization or in situ chemical treatment to address principal threat waste. Low-level threat waste is generally addressed by engineering and institutional controls, such as capping and a deed notice.

1.7.1 Mobility Potential

"Highly mobile" material is source material that is not reliably contained and has a significant potential to migrate to surface water, to sediments, or to air (EPA, 1991). The most important characteristic contributing to potential mobility is the ability of the source material to move through the subsurface (e.g., potential for NAPL to migrate). Highly mobile source material consists of unimpeded low-viscosity liquid, whereas low-mobility material could consist of either trapped low-viscosity liquid or high-viscosity liquid or solids.

NAPL Zone 1

The potential mobility of source material at NZ-1 was determined to be low. High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to 11 ft bgs or less. Further migration is not predicted to occur, given the physical characteristics of the NAPL and the age of the release that resulted in the presence of NAPL at NZ-1. At an isolated area within NZ-1, NAPL has migrated to the depth of the silty-clay

confining unit (approximately 23.5 ft bgs). At this location, further migration is prevented by the configuration of the confining unit and the absence of hydraulic gradients in the area.

NAPL Zone 2

At NZ-2, NAPL viscosities span a wide range, and NAPL thicknesses measured in several wells indicate elevated NAPL saturation levels. These factors, along with the dip of stratigraphic units toward the east, suggest that at least a portion of the NAPL at NZ-2 is characteristically mobile. The bulkhead along the shoreline extends below the base of all observed NAPL at NZ-2 and is a significant impediment to NAPL migration; however, it is not a complete barrier. An enhanced understanding of NAPL distribution behind the bulkhead at OU1, in conjunction with sediment boring information for OU2, indicate that NAPL in near shore sediments is at a similar elevation as the NAPL behind and at the flanks of the bulkhead. Data suggest that NAPL has moved and may continue to move from OU1 to OU2. Although the bulkhead was found as part of the SRI work to serve as a significant impediment to groundwater flow between OU1 and OU2, these newly collected data also indicate that groundwater is flanking the bulkhead to the north and south. More mobile forms of NAPL have migrated toward NZ-5 in the north, while to the south, most NZ-2 NAPL is residual and currently immobile. Based on the evidence supporting that at least a portion of the NAPL at NZ-2 has been in the past or is currently mobile, the remedial alternative development, evaluation, and selection presented in this FS address potential for migration to occur at NZ-2. This material is considered a principal threat waste due to its potential mobility.

NAPL Zone 3

The potential mobility of source material at NZ-3 was determined to be low. NAPL in NZ-3 has lower viscosity and interfacial tension (viscosity of 3.49 cSt and interfacial tension of 8.2 dynes/cm^2 in a NAPL sample collected at monitoring well MW-107) and has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 ft bgs. However, throughout most of NZ-3, the silty-confining layer unit slopes up to create the natural depression that prevents lateral migration of the NAPL. Along the southeastern portion of NZ-3 the silty-clay layer dips downward toward the south and east below the organic silts and is overlain by native sand. Along the leading edge of NZ-3 in this direction, NAPL is present only as thin and discontinuous lenses. This indicates that, to date, NAPL at NZ-3 has not been able to migrate beyond the natural depression in the top of the silty-clay confining unit. If additional lateral migration of the NAPL associated with NZ-3 were to occur, it would be expected that it would follow the surface of the silty-clay to depths of at least 75 ft bgs, where there would be no expected further migration. The overall mobility potential at NZ-3 is considered low; however, remedial alternatives will include monitoring to provide early detection of migration beyond the currently defined extent.

NAPL Zone 4

NAPL at NZ-4 has an elevated viscosity (13.1 cSt at 122°F) and interfacial tension (16.65 dynes/cm^2), suggesting that the NAPL here is immobile. Gravitational forces along with the impermeability and topography of the peat and depressions in the silty clay confining layer prevent further downward and lateral migration of the NAPL in this zone. If NZ-4 NAPL

were to migrate vertically further, it would be physically contained by natural depressions in the silty-clay surface.

NAPL Zone 5

During the SRI, NAPL at NZ-5 was found to accumulate in MW-135, installed north of the wooden bulkhead. The NAPL in MW- 135 has a lower viscosity (4.9 cSt at 122ºF) and interfacial tension (5.78 dynes/cm^2) than NAPL collected from monitoring wells to the south in NZ-2, located west of the bulkhead. Based on these characteristics, the material appears to be potentially mobile. NAPL in NZ-5 appears to follow the downward sloping interface between the base of the fill and the organic silt deposit. The bulkhead is not present in the area adjacent to NZ-5, increasing the potential for NAPL migration to the Hudson River. Due to the proximity of the NAPL to the Hudson River, the NAPL's characteristics, and the presence of sheens at OU2 near NZ-5 and within the sediments at similar elevations to NZ-5, the remedial alternative development, evaluation, and selection address potential for migration to occur at NZ-5. This material is considered a principal threat waste due to potential mobility.

NAPL Zone 6

NZ-6 contains NAPL observed in soil borings within the intersection of Gorge and River Roads just below the water table at depths ranging from 8.4 to 15 ft bgs. It has not accumulated in existing monitoring wells, indicating lower NAPL saturation levels than those observed in other NAPL zones. Its lateral extent is limited to the footprint of the former tank farm in this area, representing a NAPL zone separate from NZ-1. Its vertical extent is limited to the interface of the fill and underlying native sand and peat deposits. If NZ-6 NAPL were to migrate vertically further, it would be physically contained by natural depressions in the silty-clay surface.

Tar Boils

The highly viscous material making up tar boils, which have been observed on very hot days, is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil. Generally, tar boils have been observed within the footprint of NAPL zones.

High-Concentration Arsenic Area

The HCAA on the former Celotex property contains oxidizing pyritic material; however, this material is solid (immobile) and buried under a liner, eliminating the possibility of mobility via wind entrainment.

Arsenic Areas 1 through 7

In each of these areas, the source material itself, either oxidizing pyritic material or fill material with high concentrations of arsenic, is solid and does not migrate in the subsurface.

1.7.2 Toxicity Potential

Toxicity potential was evaluated as consisting of two subcategories: (1) accessibility or proximity to human receptors at OU1 or ecological receptors at OU2 and (2) the potential for vapor intrusion. Highly toxic source material would represent a significant potential risk based on characteristics of the material and based on the exposure potential of the material

(e.g., greater than 10^{-3} ELCR) and accessible under either the residential (0–2 ft bgs) or construction worker (0–10 ft bgs) exposure scenarios.

In general, direct contact with NAPL is presumed to pose an unacceptable risk, therefore wherever a pathway for exposure to a defined NAPL Zone is present, the zone was classified as having a high toxicity potential. For arsenic source material, the material must also be accessible through an exposure pathway, and have a sufficiently high concentration (i.e., with the potential to pose a risk level of greater than 10^{-3}).

A principal threat concentration threshold for arsenic in soil was developed to facilitate the classification of arsenic source material into principal or low-level threat waste categories. To pose a potential risk of 10^{-3} ELCR or greater, arsenic must be present at a high enough concentration and the material must be accessible through an exposure pathway. For the residential exposure scenario (0–2 ft bgs), a risk of 10^{-3} corresponds to a soil concentration of 390 mg/kg of arsenic. For the construction worker scenario (0–10 ft bgs), although a risk of 10^{-3} corresponds to a soil concentration of 13,000 mg/kg of arsenic, to maintain consistency with the definitions established by the NJDEP for the HCAA a concentration of 1,000 mg/kg in soil between 2 and 10 ft bgs was conservatively used as a threshold to define principal threats for arsenic across this depth interval.

Accessibility/Proximity to Receptors

The accessibility of source material to human receptors at OU1 was evaluated on the basis of the depth of constituents. Source material greater than 10 ft bgs is considered inaccessible, reflecting the fact that no reasonable exposure scenarios would exist for constituents present at this depth (CH2M HILL, 2008).

The proximity of source material to ecological receptors in OU2 was evaluated on the basis of the distance from the Hudson River shoreline. Inland surface soil or COCs adjacent to the shoreline (regardless of depth) have been determined to have a higher toxicity potential than deeper inland COCs or COCs at greater distances from OU2.

Vapor Intrusion

The potential for source material to represent a source of toxicity potential based upon the potential for a completed vapor intrusion pathway to exist was evaluated based on analytical results—or where testing was not performed, the depth of source material—molecular weight, and the presence and characteristics of existing buildings, if any.

Area-Specific Potential Toxicity Evaluation

NAPL Zone 1. The toxicity potential for source material at NZ-1 was determined to be high. NAPL is present at shallow depths and poses a potential direct contact risk. NAPL present under 115 River Road is not accessible under current conditions, and vapor intrusion investigations at 115 River Road have demonstrated that there is no existing unacceptable risk due to vapor intrusion. Vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or have been determined not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008). This material is considered a principal threat waste as a result of the potential direct contact risk.

NAPL Zone 2. The toxicity potential for source material at NZ-2 was determined to be high. NAPL is present in shallow soil, posing a potential risk through direct contact to receptors at OU1. In addition, NZ-2 is adjacent to the Hudson River and may present risk to ecological receptors.8 This material is considered a principal threat waste due to toxicity potential as well as mobility potential (discussed in Section 1.7.1).

NAPL Zone 3. Source material at NZ-3 is greater than 10 ft bgs and is therefore inaccessible to receptors at OU1. NZ-3 is not adjacent to the Hudson River. The molecular weight of NAPL in this zone and the depth NAPL here indicate a lower potential for vapor intrusion. The potential toxicity of material at NZ-3 is low.

NAPL Zone 4. The toxicity potential for source material at NZ-4 was determined to be low, because NAPL in this zone is present at 10 or more ft bgs.

NAPL Zone 5. The toxicity potential for source material at NZ-5 was determined to be moderate. Although residual NAPL is deep enough below ground surface to preclude direct contact, NZ-5 is adjacent to the Hudson River and may present a risk to ecological receptors.9 There exist no complete vapor intrusion pathways at NZ-5. This material is considered a principal threat waste due to toxicity potential as well as mobility potential (discussed in Section 1.7.1).

NAPL Zone 6. The toxicity potential for source material at NZ-6 was determined to be low. Although NAPL was observed at a depth of 8.4 ft bgs, this occurrence in a single monitoring well (MW-N1) is not representative of the elevation of the majority of the NAPL found in this zone. The majority of the NAPL in this zone is found at 10 ft bgs, which is below the depths available for direct contact through either the residential or construction worker exposure scenarios. Furthermore, NAPL in this zone is located beneath both the water table and active roadways, further limiting the possibility of direct contact.

Tar Boils. Direct contact with this material is expected to exceed acceptable risk levels (CH2M HILL, 2007). This material is considered a principal threat waste.

High-Concentration Arsenic Area (Former Celotex). At the HCAA, toxicity potential was determined to be low. Oxidizing pyritic waste material contains arsenic above applicable soil standards; however, the depth of the material eliminates the potential for direct contact with soils exceeding 390 mg/kg in surface soil or 1,000 mg/kg in soil from 2 to 10 ft bgs. The HCAA is not considered a principal threat waste; however, remedial alternatives have been developed to consider technologies that address this area.

Arsenic Area 1. At AA-1, on the Quanta property, the toxicity potential was determined to be moderate. Surface soil in this area does not contain arsenic at concentrations greater than 390 mg/kg, the threshold for 10^{-3} ELCR for the residential exposure scenario. However, subsurface soil concentrations accessible under the construction worker exposure scenario exceed 1,000 mg/kg.

8 The potential risk of material from NZ-2 to ecological receptors at OU2 will be evaluated as part of the OU2 Baseline Ecological Risk Assessment.

9 The potential risk of material from NZ-5 to ecological receptors at OU2 will be evaluated as part of the OU2 Baseline Ecological Risk Assessment.

Arsenic Area 2. At AA-2 on Block 93 Central, toxicity potential was determined to be moderate. Soil concentrations from 3 to 5 ft bgs exceed 1,000 mg/kg.

Arsenic Area 3. At AA-3 on the former Lever Brothers property, toxicity potential was determined to be moderate. Surface soil in this area does not contain arsenic at concentrations greater than 390 mg/kg. However, subsurface soil concentrations accessible under the construction worker exposure scenario exceed 1,000 mg/kg. It is anticipated that soil within AA-3 will be addressed as part of separate remedial efforts being conducted on the former Lever Brothers property as part of ISRA Case #E20040267 under oversight from NJDEP.

Arsenic Area 4. The toxicity potential for AA-4, located on the Block 93 Central property, was determined to be high. The material located between 0 and 2 ft bgs is considered a principal threat waste because arsenic concentrations are greater than the threshold for 10^{-3} ELCR of 390 mg/kg under a residential exposure scenario.

Arsenic Area 5. The toxicity potential for AA-5, located on the Block 93 North property, was determined to be high. The material located between 0 and 2 ft bgs is considered a principal threat waste because arsenic concentrations are greater than the threshold for 10^{-3} ELCR of 390 mg/kg under a residential exposure scenario.

Arsenic Area 6. At AA-6, on the Quanta property adjacent to River Road, the toxicity potential was determined to be high. Shallow soil (0–2 ft bgs) concentrations are greater than the threshold for 10^{-3} ELCR of 390 mg/kg under a residential exposure scenario. Shallow soil at AA-6 is considered a principal threat waste.

Arsenic Area 7. At AA-7, on the Quanta property, the toxicity potential was determined to be high. Shallow soil (0–2 ft bgs) concentrations are greater than the threshold for 10^{-3} ELCR of 390 mg/kg under a residential exposure scenario. Shallow soils at AA-7 are considered principal threat waste.

1.7.3 Conclusions

Of the 15 areas containing source material, the following have been characterized as principle threat waste based on their mobility and/or toxicity potential and using EPA guidance (EPA, 1991) and are addressed as such for the purpose of this FS:

- NAPL zones 1, 2, and 5
- Surficial tar boils
- Arsenic areas AA-1 through AA-7

Source materials associated with NZ-3, NZ-4, NZ-6, and the HCAA are considered low-level threat waste because these areas have been shown to pose a low potential for both toxicity and mobility, as described above. However, remedial alternatives will consider technologies to address the HCAA. The evaluation of source material toxicity and mobility potential is summarized in Table 1-4. A plan view and cross section views of source material areas are depicted in Figures 1-13 through 1-19. The alternatives presented in this FS are evaluated in Section 5.2.2 with respect to the principal threat waste criteria.

TABLE 1-1
Summary of Constituents of Concern
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

COC	Surface Soil (0–2 ft bgs)	Subsurface Soil (0–10 ft bgs)	Shallow Groundwater
1,2,4-Trimethylbenzene	—	—	X
1,3,5-Trimethylbenzene	—	—	X
2-Methylnaphthalene	X	X	X
2,4-Dinitrotoluene	X	—	—
4-Methylphenol	X	—	—
Antimony	X	X	X
Aroclor-1242	X	—	—
Aroclor-1254	X	—	—
Aroclor-1260	X	—	—
Arsenic	X	X	X
Benzene	X	X	X
Benzo(a)anthracene	X	X	X
Benzo(a)pyrene	X	X	X
Benzo(b)fluoranthene	X	X	X
Benzo(k)fluoranthene	X	—	X
Carbazole	X	—	—
Cadmium	—	—	X
Chromium	X	—	—
Chrysene	X	—	—
Copper	X	—	—
Dibenzo(a,h)anthracene	X	X	X
Fluorene	X	—	—
Heptachlor	X	—	—
Indeno(1,2,3-cd)pyrene	X	X	X
Iron	X	X	X
Lead	X	X	—
Manganese	—	—	X
Mercury	X	—	X
Naphthalene	X	X	X
Thallium	X	X	X
Vanadium	X	—	X
Xylenes, Total	X	—	X
Zinc	X	—	—

Note: As presented in the RI report (CH2M HILL, 2008) and final SRI report (CH2M HILL, 2010a). COCs are defined as contributing a chemical-specific Excess Lifetime Cancer Risk (ELCR) $>1 \times 10^{-6}$ or Hazard Index (HI) > 0.1 when receptor total ELCR (all soil pathways) $>1 \times 10^{-6}$ or HI > 1.0. COCs identified as primary risk drivers are underlined.

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Site: Quanta Resources								
Adult Trespasser			***Construction Worker***			***Construction Worker***		
Arsenic	33.8	—	Antimony	—	1.2	2-Methylnaphthalene	—	3.6
Benzo(a)anthracene	4.9	—	Arsenic	55.6	49.1	Benzo(a)anthracene	5.7	—
Benzo(a)pyrene	44.2	—	Iron	—	0.7	Benzo(a)pyrene	70.7	—
Benzo(b)fluoranthene	5.2	—	Thallium	—	0.5	Benzo(b)fluoranthene	8.2	—
Dibenz(a,h)anthracene	8.9	—	2-Methylnaphthalene	—	0.8	Benzo(k)fluoranthene	0.4	—
Indeno(1,2,3-c,d)pyrene	2.5	—	Benzo(a)anthracene	3.2	—	Dibenz(a,h)anthracene	11.1	—
Adolescent Trespasser			Benzo(a)pyrene	30.6	—	Indeno(1,2,3-c,d)pyrene	3.7	—
Arsenic	11.1	—	Benzo(b)fluoranthene	3.5	—	Naphthalene	—	93.1
Benzo(a)anthracene	6.5	—	Dibenz(a,h)anthracene	5.0	—	Benzene	—	1.7
Benzo(a)pyrene	59.5	—	Indeno(1,2,3-c,d)pyrene	1.6	—			
Benzo(b)fluoranthene	7.0	—	Naphthalene	—	46.0			
Dibenz(a,h)anthracene	11.9	—	Benzene	0.1	0.2			
Indeno(1,2,3-c,d)pyrene	3.3	—						
Commercial Worker								
Arsenic	26.0	30.7						
Aroclor-1242	0.1	—						
Aroclor-1260	0.1	—						
Benzo(a)anthracene	5.3	—						
Benzo(a)pyrene	48.7	—						

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
	Percent		Percent		Percent	
	Cancer Risk	Non-cancer Hazard	Cancer Risk	Non-cancer Hazard	Cancer Risk	Non-cancer Hazard
Benzo(b)fluoranthene	5.7	—				
Benzo(k)fluoranthene	0.3	—				
Dibenz(a,h)anthracene	9.8	—				
Indeno(1,2,3-c,d)pyrene	2.7	—				
Naphthalene	—	53.3				
Benzene	0.8	—				
Trichloroethene	0.3	—				
Adult Resident						
Antimony	—	3.1				
Arsenic	—	38.8				
Iron	—	5.9				
Thallium	—	0.9				
2-Methylnaphthalene	—	0.5				
Naphthalene	—	41.9				
Benzene	—	1.4				
Child Resident						
Antimony	—	4.7				
Arsenic	—	57.5				
Copper	—	1.6				
Iron	—	9.1				
Thallium	—	1.3				

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Vanadium	—	1.0						
Zinc	—	0.1						
Mercury	—	1.1						
Aroclor-1242	—	2.4						
Aroclor-1260	—	1.2						
2-Methylnaphthalene	—	0.8						
4-Methylphenol	—	0.3						
Fluorene	—	0.1						
Naphthalene	—	16.7						
Benzene	—	0.6						
Adult/Child Aggregate Resident								
Arsenic	8.6	—						
Heptachlor	0.01	—						
Aroclor-1242	0.03	—						
Aroclor-1260	0.02	—						
Benzo(a)anthracene	6.7	—						
Benzo(a)pyrene	61.2	—						
Benzo(b)fluoranthene	7.2	—						
Benzo(k)fluoranthene	0.3	—						
Carbazole	0.01	—						
Chrysene	0.1	—						

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Dibenz(a,h)anthracene	12.3	—						
Indeno(1,2,3-c,d)pyrene	3.4	—						
Benzene	0.1	—						
Trichloroethene	0.03	—						
Site: Edgewater								
Adult/Child Aggregate Resident			***Construction Worker***			***Construction Worker***		
Arsenic	10.4	—	Arsenic	—	47.6	Arsenic	—	79.45
Benzo(a)anthracene	6.4	—	2-Methylnaphthalene	—	1.6	Naphthalene	—	19.81
Benzo(a)pyrene	60.1	—	Naphthalene	—	30.9			
Benzo(b)fluoranthene	5.8	—						
Dibenz(a,h)anthracene	13.9	—						
Indeno(1,2,3-c,d)pyrene	3.4	—						
Site: 115 River Road								
Daycare Child			***Construction Worker***			***Construction Worker***		
Arsenic	0.7	—	Arsenic	2.0	—	Naphthalene	—	96.4
Benzo(a)anthracene	7.5	—	2-Methylnaphthalene	—	8.8			
Benzo(a)pyrene	66.7	—	Benzo(a)anthracene	10.1	—			
Benzo(b)fluoranthene	8.3	—	Benzo(a)pyrene	65.1	—			
Benzo(k)fluoranthene	0.4	—	Benzo(b)fluoranthene	6.9	—			
Dibenz(a,h)anthracene	12.3	—	Dibenz(a,h)anthracene	11.0	—			
Indeno(1,2,3-c,d)pyrene	4.0	—	Indeno(1,2,3-c,d)pyrene	2.9	—			

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Chromium	0.2	—	Naphthalene	—	81.5			
Naphthalene	—	83.2						
Site: Former Lever Brothers								
Adolescent Trespasser			***Construction Worker***			***Construction Worker***		
Arsenic	5.4	—	Arsenic	—	55.9	Arsenic	—	7.7
Benzo(a)anthracene	6.5	—	Naphthalene	—	12.1	2-Methylnaphthalene	—	6.4
Benzo(a)pyrene	64.7	—				Naphthalene	—	80.9
Benzo(b)fluoranthene	8.4	—						
Dibenz(a,h)anthracene	10.7	—						
Indeno(1,2,3-c,d)pyrene	3.9	—						
Site: Block 93 North								
Adult Trespasser			***Construction Worker***			***Construction Worker***		
Arsenic	15.9	—	Arsenic	—	3.3	Arsenic	—	91.7
Benzo(a)anthracene	8.9	—	2-Methylnaphthalene	—	2.6	Naphthalene	—	0.5
Benzo(a)pyrene	55.2	—	Naphthalene	—	86.6			
Benzo(b)fluoranthene	5.8	—						
Benzo(k)fluoranthene	0.5	—						
Dibenz(a,h)anthracene	10.2	—						
Indeno(1,2,3-c,d)pyrene	3.0	—						

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Surface Soil		Subsurface Soil		Groundwater (Above Confining Unit)	
	Percent		Percent		Percent	
	Cancer Risk	Non-cancer Hazard	Cancer Risk	Non-cancer Hazard	Cancer Risk	Non-cancer Hazard
Adolescent Trespasser						
Arsenic	4.5	—				
Benzo(a)anthracene	10.1	—				
Benzo(a)pyrene	63.0	—				
Benzo(b)fluoranthene	6.6	—				
Benzo(k)fluoranthene	0.5	—				
Dibenz(a,h)anthracene	11.6	—				
Indeno(1,2,3-c,d)pyrene	3.5	—				
Commercial Worker						
Arsenic	11.6	—				
Aroclor-1260	0.2	—				
Benzo(a)anthracene	9.2	—				
Benzo(a)pyrene	57.4	—				
Benzo(b)fluoranthene	6.0	—				
Benzo(k)fluoranthene	0.5	—				
Dibenz(a,h)anthracene	10.6	—				
Indeno(1,2,3-c,d)pyrene	3.2	—				
Naphthalene	—	84.2				
Benzene	1.1	—				

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Site: Block 93 Central								
Adult Trespasser			***Construction Worker***			***Construction Worker***		
Arsenic	93.0	97.8	Arsenic	58.8	60.9	Benzo(a)pyrene	98.7	—
Benzo(a)anthracene	0.4	–	Benzo(a)anthracene	3.1	–	Naphthalene	1.0	95.0
Benzo(a)pyrene	4.8	–	Benzo(a)pyrene	25.0	–			
Benzo(b)fluoranthene	0.4	–	Benzo(b)fluoranthene	1.9	–			
Dibenz(a,h)anthracene	1.1	–	Dibenzo(a,h)anthracene	4.2	–			
Indeno(1,2,3-c,d)pyrene	0.3	–	Indeno(1,2,3-cd)pyrene	1.1	–			
			Naphthalene	5.5	25.4			
Adolescent Trespasser								
Arsenic	82.6	97.8						
Benzo(a)anthracene	0.9	–						
Benzo(a)pyrene	11.9	–						
Benzo(b)fluoranthene	1.1	–						
Dibenz(a,h)anthracene	2.7	–						
Indeno(1,2,3-c,d)pyrene	0.8	–						
Commercial Worker								
Arsenic	90.3	97.5						
Benzo(a)anthracene	0.5	–						
Benzo(a)pyrene	6.6	–						
Benzo(b)fluoranthene	0.6	–						

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Dibenz(a,h)anthracene	1.5	—						
Indeno(1,2,3-c,d)pyrene	0.4	—						
Adult Resident								
Arsenic	—	96.6						
Child Resident								
Arsenic	—	97.7						
Adult/Child Aggregate Resident								
Arsenic	71.0	—						
Benzo(a)anthracene	1.5	—						
Benzo(a)pyrene	19.8	—						
Benzo(b)fluoranthene	1.8	—						
Benzo(k)fluoranthene	0.1	—						
Dibenzo(a,h)anthracene	4.5	—						
Indeno(1,2,3-cd)pyrene	1.3	—						
Site: Block 93 South								
Adult Trespasser			***Construction Worker***			***Construction Worker***		
Arsenic	7.8	—	Arsenic	3.4	—	Naphthalene	93.72	95.91
Benzo(a)anthracene	5.3	—	Benzo(a)anthracene	5.5	—			
Benzo(a)pyrene	65.7	—	Benzo(a)pyrene	68.6	—			
Benzo(b)fluoranthene	5.2	—	Benzo(b)fluoranthene	5.4	—			
Benzo(k)fluoranthene	0.4	—	Dibenzo(a,h)anthracene	12.6	—			

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Dibenzo(a,h)anthracene	11.9	–	Indeno(1,2,3-cd)pyrene	3.6	–			
Indeno(1,2,3-cd)pyrene	3.5	–						
Adolescent Trespasser								
Arsenic	3.0	–						
Benzo(a)anthracene	5.6	–						
Benzo(a)pyrene	69.3	–						
Benzo(b)fluoranthene	5.4	–						
Benzo(k)fluoranthene	0.4	–						
Dibenzo(a,h)anthracene	12.5	–						
Indeno(1,2,3-cd)pyrene	3.7	–						
Commercial Worker								
Arsenic	5.6	–						
Benzo(a)anthracene	5.4	–						
Benzo(a)pyrene	67.2	–						
Benzo(b)fluoranthene	5.3	–						
Benzo(k)fluoranthene	0.4	–						
Dibenzo(a,h)anthracene	12.2	–						
Indeno(1,2,3-cd)pyrene	3.6	–						
Child Resident								
Arsenic	–	67.7						
Aroclor 1254	–	7.1						

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
Aroclor 1260	–	4.3						
Adult/Child Aggregate Resident								
Arsenic	1.5	–						
Aroclor 1254	0.01	–						
Aroclor 1260	0.009	–						
Benzo(a)anthracene	5.7	–						
Benzo(a)pyrene	70.3	–						
Benzo(b)fluoranthene	5.5	–						
Benzo(k)fluoranthene	0.5	–						
Chrysene	0.1	–						
Dibenzo(a,h)anthracene	12.7	–						
Indeno(1,2,3-cd)pyrene	3.7	–						
Naphthalene	0.02	–						
Site-Wide Groundwater (Above the Confining Unit)								
Adult Resident			***Child Resident***			***Adult/Child Aggregate Resident***		
Arsenic	–	94.0	Arsenic	–	99.3	Arsenic	50.8	–
Iron	–	0.2	Iron	–	0.2	alpha-BHC	0.0002	–
Benzene	–	0.2	Benzene	–	0.1	delta-BHC	0.0002	–
Ethylbenzene	–	0.003	Ethylbenzene	–	0.002	Heptachlor	0.0001	–
Toluene	–	0.005	Toluene	–	0.004	Benzene	0.2	–
Trichloroethene	–	0.004	Trichloroethene	–	0.004	Trichloroethene	0.004	–

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
m,p-Xylene	–	0.01	m,p-Xylene	–	0.001	Benzo(a)anthracene	2.0	–
o-Xylene	–	0.01	o-Xylene	–	0.001	Benzo(a)pyrene	42.7	–
Xylene (Total)	–	0.02	Xylene (Total)	–	0.002	Benzo(b)fluoranthene	2.8	–
2,4-Dimethylphenol	–	0.02	2,4-Dimethylphenol	–	0.02	Benzo(k)fluoranthene	0.1	–
2-Methylnaphthalene	–	0.1	2-Methylnaphthalene	–	0.1	Carbazole	0.003	–
2-Methylphenol	–	0.002	2-Methylphenol	–	0.002	Chrysene	0.02	–
3&4-Methylphenol	–	0.002	3&4-Methylphenol	–	0.002	Indeno(1,2,3-c,d)pyrene	1.3	–
4-Methylphenol	–	0.1	4-Methylphenol	–	0.1			
Acenaphthene	–	0.004	Acenaphthene	–	0.004			
Benzo(g,h,i)perylene	–	0.01	Acenaphthylene	–	0.001			
1,1'-Biphenyl	–	0.001	Benzo(g,h,i)perylene	–	0.01			
Fluoranthene	–	0.01	1,1'-Biphenyl	–	0.001			
Naphthalene	–	5.2	Fluoranthene	–	0.01			
Pyrene	–	0.01	Fluorene	–	0.002			
			Naphthalene	–	0.2			
			Pyrene	–	0.01			
Site-Wide Groundwater (Below the Confining Unit)								
Adult Resident			***Child Resident***			***Adult/Child Aggregate Resident***		
Trichloroethene	–	75.3	Arsenic	–	1.2	Arsenic	1.9	–
2-Methylnaphthalene	–	0.2	Trichloroethene	–	97.2	Benzene	0.2	–
Naphthalene	–	23.0				Tetrachloroethene	2.0	–

TABLE 1-2
Percent Contribution of Risk Relative to a Medium's Cumulative Risk/Hazard for Constituents of Concern: Reasonable Maximum Exposure Scenario
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Surface Soil			Subsurface Soil			Groundwater (Above Confining Unit)		
	Percent			Percent			Percent	
	Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard		Cancer Risk	Non-cancer Hazard
						Trichloroethene	93.7	–
						Vinyl chloride	0.04	–
						Benzo(a)anthracene	2.1	–
						Carbazole	0.02	–

Note: The percent risk/hazard for each constituent represents the percent individual risk relative to the total risk by all COPCs evaluated in a medium. If a cumulative ELCR of 1×10^{-4} is exceeded for a given medium, the COPCs that pose an individual ELCR greater than 1×10^{-6} for a potential receptor/property combination were identified as COCs. If a target organ-specific HI exceeds 1.0, the COPCs that pose an individual HQ greater than 0.10 were identified as COCs. An adult/child aggregate resident represents a resident exposed first as a child and then as an adult. The total percentages for each medium and receptor do not equal 100% because only chemicals identified as COCs are included in the table. The percent risk/hazard included in this table is based on the results of BHHRAs in the RI except for the Block 93 Central and South properties (Appendix P of the RI report). The percent risk/hazard for Block 93 Central and South properties is based on the results of BHHRA (Appendix HH of the final SRI report [CH2M HILL, 2010a]).

TABLE 1-3
Source Material Determination
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Source Material Definition Criteria[a]	NAPL Zone						Tar Boils	Arsenic Areas							
	1	2	3	4	5	6		HCAA	1	2	3	4	5	6	7
Contains hazardous material that migrates to groundwater?	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contains hazardous material that migrates directly to surface water?	No	Yes	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Contains hazardous material that migrates to air?	Yes	Yes	No	No	No	No	Yes	No	No	No	No	No	No	No	No
Acts as a source for direct exposure (within 10 ft bgs)?	Yes	Yes	No	No	No	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Source material?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

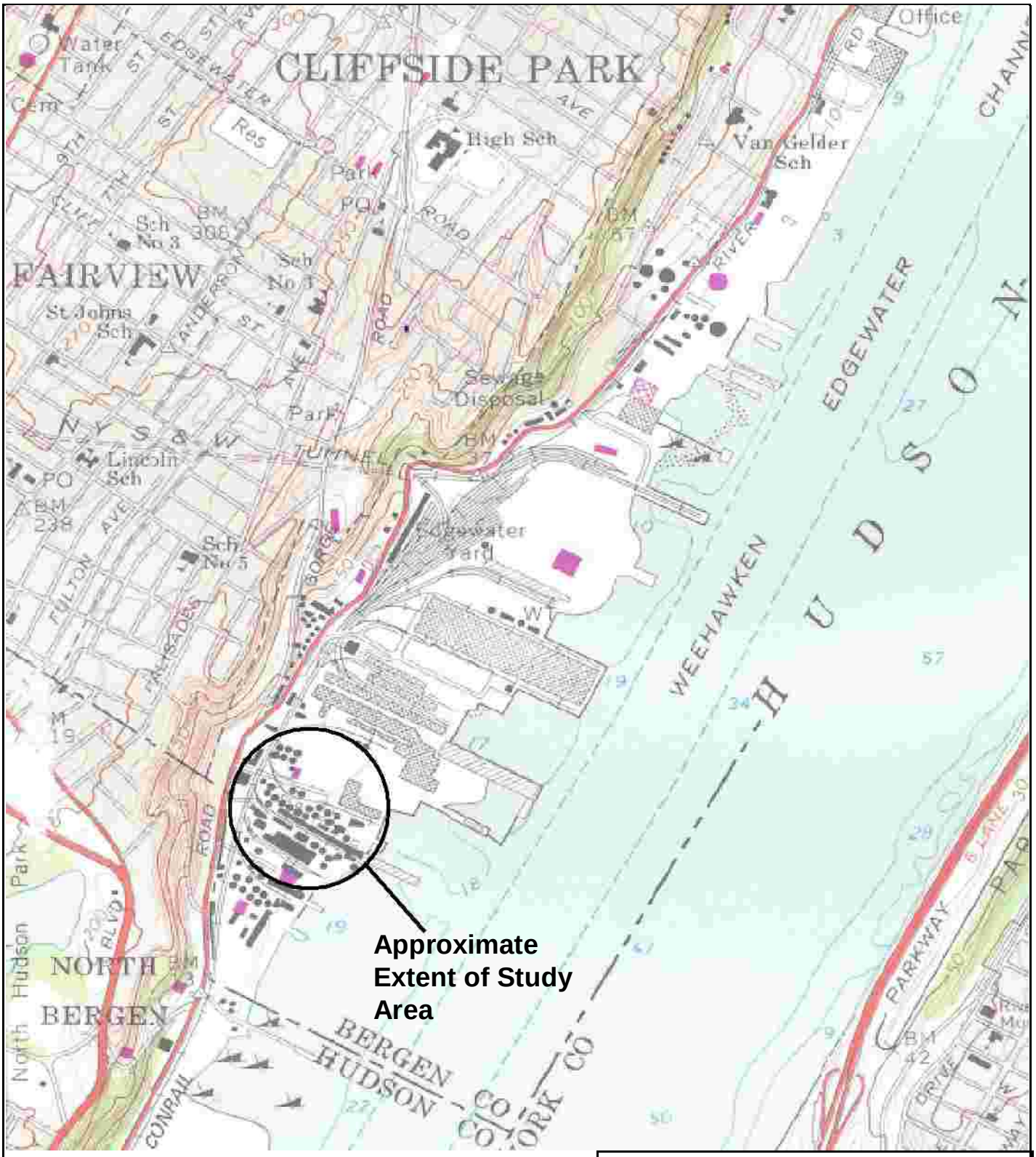
[a] Source definition criteria are based on *A Guide to Principal Threat and Low Level Threat Wastes* (EPA, 1991).

TABLE 1-4
Source Material Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Source Area	Mobility Potential	Toxicity Potential		Principal Threat Waste?
		Accessibility/Proximity to Receptors	Vapor Intrusion	
NZ-1	**LOW:** High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL to 11 ft bgs or less. Further migration is not predicted to occur, given the physical characteristics of the NAPL, the age of the release that resulted in the presence of NAPL at NZ-1. At an isolated area within NZ-1, NAPL has migrated to the depth of the silty-clay confining unit (approximately 23.5 ft bgs). At this location, further migration is prevented by the configuration of the confining unit and the absence of hydraulic gradients in the area.	**HIGH:** NAPL containing COCs is present at depths posing a potential risk of direct contact. NAPL under the 115 River Road buildings is not accessible under current conditions.	**HIGH:** NAPL containing COCs is present at depths posing a potential risk of vapor intrusion. Vapor intrusion investigations at 115 River Road have demonstrated that there is no existing unacceptable risk due to vapor intrusion under current conditions.	**Yes;** toxicity potential
NZ-2	**HIGH:** At NZ-2, NAPL viscosities span a wide range, and NAPL thicknesses measured in several wells indicate elevated NAPL saturation levels. These factors, along with the dip of stratigraphic units eastward, suggest that at least a portion of the NAPL at NZ-2 is characteristically mobile. The bulkhead along the shoreline extends below the base of all observed NAPL at NZ-2 and is a significant impediment to NAPL migration; however, it is not a complete barrier. An enhanced understanding of NAPL distribution behind the bulkhead at OU1, in conjunction with sediment boring information for OU2, show that NAPL in near shore sediments is at a similar elevation than the NAPL behind and at the flanks of the bulkhead. Data suggests that NAPL has moved and may continue to move from OU1 to OU2. Although the bulkhead has been found as part of the SRI work to serve as a significant impediment to groundwater flow between OU1 and OU2, these newly collected data also indicate that groundwater is flanking the bulkhead to the north and south. More mobile forms of NAPL have migrated toward NZ-5 in the north, while to the south, NZ-2 NAPL is residual and currently immobile.	**HIGH:** NAPL containing COCs is present at depths posing a potential risk of direct contact. NAPL under the 115 River Road buildings is not accessible under current conditions.	**HIGH:** NAPL containing COCs is present at depths posing a potential risk of vapor intrusion.	**Yes;** mobility and toxicity potential
NZ-3	**LOW:** The potential mobility of source material at NZ-3 was determined to be low. NAPL in NZ-3 has lower viscosity and interfacial tension and has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 25 ft bgs. Throughout most of NZ-3, the silty-clay confining unit slopes up to create the natural depression that prevents lateral migration of the NAPL. Along the southeastern portion of NZ-3 the silty-clay layer dips downward toward the south and east below the organic silts and is overlain by native sand. Along the leading edge of NZ-3 in this direction, NAPL is present only as thin and discontinuous lenses. This indicates that, to date, the extent of NAPL at NZ-3 has not been able to migrate beyond the natural depression in the top of the silty-clay confining unit.	**LOW:** NAPL contains COCs; however, depth limits potential for direct contact.	**LOW:** Depth of NAPL limits potential for vapor migration.	**No**
NZ-4	**LOW:** NZ-4 consists of NAPL beneath Block 93 Central, Block 93 South, River Road, and the northwestern portion of the former Lever Brothers property NAPL at NZ-4 has an elevated viscosity and interfacial tension, suggesting that the NAPL here is immobile. Gravitational forces along with the impermeability and topography of the peat and depressions in the silty clay confining layer prevent further downward and lateral migration of the NAPL in this zone.	**LOW:** NAPL contains COCs; however, depth limits potential for direct contact.	**LOW:** Depth of NAPL limits potential for vapor migration.	**No**
NZ-5	**HIGH:** NAPL at NZ-5 was found to accumulate in MW-135, installed north of the wooden bulkhead as part of the SRI. The NAPL in MW- 135 has a lower viscosity and interfacial tension than NAPL collected from monitoring wells to the south in NZ-2, located west of the bulkhead. Based on these characteristics, the material appears to be mobile. NAPL in NZ-5 appears to follow the downward sloping interface between the base of the fill and the organic silt deposit. The bulkhead is not present in the area adjacent to NZ-5, increasing the potential for NAPL migration to the Hudson River.	**MODERATE:** NAPL present adjacent to the Hudson River (ecological receptors); however, depth limits potential for direct contact.	**LOW:** Depth of NAPL limits potential for vapor migration.	**Yes;** mobility and toxicity potential
NZ-6	**LOW:** NZ-6 contains NAPL observed in soil borings within the intersection of Gorge and River Roads; however, it has not accumulated in existing monitoring wells indicating low NAPL saturation levels as compared to that observed in other NAPL zones. Its lateral extent is limited to the footprint of the former tank farm in this area, representing a NAPL zone separate from NZ-1. Its vertical extent is limited to the interface of the fill and underlying native sand and peat deposits. If NZ-6 NAPL were to migrate vertically further, it would be physically contained by natural depressions in the silty-clay surface.	**MODERATE:** NAPL containing COCs is present at depths posing a risk of direct contact; however access to this zone is limited by the presence of overlying active roadways.	**LOW:** Depth of NAPL limits potential for vapor migration.	**No**
Tar Boils	**LOW:** Solid, taffylike tar in the near surface vadose zone has been observed to seep through surface cracks in soil or pavement on very hot days. However, this very high viscosity material is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil.	**HIGH:** Coal tar is present at the ground surface, posing a potential risk of direct contact.	**HIGH:** The presence of buildings would prevent the heating caused by sunlight that creates this phenomenon. However, if a building were to be built atop existing tar boils, there would be a potential risk of vapor intrusion	**Yes;** toxicity potential

TABLE 1-4
Source Material Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Source Area	Mobility Potential	Toxicity Potential		Principal Threat Waste?
		Accessibility/Proximity to Receptors	Vapor Intrusion	
HCAA	**LOW:** Subsurface source material (pyritic signature) is not mobile.	**LOW:** Oxidizing pyritic waste material contains arsenic which is a source to groundwater; however, the depth of the material and presence of a liner limits the potential for direct contact.	**LOW:** Arsenic is not a vapor intrusion concern	**No;** however, area is addressed by remedial alternatives
AA-1	**LOW:** Subsurface source material (pyritic signature) is not mobile. Shallow material does not pose an air pathway risk.	**MODERATE:** At AA-1, on the Quanta property, the toxicity potential was determined to be moderate. Surface soil in this area does not contain arsenic at concentrations greater than 390 mg/kg, the threshold for 10^{-3}ELCR for the residential exposure scenario. However, subsurface soil concentrations accessible under the construction worker exposure scenario exceed 1,000 mg/kg.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-2	**LOW:** Subsurface source material is not mobile.	**MODERATE:** Soil concentrations of arsenic exceed 1,000 mg/kg for soil greater than 2 ft bgs.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-3	**LOW:** Subsurface source material is not mobile. Shallow material does not pose an air pathway risk.	**MODERATE:** Surface soil in this area does not contain arsenic at concentrations greater than 390 mg/kg; however, soil concentrations of arsenic exceed 1,000 mg/kg for soil greater than 2 ft bgs.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-4	**LOW:** Subsurface source material is not mobile and does not pose an air pathway risk.	**HIGH:** Arsenic concentrations result in an ELCR greater than 10^{-3} for the residential exposure scenario.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-5	**LOW:** Subsurface source material is not mobile and does not pose an air pathway risk.	**HIGH:** Arsenic concentrations result in an ELCR greater than 10^{-3} for the residential exposure scenario.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-6	**LOW:** Shallow source material is not mobile and does not pose an air pathway risk.	**HIGH:** Arsenic concentrations result in an ELCR greater than 10^{-3} for the residential exposure scenario.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential
AA-7	**LOW:** Shallow source material is not mobile and does not pose an air pathway risk.	**HIGH:** Arsenic concentrations result in an ELCR greater than 10^{-3} for the residential exposure scenario.	**LOW:** Arsenic is not a vapor intrusion concern	**Yes;** toxicity potential



Map Source:
Central Park, New York – New Jersey
United States Geological Survey
7.5 Minute Quadrangle

Topography and photogrammetric methods from aerial photographs taken in 1954 and planetable surveys in 1956. Field checked in 1966. Revised in 1979 from aerial photographs taken in 1977.

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Site Location Map

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-1

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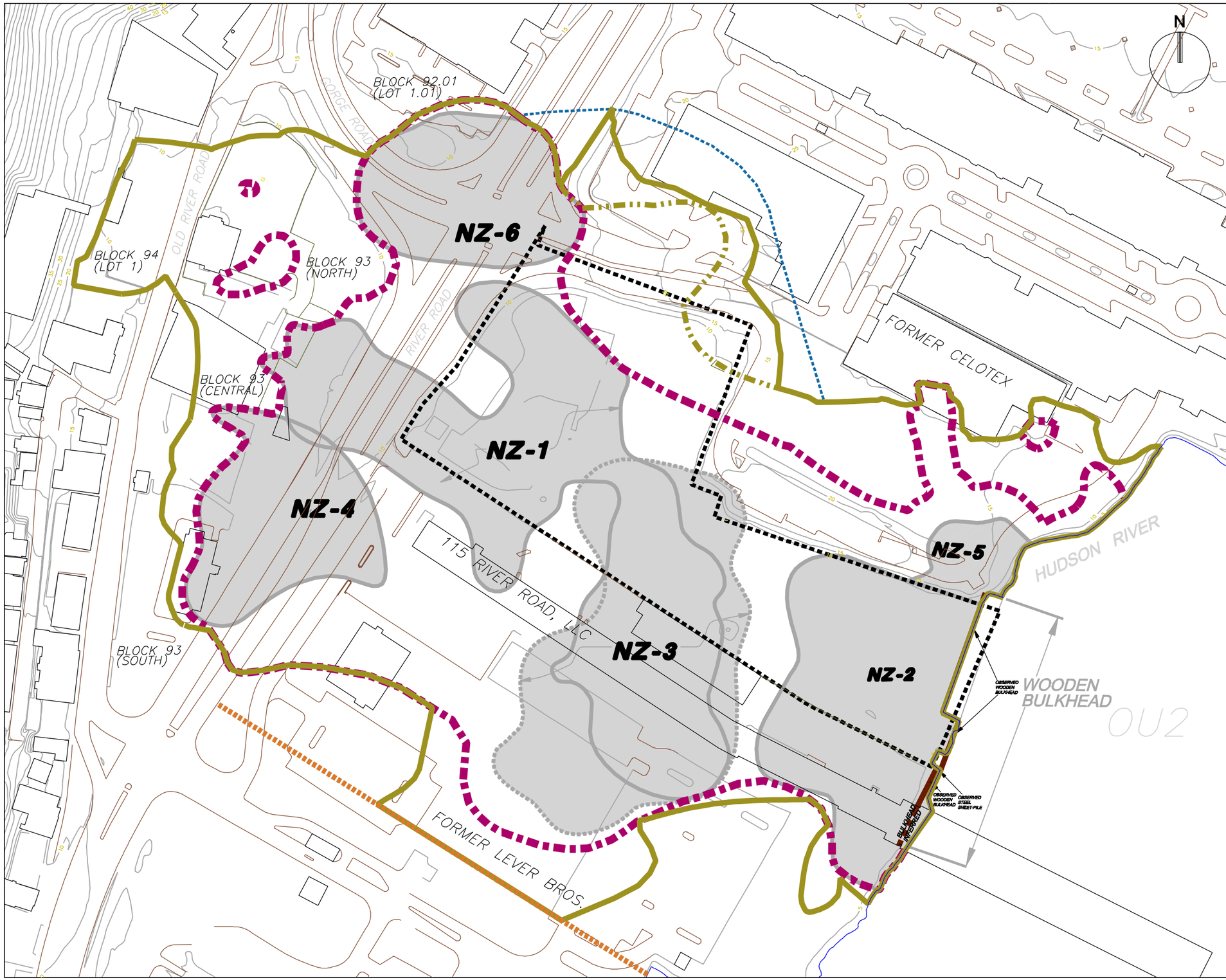

LEGEND

- QUANTA PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE
- LATERAL EXTENT OF NON-AQUEOUS PHASE LIQUID (NAPL) BASED ON TarGOST®, SOIL BORING AND MONITORING WELL OBSERVATIONS
- COMPOSITE EXTENT QUANTA RESOURCES SUPERFUND SITE (OU1) (IN ADDITION TO AREAS OF OBSERVED NAPL THIS AREA INCLUDES STAINED AND ODOROUS SOILS, AS WELL AS QUANTA-RELATED CONSTIUENTS IN SOIL & GROUNDWATER AND THE HIGH CONCENTRATION ARSENIC AREA)
- EXTENT OF QUANTA-RELATED SOIL & GROUNDWATER CONSTITUENTS IN VICINITY OF THE HIGH CONCENTRATION ARSENIC AREA
- EXTENT OF ARSENIC IN GROUNDWATER ASSOCIATED WITH THE HIGH CONCENTRATION ARSENIC AREA THAT IS BEYOND THE EXTENT OF QUANTA-RELATED CONSTITUENTS IN SOIL & GROUNDWATER
- GROUNDWATER CONVERGENCE ZONE
- NZ-2 NAPL ZONE

Note:
1. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

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EXTENT OF QUANTA RESOURCES SUPERFUND SITE OPERABLE UNIT 1 (OU1)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | FIGURE 1-2

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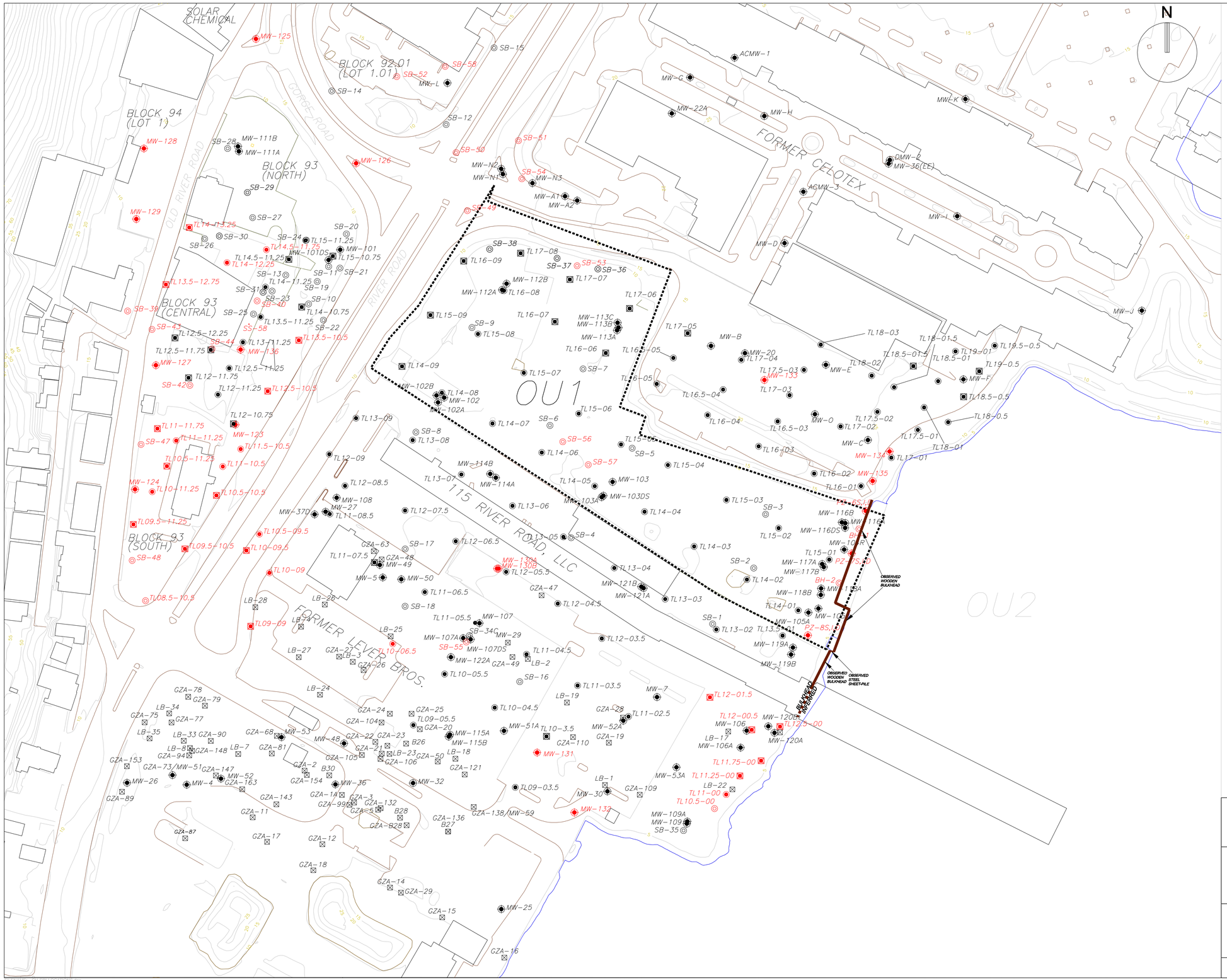
\\Taurus\proj\HoneyWellINC\Quanta_328676\GIS & Graphics\CAD Files\Working Drawings\Delineation(extents)

FILENAME: CH-Quanta_Extents-2009.0706-SRI.dgn



LEGEND

- EXISTING MONITORING WELL
- SOIL BORING (QUANTA REMEDIAL INVESTIGATION)
- SOIL BORING (OTHER SITE INVESTIGATIONS)
- TarGOST® (LIF) BORING
- TarGOST® BORING WITH SOIL SAMPLING & ANALYSIS
- INVESTIGATION LOCATION COMPLETED AS PART OF THE SRI (2008-2009)
- SURFACE SOIL SAMPLING LOCATION
- QUANTA PROPERTY BOUNDARY

GRAPHIC SCALE

80 0 40 80 160 320

(IN FEET)

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REMEDIAL INVESTIGATION AND SUPPLEMENTAL REMEDIAL INVESTIGATION LOCATIONS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-3

FILENAME: CH-SRI-LOCATIONS.dgn

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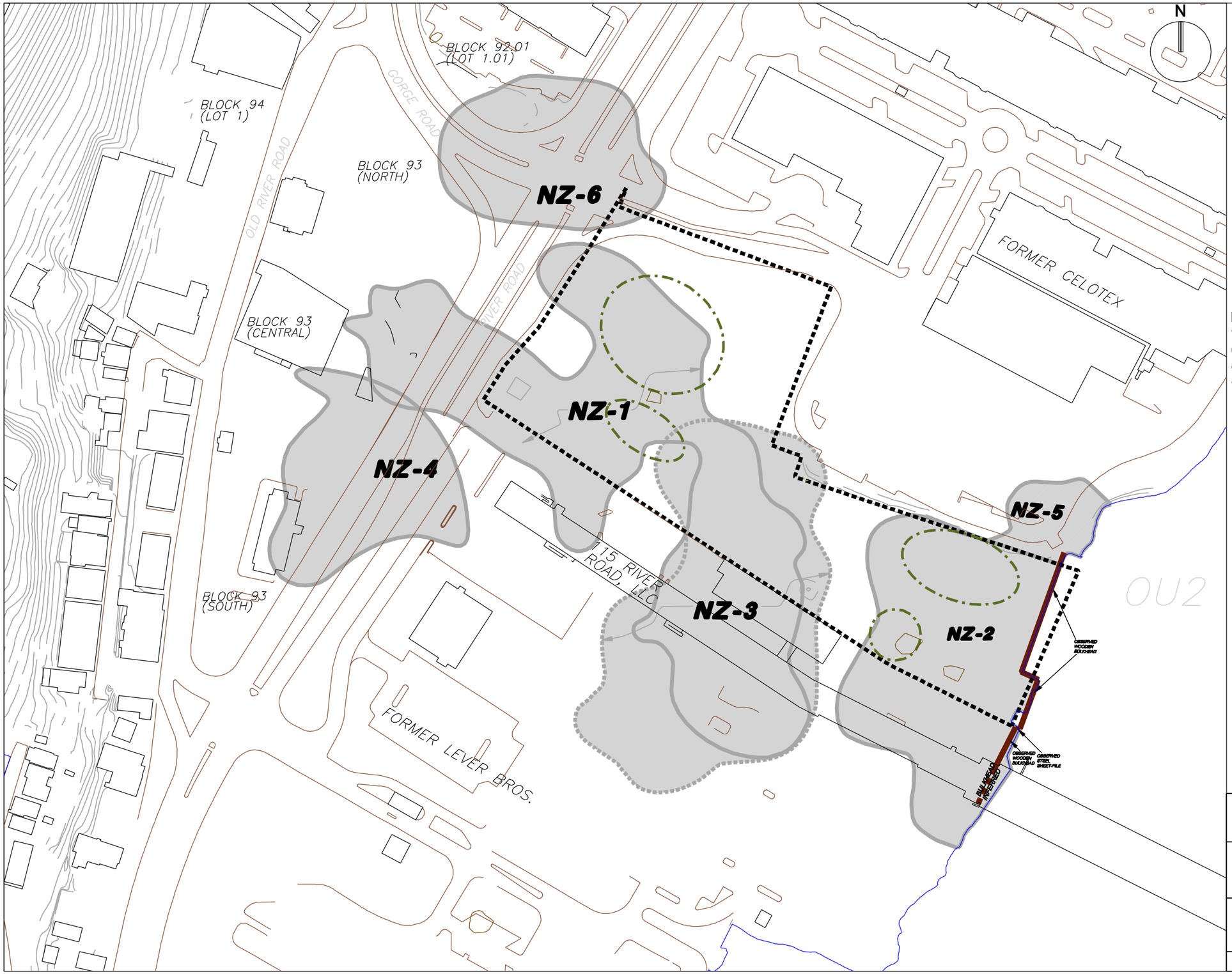

LEGEND

- QUANTA PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE
- NZ-6 NAPL ZONE
- APPROXIMATE AREA OF "TAR BOILS" (NOT NECESSARILY PRESENT THROUGHOUT DEPICTED AREA)

Note:
1. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

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LATERAL EXTENT OF NAPL AND TAR BOILS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-4

FILENAME: CH-NAPL Extent and Zones.dgn

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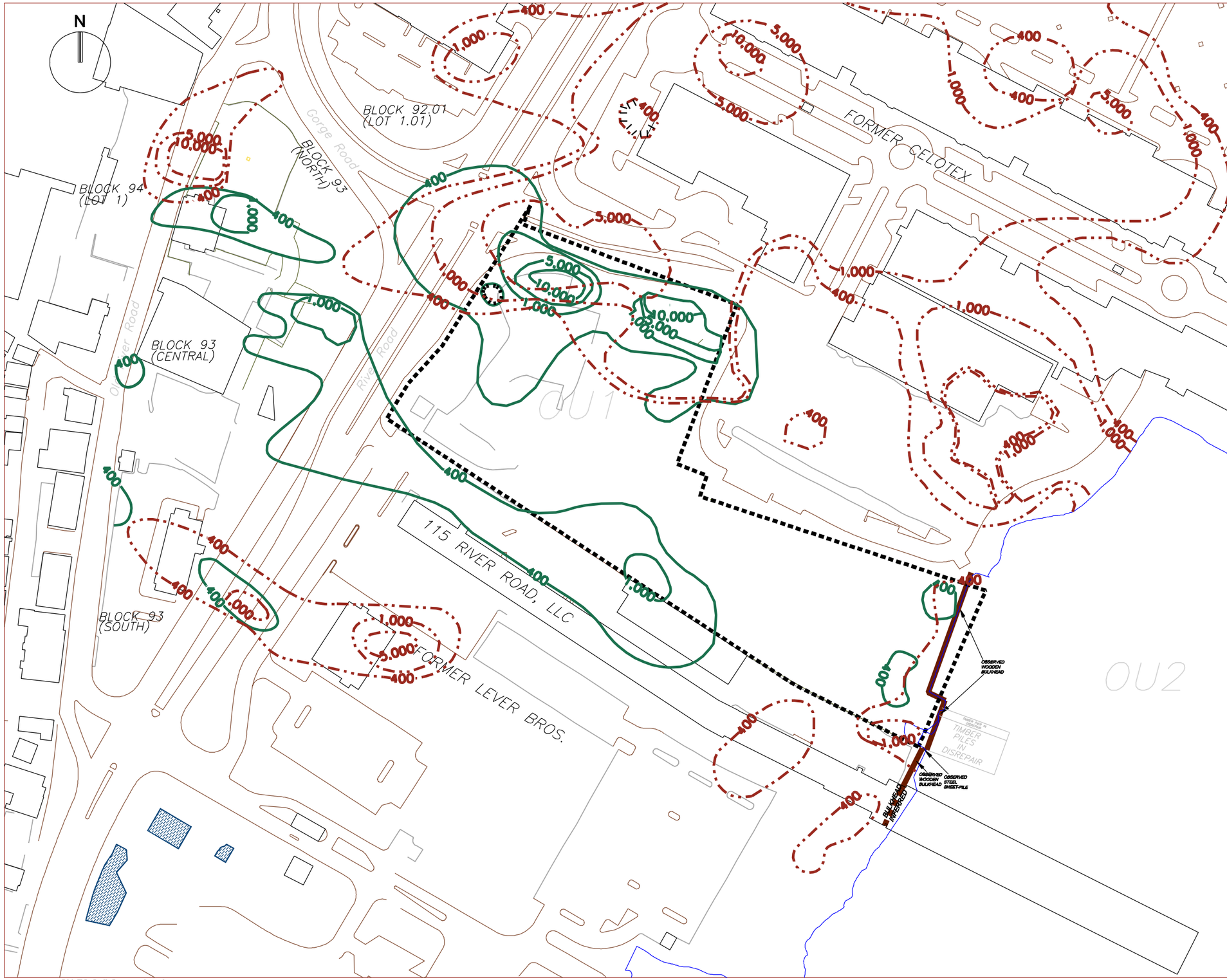
400088



LEGEND

- QUANTA PROPERTY BOUNDARY
- SOIL ISOCONCENTRATION CONTOUR (0-4 FT. BGS) (mg/kg) (AREAS OF CLOSED HATCHED CONTOURS REPRESENT ZONES OF REDUCED CONCENTRATION RELATIVE TO THOSE ADJACENT)
- SOIL ISOCONCENTRATION CONTOUR (>4 FT. BGS) (mg/kg) (AREAS OF CLOSED HATCHED CONTOURS REPRESENT ZONES OF REDUCED CONCENTRATION RELATIVE TO THOSE ADJACENT)
- HUDSON RIVER SHORELINE
- GZA SOIL EXCAVATION AREA

NOTES:

	New Jersey Direct Contact Soil Remediation Standard		EPA Regional Soil Screening Level	
Parameter	Residential	Non-Residential	Residential	Industrial
Units	mg/kg	mg/kg	mg/kg	mg/kg
Lead	400	800	400	800

1. Soil data have been contoured to lowest concentration between the NJ Direct Contact Soil Criteria and the EPA Soil Screening Criteria as shown in the table above.
2. Available historic soil data for the former Celotex and former Lever Brothers properties is shown but does not necessarily represent current conditions because of significant filling and disturbances in this area as a result of remedial efforts and redevelopment activities. Soil at these properties is being evaluated and addressed with oversight from the NJDEP as part of ongoing redevelopment activities.
3. Contours were not drawn for non Site-related material observed as part of investigations by other parties under separate administrative orders. Furthermore, not all of the material that has been contoured based on the OU1 RI is Site-related. The extent of constituents in soil and groundwater that are related to OU1 is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
4. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
5. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

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SOIL ISOCONCENTRATION CONTOURS

LEAD (0-4 and > 4 ft.)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-5

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FILENAME: CH-FS Soil Contouring.dgn

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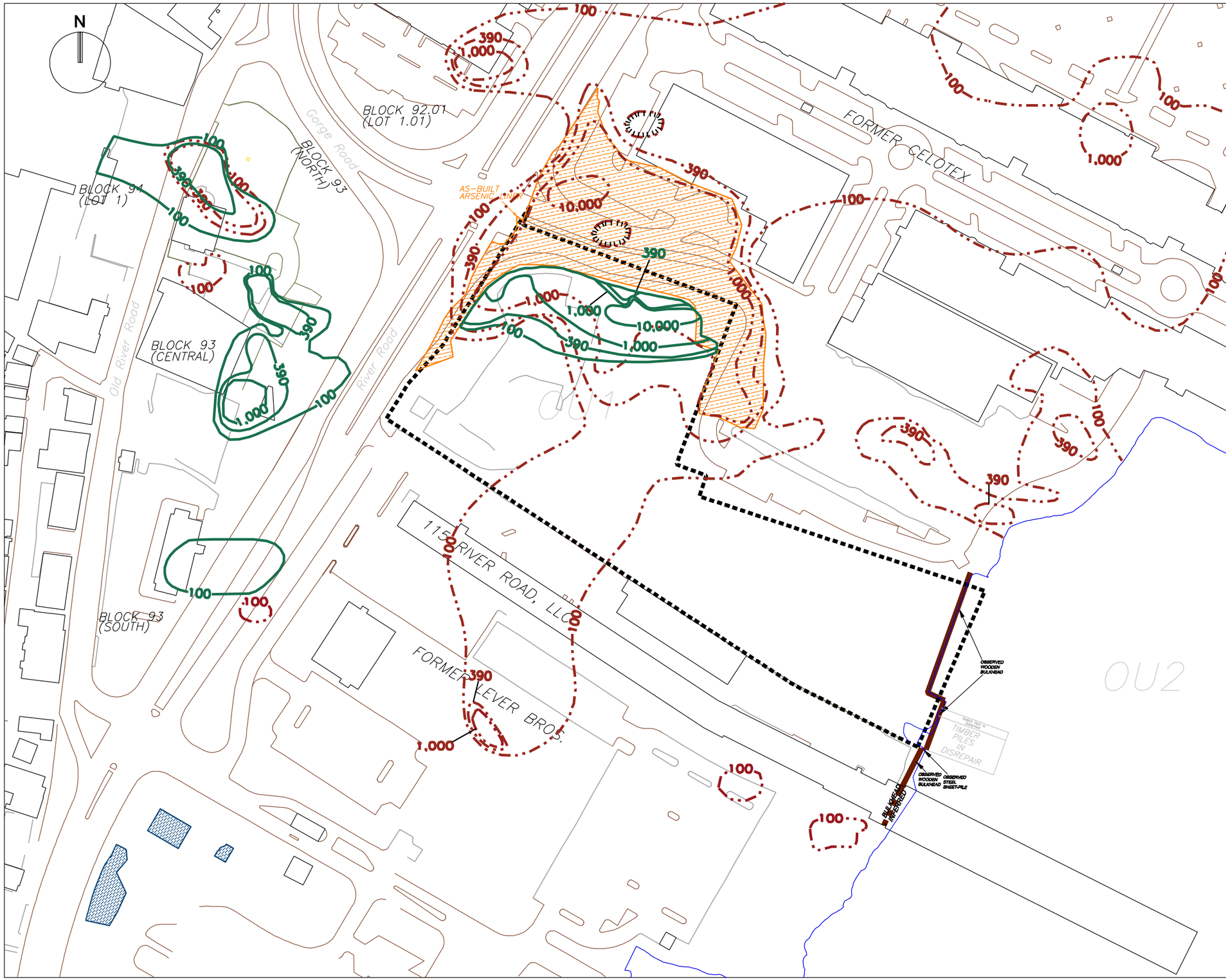

LEGEND

- QUANTA PROPERTY BOUNDARY
- SOIL ISOCONCENTRATION CONTOUR (0-4 FT. BGS) (mg/kg) (AREAS OF CLOSED HATCHED CONTOURS REPRESENT ZONES OF REDUCED CONCENTRATION RELATIVE TO THOSE ADJACENT)
- SOIL ISOCONCENTRATION CONTOUR (>4 FT. BGS) (mg/kg) (AREAS OF CLOSED HATCHED CONTOURS REPRESENT ZONES OF REDUCED CONCENTRATION RELATIVE TO THOSE ADJACENT)
- HUDSON RIVER SHORELINE
- GZA SOIL EXCAVATION AREA
- AS-BUILT ARSENIC LINER

NOTES:

	New Jersey Direct Contact Soil Remediation Standard		EPA Regional Soil Screening Level	
Parameter	Residential	Non-Residential	Residential	Industrial
Units	mg/kg	mg/kg	mg/kg	mg/kg
Arsenic	19	19	0.39	1.6

1. Due to the ubiquity of fill material and other non-site related sources often containing concentrations of arsenic above soil screening criteria data has been contoured to 100 mg/kg to help illustrate potential source ares other than that of fill. These potential source areas may or may not relate to historical operations associated with the Quanta Resources Superfund Site.
2. Available historic soil data for the former Celotex and former Lever Brothers properties is shown but does not necessarily represent current conditions because of significant filling and disturbances in this area as a result of remedial efforts and redevelopment activities. Soil at these properties is being evaluated and addressed with oversight from the NJDEP as part of ongoing redevelopment activities.
3. Contours were not drawn for non Site-related material observed as part of investigations by other parties under separate administrative orders. Furthermore, not all of the material that has been contoured based on the OU1 RI is Site-related. The extent of constituents in soil and groundwater that are related to OU1 is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
4. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
5. The 1,000 ppm isoconcentration contour line in the southwestern portion of the former Celotex property in the vicinity of the arsenic liner is based partially on data collected as part of the Final Soil RI Report for the former Celotex property (Dan Raviv Assoc., July 2002). These data were only available on existing maps, but were used to assist in the development of the 1000 ppm contour line for this area.
6. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

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SOIL ISOCONCENTRATION CONTOURS

ARSENIC (0-4 and > 4 ft.)

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | FIGURE 1-6

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FILENAME: CH-FS Soil Contouring.dgn

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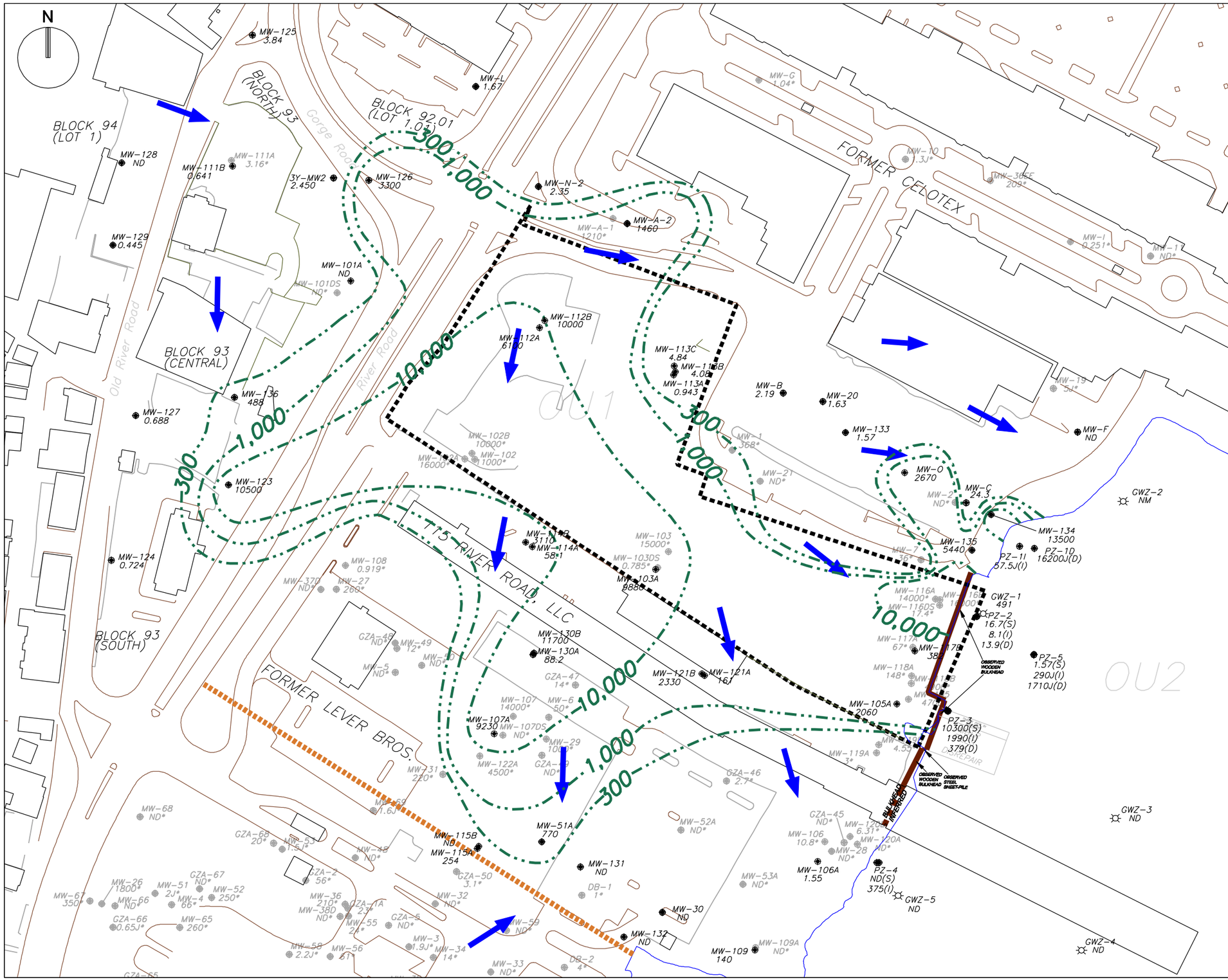

LEGEND

- MW-F 107 — MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- MW-2 ND* — PRE-SRI MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- GWZ-1 ND — TRIDENT PROBE SAMPLE LOCATION WITH PORE WATER CONCENTRATION
- QUANTA PROPERTY BOUNDARY
- GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- GROUNDWATER CONVERGENCE ZONE WHERE NON-QUANTA RELATED IMPACTS IN GROUNDWATER ORIGINATING FROM SOURCE AREAS TO THE SOUTH MERGE WITH GROUNDWATER FROM THE SITE
- HUDSON RIVER SHORELINE
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (March 2009)

NOTES:

Parameter	New Jersey Groundwater Quality Criteria: Higher of Class IIA and PQL	New Jersey Groundwater Quality Criteria: Interim Generic	EPA Regional Screening Levels - Tap Water	EPA Maximum Contaminant Levels
Units	µg/L	µg/L	µg/L	µg/L
Naphthalene	300	NA	0.14	NA

1. Groundwater data have been contoured to lowest concentration between the NJ Groundwater Quality Criteria and the EPA Maximum Contaminant Levels as shown in the table above. EPA Regional Screening Levels for tap water for this constituent are also shown above for reference.
2. Groundwater data to the south of the groundwater convergence zone in the northern portion of the Former Lever Brothers property are shown but not contoured. The depiction of data at properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there. The extent of constituents in soil and groundwater that are related to OU1 (Site-related) is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
3. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
4. The highest concentration between colocated wells was used in contouring.
5. Where 2008/2009 Supplemental Remedial Investigation (SRI) data is not available, the most recent results for that monitoring location have been posted and used to assist contouring.
6.

7. ND = analyte was not detected above the laboratory method detection limits
8. J = concentration is estimated
9. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

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GROUNDWATER ISOCONCENTRATION CONTOURS

NAPHTHALENE

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-7

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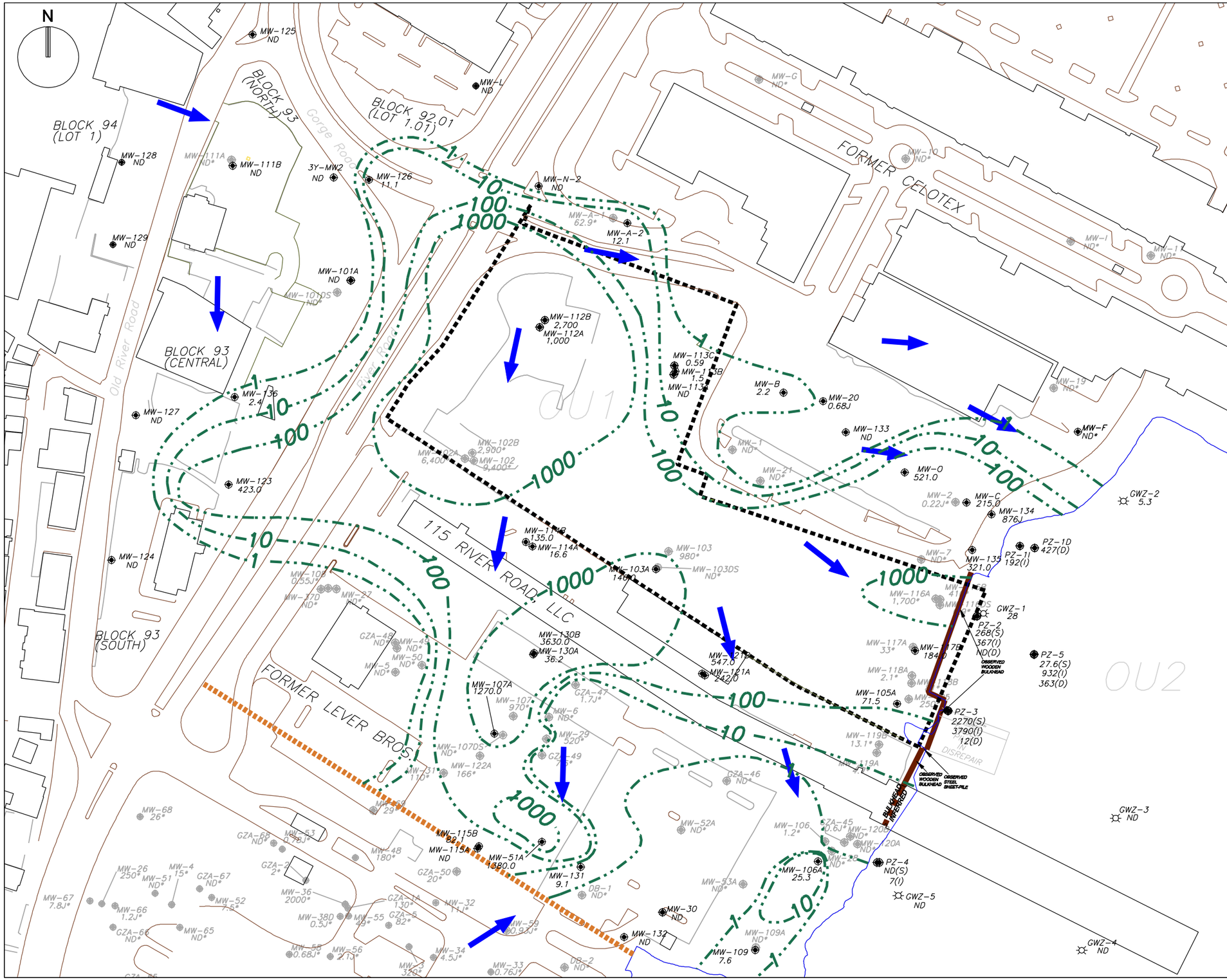
FILENAME: CH-GWConc-Contouring-SRI.dgn



LEGEND

- MW-F 107 — MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- MW-2 ND* — PRE-SRI MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- GWZ-1 ND — TRIDENT PROBE SAMPLE LOCATION WITH PORE WATER CONCENTRATION
- QUANTA PROPERTY BOUNDARY
- GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- GROUNDWATER CONVERGENCE ZONE WHERE NON-QUANTA RELATED IMPACTS IN GROUNDWATER ORIGINATING FROM SOURCE AREAS TO THE SOUTH MERGE WITH GROUNDWATER FROM THE SITE
- HUDSON RIVER SHORELINE
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (March 2009)

NOTES:

Parameter	New Jersey Groundwater Quality Criteria		EPA Regional Screening Levels - Tap Water	EPA Maximum Contaminant Levels
	Higher of Class IIA and PQL	Interim Generic		
Units	µg/L	µg/L	µg/L	µg/L
Benzene	1	NA	0.41	5

1. Groundwater data have been contoured to lowest concentration between the NJ Groundwater Quality Criteria and the EPA Maximum Contaminant Levels as shown in the table above. EPA Regional Screening Levels for tap water for this constituent are also shown above for reference.
2. Groundwater data to the south of the groundwater convergence zone in the northern portion of the Former Lever Brothers property are shown but not contoured. The depiction of data at properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there. The extent of constituents in soil and groundwater that are related to OU1 (Site-related) is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
3. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
4. The highest concentration between colocated wells was used in contouring.
5. Where 2008/2009 Supplemental Remedial Investigation (SRI) data is not available, the most recent results for that monitoring location have been posted and used to assist contouring.
6.

7. ND = analyte was not detected above the laboratory method detection limits
8. J = concentration is estimated
9. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

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GROUNDWATER ISOCONCENTRATION CONTOURS

BENZENE

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-8

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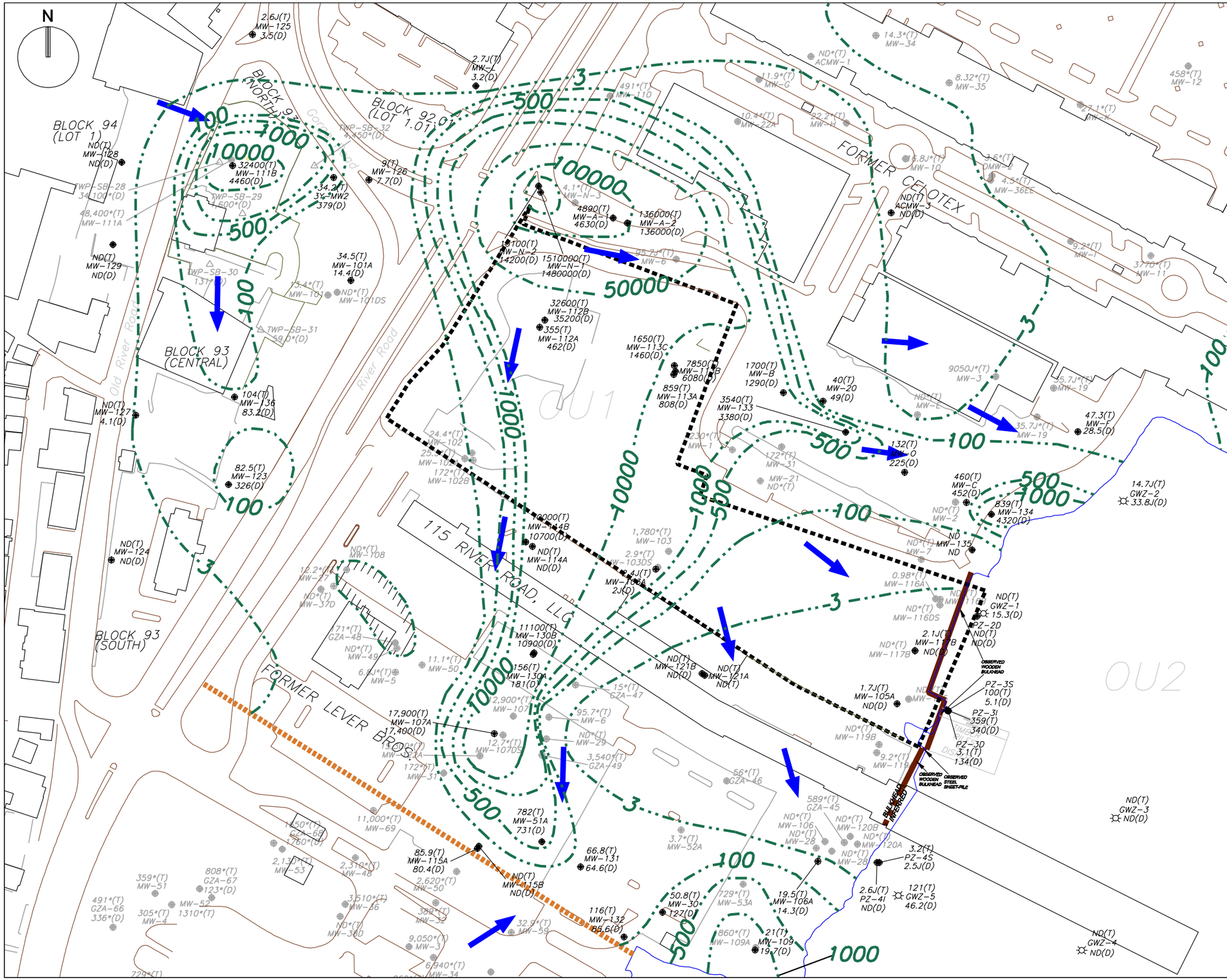
FILENAME: CH-GWConc-Contouring-SRI.dgn



LEGEND

- MONITORING LOCATION WITH GROUNDWATER/PORE WATER CONCENTRATION (4.2(T=Total Arsenic Concentration); 1.9(D=Dissolved Arsenic Concentration))
- PRE-SRI MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- TRIDENT PROBE SAMPLE LOCATION WITH PORE WATER CONCENTRATION
- QUANTA PROPERTY BOUNDARY
- GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- GROUNDWATER CONVERGENCE ZONE WHERE NON-QUANTA RELATED IMPACTS IN GROUNDWATER ORIGINATING FROM SOURCE AREAS TO THE SOUTH MERGE WITH GROUNDWATER FROM THE SITE
- HUDSON RIVER SHORELINE
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (March 2009)

NOTES:

Parameter	New Jersey Groundwater Quality Criteria		EPA Regional Screening Levels - Tap Water	EPA Maximum Contaminant Levels
	Higher of Class IIA and PQL	Interim Generic		
Units	µg/L	µg/L	µg/L	µg/L
Arsenic	3	NA	0.045	10

1. Groundwater data have been contoured to lowest concentration between the NJ Groundwater Quality Criteria and the EPA Maximum Contaminant Levels as shown in the table above. EPA Regional Screening Levels for tap water for this constituent are also shown above for reference.
2. Groundwater data to the south of the groundwater convergence zone in the northern portion of the Former Lever Brothers property are shown but not contoured. The depiction of data at properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there. The extent of constituents in soil and groundwater that are related to OU1 (Site-related) is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
3. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
4. The highest concentration between colocated wells was used in contouring.
5. Where 2008/2009 Supplemental Remedial Investigation (SRI) data is not available, the most recent results for that monitoring location have been posted and used to assist contouring.
6. Where dissolved arsenic concentrations were not available total arsenic concentrations were used to assist contouring.
7.
8. ND = analyte was not detected above the laboratory method detection limits
9. J = concentration is estimated
10. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

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GROUNDWATER ISOCONCENTRATION CONTOURS
DISSOLVED ARSENIC

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

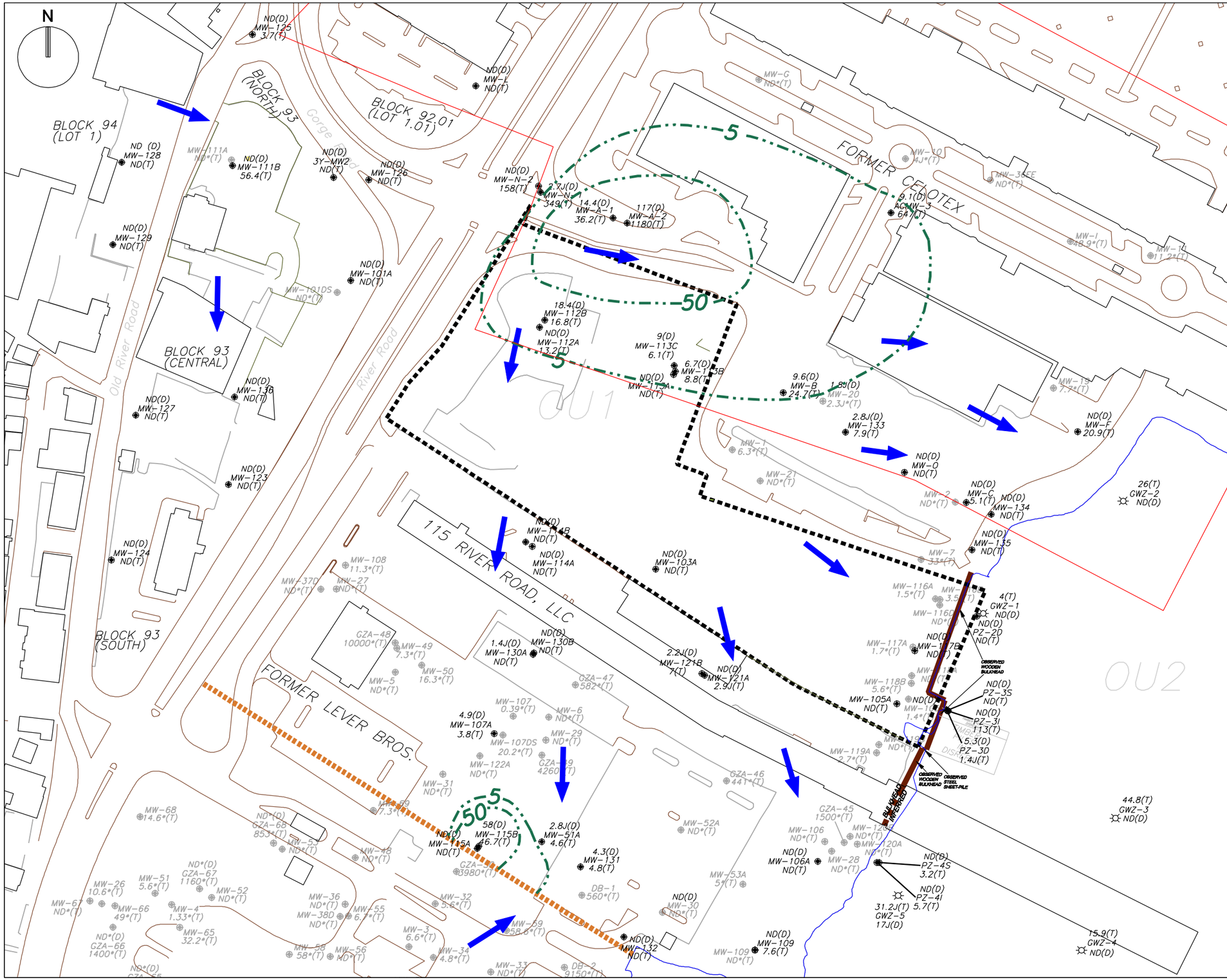
July 6, 2010

FIGURE 1-9

400093

\\Taurus\proj\HoneyWellINC\Quanta_328676\GIS & Graphics\CAD Files\Working Drawings\GWConc Contouring

FILENAME: CH-GWConc-Contouring-SRI.dgn



LEGEND

- 1.9(D=Dissolved Lead Concentration) / 4.2(T=Total Lead Concentration) — MONITORING LOCATION WITH GROUNDWATER/PORE WATER CONCENTRATION
- PRE-SRI MONITORING WELL SAMPLE LOCATION WITH GROUNDWATER CONCENTRATION
- TRIDENT PROBE SAMPLE LOCATION WITH PORE WATER CONCENTRATION
- QUANTA PROPERTY BOUNDARY
- GROUNDWATER ISOCONCENTRATION CONTOUR (ug/L)
- GROUNDWATER CONVERGENCE ZONE WHERE NON-QUANTA RELATED IMPACTS IN GROUNDWATER ORIGINATING FROM SOURCE AREAS TO THE SOUTH MERGE WITH GROUNDWATER FROM THE SITE
- HUDSON RIVER SHORELINE
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (March 2009)
- FOOTPRINT OF FORMER GENERAL CHEMICAL PLANT (DEPICTION BASED ON 1958 FIRE INSURANCE MAP)

NOTES:

Parameter	New Jersey Groundwater Quality Criteria: Higher of Class IIA and PQL	New Jersey Groundwater Quality Criteria: Interim Generic	EPA Regional Screening Levels - Tap Water	EPA Maximum Contaminant Levels
Units	µg/L	µg/L	µg/L	µg/L
Lead	5	NA	0.0029	15

1. Groundwater data have been contoured to lowest concentration between the NJ Groundwater Quality Criteria and the EPA Maximum Contaminant Levels as shown in the table above. EPA Regional Screening Levels for tap water for this constituent are also shown above for reference.
2. Groundwater data to the south of the groundwater convergence zone in the northern portion of the Former Lever Brothers property are shown but not contoured. The depiction of data at properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there. The extent of constituents in soil and groundwater that are related to OU1 (Site-related) is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
3. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
4. The highest concentration between colocated wells was used in contouring.
5. Where 2008/2009 Supplemental Remedial Investigation (SRI) data is not available, the most recent results for that monitoring location have been posted and used to assist contouring.
6. Where dissolved lead concentrations were not available total lead concentrations were used to assist contouring.
7.
8. ND = analyte was not detected above the laboratory method detection limits
9. J = concentration is estimated
10. The base map was prepared by Vargo Associates of Franklinville, New Jersey and updated as recently as November 2008 and presented in the Final 2009 SRI Report.

0 70 ft. 140 ft.

CH2MHILL

GROUNDWATER ISOCONCENTRATION CONTOURS

DISSOLVED LEAD

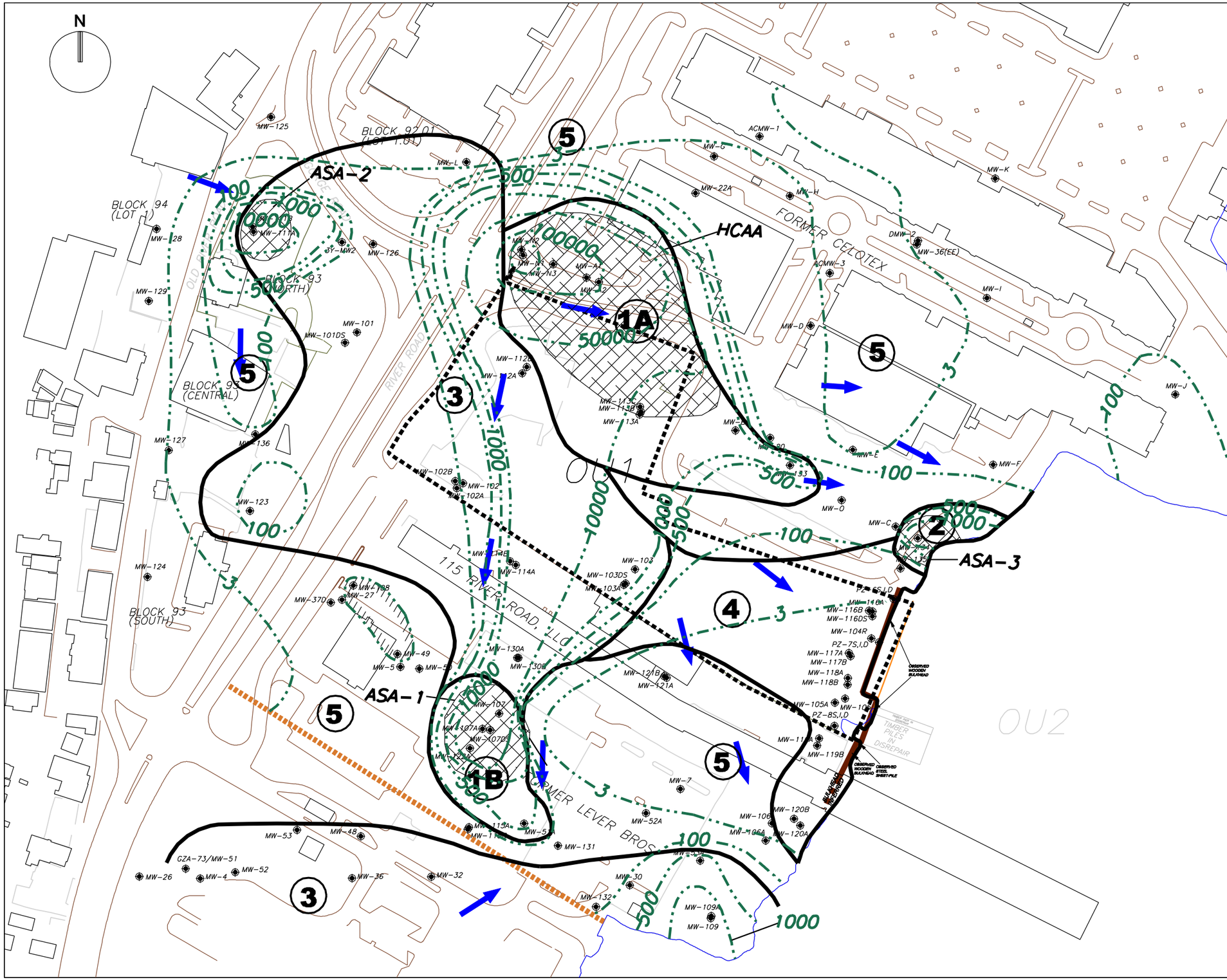
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-10

400094

\\Taurus\proj\HoneyWellINC\Quanta_328676\GIS & Graphics\CAD Files\Working Drawings\GWConc Contouring
FILENAME: CH-GWConc-Contouring-SRI.dgn



LEGEND

- MONITORING WELL LOCATION
- QUANTA PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE
- GEOCHEMICAL ZONE DESIGNATION
- APPROXIMATE DIRECTION OF SHALLOW GROUNDWATER FLOW (March 2009)
- GROUNDWATER CONVERGENCE ZONE WHERE NON-QUANTA RELATED IMPACTS IN GROUNDWATER ORIGINATING FROM SOURCE AREAS TO THE SOUTH MERGE WITH GROUNDWATER FROM THE SITE
- GROUNDWATER ISOCONCENTRATION CONTOUR (mg/L)
- ARSENIC SOURCE AREA (ASA)

NOTES:

1. This figure supersedes Figure 5-8 of the Remedial Investigation Report submitted to EPA August 2008.
2. Groundwater data have been contoured to lowest concentration between the NJ Groundwater Quality Criteria and the EPA Maximum Contaminant Levels (3 ug/L).
3. Groundwater data to the south of the groundwater convergence zone in the northern portion of the Former Lever Brothers property are shown but not contoured. The depiction of data at properties adjacent to OU1 does not necessarily mean that Site-related constituents have migrated there. The extent of constituents in soil and groundwater that are related to OU1 (Site-related) is presented in Figure 8-1 of the SRI Report entitled 'Quanta Superfund Extents'.
4. Concentration contours were developed initially using kriging and the software Surfer 8.0 ®. Computer generated contours were subsequently adjusted by hand.
5. The highest concentration between colocated wells was used in contouring (see Figure 1-9 of the Draft Final FS (CH2M HILL, 2010).
6. Where 2008/2009 Supplemental Remedial Investigation (SRI) data was not available, the most recent results for that monitoring location were used to assist contouring.
7. The hatched areas represent Arsenic Source Areas (ASAs).

BASE MAP NOTES:

A. BASE MAP WAS PREPARED BY VARGO ASSOCIATES OF FRANKLINVILLE, NEW JERSEY AND UPDATED AS RECENTLY AS NOVEMBER 2008.
B. PROPERTY LINES SHOWN HEREON IS REFERENCED TO CURRENT TAX MAPS FOR THE BOROUGH OF EDGEWATER, BERGEN COUNTY, NEW JERSEY.
C. REFERENCE PLAN ENTITLED "RIGHT OF WAY MAP, RIVER ROAD RE-ALIGNMENT, SOUTH SECTION, BOROUGH OF EDGEWATER, BERGEN COUNTY, N.J." PREPARED BY BOSWELL ENGINEERING, HACKENSACK, N.J., FILED IN THE BERGEN COUNTY CLERK'S OFFICE AS MAP NO. 9154.
D. HORIZONTAL DATUM IS REFERENCED TO THE NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 1983 BASED ON GPS OBSERVATIONS BY VARGO ASSOC. IN SEPTEMBER, 2005.
E. ELEVATIONS SHOWN HEREON ARE IN FEET AND ARE REFERENCED TO N.A.V.D. 1988.
F. TOPOGRAPHIC FEATURES SHOWN HEREON IS REFERENCED TO AERIAL PHOTOGRAPHY PROVIDED BY PROMAPS, MORRESTOWN, N.J. (FLIGHT DATE: 08-17-08).
G. TIDAL DATUMS ARE REFERENCED TO TIDE GUAGE NGS A40 AND NGS 1240 AND ARE AS FOLLOWS:
MEAN HIGHER HIGH WATER ELEVATION=1.90'
MEAN HIGH WATER ELEVATION=1.63'
MEAN TIDE LEVEL ELEVATION=-0.50
MEAN LOW WATER ELEVATION=-2.62'
MEAN LOWER LOW WATER ELEVATION=-2.83'
H. UNDERGROUND UTILITIES SHOWN HEREON ARE NOT NECCESSARILY COMPLETE AND SHALL BE FIELD VERIFIED PRIOR TO ANY CONSTRUCTION.

0 80 ft. 160 ft.

CH2MHILL

GEOCHEMICAL ZONES AND DISSOLVED ARSENIC ISOCONCENTRATION CONTOURS

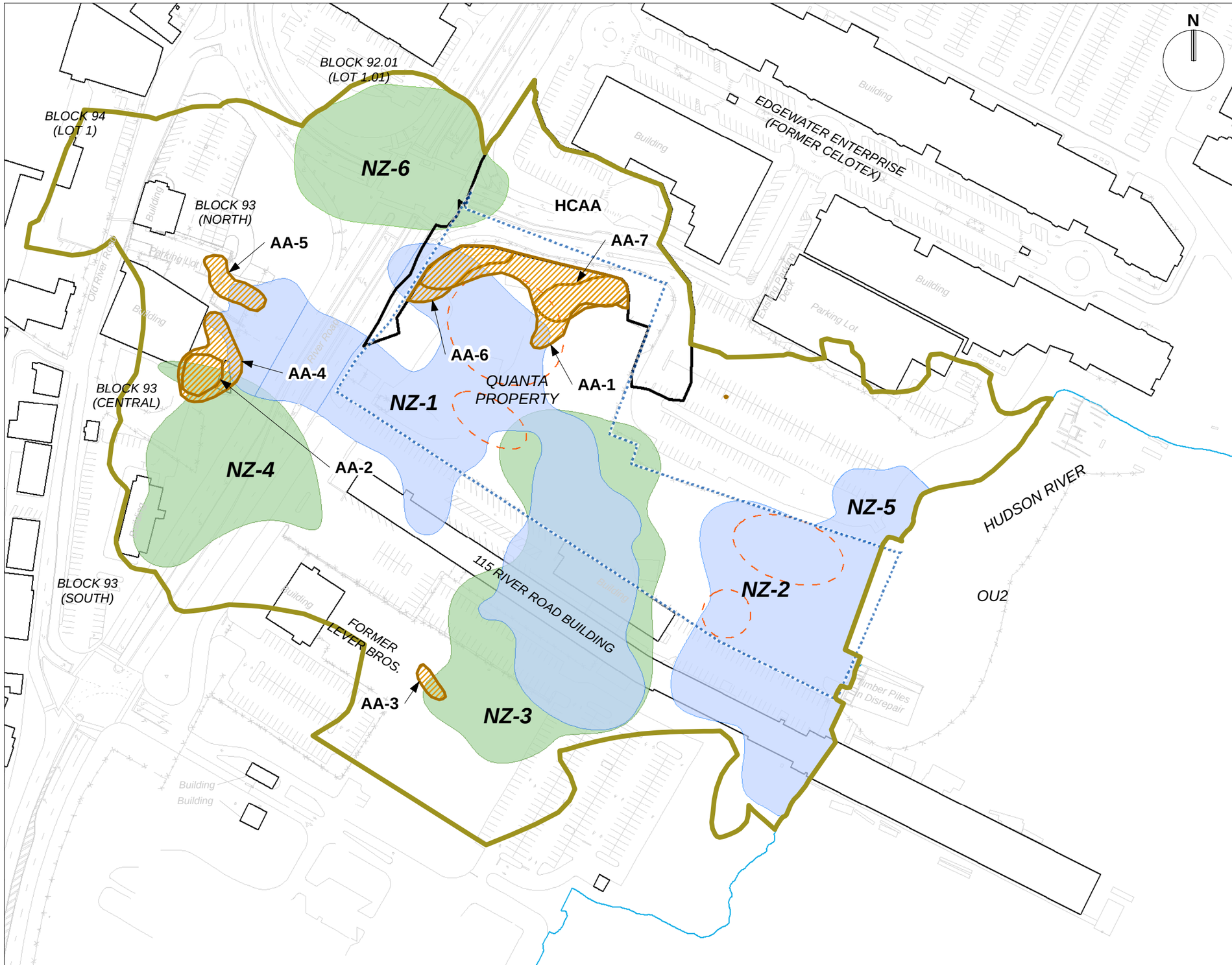
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-11

400095

FILENAME: CH-SRI-GW-GeochemZones.dgn PLOT DATE: March 4, 2010
\\Taurus\proj\HoneyWellINC\Quanta_328676\GIS & Graphics\CAD Files\Working Drawings\Geochemistry



LEGEND

- Existing Arsenic Liner
- Principal Threat Arsenic Area
- Principal Threat NAPL Zone
- Low Level Threat NAPL Zone
- Extent of OU1
- Tar Boils

Notes:

1. Source material is defined based on criteria derived from A Guide to Principal Threat and Low Level Threat Wastes. (EPA, 1991)
2. NZ = NAPL Zone, AA = Arsenic Area
3. Depth of NAPL Zones:
   - NZ-1: 1-11 ft bgs
   - NZ-2: 4-25 ft bgs
   - NZ-3: 15-25 ft bgs
   - NZ-4: 10-32 ft bgs
   - NZ-5: 10-25 ft bgs
   - NZ-6: 10-15 ft bgs
4. Depth of Arsenic Areas:
   - AA-1: 10 ft bgs
   - AA-2: 5 ft bgs
   - AA-3: 7 ft bgs
   - AA-4: 2 ft bgs
   - AA-5: 2 ft bgs
   - AA-6: 2 ft bgs
   - AA-7: 2 ft bgs

0 70 140 ft.

CH2MHILL

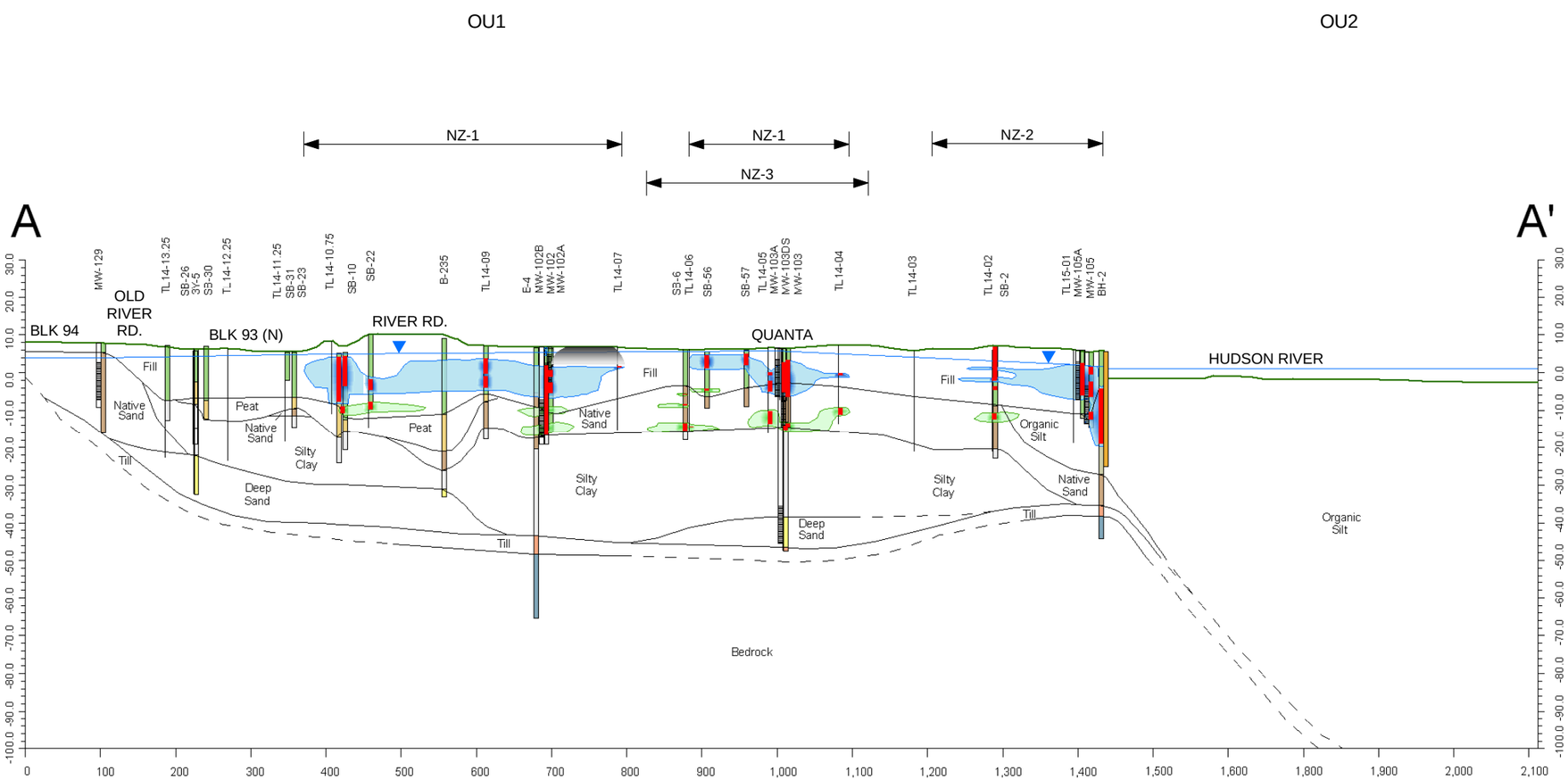
SOURCE MATERIAL

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-12**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-12_QUANTAOU1_SOURCEMATERIAL.MXD JHANSEN1 7/6/2010 14:13:27

400096



LEGEND

- Interval of Observed NAPL
- Water Table
- Wooden Bulkhead
- Tar Boils
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste

Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 36' Vertical

1" = 180' Horizontal

CH2MHILL

SOURCE MATERIAL CROSS-SECTION A - A'

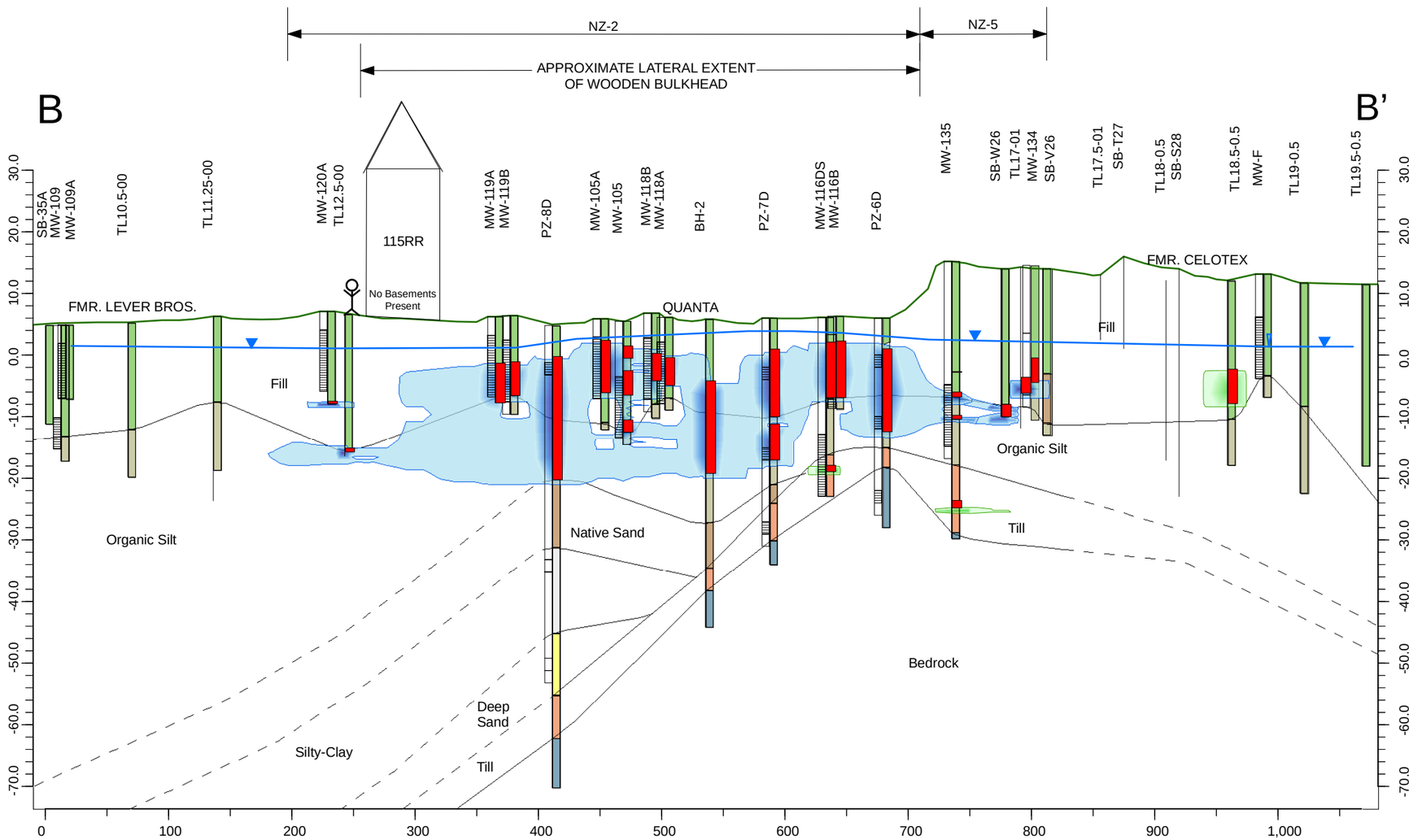
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-13

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-13_QUANTAOU1_SM_CROSSSECTIONA-A.MXD JHANSEN1 7/6/2010 14:15:17

400097



Stratigraphy

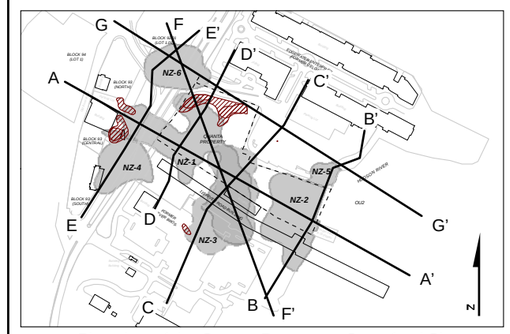
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

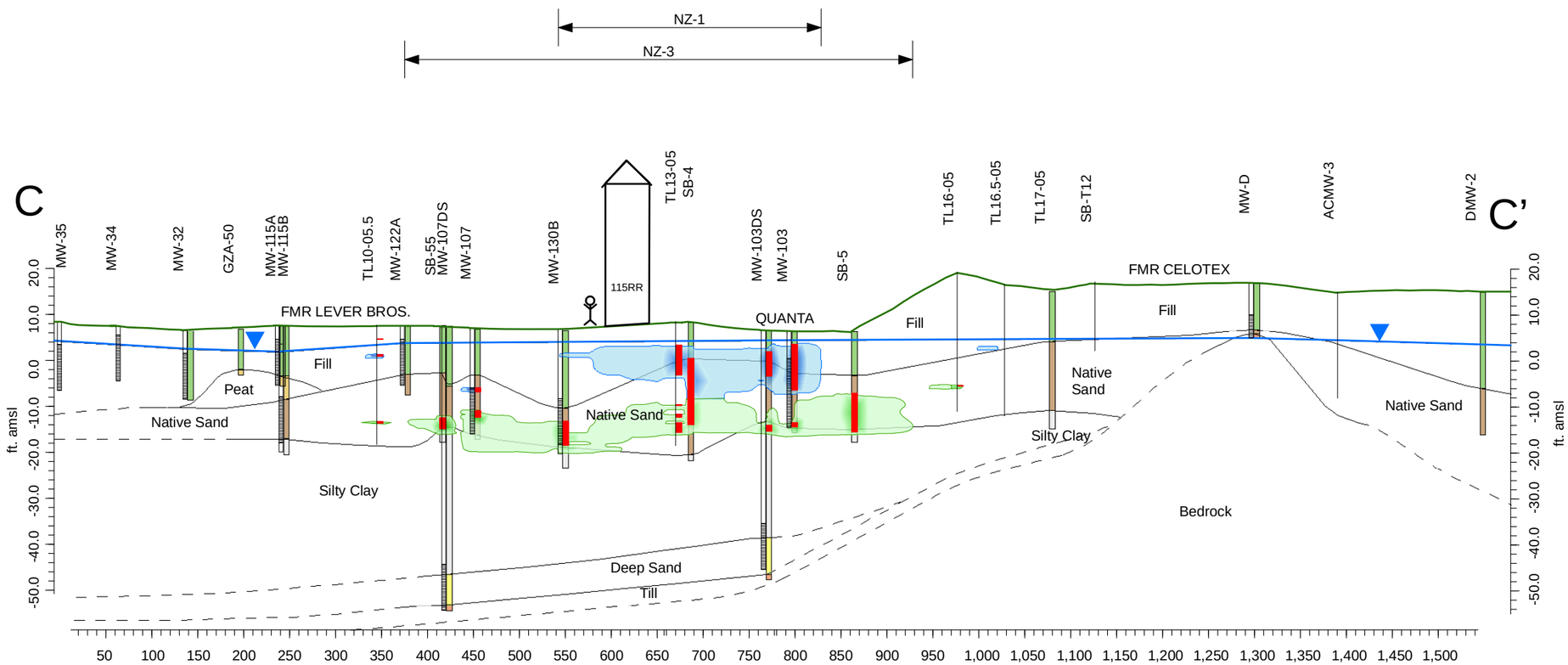
SOURCE MATERIAL CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-14**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-14_QUANTAOU1_SM_CROSSSECTIONB-B.MXD JHANSEN1 7/6/2010 14:16:52

400098



Stratigraphy

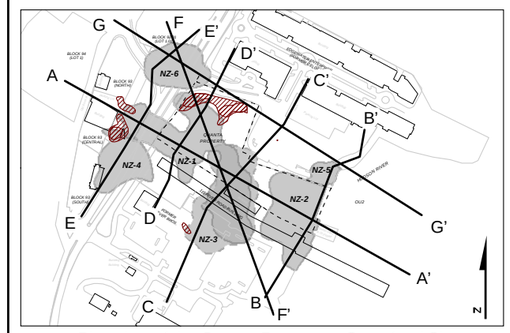
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

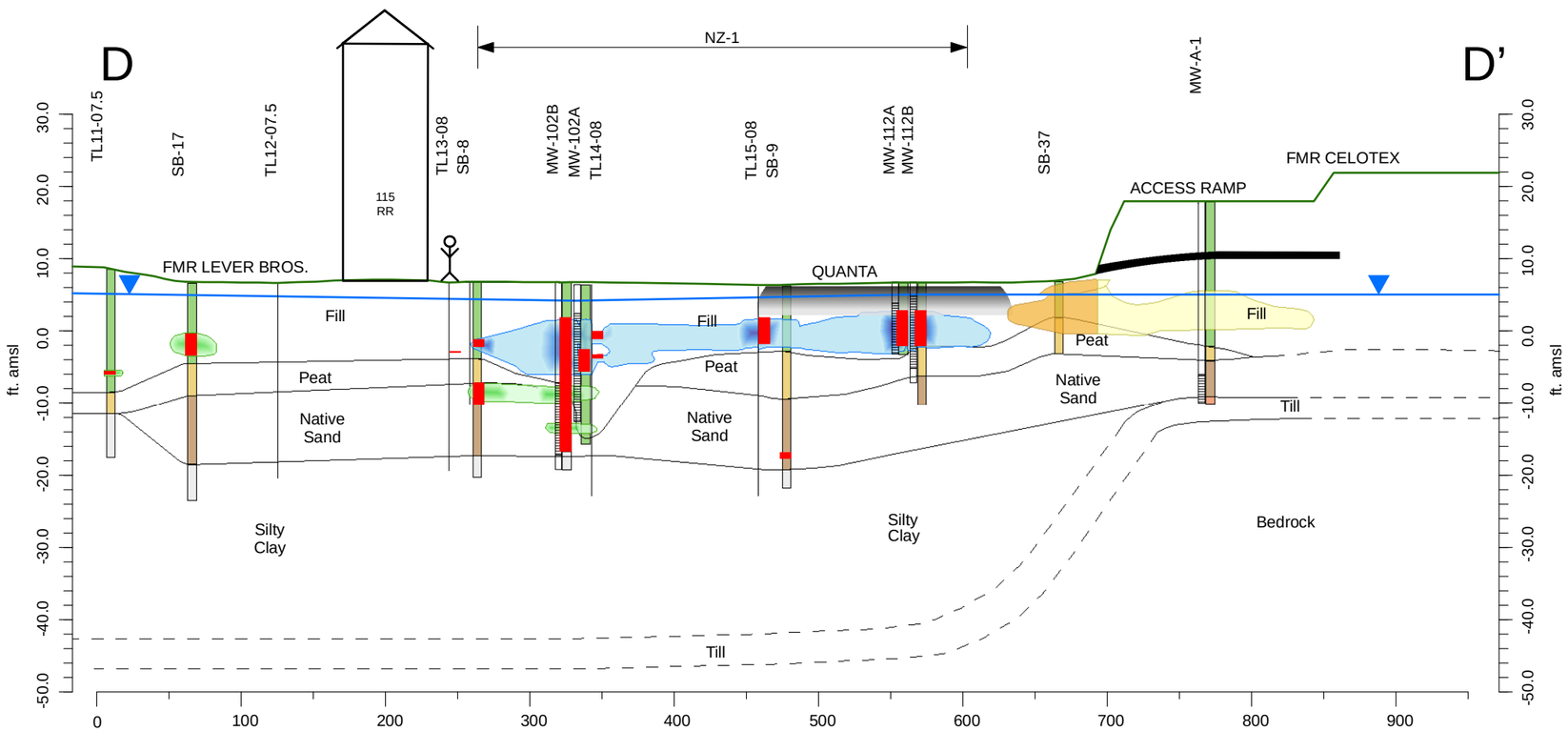
SOURCE MATERIAL CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-15**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-15_QUANTAOU1_SM_CROSSSECTIONC-C.MXD JHANSEN1 7/6/2010 14:18:55

400099



Stratigraphy

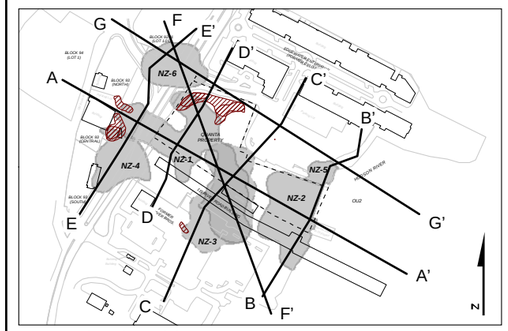
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Interval of Observed NAPL
- Water Table
- Existing Arsenic Liner
- Tar Boils
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Area



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST ® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

SOURCE MATERIAL CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-16**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-16_QUANTAOU1_SM_CROSSSECTIOND-D.MXD JHANSEN1 7/6/2010 14:19:48

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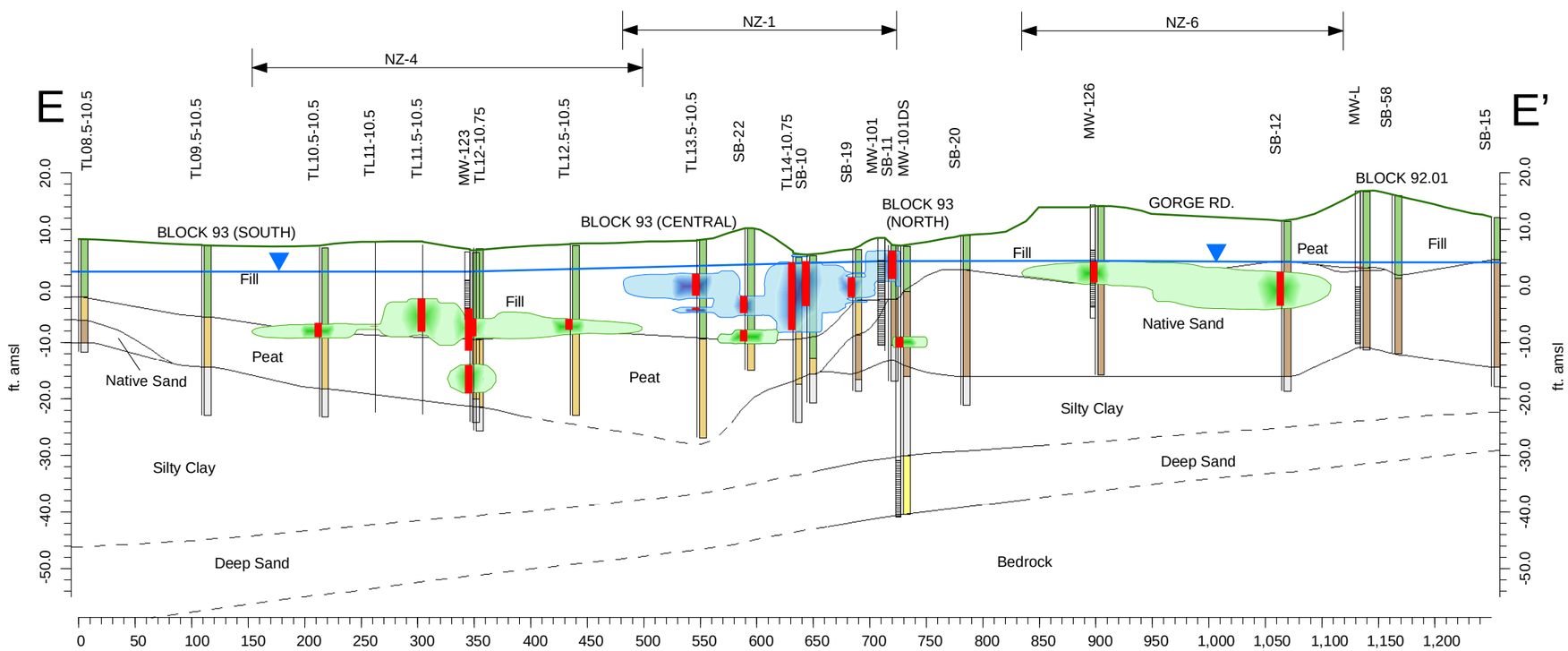


Stratigraphy

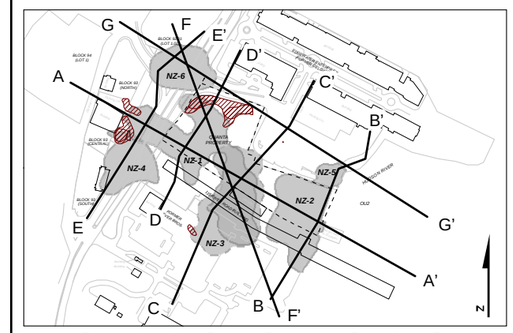
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

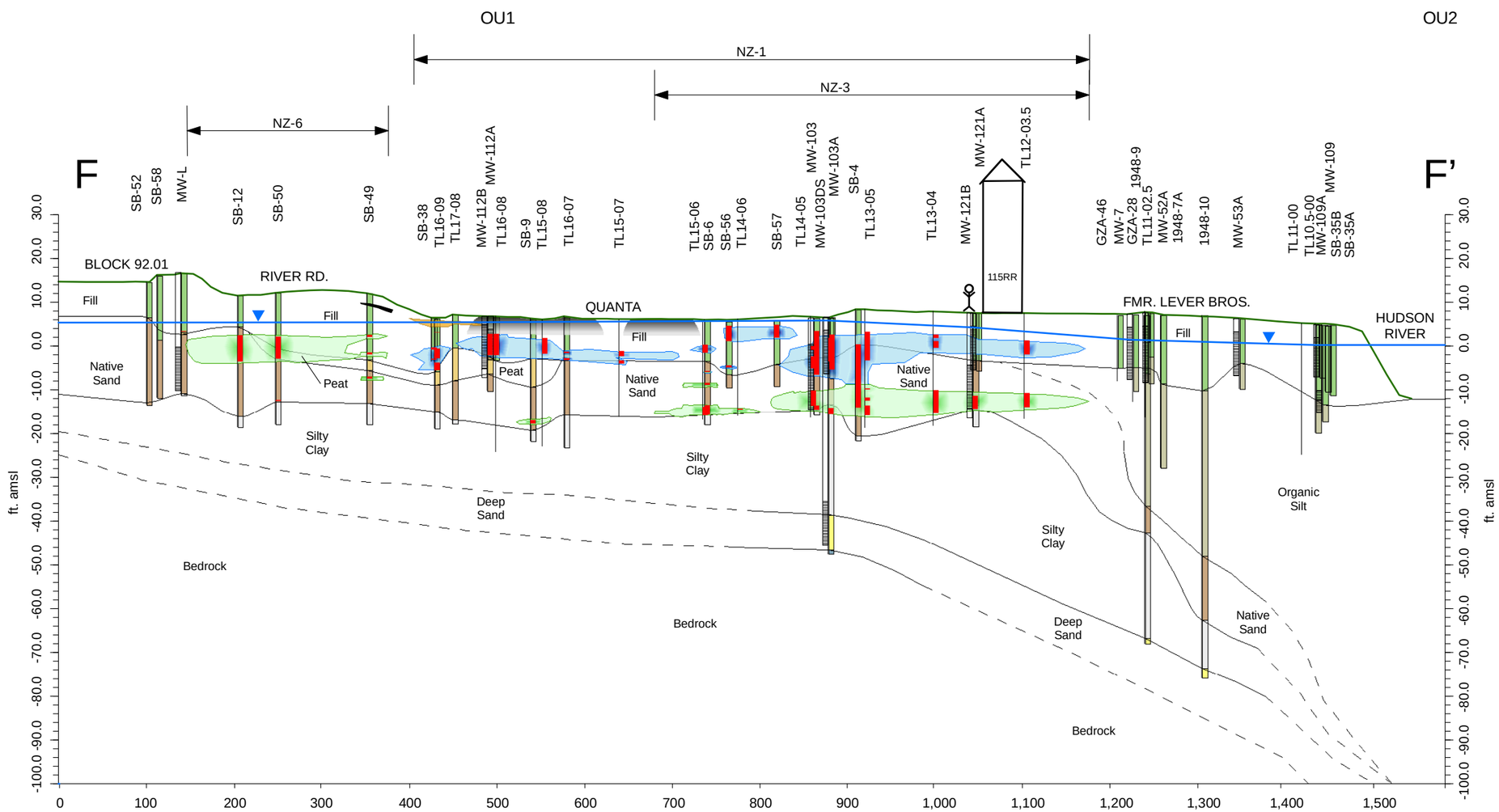
SOURCE MATERIAL CROSS-SECTION E - E'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-17**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-17_QUANTAOU1_SM_CROSSSECTIONE-E.MXD JHANSEN1 7/6/2010 14:22:37

400101



Stratigraphy

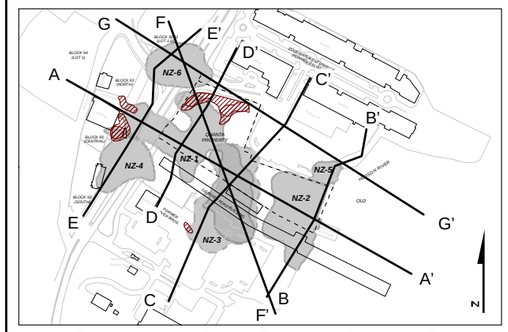
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Interval of Observed NAPL
- Water Table
- Existing Arsenic Liner
- Tar Boils
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

SOURCE MATERIAL CROSS-SECTION F - F'

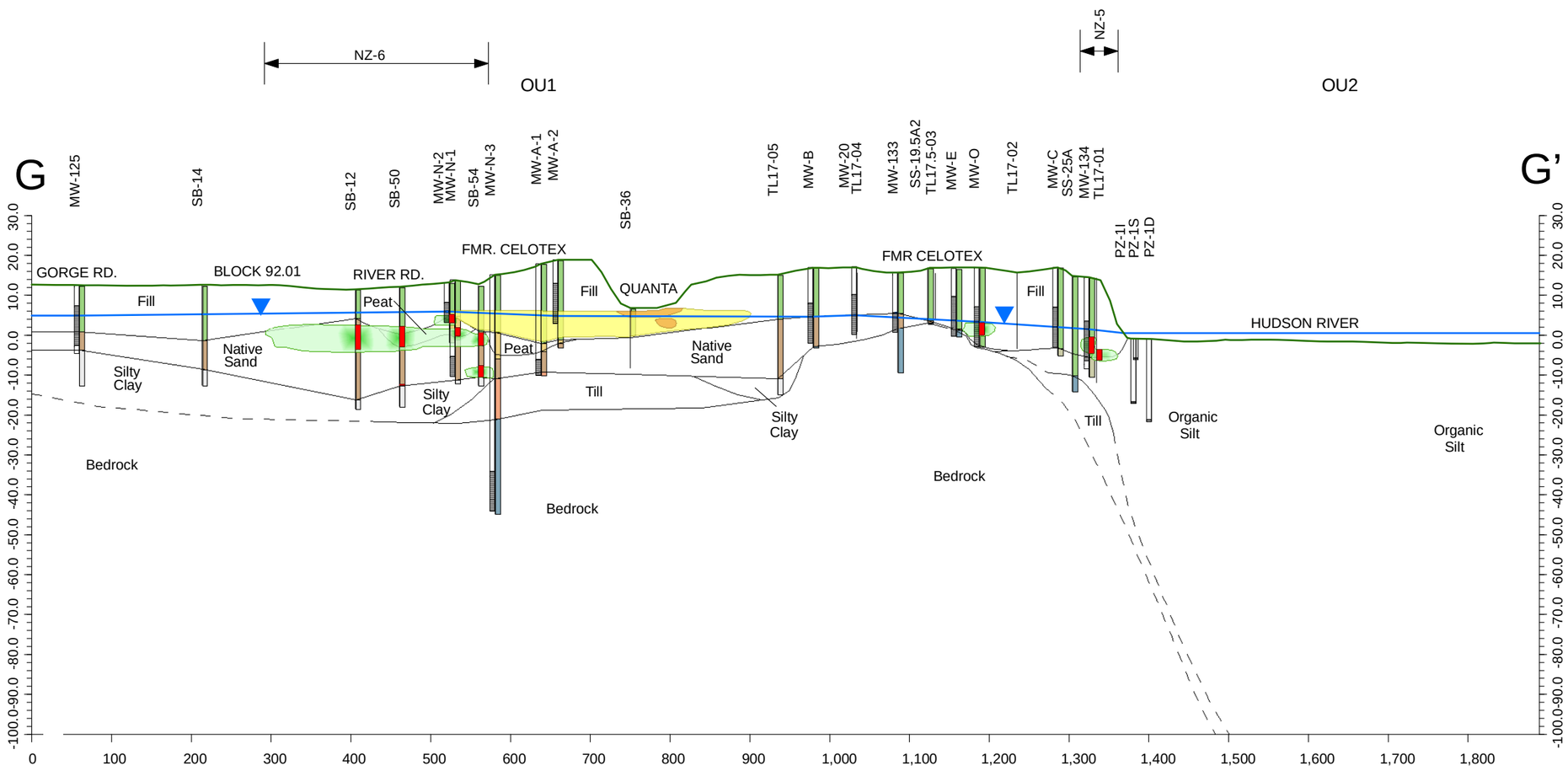
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 1-18

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-18_QUANTAOU1_SM_CROSSSECTIONF-F.MXD JHANSEN1 7/6/2010 14:24:23

400102



Stratigraphy

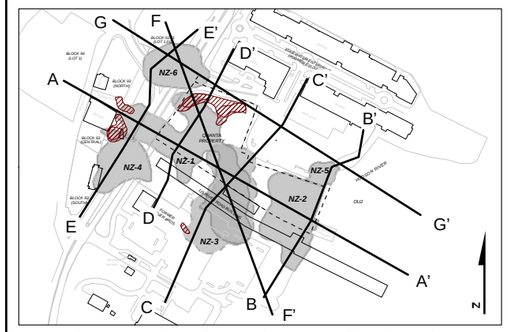
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 32' Vertical

1" = 160' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Area
- Water Table



Plan view of the Quanta Resources Superfund Site

Note:

1. **The total extent of non-aqueous phase liquid (NAPL) has been depicted using a combination of TARGOST® response data and documented observations of soil sampling and monitoring well locations during RI and SRI activities and as part of work performed at adjacent properties.**

CH2MHILL

SOURCE MATERIAL CROSS-SECTION G - G'

Quanta Resources Superfund Site Operable Unit 1 Edgewater, New Jersey

July 6, 2010 | **FIGURE 1-19**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SOURCEMATERIAL_XSECT\1-19_QUANTAOU1_SM_CROSSSECTIONG-G.MXD JHANSEN1 7/6/2010 14:26:01

400103

SECTION 2

Development and Identification of ARARs, RAOs, and PRGs

The Site has been characterized and is well understood for the purposes of supporting OU1 remedial alternative development, evaluation, and selection. The extent of OU1 contamination for groundwater, soil, and NAPL based on the data and evaluations presented in the RI (CH2M HILL, 2008) and final SRI (CH2M HILL, 2010a) is shown in Figure 1-2. As stated in the RI report, the next step is to complete the development and evaluation of OU1 remedial alternatives. Based on the RI and SRI findings, the FS for OU1 should evaluate technologies and develop and screen remedial alternatives to:

- Reduce current and/or potential future human health risks to acceptable levels at the properties comprising OU1, including mitigating potential future contact with NAPL
- Prevent erosion, transport, or migration of COCs in soil or groundwater offsite or to OU2 at concentrations resulting in human or ecological risk above acceptable levels

RAOs and PRGs were developed and/ or identified during the development of the FS. They have separate objectives in so far as RAOs provide a general description of what the cleanup will accomplish while PRGs are the more-specific statements of the desired endpoint concentration or risk levels for each exposure route that are believed to adequately protect human health and the environment. Based on consideration of factors during the nine-criterion analysis and using PRGs as a point of departure, final cleanup levels may reflect different risk levels within an acceptable risk range than the originally identified PRGs. Final cleanup levels will be specified in the draft final FS report and documented in the ROD.

The following subsections describe the process of identifying ARARs and developing specific RAOs and PRGs to achieve these objectives.

2.1 Summary of Applicable or Relevant and Appropriate Requirements

Remedial actions must protect human health and the environment. Section 121 of CERCLA requires that primary consideration be given to remedial alternatives that attain or exceed ARARs. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent federal and state environmental requirements, as well as to adequately protect human health and the environment.

Definitions of the ARARs and the "to be considered" (TBC) criteria are as follows:

- 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 directly and fully address a hazardous substance,

pollutant, contaminant, environmental action, location, or other circumstance at a CERCLA site.

- Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law, that while not "applicable," address problems or situations sufficiently similar (relevant) to those encountered at a CERCLA site for their use to be well suited (appropriate) to the particular site.
- TBC criteria are nonpromulgated, nonenforceable guidelines or criteria that may be useful for developing an interim remedial action or are necessary for evaluating what protects human health and/or the environment. Examples of TBC criteria include EPA Drinking Water Health Advisories, Reference Doses, and Cancer Slope Factors.

Another factor in determining the requirements that must be addressed by the remedial alternatives is whether the requirement is substantive or administrative. "Onsite" CERCLA response actions must comply with the substantive requirements but not with the administrative requirements of environmental laws and regulations as specified in the NCP and in 40 CFR 300.5 and as discussed in 55 FR 8756. Substantive requirements are those pertaining directly to actions or conditions in the environment. Administrative requirements are mechanisms that facilitate the implementation of the substantive requirements of an environmental law or regulation. In general, administrative requirements prescribe methods and procedures (e.g., fees, permitting, inspection, and reporting requirements) by which substantive requirements are made effective for the purposes of a particular environmental or public health program.

ARARs are grouped into one of three types: chemical-specific, action-specific, or location-specific. Chemical-specific, action-specific, and location-specific ARARs for the Site are summarized in Appendix A.

2.1.1 Chemical-Specific ARARs

Chemical-specific ARARs include laws and requirements that establish health- or risk-based numerical values or methodologies for environmental constituent concentrations or discharge. The chemical-specific ARARs for the Site can be classified into one of three categories: (1) target cleanup objectives that define the residual concentrations of constituents that may remain at the Site without presenting a threat to human health and the environment, (2) land disposal restriction concentrations that must be achieved if the contaminated medium contains a characteristic hazardous waste or contains a listed hazardous waste and is excavated or extracted and later land disposed, and (3) effluent concentrations that must be achieved in treatment of groundwater for discharge to surface water or groundwater. These three classifications are discussed below.

Residual Concentrations

For soil, the NJDEP soil remediation standards in New Jersey Administrative Code (NJAC) 7:26D are ARARs for residual concentrations. The standards include the Residential Direct Contact Soil Remediation Standards and the Non-Residential Direct Contact Soil Remediation Standards.

For groundwater, the NJDEP groundwater quality criteria (NJAC 7:9-6), the Safe Drinking Water Act maximum contaminant levels (MCLs), and the New Jersey Secondary Drinking Water Standards (NJAC 7:10-7) are ARARs for residual concentrations.

Land Disposal Restriction Considerations

The Resource Conservation and Recovery Act (RCRA) land disposal restrictions would apply to remedial actions performed at the Site if waste generated by the remedial action (e.g., contaminated soil) contained a RCRA hazardous waste. Listed hazardous wastes as defined by RCRA regulation are not known to have been released at the Site. As a result, excavated soils would not be required to be managed as listed hazardous wastes. If excavated and removed from the area of contamination (i.e., the soil is "generated"), the soil may be a characteristic hazardous waste if it exhibits one of the four characteristics defined in 40 CFR Part 261 Subpart C: ignitability, corrosivity, reactivity, or toxicity.

The waste likely to be generated during remediation at the Site consists of recovered NAPL, excavated soil containing residual NAPL or other constituents, recovered groundwater, concrete, debris, piping, or other materials. Free-phase NAPL and soil containing NAPL may be characteristic wastes exhibiting toxic characteristics. Both soil containing residual NAPL and soil containing high concentrations of arsenic will likely fail the Toxicity Characteristic Leaching Procedure (TCLP), which is required to determine requirements for disposal.

Generated soils that exceed the TCLP limit must be managed as a hazardous waste and must meet the land disposal restriction treatment standards for contaminated soil (40 CFR 268.49). The treatment standard for contaminated soil is the higher value of a 90 percent reduction in constituent concentrations or 10 times the universal treatment standards. Treatment is required for the constituent for which the soil is a characteristic hazardous waste as well as other "underlying hazardous constituents." Generators of contaminated soil can apply reasonable knowledge of the likely contaminants present to select constituents for monitoring (EPA, 1998).

Effluent Standards

For water generated during remedial actions, specific groundwater discharge requirements are necessary for the disposal of water after treatment. The two main effluent standards that are applicable, as established by NJDEP, are the following:

- **Discharge to groundwater:** Reinjecting treated groundwater to the aquifer. The discharge-to-groundwater limit for the site must meet Class IIA groundwater criteria. NJDEP will require a New Jersey Pollutant Discharge Elimination System (NJPDES) Discharge to Groundwater Permit (NJAC 7:14A-7) to allow for a discharge to groundwater.

- **Discharge to surface water**: Discharging treated groundwater to a surface water body. The surface water quality standard effluent limits for the site must meet the surface water criteria for the Hudson River classification. Surface water in the Hudson River adjacent to the Quanta Site is classified as "SE2" according to the Surface Water Quality Standards, NJAC 7:9B (Hudson River [Englewood Cliffs]—river and saline portions of New Jersey tributaries from the confluence with the Harlem River, N.Y., to a north–south line connecting Constable Hook [Bayonne, N.J.] to St. George [Staten Island,

N.Y.]). SE2 refers to saline estuarine waters' with designated uses listed in NJAC 7:9B-1.12(e). NJDEP will require an NJPDES Discharge to Surface Water Permit (NJAC 7:14A-11 through 13) to allow for a discharge to surface water.

2.1.2 Action-Specific ARARs

Action-specific ARARs regulate the specific type of action or technology under consideration or the management of regulated materials. The most important federal action-specific ARAR that may affect the RAOs and the development of remedial action alternatives is RCRA. RCRA regulations governing the identification, management, treatment, storage, and disposal of solid and hazardous waste would be ARARs for alternatives generating waste that would be moved to a location outside the area of contamination. Requirements are for waste accumulation, record-keeping, container storage, manifesting, transporting, and disposal. As discussed above, soil at the Site may be a characteristic hazardous waste. If any generated soil is a characteristic hazardous waste, RCRA land disposal restrictions would apply, and treatment would be required in accordance with RCRA prior to disposal. This also includes treatment of other underlying hazardous constituents as required by 40 CFR 268.9(a).

There are also specific state requirements, including the Technical Requirements for Site Remediation (NJAC 7:26E), and other applicable state regulations that are action-specific ARARs for the Site, such as wastewater discharge requirements (NJAC 7:9-5.1).

2.1.3 Location-Specific ARARs

Location-specific ARARs are requirements that relate to the geographical position of the Site. State and federal laws and regulations that apply to the protection of wetlands, construction in floodplains, and protection of endangered species in streams or rivers are examples of location-specific ARARs. Location-specific ARARs that may be applicable to the remedial activities, depending on the remedial action selected, are the following:

- Coastal Area Facility Review Act Permit (New Jersey Statutes Annotated [NJSA] 13:19-1 et seq.)
- Waterfront Development/Upland Waterfront Permit (NJSA 12:5-3)
- Flood Hazard Area Control Act (NJAC 7:13)
- Wetlands Permit (NJSA 13:9A-1)
- Deed Notice (NJSA 58:10B-13)
- Freshwater Protection Act (NJSA 13:9B-1)
- Stream Encroachment Permit (Construction Within a Flood Plain) (NJSA 58:16A-50 et seq.; NJAC 7:8-3.15)

Additional assessments (e.g., floodplain assessment, coastal zone consistency assessment, wetlands/water resources assessment) necessary to meet the ARARs for the selected remedial action will be developed and submitted during the design phase of the project.

2.2 Remedial Action Objectives

EPA's (1988b) *Guidance on Remedial Actions for Contaminated Ground Water at Superfund Sites* and the NCP define RAOs as medium-specific or site-specific goals for protecting human health and the environment. The RAOs are established on the basis of the nature and extent

of the contamination, the receptors that are currently and potentially threatened, and the potential for human and environmental exposure. Remediation goals are site-specific, quantitative goals that define the extent of cleanup required to achieve the RAOs. These goals are PRGs in the FS, and they will be finalized in the ROD for the Site. In this section, the RAOs have been developed for media at OU1. RAOs have been based on the exposure pathways found during the BHHRA to present unacceptable risks.

Nine RAOs were identified (four for principal threat waste, three for low-level threat waste, and two for groundwater) to mitigate the potential risks associated with the Site (Table 2-1). These RAOs were originally presented in a May 14, 2007, meeting with EPA and NJDEP. Below is a summary of the RAOs developed for the Site, with slight modifications made on the basis of the May meeting, subsequent discussions, and EPA's April 2008 letter (EPA, 2008).

TABLE 2-1
Remedial Action Objectives
Quanta Resources Superfund Site, OU1, Edgewater New Jersey

	Remedial Action Objective
Principal Threat Source Material	
1	Remove, treat or contain free product, pursuant to NJAC 7:26E-6.1(d).
2	Prevent human exposure to NAPL and arsenic source material that poses human health risk in excess of 10^{-3} ELCR or otherwise constitutes a principal threat as defined in Section 1.7.
3	Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure.
4	Prevent migration of source material that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable.
Low-Level Threat Source Material	
1	Prevent/minimize potential human exposure through contact, ingestion, inhalation (dust), or vapor intrusion that presents unacceptable risk.
2	Prevent/minimize potential erosional transport offsite or to OU2 of Site COCs at concentrations posing unacceptable risk.
3	Remove, treat or contain free and residual product, pursuant to NJAC 7:26E-6.1(d).
Groundwater	
1	Prevent/minimize potential exposure by contact, ingestion, inhalation/vapor intrusion that presents that presents unacceptable risk.
2	Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors.

2.2.1 RAOs for Principal Threats

These RAOs for source material are intended to address the principal threats discussed in Section 1.7:

- Remove, treat, or contain free product pursuant to NJAC 7:26E-6.1(d)
- Prevent human exposure to NAPL and arsenic source material that poses human health risk in excess of 10^{-3} ELCR or otherwise constitutes a principal threat as defined in Section 1.7
- Prevent current or potential future migration of free-phase NAPL to the Hudson River or to areas that would result in direct contact exposure
- Prevent migration of NAPL that poses a potential source of vapor intrusion and resulting inhalation exposure within existing or potential future structures, to the extent practicable

Each of these RAOs is discussed in further detail below.

Remove, Treat, or Contain Free Product

This RAO is intended to address source material determined to pose a principal threat due to potential mobility.

Prevent Human Exposure to Principal Threat Waste

Exposure to accessible source materials (e.g., tar boils, shallow free-phase NAPL, or arsenic in soil) through direct contact, ingestion, or inhalation is not likely to occur under existing conditions. Although tar boils are present at the surface, the Site is fenced and marked with signage. The undeveloped portion of the Site is currently unoccupied and fenced. The developed area of the Site currently has existing engineering controls (building foundations and paved parking areas) that eliminate direct contact or ingestion. The results of vapor intrusion studies conducted during the RI conclude that the vapor intrusion pathways are unlikely to be present or are of a sufficiently small magnitude such that they do not pose an unacceptable human health risk to current receptors. There is, however, the potential that redevelopment of the Site may result in potential exposure if appropriate remedial actions are not implemented. This RAO is intended to mitigate potential risks to potential future industrial or excavation workers as a result of exposure to highly toxic source material at the Site.

Prevent Current or Potential Future Migration of Free-Phase NAPL to the Hudson River or to Areas That Would Result in Direct Contact Exposure

Without additional remedial effort, there is the potential for the migration of free-phase NAPL to surface water and sediment in the Hudson River from NZ-2 and NZ-5. This RAO is intended to prevent unacceptable risks from surface water and sediment through potential migration of free-phase NAPL to OU2.

Prevent Migration of NAPL That Poses a Potential Source of Vapor Intrusion

Without additional remedial effort, there is the potential for the migration of shallow free-phase NAPL to areas with existing or potential future buildings. This RAO is intended to prevent potential future unacceptable risks as a result of vapor intrusion.

2.2.2 RAOs for Low-Level Threat Waste

There is a potential for exposure to low-level threat waste by receptors (e.g., construction/utility workers, commercial workers, daycare children, and residents) that

may present an unacceptable risk under existing or future conditions if not addressed appropriately by the remedial action selected for the Site. A primary objective of this FS is to develop alternatives that will mitigate potential risks to onsite receptors. In addition, contaminated soil at the Site may contribute to the presence of COCs in groundwater, surface water, and sediment through potential migration. Consequently, an additional objective for remediation of the contaminated soil is to allow the RAOs for groundwater, surface water, and sediment remediation to be met.[1]

The RAOs for remediation of low-level threat waste at the Site include the following:

- Prevent or minimize potential human exposure through contact, ingestion, dust inhalation, or vapor intrusion that presents unacceptable risk
- Prevent or minimize potential erosional transport offsite or to OU2 of Site COCs at concentrations posing unacceptable risk
- Remove, treat, or contain free and residual product, pursuant to NJAC 7:26E-6.1(d)

Each of these RAOs is discussed in further detail below.

Prevent/Minimize Potential Human Exposure Through Contact, Ingestion, Inhalation (Dust), or Vapor Intrusion That Presents Unacceptable Risk

Exposure to contaminated soil through direct contact, ingestion, or inhalation is not likely to occur under existing conditions since the undeveloped portion of the Site is currently unoccupied and fenced. The developed area of the Site has existing engineering controls (building foundations and paved parking areas) that eliminate direct contact or ingestion. The results of vapor intrusion studies conducted during the RI conclude that the vapor intrusion pathways are unlikely to be present or are of a magnitude sufficiently small that they do not pose an unacceptable human health risk to the occupants of these buildings under current conditions. There is, however, the potential that redevelopment of the Site may result in potential exposure to COCs in soil if appropriate remedial actions are not implemented. This RAO is intended to prevent unacceptable risks to potential future construction workers as a result of exposure to contaminated soil at the Site.

Prevent or Minimize Potential Transport Offsite or to OU2 of Site COCs at Concentrations Posing Unacceptable Risk

Possible erosion of surficial soil not covered with asphalt, concrete paving, or vegetation could result in the offsite migration of COCs at concentrations posing unacceptable risks through direct contact and ingestion. Although this potential risk is minimal under existing conditions, if future use dictates the need to remove the existing covers, erosion and transport could occur. This RAO is intended to prevent unacceptable risks to offsite receptors as a result of exposure to contaminated soil.

Remove, Treat, or Contain Free and Residual Product

This RAO is intended to address New Jersey requirements concerning free and residual product (NJAC 7:26E-6.1(d)). The range of remedial alternatives addresses potential

[1] Surface water and sediment remediation goals will be discussed as part of the FS for OU2.

exposure through a combination of removal, treatment, or containment as practicable and appropriate.

2.2.3 RAOs for Groundwater

The RAOs for groundwater at the Site were developed to minimize further migration of the contaminant plume and mitigate impacts to the downgradient receptors. The RAOs for remediation of groundwater at the Site include the following:

- Prevent or minimize potential exposure by contact, ingestion, or inhalation/vapor intrusion that presents that presents unacceptable risk
- Prevent migration and preferential flow of COCs to OU2 at levels resulting in risk above acceptable levels to human health or ecological receptors

Each of these RAOs is discussed in further detail below:

Prevent or Minimize Potential Exposure by Contact, Ingestion, or Inhalation/Vapor Intrusion That Presents Unacceptable Risk

Exposure to contaminated groundwater through direct contact, ingestion, or inhalation is not likely to occur since groundwater is not used as source of potable water in this area. This RAO is intended to prevent unacceptable risks to potential future industrial or excavation workers as a result of exposure to contaminated groundwater at the Site, or exposure to constituents in indoor air that may migrate from shallow groundwater.

Prevent Migration and Preferential Flow of COCs to OU2 at Levels Posing Unacceptable Risk

This RAO is intended to prevent unacceptable risks in surface water and sediment through migration of groundwater constituents. The potential for groundwater constituents to migrate to surface water and sediment in the Hudson River at levels posing unacceptable risk is being evaluated in the OU2 BERA.

2.3 Preliminary Remediation Goals

To meet the RAOs defined in Section 2.2, PRGs were developed to aid in defining the extent of contaminated media requiring remedial action. This section presents the PRGs that will be addressed in the FS process. In general, PRGs establish media-specific concentrations of COCs that will pose no unacceptable risk to human health and the environment. COCs are those chemicals that result in unacceptable risk based on the results of the BHHRA. The PRGs are developed taking the following into consideration:

- Chemical-specific ARARs or TBCs, including applicable New Jersey remediation standards, groundwater quality criteria, and federal MCLs
- Concentration levels corresponding to an excess cancer risk between 1×10^{-4} and 1×10^{-6}, a chronic health risk defined by an HI of 1, or a significant ecological risk
- Factors related to technical limitations, uncertainties, and other pertinent information

Below is a summary of the PRGs for soil and groundwater established for OU1.

2.3.1 PRGs for Soil

Risk-based soil PRGs were developed based on the potential exposure risks and the RAOs as part of the BHHRA for ingestion, dermal contact, and inhalation human health exposure pathways. The human health exposure pathways that have been evaluated included both residential and nonresidential exposures. Soil PRGs were selected as the lowest of these risk-based concentrations, and New Jersey Soil Remediation Standards[2] for residential and nonresidential land use. Where a remediation standard is not available, the risk-based concentration corresponding to an ELCR of 1×10^{-4} or an HI of 1 was selected. Soil PRGs are presented in Table 2-2 for all constituents exceeding one or more of the N.J. Soil Remediation Standards and risk-based concentrations developed as part of the BHHRA.

2.3.2 PRGs for Groundwater

PRGs were developed for groundwater based on the RAOs discussed earlier. The minimum concentration of the EPA federal MCLs, NJ MCLs, NJDEP groundwater quality criteria, and risk-based concentrations developed as part of the BHHRA was selected as the PRG. The PRGs for groundwater are listed in Table 2-3.

2.4 Media Exceeding PRGs

2.4.1 Horizontal Extent

The extent of OU1 has been defined and is shown in Figure 1-2. OU1 includes the observed extent of Site-related NAPL and constituents detected in soil and groundwater related to former operations. The lateral extent of OU1 also includes the HCAA as defined in Section 1-3. The northern boundary of OU1 is defined by the extent of Site-related NAPL and constituents exceeding EPA and state screening criteria in subsurface soils and groundwater, as well as by the HCAA. The southern boundary of OU1 is the extent of dissolved-phase, Site-related constituents and the groundwater convergence zone in the northern portion of the former Lever Brothers property. To the west, the OU1 boundary is the extent of Site-related NAPL and constituents exceeding EPA or state screening levels in soil and groundwater on Block 93 and soil on a portion of Block 94. The eastern boundary of OU1 is administratively defined as the wooden bulkhead on the Quanta property and portions of the shoreline north and south of the bulkhead.

2.4.2 Vertical Extent

The vertical extent of Site-related constituents at OU1 generally extends from the ground surface to a maximum depth of the top of the silty-clay confining unit, which is generally at a depth of 25 to 30 ft bgs. However, shallow soil (0 to 2 ft bgs) in several areas within the horizontal extent of OU1 is not considered part of OU1. The presence of Site-related constituents in these soils is the result of the presence of historic fill documented to contain PAHs and metals above PRGs as well as overlapping historical industrial operations unrelated to the Site. These areas of shallow soil within the lateral boundaries of OU1 that are unaffected by former Site operations include:

[2] Source: http://www.nj.gov/dep/srp/regs/rs/, accessed September 9, 2008.

- Soil currently within the interval of 0 to 2 ft bgs on the former Celotex property is above the water table and consists entirely of fill material imported during recent property redevelopment.
- Soil within the range of 0 to 2 ft bgs on the former Lever Brothers property and the Block 93 South property is above the water table and does not contain Site-related constituents; buildings and other surface improvements on these properties associated with historical operations would have physically prevented the migration of surface soil from the Site to these properties.
- Soil within the range of 0 to 2 ft bgs on the Block 93 South property does not contain Site-related constituents. The presence of active operations between former Site operations and Block 93 South has prevented the migration of Site-related constituents between these areas.
- Soil within the range of 0 to 2 ft bgs within the footprint of River and Gorge Roads is above the water table and consists of fill material imported during road construction in the 1990s.

Dissolved-phase COCs in groundwater are limited generally to the shallow overburden fill and native sand deposits overlying the silty-clay confining unit. Deep sand beneath the confining unit is impacted with chlorinated solvents that are the result of an unidentified offsite upgradient source unrelated to OU1. Only low levels of PAHs and xylene have been detected in the central portion of OU1.

2.5 Technical Impracticability

In addition to the RAOs that have been defined in this FS for remediation of groundwater that are specified in Section 2.2.3, it is further specified in the NCP that "EPA expects to return usable ground waters to their beneficial uses wherever practicable, within a time frame that is reasonable given the particular circumstances of the site. When restoration of ground water to beneficial uses is not practicable, EPA expects to prevent further migration of the plume, prevent exposure to the contaminated groundwater, and evaluate further risk reduction" (NCP 300.430(a)(1)(iii)(F)). However, as stated by EPA (1993), "experience over the past decade has shown that restoration to drinking water quality (or more stringent levels where required) may not always be achievable due to the limitations of available remediation technologies.… EPA, therefore, must evaluate whether ground-water restoration at Superfund and RCRA ground-water cleanup sites is attainable from an engineering perspective" (p. 1).

A draft technical impracticability (TI) evaluation (CH2M HILL, 2010b) was prepared to assess the potential for restoring groundwater at OU1 to a source of potable water through achieving certain ARARs. The draft TI evaluation documents in the context of feasibility, reliability, and cost and from an engineering perspective the conditions that make it impracticable to achieve specific ARARs within a reasonable timeframe.

Groundwater restoration potential at OU1 is significantly influenced by contaminant-related factors and hydrogeologic factors that may limit the effectiveness of subsurface remediation. Other Site-specific factors may also limit the effectiveness of remediation and (or) limit the applicability of certain technologies, or render complete restoration impractical. This

evaluation is consistent with the examples of factors affecting groundwater restoration provided in Figure 1 of EPA's *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration* (EPA, 1993).

The evaluation of factors as they relate to the potential for groundwater restoration at the Site includes the following:

- Contaminant-related factors such as
  - The widespread presence of DNAPL and recalcitrant NAPL-related constituents
  - The long history of releases at the Site
  - The volume and depth of contaminated media
  - The presence of arsenic in soil and groundwater, and the colocation of arsenic and NAPL
- Hydrogeologic factors such as
  - The complex geology consisting of interbedded and undulating layers of sands, silts and clays with discontinuous peat deposits
  - Heterogeneous soil conditions and the presence of low permeability materials such as silts and clays
- Site-setting factors such as the highly urbanized environment with significant surficial and subsurface infrastructure

In addition, the presence of offsite sources and regional characteristics would render any restoration within OU1 futile, as these sources would recontaminate the area and continue to render groundwater unusable as a potable source for reasons beyond the scope of the Quanta Resources Superfund Site. Further, conventional water resource planning practices render the potential potable use of groundwater in the area impossible. Such Site-related factors that have been considered include the saline content of the groundwater, given its proximity to the Hudson River, as well as drinking water well construction requirements.

A significant RAO for groundwater at the Site is to mitigate potential risks posed by upland sources of dissolved phase constituents migrating from OU1 to the Hudson River (OU2). Given the additional NAPL and NAPL-related constituents present in the deeper sediments of OU2 and the inevitable recontamination of groundwater as it moves through these sources, the elimination of the relatively small and indistinguishable mass of dissolved impacts coming from OU1 via groundwater would not add any significant incremental risk benefit to the resource. The OU2 RI/FS will evaluate remedial alternatives for addressing free-phase NAPL and NAPL-related constituents in sediments; however, the conditions are similar to OU1, where there are areas of free-phase NAPL and then extensive zones of more diffuse NAPL, making restoration impracticable even in the river sediments.

The findings of the TI evaluation (CH2M HILL, 2010b) reveal that it is technically impracticable from an engineering perspective to restore groundwater at the Site. Groundwater restoration simply cannot be achieved with the available means given the contaminant-related, Site-specific, and Site setting factors. It is feasible, however, to implement a remedy at the Site that is protective of human health and the environment and achieves the RAOs for groundwater. Remedial alternatives are developed in this FS and provide approaches to protect human health and the environment, maintain that protection

over time, and are consistent in defining and addressing risk at the Site. The waiver is requested throughout the extent of OU1 (Figure 2-1) because this is the area over which the Site-specific factors are relevant, in which it is impracticable to achieve ARARs for groundwater, and in which risk can be managed appropriately through the implementation of alternate remedial measures.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Surface Soil (0–2 ft)								
2-Methyl-naphthalene	—	—	310	230	2,400	**230**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
2,4-Dinitrotoluene	1.6	160	120	0.7	3	**0.7**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
4-Methylphenol	—	—	310	31	340	**31**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Antimony	—	—	31	31	450	**31**	RSS/HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Aroclor-1242	0.22	22	—	0.2	1.0	**0.2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Aroclor-1254	0.22	22	1.1	0.2	1.0	**0.2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Aroclor-1260	0.22	22	—	0.2	1.0	**0.2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Arsenic	0.39	39	22	19	19	**0.39**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzene	1.1	110	90	2	5	**1.1**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzo(a)anthra-cene	0.15	15	—	0.6	2	**0.15**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzo(a)pyrene	0.015	1.5	—	0.2	0.2	**0.015**	ELCR	Risk-based concentration is lower than the NJ Soil Standards

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Benzo(b)fluoran-thene	0.15	15	—	0.6	2	**0.15**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Benzo(k)fluoran-thene	1.5	150	—	6	23	**1.5**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Carbazole	24	2,400	—	24	96	**24**	RSS/ ELCR	NJ Residential Soil Standard equals the risk-based concentration for and ELCR value of 10^{-6}
Chromium	39	3,900	230	NA	NA	**39**	ELCR	NJ Soil Standards for chromium are not available
Chrysene	15	1,500	—	62	230	**15**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Copper	—	—	3,100	3,100	45,000	**3,100**	RSS/HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Dibenzo(a,h)an-thracene	0.015	1.5	—	0.2	0.2	**0.015**	ELCR	Risk-based concentration is lower than the NJ Soil Standards.
Fluoranthene	—	—	2,300	2,300	24,000	**2,300**	RSS/HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Fluorene	—	—	2,300	2,300	24,000	**2,300**	RSS/HQ	NJ Residential Soil Standard equals the HQ=1 concentration
Heptachlor	0.11	11	31	0.1	0.7	**0.1**	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Indeno(1,2,3-cd)pyrene	0.15	15	—	0.6	2	**0.15**	ELCR	Risk-based concentration is lower than the NJ Soil Standards.
Iron	—	—	55,000	NA	NA	**55,000**	HQ	NJ Soil Standards for iron are not available
Lead	—	—	400[a,b]	400	800	**400**	RSS/HQ	NJ Residential Soil Standard equals the risk-based concentration.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Mercury	—	—	23	23	65	**23**	RSS/HQ	NJ Residential Soil Standard equals the HQ=1 concentration.
Naphthalene	3.9	390	150	6	17	**3.9**	ELCR	Risk-based concentration is lower than the NJ Soil Standards.
Thallium	—	—	5.1	5	79	**5**	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Trichloroethene	2.8	280	—	7	20	**2.8**	ELCR	Risk-based concentration is lower than the NJ Soil Standards.
Vanadium	—	—	390	78	1100	**78**	RSS	NJ Residential Soil Standard is more conservative than risk-based concentration.
Xylenes, Total	—	—	600	12,000	170,000	**600**	HQ	Risk-based concentration is lower than the NJ Soil Standards
Zinc	—	—	23,000	23,000	110,000	**23,000**	RSS	NJ Residential Soil Standard equals the HQ=1 concentration.
Subsurface Soil (0–10 ft)								
2-Methyl-naphthalene	—	—	1,200	230	2,400	**230**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
2,4-Dinitrotoluene	—	—	—	0.7	3	**0.7**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
2,6-Dinitrotoluene	—	—	—	0.7	3	**0.7**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Antimony	—	—	120	31	450	**31**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Aroclor-1242	—	—	—	0.2	1.0	**0.2**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Aroclor-1248	—	—	—	0.2	1.0	**0.2**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Aroclor-1254	—	—	—	0.2	1.0	**0.2**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Aroclor-1260	—	—	—	0.2	1.0	**0.2**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Arsenic	13	1,300	80	19	19	**13**	ELCR	Risk-based concentration is lower than the NJ Soil Standards
Beryllium	—	—	—	16	140	**16**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Benzene	98	9,800	320	2	5	**2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(a)anthra-cene	21	2,100	—	0.6	2	**0.6**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(a)pyrene	2.1	210	—	0.2	0.2	**0.2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(b)fluoran-thene	21	2,100	—	0.6	2	**0.6**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Benzo(k)fluoran-thene	—	—	—	6	23	**6**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Carbazole	—	—	—	24	96	**24**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Chrysene	—	—	—	62	230	**62**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Copper	—	—	—	3,100	45,000	**3,100**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Dibenzo(a,h)an-thracene	2.1	210	—	0.2	0.2	**0.2**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Fluoranthene	—	—	—	2,300	24,000	**2,300**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Fluorene	—	—	—	2,300	24,000	**2,300**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Indeno(1,2,3-cd)pyrene	21	2,100	—	0.6	2	**0.6**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Iron	—	—	220,000	NA	NA	**220,000**	HQ	NJ Soil Standards for iron are not available.
Lead	—	—	618 [b]	400	800	**400**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Mercury	—	—	—	23	65	**23**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Naphthalene	410	41,000	530	6	17	**6**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Nickel	—	—	—	1,600	23,000	**1,600**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Pyrene	—	—	—	1,700	18,000	**1,700**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.

TABLE 2-2
Summary of Soil Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Constituent	Risk-Based PRGs (mg/kg)			NJ Soil Standard (Residential) (mg/kg)	NJ Soil Standard (Non-Residential) (mg/kg)	PRG (mg/kg)	Basis for PRG	Comments
	ELCR = 10^{-6}	ELCR = 10^{-4}	HQ = 1					
Tetrachloro-ethene	—	—	—	2	5	**2**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Thallium	—	—	20	5	79	**5**	RSS	NJ Residential Soil Standard is more conservative than the risk-based concentration.
Vanadium	—	—	—	78	1100	**78**	RSS	PRG selected to meet an ARAR; constituent is not a COC for this medium.

NA, not available; RSS, N.J. Residential Soil Standard; HQ, hazard quotient; ELCR, excess lifetime cancer risk. Surface soil risk-based remedial goals are based on the EPA Regional Screening Level (RSL) Table for Residential Soil (April 2009). RSL for “chromium VI (particulates)” used for chromium. RSL for “mercury, inorganic salts” used for mercury. RSL for “thallium (soluble salts)” used for thallium. RSL for “vanadium and compounds” used for vanadium. RSL for “zinc (metallic)” used for zinc. The risk-based PRG for carbazole was calculated using the EPA Health Effects Assessment Summary Tables (HEAST) at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm.

[a] Based on the EPA Lead Working Group.
[b] Calculated using the adult lead methodology.

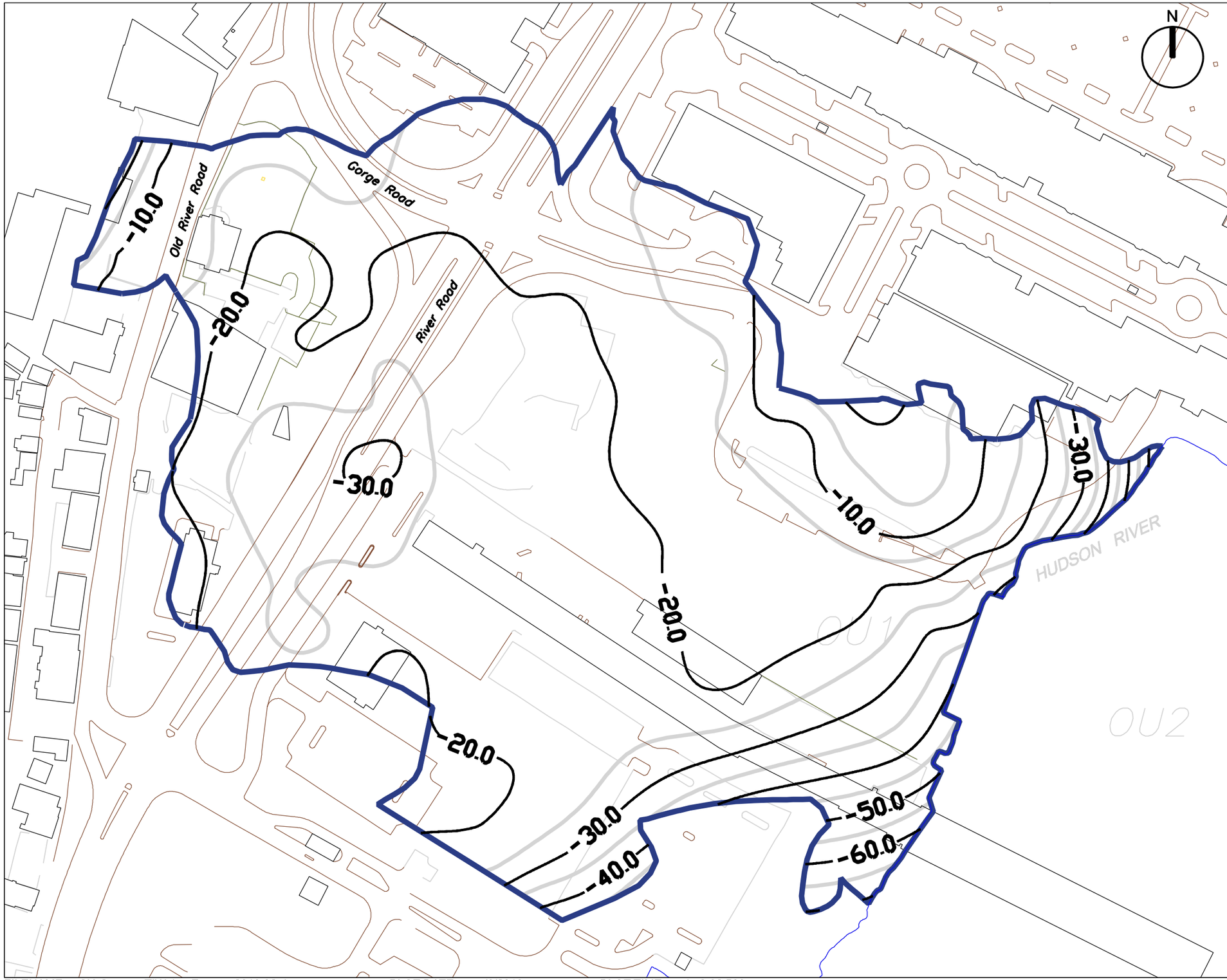
TABLE 2-3
Summary of Groundwater Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Federal and State Promulgated Standards			Site-Specific Risk-Based PRGs						
Constituent	**NJ GWQS (Class IIA)[a] (µg/L)**	**NJ GWQS (Interim)[b] (µg/L)**	**State MCL[c] (µg/L)**	**Federal MCL[d] (µg/L)**	**ELCR = 10^{-6} (µg/L)**	**ELCR = 10^{-4} (µg/L)**	**HQ = 1 (µg/L)**	**PRG[e] (µg/L)**	**Basis for PRG**	**Comments**
Metals										
Aluminum	200	NA	NA	NA	NA	NA	NA	200	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Antimony	6	NA	6	6	NA	NA	5,600	6	NJ GWQS/NJ MCL	—
Arsenic	3	NA	5	10	4,300	430,000	28,000	3	NJ GWQS	—
Beryllium	1	NA	4	4	NA	NA	NA	1	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Cadmium	4	NA	5	5	NA	NA	2,300	4	NJ GWQS	—
Cobalt	NA	100	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Iron	300	NA	NA	NA	NA	NA	65,000,000	300	NJ GWQS	—
Lead	5	NA	15	15	NA	NA	NA	5	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Manganese*	50	NA	NA	NA	NA	NA	520,000	50	NJ GWQS	—
Mercury	2	NA	2	2	NA	NA	19,000	2	NJ GWQS/NJ MCL	—
Nickel	100	NA	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Selenium	40	NA	50	50	NA	NA	NA	40	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Sodium*	50,000	NA	NA	NA	NA	NA	NA	50,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Thallium	2	NA	2	2	NA	NA	6,000	2	NJ GWQS/NJ MCL	—
Zinc	2,000	NA	NA	NA	NA	NA	NA	2,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
VOCs										
1,1-Dichloroethane*	50	NA	50	NA	NA	NA	NA	50	NJ GWQS/NJ MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
1,2,4-Trichlorobenzene	9	NA	9	70	NA	NA	NA	9	NJ GWQS/NJ MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
1,2-Dichloroethane*	2	NA	2	5	NA	NA	NA	2	NJ GWQS/NJ MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Benzene	1	NA	1	5	810	81,000	2,700	1	NJ GWQS/NJ MCL	—
Chloroethane	NA	5	NA	NA	NA	NA	NA	5	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Ethylbenzene	700	NA	700	700	NA	NA	NA	700	NJ GWQS/NJ MCL/Federal MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Styrene	100	NA	100	100	NA	NA	NA	100	NJ GWQS/NJ MCL/Federal MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Tetrachloroethene*	1	NA	1	5	NA	NA	NA	1	NJ GWQS/NJ MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Toluene	600	NA	1,000	1,000	NA	NA	NA	600	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Trichloroethene*	1	NA	1	5	NA	NA	NA	1	NJ GWQS/NJ MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Vinyl Chloride*	1	NA	2	2	NA	NA	NA	1	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Xylenes, m/p-	1,000	NA	1,000	1,000	NA	NA	NA	1,000	NJ GWQS/NJ MCL/Federal MCL	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Xylenes, Total	1,000	NA	1,000	1,000	NA	NA	10,000	1,000	NJ GWQS/NJ MCL/Federal MCL	—
PAHs										
2-Methylnaphthalene	NA	30	NA	NA	NA	NA	4,300	30	NJ GWQS	—
Acenaphthene	400	NA	NA	NA	NA	NA	NA	400	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Acenaphthylene	NA	100	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Benzo(a)anthracene	0.1	NA	NA	NA	9.5	950	NA	0.1	NJ GWQS	—

TABLE 2-3
Summary of Groundwater Preliminary Remediation Goals
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	Federal and State Promulgated Standards			Site-Specific Risk-Based PRGs						
Constituent	**NJ GWQS (Class IIA)[a] (µg/L)**	**NJ GWQS (Interim)[b] (µg/L)**	**State MCL[c] (µg/L)**	**Federal MCL[d] (µg/L)**	**ELCR = 10^{-6} (µg/L)**	**ELCR = 10^{-4} (µg/L)**	**HQ = 1 (µg/L)**	**PRG[e] (µg/L)**	**Basis for PRG**	**Comments**
Benzo(a)pyrene	0.1	NA	0.2	0.2	0.56	56	NA	0.1	NJ GWQS	—
Benzo(b)fluoranthene	0.2	NA	NA	NA	5.5	550	NA	0.2	NJ GWQS	—
Benzo(g,h,i)perylene	NA	100	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Benzo(k)fluoranthene	0.5	NA	NA	NA	59	5,900	NA	0.5	NJ GWQS	—
Chrysene	5	NA	NA	NA	NA	NA	NA	5	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Dibenzo(a,h)anthracene	0.3	NA	NA	NA	0.36	36	NA	0.3	NJ GWQS	—
Fluoranthene	300	NA	NA	NA	NA	NA	NA	300	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Fluorene	300	NA	NA	NA	NA	NA	NA	300	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Indeno(1,2,3-cd)pyrene	0.2	NA	NA	NA	5.3	530	NA	0.2	NJ GWQS	—
Naphthalene	300	NA	300	NA	250	25,000	370	250	ELCR 10^{-6}	—
Phenanthrene	NA	100	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Pyrene	200	NA	NA	NA	NA	NA	NA	200	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
SVOCs										
2,4-Dimethylphenol	100	NA	NA	NA	NA	NA	NA	100	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Biphenyl	400	NA	NA	NA	NA	NA	NA	400	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
bis(2-Ethylhexyl) phthalate*	3	NA	6	6	NA	NA	NA	3	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Dibenzofuran	NA	NA	NA	NA	NA	NA	860	860	HQ = 1	—
Nitrobenzene	6	NA	NA	NA	NA	NA	NA	6	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Pentachlorophenol	0.3	NA	1	1	NA	NA	NA	0.3	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Phenol	2,000	NA	NA	NA	NA	NA	NA	2,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Pesticides										
4,4'-DDD	0.1	NA	NA	NA	NA	NA	NA	0.1	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
4,4'-DDE	0.1	NA	NA	NA	NA	NA	NA	0.1	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
alpha-BHC	0.02	NA	NA	NA	NA	NA	NA	0.02	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Wet Chemistry										
Ammonia	3,000	NA	NA	NA	NA	NA	NA	3,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Chloride*	250,000	NA	NA	NA	NA	NA	NA	250,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Hardness, total as $CaCO_3$	250,000	NA	NA	NA	NA	NA	NA	250,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.
Sulfate	250,000	NA	NA	NA	NA	NA	NA	250,000	NJ GWQS	PRG selected to meet an ARAR; constituent is not a COC for this medium.

GWQS, groundwater quality standard; MCL, maximum contaminant level; HQ, hazard quotient. Values in grey are not exceeded within OU1 during sampling conducted by CH2M HILL during RI-related groundwater-sampling events from 2005 to 2009. Monitoring wells outside the lateral extent of OU1 or screened within the deep sand or bedrock are excluded. Risk-based PRGs are applicable to monitoring wells screened at 10 ft bgs or less.
*Constituent is not Site related.
[a]New Jersey Groundwater Quality Standard; http://www.state.nj.us/dep/wms/bwqsa/gwqs_table1.html; accessed December 29, 2009.
[b]New Jersey Interim Groundwater Quality Criteria; http://www.state.nj.us/dep/wms/bwqsa/gwqs_interim_criteria_table.htm; accessed December 29, 2009.
[c]NJDEP (2005).
[d]EPA Maximum Contaminant Levels; http://www.epa.gov/safewater/contaminants/index.html#mcls; accessed December 29, 2009. NA, not applicable or not available.
[e]PRGs are selected as the lowest of federal, state or site-specific risk-based PRG values.



LEGEND

- APPROXIMATE CURRENT PROPERTY BOUNDARY
- HUDSON RIVER SHORELINE
- LATERAL EXTENT OF GROUNDWATER ABOVE THE SILTY-CLAY AND/OR BEDROCK SURFACE REQUIRING A TECHNICAL IMPRACTICABILITY (TI) WAIVER
- 5 FOOT ELEVATION CONTOUR FOR THE BASE OF THE TI WAIVER FOR GROUNDWATER
- 10 FOOT ELEVATION CONTOUR FOR THE BASE OF THE TI WAIVER FOR GROUNDWATER

NOTES:
1.) THE LOWER ELEVATION OF THE TECHNICAL IMPRACTICABILITY (TI) AREA FOR GROUNDWATER AS CONTOURED HERE REPRESENTS AN ELEVATION EQUAL TO A DEPTH OF FIVE FEET BELOW THE SURFACE OF THE SILTY-CLAY CONFINING UNIT OR THE BEDROCK SURFACE, WHICHEVER IS SHALLOWER.

BASE MAP NOTES:
A. BASE MAP WAS PREPARED BY VARGO ASSOCIATES OF FRANKLINVILLE, NEW JERSEY AND UPDATED AS RECENTLY AS NOVEMBER 2008.
B. PROPERTY LINES SHOWN HEREON IS REFERENCED TO CURRENT TAX MAPS FOR THE BOROUGH OF EDGEWATER, BERGEN COUNTY, NEW JERSEY.
C. REFERENCE PLAN ENTITLED "RIGHT OF WAY MAP, RIVER ROAD RE-ALIGNMENT, SOUTH SECTION, BOROUGH OF EDGEWATER, BERGEN COUNTY, N.J." PREPARED BY BOSWELL ENGINEERING, HACKENSACK, N.J., FILED IN THE BERGEN COUNTY CLERK'S OFFICE AS MAP NO. 9154.
D. HORIZONTAL DATUM IS REFERENCED TO THE NEW JERSEY STATE PLANE COORDINATE SYSTEM, NAD 1983 BASED ON GPS OBSERVATIONS BY VARGO ASSOC. IN SEPTEMBER, 2005.
E. ELEVATIONS SHOWN HEREON ARE IN FEET AND ARE REFERENCED TO N.A.V.D. 1988.
F. TOPOGRAPHIC FEATURES SHOWN HEREON IS REFERENCED TO AERIAL PHOTOGRAPHY PROVIDED BY PROMAPS, MORRESTOWN, N.J. (FLIGHT DATE: 08-17-08).
G. TIDAL DATUMS ARE REFERENCED TO TIDE GUAGE NGS A40 AND NGS 1240 AND ARE AS FOLLOWS:
MEAN HIGHER HIGH WATER ELEVATION=1.90'
MEAN HIGH WATER ELEVATION=1.63'
MEAN TIDE LEVEL ELEVATION=-0.50
MEAN LOW WATER ELEVATION=-2.62'
MEAN LOWER LOW WATER ELEVATION=-2.83'
H. UNDERGROUND UTILITIES SHOWN HEREON ARE NOT NECCESSARILY COMPLETE AND SHALL BE FIELD VERIFIED PRIOR TO ANY CONSTRUCTION.

0 70 140

CH2MHILL

TECHNICAL IMPRACTICABILITY BOUNDARY FOR GROUNDWATER

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 2-1

FILENAME: CH-Quanta_TIWaiverExtents-2010.02.dgn PLOT DATE: 7/6/2010 PLOT TIME: 4:59:08 PM

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SECTION 3

Identification and Screening of Technologies

3.1 General Response Actions

General response actions are actions that might be undertaken to satisfy the RAOs for a site. After the RAOs and PRGs were developed, general response actions consistent with these objectives were identified for each media type at OU1. As part of the OU1 FS alternatives analysis process, general response actions have been further divided into a series of specific technologies and process options, as described in Section 3.2. These technologies have then been screened for applicability and potential effectiveness. The following sections present the general response actions that may be applicable to each media type at the Site and detail the subsequent technology-screening process. The technologies and process options remaining after screening have been assembled into alternatives for OU1 that are detailed in Section 4.

3.1.1 General Response Actions for Free-Phase NAPL

The general response actions for free-phase NAPL at OU1 are the following:

- No further action (NFA)
- Institutional controls
- Containment
- In situ treatment
- Removal/disposal

These are outlined below:

No Further Action

A no further action response would assume no remedial action for free-phase NAPL beyond what may have been implemented in the past. The NCP requires that the no further action alternative be retained through the FS process as a basis of comparison.

Institutional Controls

Institutional controls consist of restricting access to source material through options such as land-use restrictions (i.e., deed notices). Institutional controls considered would be prepared in accordance with NJDEP requirements for deed notices and biennial monitoring (NJAC 7:26E-8.4 through 8-6). Deed notices are NJDEP's presumptive remedy for sites with contaminated historic fill material (NJAC 7:26E-6.2(c)).

Containment

Containment technologies may be used to reduce the potential for NAPL to migrate offsite. For example, interlocking steel piles may be driven into the subsurface along the boundaries of the NAPL zones, or trenches around the NAPL zones may be excavated and filled with a slurry of low-permeability material to create a barrier. Permeable barriers may be

constructed using a material that allows the flow of groundwater while restricting the flow of NAPL.

In Situ Treatment

In situ treatment of NAPL involves treating it without removing it from the subsurface. Such treatment may be achieved by applying physical, chemical, or thermal technologies. Examples include chemical oxidation or solidification/stabilization technologies.

Removal/Disposal

NAPL may be excavated or collected for offsite disposal using interception trenches or recovery wells. Excavated or recovered NAPL may require processing prior to its being disposed of offsite.

3.1.2 General Response Actions for Soil

The general response actions for surface soil (0 to 2 ft bgs) and subsurface soil (0 to 10 ft bgs) at OU1 are the following:

- NFA
- Institutional controls
- Containment
- In situ treatment
- Removal/disposal and ex situ treatment

These are outlined below:

No Further Action

The no further action response assumes no remedial action for soil beyond what may have been implemented in the past. The NCP requires that the no further action alternative be retained through the FS process as a basis of comparison.

Institutional Controls

Institutional controls for soil consist of restricting access to contaminated soil through options such as land-use restrictions (i.e., deed notices). Institutional controls considered would be prepared in accordance with NJDEP requirements for deed notices and biennial monitoring (NJAC 7:26E-8.4 through 8-6). Deed notices are NJDEP's presumptive remedy for sites with contaminated historic fill material (NJAC 7:26E-6.2(c)).

Containment

Containment response actions, such as caps, are used to prevent direct contact exposures to or migration of constituents following their dissolution or volatilization. Asphalt, soil caps, concrete caps, and liner materials are applicable remedial technologies for restricting exposure to contaminated soil. These technologies also minimize the infiltration of precipitation and help prevent migration of constituents offsite. Surface controls such as grading and revegetation can also be used to reduce infiltration of precipitation through contaminated soil and prevent erosion and transport of contaminated soil.

In Situ Treatment

In situ treatment includes remedial actions that do not require removing contaminated soil. Applicable in situ remedial technologies that can be used include physical, chemical, biological, and thermal processes. Some examples of in situ treatment that may be applicable for sites with metals contamination in soil include solidification/stabilization and phytoremediation. A variety of in situ methods is available for treating organic contaminants in soil, including soil vapor extraction (SVE), in situ chemical oxidation (ISCO) below the water table, thermal technologies, and solidification/stabilization to reduce or eliminate leachability.

Removal/Disposal and Ex Situ Treatment

Excavation and removal of soil would prevent direct contact, ingestion, or inhalation of contaminated soil. Excavated soils could be treated onsite with solidification/ stabilization or biopiles and disposed of offsite or sent for desorption or soil washing.

3.1.3 General Response Actions for Groundwater

The general response actions applicable to groundwater containing dissolved COCs above PRGs are the following:

- NFA
- Institutional controls
- Containment
- Monitored natural attenuation (MNA)
- In situ treatment
- Ex situ treatment, and disposal

These are outlined below:

No Further Action

The no further action response assumes no further action for groundwater. The NCP requires that the no further action alternative be retained through the FS process as a basis of comparison.

Institutional Controls

Institutional controls for groundwater include restrictive covenants that limit the potential future use of affected groundwater. In New Jersey, NJDEP may exclude the strict application of New Jersey Ground Water Quality Standards to a certain area by designating it a Classification Exception Area (CEA). Continued groundwater monitoring may also be necessary to track the groundwater contaminant plume as part of the institutional controls.

Other institutional controls may be applied through local ordinances such as easements, well-drilling prohibitions, building permit restrictions, land-use zoning restrictions, fishing bans, and the use of state registries of contaminated sites. Such institutional controls would typically specify the nature and extent of the groundwater constituents and prohibit its use until the groundwater returns to drinking water standards.

Containment

Containment of groundwater refers to controlling migration of dissolved phase constituents through the use of barriers or hydraulic gradient control. Examples of groundwater containment include using slurry or sheet-pile walls, permeable absorptive barriers (PABs), permeable reactive barrier (PRBs), or pumping groundwater. Treatment barriers can also be used in a funnel-and-gate configuration: a contaminant plume is channeled between impervious vertical walls (the "funnel"), and flows naturally through a PRB gate, where the pollutants are treated in situ during the flow process.

Monitored Natural Attenuation

Natural attenuation is the reduction of constituent concentrations through natural physical, chemical, or biological processes. These processes may include biodegradation, dilution, dispersion, and retardation. When natural attenuation is implemented as a remedy, monitoring is typically required to document the decrease in constituent concentrations.

In Situ Treatment

In situ treatment of groundwater entails treating the groundwater in the aquifer, which can be achieved by applying physical, chemical, and biological techniques. Examples of possible approaches to in situ treatment include chemical oxidation, air sparging/SVE, and biological treatment technologies.

Ex Situ Treatment, and Disposal

In this response action, groundwater is collected using extraction wells or interception trenches, treated using physical, chemical, and/or biological treatment methods to remove the constituents, and then discharged. The treated groundwater can be discharged to surface water or to a publicly owned treatment works (POTW). The collection, treatment, and discharge response action can also control migration of impacted groundwater.

3.2 Technology Screening

3.2.1 Methodology

Technology screening for remediation of NAPL, soil, and groundwater begins with inventorying technology types and process options based on professional experience, published sources, computer databases, and other available documentation for the general response actions identified in Section 3.1.

Each technology type and process option retained after the screening process is either a demonstrated, proven process or a potential process that has undergone laboratory trials or bench-scale testing. The initial screening of technology types and process options is based on technical implementability. The following factors are included in this evaluation:

- State of technology development
- Site conditions
- Waste characteristics
- Nature and extent of contamination
- Presence of constituents that could reduce the effectiveness of the technology

Entire technologies or individual process options may be screened from further consideration on the basis of technical implementability.

Process options that remain after the initial screening are further evaluated using a qualitative comparison based on the criteria of potential effectiveness, implementability, and cost. The effectiveness of a process option is determined based on the ability of the process option to perform as part of a comprehensive remedial plan to meet RAOs under the conditions and limitations present at the Site. The NCP defines effectiveness as the "degree to which an alternative reduces toxicity, mobility, or volume through treatment, minimizes residual potential risk, affords long-term protection, complies with ARARs, minimizes short-term impacts, and how quickly it achieves protection." Effectiveness is a relative measure used to compare process options that perform the same or similar functions.

"Implementability" refers to the relative degree of difficulty anticipated in implementing a particular process option under regulatory, technical, and schedule constraints posed at the Site. At this point, the cost criterion is used for comparative purposes only. Similarly, implementability is used to preclude further evaluation of process options that are very costly if there are other choices that perform similar functions with similar effectiveness. The cost criterion addresses costs of construction and long-term costs to operate and maintain technologies that are part of an alternative.

NAPL, soil, and groundwater remedial technologies screened using the methodology described are summarized in Tables 3-1, 3-2, and 3-3 for NAPL, soils, and groundwater, respectively. Technologies considered infeasible after screening are shown in italics and boldface. Screening comments are provided to note items of interest or concern for each option. This approach highlights differences within a remedial technology group to allow the best process within each group to be identified and selected. Following the qualitative screening, those remedial technology types and process options considered potentially viable for remediating the media at the Site are carried forward for incorporation into alternatives or screened from further consideration on the basis of technical implementability or cost.

3.2.2 Technology Screening for Free-Phase NAPL

Table 3-1 presents the screening of remedial technologies and process options for NAPL. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.
- **Institutional controls:** Restricting future land use and controlling future construction and redevelopment activities.
- **Physical containment:** Installing impermeable vertical barriers, such as sheet piling or slurry walls, or PABs that allow groundwater flow but restrict NAPL migration.
- **ISCO:** Injecting an oxidant such as sodium persulfate or Fenton's reagent into the target treatment zone to chemically oxidize organic constituents below the water table. The ensuing reaction then oxidizes the organic constituents it contacts. Multiple injections may be required to achieve remediation goals. ISCO may also be effective in changing

the redox conditions so that some arsenic precipitates within the soil matrix. A bench-scale treatability test was conducted to determine the effectiveness of ISCO on NAPL, arsenic, and other Site constituents; the test is described in Appendix B.

- **Solidification/stabilization:** Physically binding constituents within a stabilized mass (solidification) or inducing chemical reactions to reduce constituents' mobility (stabilization). Solidification/stabilization has been proven to be effective to treat coal tar wastes and inorganics such as arsenic wastes.
- **NAPL recovery wells and trench:** Using passive recovery well and trench technology to separate NAPL from groundwater for extraction and offsite disposal, thereby controlling migration. Recovery wells could be either standard vertical wells or directionally drilled wells. Extracted NAPL would be disposed of offsite but may require some treatment prior to disposal.
- **Excavation and offsite disposal:** Physically removing NAPL. Excavation below the water table generally requires managing the NAPL and water generated through the dewatering process and, in some cases, requires the need for barrier walls to manage the groundwater flow. Excavated material may be disposed offsite at a Subtitle C or D permitted disposal facility.

3.2.3 Technology Screening for Soil Media

Table 3-2 presents the screening of remedial technologies and process options for soil media, including residual NAPL. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.
- **Institutional controls:** Restricting access to contaminated soil through land use restrictions (such as deed notices under NJDEP requirements).
- **Soil cover:** Placing a soil cover over contaminated soils to control erosion and prevent direct contact exposure. A cover is distinguished from a cap in that the purpose of the cover is not to minimize infiltration. Surface controls such as grading and revegetation are typically used to reduce erosion and manage surface water.
- **Soil multilayer cap:** Placing a multilayer soil cap over contaminated soils and using controls for managing surface drainage. This approach differs from a soil cover in that a synthetic liner material is used to minimize the infiltration of surface water. As with the soil cover technology, surface controls such as grading and revegetation are usually included to control drainage.
- **Solidification/stabilization:** Physically binding constituents within a stabilized mass (solidification) or inducing chemical reactions to reduce constituents' mobility (stabilization). Solidification/stabilization has been proven to be effective in treating coal tar wastes and inorganic material such as arsenic wastes. It can be applied to impacted soils above and below the water table.

- **ISCO:** Injecting an oxidant such as sodium persulfate or Fenton's reagent into the target treatment zone to chemically oxidize organic constituents below the water table. The ensuing reaction then oxidizes the organic constituents it contacts. Multiple injections may be required to achieve remediation goals. ISCO may also be effective in changing the redox conditions so that some arsenic precipitates within the soil matrix. A bench-scale treatability test was conducted to determine the effectiveness of ISCO on residual NAPL, arsenic, and other Site constituents; the test is described in Appendix B.

- **Excavation:** Physically removing contaminated soils, typically above the water table. Excavation of soils below the water table generally requires management of the water generated through the dewatering process and, in some cases, requires the need for barrier walls to manage the groundwater flow. Excavated materials could be stabilized ex situ prior to offsite disposal. Adding a solidification agent such as cement could reduce the leachability of the constituents. It would be used only if needed to meet land disposal restriction limits in excavated soil prior to landfilling it. Treated material could be disposed of in a RCRA Subtitle C or D permitted landfill.

3.2.4 Technology Screening for Groundwater Media

Table 3-3 presents the screening of remedial technologies and process options for groundwater media. The following technologies were retained for further consideration:

- **NFA:** Retained to meet requirements of the NCP. No remedial technologies are implemented with the option.

- **Institutional controls:** Restricting groundwater use through a CEA, in accordance with the NJDEP regulations (NJAC 7:26E-8.4), is the applicable groundwater use restriction for the Site. The components of the CEA include the location of the restriction (which includes the potential migration locations before degradation reduces concentrations to below applicable cleanup criteria), the compounds detected over the applicable cleanup criteria within the restricted area, and the proposed duration of the restriction. This control would prohibit future use of the groundwater within this area and would restrict the installation of wells over the duration of the CEA.

- **Physical containment:** Installing impermeable vertical barriers such as sheet piling or slurry walls. Mounding can result in flooding on the upgradient side of the barrier or flow around or beneath the barrier. These conditions are typically addressed through groundwater extraction. Where hydraulic and vegetative conditions allow, the planting of phreatophytic trees has been demonstrated to effectively control groundwater mounding inside containment systems.

- **In situ passive treatment barrier:** Treating dissolved-phase constituents in shallow groundwater as it passes through the barrier reacting with the media. The dissolved-phase constituents would either be degraded or retained in a concentrated form by the barrier material. Designs for this technology may consist of zero-valent iron, activated red mud (trade name GeoBind™), granular activated carbon (GAC), or air sparging.

- **Subaqueous reactive barrier:** Using a mat consisting of a reactive material to treat groundwater prior to its discharge to the river. The mat is installed in the river at the area of discharge and with a sand or armor layer to secure it in place.

- **MNA:** Reducing constituent concentrations through natural physical, chemical, or biological processes. These processes may include biodegradation, dilution, dispersion, and retardation. When natural attenuation is implemented as a remedy, monitoring is typically required to document the decrease in constituent concentrations. Only unaugmented natural processes are considered under this technology.
- **Groundwater extraction and treatment:** Extracting groundwater to create a hydraulic barrier to prevent further migration of constituents from the source area. Groundwater is extracted from the shallow aquifer using pumping wells. The constituents are then treated ex situ (as discussed in the following paragraphs) for ultimate disposal, as required according to the requirements of the chosen discharge option. Active hydraulic controls extract groundwater not for the purpose of collecting and treating contaminated water, but to prevent offsite migration of groundwater by capturing the downgradient edge of the plume as it naturally migrates through the area.
- **Groundwater discharge:** Using one or more of several discharge options for treated groundwater, including discharge to the POTW and discharge to surface water. After a review of the hydrogeologic conditions at the Site, and the discharge requirements necessary, reinjection was determined to not be appropriate for the Site because of the high water table. Mounding concerns and nearby surface water also make this option undesirable. Discharge to the POTW may be an option, but connection and discharge fees for the life of the remedial action might be required. Additional monitoring requirements—such as total solids, lower explosive limits, biological oxygen demand and chemical oxygen demand, and limitations of permits—may also dictate discharge to the POTW. The POTW, through an application-to-discharge process, would have to approve the acceptance of any discharge. Discharge to surface water must also meet specific discharge permit requirements.

TABLE 3-1
Technology/Process Options for Operable Unit 1: Free-Phase NAPL
Quanta Resources Superfund Site,OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Adminis-trative Implement-ability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action.	Technically implementable	None	Good	None/None	Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Institutional Controls	Deed Restrictions on Access and Use	None	Deed restrictions issued for property and/or source area to restrict future land use and control future construction and redevelopment activities. Deed restrictions are often used in conjunction with other technology approaches.	Technically implementable	Poor	Good	NA/Low	May be applicable in conjunction with other technologies.
	Monitoring	None	Short- and/or long-term monitoring is implemented to record Site conditions and concentration levels.	Technically implementable	Good	Good	NA/Low	May be applicable in conjunction with other technologies.
Containment	Vertical Barriers	Sheet Pile	Interlocking steel piles are driven into the subsurface along the boundaries of the NAPL zones.	Limited by existing structures and large fill debris	Good	Fair	High/Medium	In situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
		Slurry/Jet Grout Wall	Excavate trench around the NAPL zones and filled with a slurry of low permeability material or jet grouted to provide a barrier.	Potentially limited by existing structures	Good	Fair	Low/Medium	In situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
		Permeable Absorptive Barrier (PAB)	PABs use organophilic clays which are modified to be hydrophobic allowing groundwater to flow through and capturing free-phase and dissolved NAPL.	Technically implementable	Potential	Fair	High/Medium	PAB technology may be applicable to mitigate the potential risk of NAPL migration without obstructing groundwater flow. PABs could also be used in conjunction with containment options to create a barrier which would not transmit dissolved constituents.
In Situ Treatment	Chemical	ISCO	ISCO that employs various oxidants and delivery techniques to mineralize contaminants. Oxidants may include hydrogen peroxide, potassium and sodium permanganate, sodium persulfate, and ozone. Oxidant chemicals are injected directly into the source zone and downgradient plume. Multiple injections may be required to achieve remediation goals.	Technically implementable	Good	Low	High/Medium	This technology may be capable of reducing the quantity of free-phase NAPL at the Site; however, the quantity of reagent required to oxidize free-phase NAPL in situ would likely be difficult to inject.
		Surfactant-Enhanced ISCO	***S-ISCO technology uses the injection of a surfactant-oxidant mixture to dissolve NAPL into an aqueous phase. This allows aqueous phase oxidant reactions to destroy solubilized NAPL. Multiple injections may be required to achieve remediation goals.***	***Technically implementable***	***Potential***	***Low***	***High/Medium***	***This technology may be capable of reducing the quantity of NAPL; however, there is very limited experience with this technology on coal tar sites full scale (one to date). In addition, the ability to recover the surfactant-cosolvent mixture would be a concern adjacent to the Hudson River and would be difficult due to the heterogeneity of the soils and unknown substructures.***
	Solidification/ Stabilization	Auger/caisson/ jet grout system	Constituents are physically bound within a stabilized mass (solidification), and/or chemical reactions are induced to reduce contaminants' mobility (stabilization). These systems are used to apply solidifying/stabilizing reagents to soils. Surface and subsurface objects, >12 inches in diameter, must be removed before treatment.	Technically implementable	Good	Good	High/Medium	Solidification/stabilization can reduce the mobility of contaminants and provides a decreased exposed surface area across which contaminant loss may occur.

TABLE 3-1
Technology/Process Options for Operable Unit 1: Free-Phase NAPL
Quanta Resources Superfund Site,OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Adminis-trative Implement-ability	Capital/ O&M Cost	Screening Comments
In Situ Treatment	***Surfactant/co-solvent flushing***	***—***	***In situ soil washing involves the upgradient injection or infiltration of a cosolvent (such as an alcohol) to dissolve otherwise insoluble contaminants into groundwater for extraction, treatment, and disposal. Extracted groundwater with flushing fluids or cosolvents is often treated to recover and reuse the cosolvent. This technology would likely not work effectively on heavy PAH-impacted soils.***	***Limited by existing structures and large fill debris***	***Poor for arsenic and residual NAPL***	***Low***	***High/ medium***	***Effectiveness may be limited in lower-permeability soils, and this technology has not been effective at non-aqueous phase liquid (NAPL) sites. This technology was not retained because more cost-effective in situ treatment technologies for metal contamination are available.***
	In situ thermal	***Steam Enhanced Extraction, Electrical Resistance Heating, and Thermal Conductive Heating***	***Variety of heating methods to promote heat to vaporize water and contaminants. The heat dries out the soil, causing it to fracture. These fractures make the soil more permeable. Vapors are recovered and treated, prior to discharge to the atmosphere.***	***Technically implementable***	***Potential***	***Fair***	***High/NA***	***This technology may potentially be applicable for source zone treatment at the Site, however, this technology is not retained because NAPL mobilized during heating would be difficult to control and recover due to Site conditions. In addition, full-scale application may be cost-prohibitive while more cost-effective in situ treatment of NAPL is available.***
Removal	NAPL Extraction	Recovery Wells and Trenches	Trenches within areas of free-phase NAPL are installed and backfilled with high-permeability material such as pea gravel. Boreholes are installed with extraction wells and sumps. NAPL preferentially flows into the high-permeability material and collects in sumps for extraction.	Technically implementable	Good	Fair	Medium-High/Medium	Recovery wells could be installed in areas with subsurface obstructions using air-rotary or other drilling methods. Installation of trenches may be infeasible below 25 feet bgs or in areas with subsurface obstructions.
	Excavation	—	Excavation of NAPL using standard construction equipment (i.e., backhoes, bulldozers, and front-end loaders).	Technically implementable	Good	Fair	High/NA	May be applicable in conjunction with other technologies
Disposal	Offsite Disposal	—	This technology involves offsite disposal of recovered NAPL.	Technically implementable	Good	Fair	Medium/NA	May be applicable in conjunction with other technologies

Note: Italicized and boldface text indicates technology or process option was screened from further consideration.

TABLE 3-2
Technology/Process Options for Operable Unit 1 : Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action.					Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Institutional Controls	Institutional Controls	Land Use Restrictions	Restrict access to contaminated soils through local ordinances, building permits, restrictive covenants on property deeds (Deed Notice) and state registries of contaminated sites.	Technically implementable	Fair – Must be combined with other technologies	Fair	Low/Low	Does not meet RAOs when implemented alone; may be applicable in conjunction with other technologies.
Containment	Cover	Soil	Placing a soil cover over contaminated soils would control erosion and allow infiltration while preventing direct contact exposure. Surface controls such as grading and revegetation are typically used to reduce erosion and mange surface water.	Technically implementable	Demonstrated	Good	Moderate/ Low	A soil cover may be feasible to prevent direct contact with impacted soil.
	Cap	Multi-layer	Capping the soil to prevent direct contact and to reduce infiltration is often combined with barrier wall technology, and could include clay, geotextile, asphalt, or multilayer caps with vegetative cover.	Technically implementable	Demonstrated	Good	High/low	Encapsulation does not reduce concentrations of constituents. Inspection and replacement requirements of either a barrier wall or a cap would limit future Site use.
In Situ Treatment	***Surfactant/co-solvent flushing***		***In situ soil washing involves the upgradient injection or infiltration of a cosolvent (such as an alcohol) to dissolve otherwise insoluble contaminants into groundwater for extraction, treatment, and disposal. Extracted groundwater with flushing fluids or cosolvents is often treated to recover and reuse the cosolvent. This technology would likely not work effectively on heavy PAH-impacted soils.***	***Limited by existing structures and large fill debris***	***Poor for arsenic and residual NAPL***	***Low***	***High/ medium***	***Effectiveness may be limited in lower-permeability soils, and this technology has not been effective at non-aqueous phase liquid (NAPL) sites; The presence of NAPL in the treatment area may limit the effectiveness of this technology. This technology was not retained because more cost-effective in situ treatment technologies for metal contamination are available.***
	In situ soil vapor extraction (SVE)		***Volatilized contaminants migrate into the unsaturated zone where they can be extracted by an SVE system and treated or sequestered. SVE is typically effective for contaminants with low boiling points and high vapor pressures.***	***Potentially implementable – would need to be confirmed with pilot test***	***Poor for arsenic and PAHs***	***Fair***	***Medium/ medium***	***This technology is likely to be ineffective for NAPL-impacted areas. Dewatering may be required in order to install an effective SVE system at the Site as a result of the high water table. This technology may not be effective for semi-volatile organic compounds (SVOCs) and PAHs, and would not be effective for arsenic.***
	In situ thermal	***Steam Enhanced Extraction, Electrical Resistance Heating), and Thermal Conductive Heating***	***Variety of heating methods to promote heat to vaporize water and contaminants. The heat dries out the soil, causing it to fracture. These fractures make the soil more permeable. Vapors are recovered and treated, prior to discharge to the atmosphere.***	***Technically implementable***	***Potential (possible NAPL mobilization)***	***Fair***	***High/NA***	***This technology may potentially be applicable for source zone treatment at the Site, removing more volatile contaminants, leaving relatively stable and immobile contaminants in place, although full-scale application may be cost-prohibitive. Additionally, potential for mobilization of NAPL exists. More cost-effective in situ treatment of soil COCs is available.***
Solidification/ Stabilization/		Auger/caisson/jet grout system	Constituents are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce contaminants' mobility (stabilization). Auger-caisson and similar systems are used to apply S/S reagents to soils. Reagents and dosage used is the primary design and remediation considerations.	Technically implementable	Potential	Good	High/ NA	S/S can reduce the mobility of organic and inorganic contaminants and provides a decreased exposed surface area across which contaminant loss may occur.

TABLE 3-2
Technology/Process Options for Operable Unit 1: Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In Situ Treatment	ISCO	Fenton's reagent or sodium persulfate	ISCO is a group of technologies that employs various combinations of oxidants and delivery techniques to mineralize contaminants. Oxidants may include hydrogen peroxide, potassium and sodium permanganate, sodium persulfate, and ozone. Oxidant chemicals are injected directly into the source zone and downgradient plume. Multiple injections may be required to achieve remediation goals.	Technically implementable	Potential	Fair	Med-high/ Low	This technology may be capable of reducing contaminant concentrations at the Site. Low permeability soils and the presence of NAPL may limit the effectiveness of this technology. Chemical oxidation is typically applied to dissolved phase contaminants and residual non-mobile product (particularly lighter end petroleum products), and is typically used in combination with other technologies at NAPL sites where it has been applied. In-situ oxidation changes the redox conditions in the subsurface and the effect on all constituents of concern at the Site should be evaluated prior to implementation.
	Phyto-remediation/ Bioremediation		***Phytoremediation/bioremediation uses plants and microbes associated with the plant root system to stabilize, degrade, or extract contaminants from the soil and groundwater by either adsorption or absorption. These processes can work for both inorganic and organic contaminants depending on the type of plant uses. Generally, this treatment works on low levels of contamination and works best when combined with other treatment remedies.***	***Potentially implementable***	***Potential***	***Fair***	***Low/Low***	***This technology may be capable of reducing low levels of volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs) and providing extraction of metals. A potential air hazard may arise if contaminants are volatilized without being fully metabolized by the plant. Additionally, if metals are absorbed into the plant, it may be a biological hazard to surrounding wildlife and residents unless the plants are harvested and disposed offsite. Treatment time and space may limit the applicability of this technology to the Site.***
Removal/ Disposal and Ex Situ Treatment	Removal and Disposal	Excavation	Excavation of impacted solids using standard construction equipment (i.e., backhoes, bulldozers, and front-end loaders).	Technically implementable	Good	Fair	High/NA	May be applicable in conjunction with other technologies.
		Solidification/ Stabilization	Constituents are physically bound within a stabilized mass (solidification), or chemical reactions are induced to reduce contaminants' mobility (stabilization). Ex situ forms of this technology may include asphalt batching or incorporation of contaminated soil in concrete. Asphalt batching technologies have been applied to tar soils.	Potentially implementable	Potential for PAHs	Fair	High/NA	Ex situ solidification/stabilization may require dewatering to allow excavation of contaminated soil below the water table. Asphalt batching with subsequent reuse has been applied successfully at other sites for tar-impacted soils. Geotechnical properties of the final processed material would need to be considered during the feasibility study process.
		Offsite Disposal	This technology involves the removal of contaminated material for disposal in a permitted landfill.	Technically implementable	Demonstrated	Good	Medium/ Low	This disposal option may be included in alternatives involving excavation and/or treatment of impacted soil.
		Offsite low-temperature thermal desorption	***Low-temperature thermal desorption involves heating soil to temperatures of up to 650°C (1,200°F) to volatilize and contaminants for subsequent removal from the air stream using control technology.***	***Technically implementable***	***Demonstrated for organic constituents***	***Fair***	***High/NA***	***This technology may be included in a soil remedial alternative involving excavation and ex situ treatment. Soils typically require rendering prior to treatment. Clay and silt and high moisture content can affect effectiveness of the technology. Onsite desorption may not be feasible due to permit requirements and the proximity of residential and commercial facilities to the Site.***

TABLE 3-2
Technology/Process Options for Operable Unit 1: Soil Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
Removal/ Disposal and Ex Situ Treatment		***Soil washing***	***COCs sorbed onto fine soil particles are separated from bulk soil in an aqueous-based system on the basis of particle size. Wash water may be augmented with a basic leaching agent, surfactant, pH adjustment, or chelating agent to help remove organics and heavy metals. The process removes contaminants from soils in one of two ways: By dissolving or suspending them in the wash solution. By concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing. It does not destroy or immobilize the contaminants. Consequently, the resulting concentrated soil must be disposed of carefully.***	***Technically implementable***	***Potential***	***Fair***	***High/ Medium***	***A high coarse-to-fine-grained material ratio is required to make soil washing cost effective. The principal idea that contaminants are preferentially found with finer grain material allowing for particle size separation to remove most of the contaminated media would not be effective at the Site.***
		Landfarming or Biopiles	***Landfarming and biopiles are bioremediation technologies, which usually incorporates liners and other methods to control leaching of contaminants during biological treatment. Landfarming requires excavation and placement of contaminated soils, sediments, or sludges in lined beds that are periodically turned over or tilled to aerate the waste. Soil conditions are typically controlled to optimize the rate of contaminant degradation.*** ***Biopile treatment is similar to landfarming, but requires less area because the piles can be constructed to heights of ten feet or more. Excavated soils are mixed with soil amendments and placed in a treatment area that includes leachate collection systems and some form of aeration. Moisture, heat, nutrients, oxygen, and pH can be controlled to enhance biodegradation.***	***Potentially implementable – would require suitable offsite location***	***Potential***	***Low***	***Medium/ Low***	***Not applicable onsite due to space limitations, the close proximity of commercial and residential facilities, presence of NAPL in the soils, and shallow groundwater conditions. Excavated waste would likely have to be treated at another location or be performed with engineering controls in place to prevent unacceptable impacts to the community. Ex situ treatment technologies more likely to be effective and with fewer impacts to the community are available for soil constituents of concern. It is also difficult to achieve low levels of some of the PAHs with bioremediation.***
	Onsite reuse	***None***	***This technology involves reusing treated soil onsite as backfill after reuse requirements are met. Soil containing NAPL may be reused as asphalt for certain applications.***	***Technically implementable***	***Demonstrated***	***Fair***	***Low/NA***	***Excavated soil would likely be treated offsite. Administrative implementability for this disposal option is lower than for offsite disposal and import of clean fill to the Site.***

Note: Italicized and boldface text indicates technology or process option was screened from further consideration.

TABLE 3-3
Technology/Process Options for Operable Unit 1: Groundwater Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
No Action	No Further Action	None	No action.	Not implementable – does not meet RAOs	Poor	Poor	NA/NA	Required for comparison by National Contingency Plan (NCP); does not meet remedial action objectives (RAOs).
Institutional Controls	Institutional Controls	Classification Exception Area (CEA)	Restrict access to contaminated groundwater by establishing a CEA whose purpose is to designate that constituents exceed water quality standards and ultimately prevent use of the affected aquifer for potable and/or other purposes.	Technically implementable	Good	Good	Low/Low	Does not meet RAOs when implemented alone; may be applicable in conjunction with other technologies.
Containment	Vertical Barriers	Sheet Pile	Interlocking steel piles are driven into the subsurface along the boundaries of the NAPL zones.	Limited by existing structures and large fill debris	Good	Fair	High/Medium	In situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
		Slurry/Jet Grout Wall	Excavate trench around the NAPL zones and filled with a slurry of low-permeability material or jet grouted to provide a barrier.	Potentially limited by existing structures	Good	Fair	Low/Medium	In situ barrier wall technology alone does not reduce contaminant concentrations. Barrier technology could be combined with passive treatment barrier (see below) to create a funnel and gate directing groundwater flow through the treatment area.
	In situ Passive Treatment Barrier	Permeable reactive barrier (PRB) and Permeable absorptive barrier (PAB)	Passive treatment wall technology provides for in situ treatment of dissolved-phase constituents in shallow groundwater prior to discharge offsite. Designs for this technology typically consist of air sparging, zero-valent iron, organoclay, activated red mud, GAC, biological stimulation, or other process options.	Technically implementable	Demonstrated	Good	High/low	Passive treatment barrier technology may be applicable to reduce dissolved-phase constituent concentrations and can be combined with barrier wall to create a funnel and gate configuration to direct groundwater flow through the treatment area.
	Subaqueous Reactive Barrier		A mat consisting of reactive material(s) is encapsulated in a nonwoven core matrix bound between two geotextiles and installed in the area of the river where groundwater is discharging through the sediments. The subaqueous reactive barrier provides a reactive material that treats contaminants which are carried by advective or diffusive flow of groundwater into the adjacent river.	Technically implementable	Demonstrated	Good	Medium/low	This passive treatment technology may be capable of treating the groundwater prior to discharging to the Hudson River through the river sediments.
	Evapo-transpiration		***An evapotranspiration cover is composed of soil and plants selected to maximize the available storage capacity of soil, evaporation rates, and transpiration processes of plants to minimize water infiltration. Hydraulic control can be established by planting vegetation or trees that establish a large root mass at the water table and take up large quantities of water.***	***Potentially implementable***	***Potential***	***Fair***	***Low/low***	***Effectiveness may vary seasonally, and sufficient plant growth may be difficult to establish in portions of the Site due to existing contamination (such as the presence of NAPL). Hydraulic control alone does not reduce contaminant concentrations or eliminate exposure pathways.***
Monitored natural attenuation	Sampling and Analysis		Natural attenuation is the process by which contaminant concentrations are reduced by various naturally occurring physical, chemical, and biological processes. The main processes include dilution, biodegradation, and retardation. Only unaugmented natural processes are relied upon under this technology.	Technically implementable	Good	Good	Low/low	This technology may be capable of reducing residual organic contaminant concentrations and thereby economically reduce ecological and/or human health risk after source zone treatment or removal.

TABLE 3-3
Technology/Process Options for Operable Unit 1: Groundwater Media
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Technology General Response Action	Remedial Technology	Process Option	Description	Technical Implementability Screening Comments	Effectiveness	Technical and Administrative Implementability	Capital/ O&M Cost	Screening Comments
In Situ Treatment	***In situ air sparging and SVE***		***In situ air sparging is a technology in which air is injected through a contaminated aquifer. Injected air strips contaminants out of impacted groundwater by volatilization. Volatilized contaminants migrate into the unsaturated zone where they can be extracted by an SVE system and treated or sequestered. The oxygen added during the sparging process can also enhance biodegradation of contaminants below and above the water table.***	***Technically implementable***	***Potential—VOCs and some SVOCs***	***Fair***	***Medium/ medium***	***This technology may not be effective for high molecular weight semi-volatile organic compounds (SVOCs), and would not be directly effective for arsenic, although changes in redox conditions as a result of sparging may have an effect on the dissolution of arsenic in groundwater.***
	Phyto-remediation/ Bioremediation		***Phytoremediation/bioremediation uses plants and microbes associated with the plant root system to stabilize, degrade, or extract contaminants from the soil and groundwater by either adsorption or absorption. These processes can work for both inorganic and organic contaminants depending on the type of plant uses. Generally, this treatment works on low levels of contamination and works best when combined with other treatment remedies.***	***Potentially implementable***	***Potential***	***Fair***	***Low/low***	***This technology may be capable of reducing low levels of volatile organic compounds (VOCs), SVOCs and providing stabilization of extraction of metals. A potential air hazard may arise if contaminants are volatilized without being fully metabolized by the plant. Additionally, if metals are absorbed into the plant, it may be a biological hazard to surrounding wildlife and residents unless the plants are harvested and disposed offsite. Treatment time and space may limit the applicability of this technology to the Site.***
Ex situ treatment	Groundwater extraction and treatment	(Treatment train TBD)	Extracted groundwater and/or vapor are treated onsite at a treatment facility which may include more than one process option to remove or degrade contaminants. Process options may include air stripping, activated carbon adsorption, separation, oxidation, bioreactors, scrubbers or other technologies selected based on the profile of the influent water and/or vapor.	Technically implementable	Good	Fair	Medium-high/high	These technologies may be included in any remedial alternatives involving the extraction or removal of vapor or groundwater that does not already meet discharge or disposal requirements. Pretreatment would be required to remove NAPL, turbidity, heavy metals, and/or insoluble oils from the influent stream.
Disposal	***Reinjection***		***This technology involves injection of treated groundwater back into the unconfined aquifer at the Site. Treatment requirements would be based on any applicable permitting requirements.***	***Technically implementable***	***Potential***	***Fair***	***Low/NA***	***This disposal option may be included in alternatives involving onsite ex situ groundwater treatment. Due to the proximity to the Hudson River and shallow groundwater, this technology would have a similar effect as discharge to surface water. Implementation is more difficult than surface water discharge. This technology is not retained because the effect would be similar to the retained surface water discharge technology but is more difficult to implement.***
	Surface Water Discharge		This technology involves discharge of treated groundwater into the Hudson River adjacent to the Site. Treatment requirements would be based on the selected discharge location and any applicable permitting requirements.	Technically implementable	Good	Fair	Low/NA	This disposal option may be included in alternatives involving onsite ex situ groundwater treatment. Regulatory and community acceptance of this process option may be difficult to obtain.
	Publicly Owned Treatment Works (POTW)		This technology involves discharge of treated groundwater into the Edgewater sewer system flowing to the local POTW. Treatment requirements would be based on the selected discharge location and any applicable permitting requirements.	Technically implementable	Good	Fair	Low/NA	This disposal option may be included in alternatives involving onsite ex situ groundwater treatment.

Note: Italicized and boldface text indicates technology or process option was screened from further consideration.

SECTION 4

Development of Alternatives

The remedial technologies and process options that remained after screening were assembled into the following comprehensive remedial action alternatives (with HCAA process options) that address the RAOs for the site:

- Alternative 1—No Further Action
- Alternative 2—NAPL and Arsenic Containment
- Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
- Alternative 4a—NAPL and Arsenic In Situ Solidification/Stabilization
- Alternative 4a (HCAA process option)—NAPL and Arsenic In Situ Solidification/Stabilization with Containment of the HCAA
- Alternative 4b—NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of 115 River Road Buildings
- Alternative 5a—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
- Alternative 5a (HCAA process option)—NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Containment of the HCAA
- Alternative 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Demolition of 115 River Road Buildings
- Alternative 6a—NAPL and Arsenic Excavation
- Alternative 6b—NAPL and Arsenic Excavation with Demolition of 115 River Road Buildings

The remedial action alternatives are consistent in how they mitigate potential risks posed by principal threat and low-level threat waste, although specific technologies vary among the alternatives. The remedial alternative summary table with designation by technology is provided in Table 4-1. Each alternative, with the exception of the no further action alternative, mitigates risk posed by the site to acceptable levels. However, risk posed by areas defined as principal threat waste is generally managed differently than areas defined as low-level threat waste. Alternatives 4 through 6 address principal threat areas with treatment or removal and Alternative 2 and 3 address principal threat waste primarily through containment. For the most part, low-level threat waste is addressed through natural containment as a result of the geology or the characteristics of the source material, in addition to limiting physical access by capping.

Removal or treatment of low-level threat waste in NZ-3, NZ-4, and NZ-6 (i.e., deep NAPL) would not result in a significant improvement to groundwater quality and would not improve the overall risk profile at the site. The presence of certain site-specific and

contaminant-specific factors, including residual NAPL and complex hydrogeologic site conditions, render the restoration of groundwater quality technically impracticable. However, technologies that can provide some mass removal or treatment for portions of NZ-3, NZ-4, and NZ-6 have been considered and included in some remedial alternatives. Specifically, where NZ-1 and NZ-3 overlap on the Quanta property and are separated vertically by approximately 5 ft or less, treatment of the low-level threat waste in NZ-3 is considered. Additionally, limited NAPL recovery from existing monitoring wells in NZ-3 and NZ-4 is considered where conditions are amenable to NAPL recovery. Passive recovery efforts would be focused on a select number of wells with the intention of optimizing the benefit of the recovery efforts in terms of NAPL mass removed.

The assumptions, estimates of impacted media volumes, and treatment process conceptual design components were generated for each alternative to develop +50/-30 percent accuracy level cost estimates (Appendix C). Other viable process options within remedial technologies that achieve the same objectives may be evaluated during remedial design activities for the site. The results of preremedial design investigations, treatability studies, and the remedial design will be used to specify the exact components of the selected alternative and evaluate basis of design criteria.

4.1 Common Issues

Prior to examining the remedial action alternatives, four specific issues common to most of the alternatives will be discussed. These issues required special consideration during the development of the five remedial action alternatives due to the unique challenges they would present during the implementation of any remedial alternatives selected for the site:

- Backfilling as a part of the redevelopment plans for the Quanta property
- Shallow NAPL beneath the 115 River Road buildings
- Shallow NAPL beneath River Road
- High-concentration arsenic area

These areas and their unique challenges are described in further detail below.

4.1.1 Redevelopment and Backfilling of Quanta Property

The Quanta property will likely undergo redevelopment activities sometime in the future. It is likely that redevelopment activities will result in a change in site grade from current conditions. Based on the development activities on surrounding properties, it is likely that fill will be added to the property in order to make the property more suitable for development. In addition, NJAC 7:13 Flood Hazard Area Control Act rules do not allow the construction of a new building in a floodway. The lowest floor must be constructed at least 1 ft above the flood hazard area design flood elevation. It is estimated that raising the existing grade by 2 to 10 ft would bring the elevation of the site into alignment with surrounding properties and out of the floodway.

Although the placement of the fill may be needed to meet the objectives of a future site development project, the placement of additional fill material will not be considered a component of the remedial alternatives in the FS, since it is not needed to achieve the RAOs for the site. For purposes of this FS, it is assumed that the alternatives that include placement of an engineered cap will be developed to achieve the RAOs based on current site

conditions. If a development plan is available prior to implementation of the selected remedial alternative, modifications to the design of the engineered cap may be proposed to incorporate the fill that would be placed into an equivalent cap that provides the same level of protectiveness.

Backfilling and compaction are considered the redevelopment activities that have the most potential to affect NAPL mobility at the site. Consolidation of the subsurface soil as a result of the placement of fill will cause temporary fluid displacement and shifts in lithologic interfaces. Consolidation of the organic silt and the deeper silty-clay confining unit as a result of the placement of fill will displace pore fluids as void space is compressed. The displaced fluids will be expelled and drained into the overlying fill or sand until the displaced water equalizes. Displaced fluids may include a fraction of NAPL if it is present in the compressible unit; however, due to significantly higher conductivity for groundwater than for NAPL, it is assumed that groundwater will be the primary fluid that is displaced during this relatively short time period for equalization.

Impacts on the mobility of NAPL above these compressible units can also occur as a result of the placement of fill. NAPL seepage velocities may increase as a result of increases in NAPL gradients, either as the result of increases in hydraulic gradients caused by the displacement of water from the compressible soils (short-term effect) or as the result of uneven shifts in lithologic interfaces (potentially long term). In the latter condition, settlement of the subsurface may reduce or increase the slope of the fill or of native sands where NAPL is present through nonuniform settlement of the underlying silty-clay or organic silts. This could result in either an increase or decrease in NAPL gradients. The degree to which this would occur will depend on the extent and intensity of filling. Despite the potential for temporary increases in NAPL gradients deeper inland, NAPL (e.g., NZ-3) will remain substantially contained by the silty-clay. At the southeastern downgradient edge of NZ-3, any potential future NAPL movement would result in NAPL migration along the interface of silty-clay and sand to depths that would preclude the potential for it to migrate to surface water, to sediments, or to air or act as a source for direct exposure. Each remedial alternative would include monitoring for potential migration of NAPL in NZ-3.

4.1.2 Shallow NAPL Beneath 115 River Road Buildings

Shallow NAPL associated with NZ-1 and NZ-2 is located below the 115 River Road buildings. The accessibility of portions of the shallow NAPL in NZ-1 and NZ-2 to human receptors at OU1 is restricted by the presence of the buildings; therefore, the principal threat toxicity potential is associated only with the potential for a completed vapor intrusion pathway to exist. Vapor intrusion investigations at 115 River Road have demonstrated that there is no existing unacceptable risk due to vapor intrusion under current building conditions; however, remedial alternatives need to address potential exposure pathways through engineering and institutional controls.

In addition, NAPL's proximity to the river and ecological receptors in OU2 requires that the remedial alternatives address the potential migration of the NAPL in NZ-2 to the river. The narrowness of the building provides an opportunity to implement technologies along the shoreline beneath the building to prevent the potential migration of NAPL to the River.

Remediation of the NAPL lying directly under 115 River Road was considered and determined to be infeasible. This brick building was constructed in the early 1900s and is

believed to have been constructed on wooden piles at intervals of between 5 and 10 ft. Any intrusive activity under the building has the potential to damage the wooden pilings and cause instability in the foundation. This includes cutting or physically damaging the piles, introducing chemicals or conditions which will destroy the piles, or altering the material around the piles. If the building's supporting piles are compromised, then the building stability is in jeopardy because the underlying material is primarily compressible fill material and sediments with a very shallow water table. Other technology-specific issues associated with remediating the NAPL beneath the building are summarized below.

- In Situ Solidification/Stabilization
  - Access for mixing impeded due to pilings and basements
  - Physical heaving of building due to soil expansion
  - Damage to pilings and structural supports or piles during mixing or due to heaving
- Excavation
  - Access for excavation impeded due to pilings and basements
  - Excavation depth impeded by presence of pilings
  - Damage to pilings and structural supports or piles during mixing or due to heaving
- ISCO
  - Reaction with wood in pilings with oxidant
  - Damage to supports, causing building instability
  - Uncontrolled mobilization of NAPL without ability to capture
  - Uncontrolled vapor emissions without ability to capture

4.1.3 Shallow NAPL Beneath River Road

Based on an evaluation of NAPL data collected during the SRI, it was determined that NAPL extended from the Quanta property beneath River Road to the Block 93 property. As part of the construction of River Road, Bergen County (per the AOC II-CERCLA-96-1010 among Metropolitan Edgewater Associates, Limited Partnership; the County of Bergen; and EPA) imported fill material to raise the grade of the new road, allowing utilities to be installed in the fill material rather than burying them below grade. In addition, the roadway work included placement of an impermeable synthetic barrier over the ground at grade level of the right-of-way (specifically in the intersection of Gorge Road and River Road) prior to the placement of 3 ft of clean fill above the synthetic barrier. The synthetic barrier is installed to provide a demarcation of the original site soils and the new fill material. The clean fill and barrier isolate the site soils from future construction workers and limit accessibility to human receptors at OU1 under current conditions. The barrier was installed in front of the Quanta property. NAPL observed in front of 115 River Road is associated with NZ-4. The NAPL located within NZ-4 likely resulted from lateral migration of NAPL from the NZ-1 area and is not believed to be present in the shallow soils in this area.

Further, a traffic study supplied by Bergen County (2007) was used to evaluate the potential impact of phased demolition and replacement of portions of River Road to accommodate access for the purposes of remediation of NAPL, if present. Based on the available traffic volumes and field reconnaissance, the 600- to 700-ft section of River Road at, and immediately south of, Gorge Road should not be closed to traffic for an extended period of time. The review and observations concluded:

1. The magnitude of existing traffic volumes require the number of lanes that are currently on River Road to operate safely and efficiently.
2. There is no other roadway "through" roadway or connecting local road system] serving Edgewater in which to divert and accommodate these traffic volumes.
3. Direct access to several highly active residential and commercial properties adjacent to and proximate to this section of River Road would be adversely affected.
4. The roadway closure would negatively impact the town's community and emergency services.
5. Access to the Palisades Medical Center in responding to life-threatening situations would be negatively impacted.
6. There is no existing roadway network in the vicinity of River Road to serve as a detour around the potential closure.
7. There is no available River Road right-of-way to construct a detour in the vicinity of the potential River Road closure.
8. Through and local truck traffic would be impeded and, therefore, may negatively impact other municipal roads.
9. A potential River Road closure at this location may negatively impact the entire length of River Road from a traffic congestion perspective due to the separation of the Cliffs from other parallel roads and the limited road system that traverses the Cliffs.
10. A potential River Road closure at this location may negatively impact roadway systems in other communities above the Cliffs such as along Boulevard East and Palisades Avenue.

In addition, if the closure of River Road also results in the closure of part or all of Gorge Road at the River Road intersection, the situations associated with the above issues would be further exacerbated.

Based on the design of River Road and the traffic study described above, no action is proposed for under River Road or Gorge Road at this time. If future road construction were to expose residual NAPL, remedial response actions would be coordinated with Bergen County. The selected remedial response action would be determined at the time of construction, but could include health and safety measures, solidification/stabilization, or excavation. Bergen County would have the responsibility for demolition and reconstruction of the roadway, and related costs would not be included as part of the remedial costs. The costs associated with the potential remedial response action within the roadway are not currently included in the detailed cost estimates development for each remedial alternative in Appendix C.

4.1.4 High-Concentration Arsenic Area

Remedial actions have been performed as part of the construction of Edgewater redevelopment per the June 2002 AOC Amendment between Edgewater Enterprises and

NJDEP and AOC CERCLA-02-2003-2014 between Edgewater Enterprises and EPA. The major work included the following:

- Further delineation of the HCAA.
- Removal of structures, underground pipes, underground storage tanks, and other waste encountered during the performance of work at the site and excavation of small hot spots outside the HCAA that exceeded 1,000 mg/kg
- Construction of Building 400 (now the hotel) with a "buffer zone" between the building and the HCAA that would allow for the construction of a vertical containment wall, if required by NJDEP in the future.
- Placement of an impermeable synthetic liner, clean fill, and cap over the ground at grade level of the easement over the HCAA, as approved by the NJDEP; no utilities or pilings could be installed in the HCAA, except stormwater conveyance and electrical service within the upper layers of fill, as approved by NJDEP
- Construction of a right-turn lane into the City Place development from north-bound River Road within the easement
- Long-term maintenance of the slope, drainage, and grading on the easement

The arsenic located beneath the existing liner has limited accessibility to human receptors at OU1 under current conditions; therefore, the impact associated with this arsenic is the dissolved phase arsenic. Remedial alternatives consider technologies to address the HCAA.

4.2 Detailed Alternative Descriptions

4.2.1 Alternative 1: No Further Action

Under this alternative, there would be no remedial actions conducted at the site to control or remove COCs or NAPL, or to prevent exposure at the site. No further remedial action would be taken for groundwater, and COCs in groundwater may continue to reach the Hudson River. Vapor intrusion mitigation would not be provided for 115 River Road or other buildings. Alternative 1 does not include monitoring or institutional controls. The objective of Alternative 1 is to provide a baseline for comparison to other alternatives, as required by the NCP.

4.2.2 Alternative 2: NAPL and Arsenic Containment

Alternative 2 combines sitewide NAPL and groundwater containment with in situ passive treatment (i.e., funnel-and-gate system) and soil capping. This alternative also includes maintaining existing roads and parking surfaces. Engineering controls that would reduce the potential for vapor intrusion under future conditions along with institutional controls to prevent exposures to soil or groundwater are incorporated into this alternative.

Principal threats that Alternative 2 addresses are identified in Section 1.7 and described below and in Table 4-2:

- Toxicity potential due to direct human contact with principal threat waste NAPL (NZ-1, NZ-2, NZ-5, and tar boils) is addressed by eliminating the direct contact exposure pathway through capping and institutional controls.
- Toxicity potential due to direct contact with principal threat waste in AA-1 through AA-7 is addressed by eliminating the direct contact exposure pathway through capping and institutional controls.
- Toxicity potential for ecological receptors at OU2 (principal threat risk at NZ-2 and NZ-5) is reduced through the installation of a funnel-and-gate system to isolate the NAPL zones from the Hudson River.
- The unoccupied basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system to address toxicity potential for vapor intrusion. Other occupied buildings would be sampled periodically and vapor intrusion mitigation provided, if warranted.
- Mobility potential for free-phase NAPL adjacent to the river (principal threat risk at NZ-2 and NZ-5) is reduced through NAPL containment and a funnel-and-gate system to isolate the NAPL zones from the Hudson River.

Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5.

A summary of the remedial actions taken in this alternative is provided in Table 4-3.

4.2.2.1 Non–Aqueous Phase Liquid and Groundwater Containment

Physical containment of NAPL and groundwater would be achieved through the installation of a funnel-and-gate system along the boundary of OU1 and OU2. The funnel-and-gate system would be installed on the east side of the existing bulkhead down to the silty-clay layer, as shown in Figure 4-1. Figures 4-2 through 4-6 depict this alternative in cross-section view. Groundwater flowing north would be monitored to assure the continued natural attenuation of COCs. Site groundwater conditions would be monitored to verify that natural attenuation is continuing and the footprint of the site-related groundwater impacts is not increasing. Institutional controls (groundwater use restrictions in the form of a CEA and TI waiver) would be applied to prevent future exposure to groundwater.

Impacted groundwater would be captured and funneled through treatment gates designed to reduce the concentrations of naphthalene, arsenic, and other COCs prior to its being discharged to the Hudson River. The objective of the treatment gates would be to reduce COC concentrations in pore water as a preventative measure, to eliminate the possibility that groundwater originating from the site could represent a potential risk to ecological receptors following discharge to the Hudson River. Although the BERA has not been completed, preliminary evaluations suggest very limited potential for risk to ecological receptors from the discharge of groundwater to surface water. Therefore, the objective of reducing the COC concentrations is to account for uncertainty prior to completion of the BERA and proactively eliminate any potential for ecological risk associated with this exposure pathway. Literature-based standards and other applicable surface water screening values (e.g., New Jersey Surface Water Quality Standards, NJAC. 7:9B) will be used as a

highly conservative indicators of possible risk for the ecological COCs and to guide the development of the remedial technology.

Treatment gates could consist of air sparging, zero valent iron, organoclay, activated red mud, granular activated carbon, or biological stimulation. For FS cost-estimation purposes, the treatment gate technology is assumed to be air sparging.

Air sparging has been used to address a broad range of volatile and semivolatile groundwater contaminants. Due to the complexity of the geochemistry, hydrogeology, range of contaminant, and concentrations at the site, pilot testing would be necessary to determine the overall effectiveness of reducing the concentration of COCs through air sparging treatment. A sparge system could be installed as closely spaced vertical injection wells or horizontal slotted pipe installed in a trench. For FS cost-estimating purposes, it has been assumed the air sparge would be a horizontal slotted pipe installed in a trench. Air sparging is expected to be effective for reducing naphthalene concentrations and changing the redox conditions of the groundwater so that dissolved arsenic would precipitate within the wall. The high levels of dissolved iron in groundwater may foul the air sparge gate piping and high-permeability pipe-bedding material. Periodic scouring of the system would be required to maintain the air sparge system. Capture of vapors would be achieved through soil vapor extraction.

For FS cost-estimating purposes, the impermeable barrier would be constructed with sheet piles keyed into the lower-permeability silty clay layer or, where the silty-clay is not present in northern portions of the site, bedrock. The sheet pile is estimated to be 1,000 ft long, extending to the silt clay layer at 30 ft bgs (north of NZ-5), and sloping to nearly 70 ft bgs (south of NZ-2). Installation of the sheet pile would require the demolition of the concrete platform on the shoreline of the Quanta property and the removal of the rip-rap along the shoreline of NZ-5; however, the existing bulkhead is intended to remain in place. The quantity, size, and location of treatment gates and the layout of the barrier walls would be determined based on groundwater flow modeling so that the following criteria are met:

- Acceptable groundwater flow velocities are maintained through the site.
- There is adequate residence time of groundwater flowing through the treatment gates.
- The desired remediation area is captured by the funnel-and-gate system.

To prevent migration of NAPL from under the 115 River Road buildings to the river, a cutoff wall would be installed under the building. For FS cost-estimating, it is assumed that cutoff wall will be installed to a depth of 70 ft bgs (down to the silty clay confining unit) and integrated with the barrier wall being installed to the north and south of the building. It is anticipated that a portion of the parking area decking would be demolished to allow for the installation of a barrier wall constructed of piles (vertical and inclined), timber or plastic lagging, and a water proof membrane. To complete the impermeable barrier at the shoreline, a jet grout wall (a minimum of 6 ft thick) would be installed on the front of the lagging (i.e., the land side of the pile and lagging wall). Following installation of the barrier wall, the parking lot decking would be reconstructed.

4.2.2.2 Natural Attenuation and Groundwater Monitoring

Several primary lines of evidence, including the fate and transport evaluations presented in the final RI (CH2M HILL, 2008) and final SRI (CH2M HILL, 2010), suggest that the

attenuation of both the organic constituents and arsenic is occurring within and downgradient of OU1 and that the contaminant plume is not expanding, with the exception of arsenic at the southeastern corner of the former Celotex property (ASA-3). Attenuation mechanisms include degradation, adsorption, dispersion, dilution from recharge, and volatilization. Adsorption and degradation reactions are the most dominant factors in dissolved constituent fate and transport at the site.

As part of this alternative, groundwater monitoring would be completed to verify that (1) natural attenuation is occurring, (2) the footprint of site-related groundwater impacts is not increasing, and (3) the funnel-and-gate technology is effectively reducing COC concentrations to levels protective of the Hudson River.

The postremediation monitoring network (number of wells, sampling locations, constituent analysis list) would be dependent on the final design for the site and complete site remedial approach. The need for additional wells would be considered during the remedial design. For cost estimating, it is assumed that 40 monitoring wells would be sampled quarterly for the first year and annually thereafter for VOCs, SVOCs, arsenic, and parameters necessary for evaluating natural attenuation. After the remedy has been implemented and groundwater concentrations are stable, the monitoring network and sampling frequency would be reevaluated.

4.2.2.3 Soil and Residual Soil Capping

Areas where site-related constituents exceed PRGs in surface soil (i.e., residual soil) would be capped with an engineered cap to prevent direct contact, thereby eliminating the exposure pathway for this medium and to prevent erosion of contaminated soil. Capping also prevents or reduces infiltration of precipitation through impacted surface soils. The engineered cap would be placed over the Quanta property and the outdoor areas on the 115 River Road, Block 93 North, Block 93 Central, Block 92.01, and Block 94 properties, replacing existing asphalt or other material (Figure 4-7).

Within the northwest portion of the Quanta property and the southwest corner of the former Celotex property, the concentrations of arsenic greater than 1,000 mg/kg in soil have been covered with an impermeable liner and fill material as part of the construction of the roadway to the City Place development (HCAA). The impermeable liner prevents direct contact and infiltration and would remain in place. Inspection and maintenance of the existing cap area is required by AOC CERCLA-02-2003-2014 between EPA and Edgewater Enterprises, LLC. As indicated in Section 4.1.4, the existing liner and the newly capped areas would continue to be inspected periodically.

The cap for the 115 River Road, Block 93 North, Block 93 Central, Block 92.01, and Block 94 properties would be a single-layer engineered cap consisting of either a 4-inch-thick paved surface underlain by a 6-inch sub-base or a multilayer vegetative cap, depending on redevelopment. The multilayer vegetative cap would consist of the following (from visible surface to top of existing soil):

- Vegetative and protective layer
- Geotextile filter fabric
- Drainage layer of granular soil
- High-density polyethylene liner

- Protective layer

Cap design would be consistent with NJDEP (1998a) guidance for the remediation of contaminated soils. The capped area would require periodic inspection by the respective property owner to ensure that no breaches that could serve as sources to infiltration or allow direct contact with soil are present.

Fill may be imported to bring the vegetative cap on the Quanta property up to the same elevation as the adjacent properties (i.e., former Celotex and 115 River Road properties) for redevelopment purposes; however, this action is not considered a component of the alternative.

The current slab-on-grade and other building foundations on the 115 River Road, Block 93 North, Block 93 Central, Block 93 South, and former Lever Brothers properties would remain in place as engineering controls unless replaced in the future by similar or more protective surfaces. The existing surfaces of River and Gorge Roads would also remain in place. These existing surfaces would be inspected and maintained to ensure their continued effectiveness as engineering controls.

4.2.2.4 Vapor

Although vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or have been determined not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008), the basements of the 115 River Road building would be upgraded with a vapor intrusion mitigation system and sealing of the sumps and slab.

The basements of Buildings 7 and 8 are currently equipped with ventilation fans, and openings in the foundation (i.e., french drains and open sumps) have been covered. For FS cost estimating, it is assumed that this system would be upgraded to an automated subslab depressurization system. Regular and periodic maintenance would be performed. Should the system become non-operational or if specified operating parameters are not met, the system would provide notification to operation and maintenance staff and any identified conditions would be corrected. A monitoring plan would be developed, and performance monitoring would be conducted as needed to evaluate system performance.

The existing french drain system in the basements of Buildings 7 and 8 would be upgraded to allow for additional dewatering of the subsurface during high-water-table conditions to maintain an unsaturated zone where vapor can be recovered. The upgrade of the french drain system would include an increase in the pumping capacity of the system, a treatment system with particulate removal and GAC, and discharge to the Bergen County Utilities Authority.

Institutional controls (e.g., deed restrictions) and engineering controls (e.g., vapor barriers, subslab depressurization systems, or monitoring) would be established and maintained to control new construction. Institutional controls would specify that appropriate vapor intrusion mitigation system be installed in any new buildings during construction. Vapor intrusion mitigation measures would be installed and/or maintained in other occupied buildings, if necessary, as determined by indoor air sampling or other vapor intrusion evaluations.

4.2.2.5 Institutional Controls

The institutional controls for Alternative 2 include land-use, construction, and groundwater use restrictions.

Land-Use Restrictions. The purpose of institutional controls is to further reduce the potential for exposure to impacted media left in place through land use restrictions and to protect engineering controls such as capping. Land -use restrictions would apply for all areas at which COCs remain in place in exceedance of PRGs. Deed notices for each impacted property would be prepared in accordance with NJDEP Technical Requirements for Site Remediation (NJAC 7:26E). Property owners would need to concur with restriction of usage for each parcel on which institutional controls are established. As part of the land use restriction, biennial certifications would be submitted to NJDEP while the engineering and institutional controls remain in place. Institutional controls would require that appropriate engineering controls are used to ensure the continued protection of human health and the environment before, during, and after potential redevelopment.

Institutional controls would necessitate the use of construction techniques that limit impact to the cap or would require specific restoration to the functionality of the cap were it affected. Additional restrictions may be implemented to limit activities involving penetration of existing and newly installed caps and NAPL zones. Institutional controls would establish criteria for new construction and dictate that prior to construction of a building, a vapor intrusion evaluation be conducted. Buildings would be required to be designed to address potential vapor intrusion risks. Institutional controls would also require that construction workers use appropriate personal protective equipment (PPE) and that other measures be taken as necessary during redevelopment or other construction activities.

Construction Restrictions. Future site activities may require the installation of deep foundations (such as piling or drilled shafts [caissons]) for building construction due to the presence of compressive soils in the subsurface. For future construction, the specific technologies to be used for installation of piling would be dependent on the unconfined compressive strength of the soil following remedial action implementation. Various options are available, including direct driving of nondisplacement piles (H piles) if the strength is relatively low; or, for higher strengths, predrilling with rotary augers could be used for either driven piles or drilled shafts. Institutional controls would also require construction techniques that limit the potential of vertical migration of NAPL along the pile. Required techniques may include use of a cased shaft through any NAPL zone if driven piles are used, two-stage drilling and casing through NAPL zones if cast-in-place drilled shafts are used, or pressure-injected drilled shafts. H piles should not be driven through NAPL zones with cast iron shoes because the shoes, or reinforced (built-up) tips, are slightly larger than the pile cross-section and could leave a void that may create a vertical fluid pathway. Pipe piles with shoes or oversized tips should not be driven through NAPL zones, again to limit the potential for creation of a fluid pathway along the pile. These future construction restrictions would be included in a deed notice submitted to and approved by NJDEP.

Groundwater Use Restrictions. A CEA serves as an institutional control by providing notice that the constituent standards for a given aquifer classification are not or will not be met in a localized area due to natural water quality or anthropogenic influences, and that designated aquifer uses are suspended in the affected area for the term of the CEA. As part of this

alternative, NJDEP would be requested to establish a groundwater CEA in accordance with NJDEP regulations (NJAC 7:26E-8.3) to ensure that the uses of the aquifer are restricted until standards are achieved. The components of the CEA include the location of the restriction (which takes in the potential migration locations before degradation reduces constituent concentrations to below applicable cleanup criteria), the compounds detected over the applicable cleanup criteria within the restricted area, information regarding current and projected future use of the groundwater within the restricted area, and the proposed duration of the restriction. This designation would prohibit future use of the groundwater within this area and would restrict the installation of wells (other than for monitoring or remediation purposes) in the area for the duration of the CEA. The CEA would be submitted to and approved by NJDEP and placed within the New Jersey geographic information system database for the duration of the control. Preparation of a Biennial Certification Monitoring Report for the CEA would be required every 2 years until the CEA is no longer required because of a reduction in COC concentrations below PRGs.

NJAC 7:9-6.6 states that the NJDEP may designate a CEA

> …only when the Department determines that constituent standards for a given classification are not being met or will not be met in a localized area due to (1) natural quality; (2) localized effects of a discharge approved through a New Jersey Pollutant Discharge Elimination System (NJPDES) permit action; (3) pollution caused by human activity within a contaminated site as defined by the Department in the context of an applicable regulatory program (for example, Site Remediation Program Oversight Document); or (4) an alternative concentration limit (ACL) as approved by the Department pursuant to NJPDES.

According to NJDEP (1998b) CEA guidance,

> CEAs are typically of limited duration and are related to the term of a permit approval or estimated time for completion of a remediation. In some cases (e.g., sites where ground water has been contaminated by metals from historic fill or other discharges), the Department may accept a proposal for a CEA of "indeterminate" longevity. If necessary, the term of a CEA also can be renewed or extended in the context of the permit or program providing regulatory oversight….The time frame within which a CEA remains in effect can be indeterminate, but not permanent. The only exception to this is when the GWQS [groundwater quality standards] are exceeded due to natural water quality. Since the Department will not require anyone to enhance natural water quality in an aquifer, permanent CEAs can be established in such areas.

In accordance with NJAC 7:26E-8.7, the existing and newly capped areas would be visually inspected periodically by the property owner to ensure there are no breaches that could be sources of infiltration or direct contact with soil.

In addition to a CEA, this alternative would also include a TI evaluation to identify those ARARs and related cleanup standards that are technically impracticable to achieve within a timeframe that is reasonable, given site-specific conditions and technical limitations. The TI evaluation documents the assessment of those ARARs associated with constituent concentrations in groundwater and residual constituent concentrations in soil that are technically impracticable to achieve for portions of the site, given the contaminant-related factors and engineering limitations. The draft TI evaluation was prepared in accordance with the requirements specified in EPA (1993) guidance.

4.2.3 Alternative 3: NAPL and Arsenic Containment with NAPL Recovery

Alternative 3 combines free-phase NAPL recovery using directionally drilled wells under the 115 River Road building and vertical recovery wells in NZ-1, NZ-2, and NZ-5, with sitewide NAPL and groundwater containment using a barrier cutoff wall with groundwater extraction and treatment. In addition, passive NAPL recovery would be conducted at a select number of existing wells to remove NAPL mass from existing well installations screened in NZ-3 and NZ-4 where conditions may be amenable to NAPL recovery. Passive recovery efforts would be focused on a select number of wells with the intention of optimizing the benefit of the recovery efforts in terms of NAPL mass removed. This alternative includes the maintenance of existing roads and parking surfaces and soil capping. Engineering controls that would reduce the potential for vapor intrusion under future conditions are incorporated into this alternative, along with institutional controls to prevent exposures to soil or groundwater. Alternative 3 addresses principal threats identified in Section 1.7 as described below and shown in Table 4-2:

- Toxicity potential due to direct human contact with principal threat waste NAPL (NZ-1, NZ-2, NZ-5, and tar boils) is addressed by eliminating the direct contact exposure pathway through capping and institutional controls.
- Toxicity potential due to direct contact with principal threat waste in AA-1 through AA-7 is addressed by eliminating the direct contact exposure pathway through capping and institutional controls.
- Toxicity potential for ecological receptors at OU2 (principal threat risk at NZ-2 and NZ-5) is reduced through the installation of a barrier cutoff wall with groundwater extraction and treatment system and NAPL recovery to isolate the NAPL zones from the Hudson River.
- The unoccupied basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system. Other occupied buildings would be sampled periodically and vapor intrusion mitigation would be provided, if warranted.
- Mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) is reduced through the installation of a barrier cutoff wall with groundwater extraction and treatment to isolate the NAPL zones from the Hudson River and NAPL recovery.

Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Hydraulic containment of groundwater migrating to the Hudson River is achieved by the barrier cutoff wall and groundwater extraction. Restoration of the groundwater to drinking water quality is considered technically impracticable as described in Section 2.5.

A summary of the remedial actions taken in this alternative is provided in Table 4-3.

4.2.3.1 Non–Aqueous Phase Liquid and Groundwater

Physical containment of NAPL and groundwater would be achieved through the installation of a barrier cutoff wall along the boundary of OU1 and OU2 with a groundwater extraction and treatment system, as shown in Figure 4-8. The cutoff wall would be installed between the river and the existing bulkhead down to the silty-clay layer. Principal threat

free-phase NAPL would be recovered and disposed of offsite. The components of this alternative are shown in cross section in Figures 4-9 through 4-13.

Recovery Wells. Free-phase NAPL could be recovered, to the extent practicable, from recovery wells, as shown in Figure 4-8. Recovery wells could be either the conventional vertical type or the directionally drilled type. A vertical well would consist of a borehole with a stainless steel screen extending through the NAPL zones constructed with a sump at the bottom for NAPL collection. The base of the vertical well would be grouted to act as a sump for product accumulation and prevent the migration of product. A directionally drilled recovery well would be a borehole installed to intercept the base of the NAPL zone and sloped to a single sump for product accumulation.

For purposes of this FS, the NAPL recovery system is assumed to be 10 vertical recovery wells installed in OU1 at locations where free-phase NAPL has been identified. Each standard recovery well is assumed to consist of 24-inch-diameter borehole with an 8-inch stainless steel screen extending through the NAPL zone and a 3-ft sump. Three wells in NZ-1 would be installed to 17 ft bgs, one well in NZ-5 to 25 ft bgs, and the six wells in NZ-2 to 25 ft bgs. Three directionally drilled passive recovery wells with sumps would be installed under 115 River Road. In addition, it is assumed that passive recovery efforts would be performed in existing monitoring wells screened in NZ-3 and NZ-4.

Investigation of the building foundation and pile placement would be performed during remedial design; if directional drilling is not feasible, then vertical wells may be considered; however, for the purposes of this FS, directionally drilled wells have been assumed. The exact number of recovery wells and their configuration would be finalized during the design phase of the work, should this alternative be selected.

NAPL recovery wells would be monitored periodically to measure the accumulated thickness of free-phase NAPL. If measurable amounts of NAPL are present, NAPL would be extracted from the recovery wells and sumps using product-only pumps or bailing, depending on NAPL viscosity. If the viscosity of the NAPL collected in the sump is too high for the automated pumps, the NAPL may be manually bailed or removed by a vacuum truck. It is assumed for the FS that an automated pumping system would be used to extract NAPL from the sumps. The pumps (top-head-drive, positive-displacement piston pumps similar to those available from Blackhawk Technology Company, Glen Ellyn, Ill.) sense the level of NAPL collected in the sump. When a sufficient volume of NAPL has accumulated, the NAPL is pumped to the surface for collection.

Offsite Treatment and Disposal. NAPL from the recovery wells would be collected in 55-gallon drums or a storage tank within a centralized area with secondary containment adequate to contain a spill from failure of the tanks/drums. The pumps would be equipped with control panels that would be remotely accessible and have alarm systems tied to an autodialer that would notify the system operator of high product levels in the tanks or any system problems.

During a NAPL recovery test performed in July and August 2007, NAPL samples were collected from below the water table from five monitoring wells (MW-102A, MW-105, MW-116B, MW-107, and MW-112B). The chemical analysis results were evaluated to determine if the NAPL exhibited any of the hazardous characteristics identified in 40 CFR

261 Subpart C. Based on the comparison of the chemical analysis results and the maximum concentration of constituents for the toxicity characteristic (Table 1 of 40 CFR 261 Subpart C), it is likely that the NAPL collected would be considered a characteristic hazardous waste; therefore, the storage area on the Quanta property would need to comply with federal, state, and local RCRA requirements for hazardous waste. Storage location would be coordinated with future development options.

Offsite disposal options would be finalized during remedial design, and may include oil recycling or stabilization. For cost-estimating purposes, offsite disposal of NAPL is assumed to be via oil recycling.

4.2.3.2 Hydraulic Containment

Groundwater would be contained through installation of a barrier cutoff wall and groundwater extraction as depicted in Figure 4-8. The barrier cutoff wall would be keyed into the lower-permeability silty clay layer or bedrock in areas where the silty clay is not present. Groundwater would be extracted via a network of extraction wells distributed throughout the areas and installed to the confining layer. All wells would be equipped with an electric submersible pump and piped to one centralized ex situ groundwater treatment system.

For preliminary costing purposes, it is assumed that the treatment system would be located on the south side of the Quanta property near River Road. It is assumed that the treatment system would be design to treat a maximum flow of 50 gallons per minute (gpm). The maximum design flow rate is based on an estimated groundwater flux to the river of 25 gpm and an additional 25-gpm capacity to account for periods of higher flow rates resulting from treatment of process equipment backwash or increased influent flow during large rain events. It is assumed that the groundwater treatment system would consist of the following components prior to permitted effluent discharge to the Hudson River:

- Extraction pumps to transfer groundwater to the treatment system
- Equalization tanks and mixers to provide more uniform influent characteristics
- Oil–water separator to remove oil from the influent stream
- Addition of chemicals (coagulants and flocculants) to facilitate solids removal in the wastewater, primarily removal inorganics (iron, manganese, etc.) that would form a precipitate in downstream process equipment and limit the effectiveness of the treatment
- Inclined plate clarifier and bag filters for the removal and separation of the solids from the wastewater
- Rotary drum vacuum filter to dewatering the process residual from the clarifier prior to offsite disposal.
- GAC to remove organic constituents in the wastewater (benzene, PAHs, etc).
- Ion exchange resin to remove arsenic from the wastewater

Arsenic removal will occur during the chemical treatment and solid removal; therefore, this is assumed to be a polishing step in the process

Modeling of the groundwater–river interaction would be required during the remedial design to determine the optimal groundwater extraction rates required and the final configuration of the extraction wells and cutoff wall. The number of wells could be reduced or increased to achieve the same effective capture depending on results of aquifer testing to be performed prior to or as part of the remedial design.

Bench-scale testing and pilot scale testing would be performed as necessary to determine specific design information needed to complete the treatment system design. The bench-scale tests would be used to determine the chemistry that will be used to effectively remove solids, to determine the technology and its effectiveness for dewatering the process residuals, and to determine the utilization rates of the carbon and resin. The pilot tests would focus on collection of specific design data for equipment operations and evaluating the potential performance of the carbon and resin following implementation of the clarifier pretreatment.

The extraction and treatment system would require long-term operation and maintenance including but not limited to operating labor, materials for repairs, chemicals, consumables, process monitoring and laboratory, hazardous waste disposal, utilities, and reporting. The FS cost estimates assumed a full-time operator would be onsite to perform operation, maintenance, and sampling activities; however, long-term operation and maintenance costs are highly dependent on the results of the treatability testing and final selected treatment process. Detailed assumptions are provided in the cost estimates (Appendix C).

4.2.3.3 Natural Attenuation and Groundwater Monitoring

Several primary lines of evidence, including the fate and transport evaluations presented in the final RI (CH2M HILL, 2008) and final SRI (CH2M HILL, 2010a), suggest that the attenuation of both the organic constituents and arsenic is occurring within and downgradient of OU1 and that the contaminant plume is not expanding, with the exception of arsenic at the southeastern corner of the former Celotex property (ASA-3). Natural attenuation for the alternative would be similar to the natural attenuation described for Alternative 2.

As part of this alternative, monitoring of groundwater would be completed to verify that (1) natural attenuation is occurring, (2) the footprint of site-related groundwater impacts is not increasing, and (3) the barrier cutoff wall with groundwater extraction and treatment system is effectively reducing COC concentrations to levels that are considered protective of the Hudson River.

The postremediation monitoring network (number of wells, sampling locations, constituent analysis list) would be dependent on the final design for the site and complete site remedial approach. The need for additional wells would be considered during the remedial design. For cost estimating, it is assumed that 40 monitoring wells would be sampled quarterly for the first year and annually thereafter for VOCs, SVOCs, arsenic, and parameters necessary for evaluating natural attenuation. After the remedy has been implemented and groundwater concentrations are stable, the monitoring network and sampling frequency would be reevaluated.

4.2.3.4 Arsenic

Physical containment of groundwater flowing through the HCAA would be achieved through the installation of a downgradient barrier cutoff wall and groundwater extraction as depicted in Figure 4-8. The barrier cutoff wall would be keyed into the lower-permeability silty clay layer or bedrock in areas where the silty clay is not present. Groundwater would be extracted via a network of extraction wells to manage groundwater flow.

For preliminary costing purposes, the extracted groundwater is assumed to be treated with the same treatment system treating groundwater extracted upgradient of the barrier cutoff wall at the shoreline (Section 4.2.3.2).

Aquifer testing and modeling of groundwater flow during the remedial design phase would be used to determine the optimal groundwater extraction rates required and the final configuration of the extraction wells and cutoff wall.

4.2.3.5 Soil and Residual Soil Capping

Areas where site-related constituents exceed PRGs in surface soil would be capped with an engineered cap to prevent direct contact and to minimize erosion by controlling surface water runoff. The cap would be placed over the Quanta property and the remaining remedial areas on the 115 River Road, Block 93 North, Block 93 Central, Block 92.01, and Block 94 properties, replacing existing asphalt or other material (Figure 4-7). Caps are assumed to be composed of the materials described in Section 4.2.2.3 for Alternative 2.

4.2.3.6 Vapor

Although vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or do not pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008), the basements of the 115 River Road building would be equipped with a vapor intrusion mitigation, as described in Section 4.2.2.4 for Alternative 2.

4.2.3.7 Institutional Controls

The institutional controls for Alternative 3 include land-use restrictions, liner inspections, and groundwater use restrictions described in Section 4.2.2.5 for Alternative 2.

4.2.4 Alternative 4a: NAPL and Arsenic In Situ Solidification/Stabilization

The primary component of Alternative 4a is in situ solidification/stabilization of principal threat waste NAPL and arsenic. In situ passive treatment of dissolved COCs in groundwater discharging to the Hudson River would be achieved by means of a subaqueous reactive barrier (SRB) placed in OU2. Principal threat arsenic and the HCAA would be addressed with solidification/stabilization. In addition, passive NAPL recovery would be conducted at a select number of existing wells to remove NAPL mass from existing well installations screened in NZ-3 and NZ-4 where conditions may be amenable to NAPL recovery. Passive recovery efforts would be focused on a select number of wells with the intention of removing NAPL mass from existing well installations screened in deep NAPL zones where conditions are amenable to NAPL recovery. Passive recovery efforts will be focused on a select number of wells with the intention of optimizing the benefit of the recovery efforts in terms of NAPL mass removed. This alternative includes the maintenance of existing roads

and parking surfaces and capping. Engineering controls that would reduce the potential for vapor intrusion under future conditions are incorporated into this alternative, along with institutional controls to prevent exposures to soil or groundwater.

Alternative 4a addresses principal threats identified in Section 1.7 as described below and shown in Table 4-2:

- Toxicity potential due to direct contact with NAPL principal threat waste at NZ-1, NZ-2, and NZ-5 and from tar boils is mitigated through the sequestration of COCs within a solidified/stabilized mass.
- Toxicity potential due to direct contact with arsenic principal threat waste in AA-1 through AA-7 is addressed by sequestration of COCs within a solidified/stabilized mass.
- The unoccupied basements of the 115 River Road would be equipped with a vapor intrusion mitigation system. Other occupied buildings would be sampled periodically, and vapor intrusion mitigation would be provided, if warranted.
- Mobility potential for free-phase NAPL (principal threat waste at NZ-2 and NZ-5) and toxicity potential for ecological receptors at OU2 is reduced through solidification/stabilization, which restricts leaching and migration.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of an SRB. The extent and placement of the SRB would be determined following modeling of the groundwater flow into OU2 following stabilization of the monolith. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5.

A summary of the remedial actions taken in this alternative is provided in Table 4-3.

4.2.4.1 Non–Aqueous Phase Liquid

Principal threat NAPL (present at NZ-1, NZ-2, and NZ-5 and from tar boils) would be solidified/stabilized in situ. Figure 4-14 depicts the NAPL areas to be treated with solidification/stabilization as part of this alternative. In situ solidification/stabilization reduces the mobility of principal threat waste. This method sequesters COCs to eliminate the potential for NAPL mobility and reduce leaching to groundwater. Figures 4-15 through 4-19 depict in cross-section view the NAPL mitigation measures associated with this alternative. Soil underneath the 115 River Road building would not be stabilized because the exposure pathway can be addressed via other means, such as engineering controls.

Prior to implementation of in situ mixing, the solidification/stabilization area would be cleared of vegetation and excavated for surface and subsurface debris removal (including large boulders, tank pads, conduits, and concrete), and these materials would be disposed of offsite. It is assumed that the depth of debris removal would primarily be to 4 ft, with some deeper debris removed as necessary. Deeper items of this type, as well as former piping and conduits that may be encountered during mixing, would need to be excavated, as they would interfere with the mixing process. Based on field experience at this site and preliminary geophysical evaluation, several subsurface structures (such as concrete slabs

and pads, buried metal, and buried wooden structures) would also have to be excavated prior to solidification/stabilization implementation. The clean fill material present on top of NZ-5 does not need to be stabilized and may be temporarily removed and stockpiled prior to remediation and then replaced after completion. For cost-estimating purposes, cleared material to be disposed of offsite is assumed to be hazardous.

A temporary barrier of sheet piles would be installed along the shoreline to mitigate NAPL migration during implementation and to act as a turbidity barrier. The temporary barrier would not be designed for long-term use. The portions of the barrier adjacent to the existing bulkhead would be removed after construction activities are completed. The temporary barrier would not be required following solidification/stabilization as the monolith would extend to the silty clay later and would be a barrier to fluid migration.

A stability analysis would be needed to determine the measures that would need to be taken and the distance required to be maintained between the treatment zone and the existing buildings (i.e., 115 River Road) or utilities to ensure that the integrity of structures (i.e., buildings, utilities, and roads), is not compromised during implementation of solidification/stabilization. The solidification/stabilization would be performed as close to the buildings as technically feasible. Jet grouting could also be employed to stabilize the area close to the structure where the augers would not be appropriate.

Solidification/stabilization would be implemented from the shoreline moving inland, so that equipment remains on unsolidified material. The material directly behind the bulkhead and along the shoreline would be stabilized to create a vertical barrier to prevent potential NAPL migration from NZ-2 and NZ-5 to the Hudson River. This cutoff wall is estimated to be 6 to 8 ft thick and extend beyond the maximum extent of the NAPL present, as shown on Figure 4-16. Following the deep stabilization to create the cutoff wall of solidified material, the remaining area of NZ-2 would be stabilized.

Treatment or removal of deeper NAPL was evaluated to determine if smaller target areas could be included in the remedy to provide mass reduction in a cost effective manner. Identification of the target area considered for treatment was based on identifying the following:

- Those areas where NZ-1 and NZ-3 overlap on the Quanta property (The Quanta property provides relatively unencumbered access to both NZ-1 and NZ-3, as opposed to areas further south where buildings and utilities hinder access.)
- Those points where multiple lines of evidence have defined the presence of both NZ-1 and NZ-3
- Where these lines of evidence indicate those specific points where the base of NZ-1 and the top of NZ-3 are separated by approximately 5 ft or less

The area of NZ-3 treatment, as depicted in Figure 4-14, was determined as an estimate of the area on Quanta property that meets the above criteria. The representation shown is conceptual and further refinement of the area could be considered during the design phase of the project. The polygon was drawn with simple straight lines (where not coinciding with an existing NZ boundary or Quanta property line) with the primary goal of incorporating those points meeting the criteria described above. This approach targets both shallow and

deeper NAPL (approximately 0–23 ft bgs) in an area of NZ-1 and NZ-3 where NAPL is relatively contiguous within the vertical column of NZ-1/NZ-3. As such, addressing this area provides the greatest benefit for addressing NAPL mass.

In addition to the treatment of this portion of NZ-3, deep passive NAPL recovery would be conducted at a select number of existing wells (MW-103, MW-107, and MW-123) to remove NAPL mass from existing well installations screened in NZ-3 and NZ-4 where conditions may be amenable to NAPL recovery.

Soils underneath the 115 River Road building would not be stabilized; however, the potential migration pathway under the building to the river would be addressed via installation of a barrier wall to prevent potential NAPL migration from under the building as shown on Figure 4-16. The construction will be similar as described in Section 4.2.2.1 for Alternative 2, except the barrier for Alternative 4a would extend to 25 ft below grade.

As part of the predesign tasks and prior to implementation of the soil mixing, bench-scale testing would be required to:

- Develop and optimize a reagent formulation (reagent(s) and concentrations) that would achieve the cleanup goals, including evaluation of "green cements" such as slag and fly ash
- Estimate the amount of expansion that would occur (i.e., increase in volume from added material and from swelling)
- Evaluate physical properties of the soil following solidification/stabilization, and determine improvement in physical properties (i.e., reduced permeability, increased strength, etc.)
- Evaluate potential impacts that solidification/stabilization and the selected reagent(s) could have on adjacent structures

The scope of work for the treatability testing including performance criteria and analytical methodology would be proposed in the treatability study work plan and provided to EPA for review and approval. Based on a preliminary evaluation, the anticipated the following performance criteria would be used; however, alternative methods may be proposed in the work plan:

- A minimum unconfined compressive strength of 40 psi measured by ASTM standard D1633
- A maximum permeability of 1×10^{-6} cm/sec measured by ASTM standard D5084

The treatability testing would establish a correlation between proposed performance criteria (unconfined compressive strength and permeability), and the potential leachability of site-specific chemical constituents to groundwater measure with ANSI 16.1. Although leachability is not a specific performance criteria, the correlation data would be used to evaluate the potential reduction in constituents that could be achieved through stabilization. The evaluation would consider the fact that the surface area available for the potential leaching of COCs is significantly reduced by the solidification of the waste material. The low permeability of the monolith would create a barrier to groundwater flow and diverting it

around or under the monolith. The groundwater would be unable to contact the source; therefore, the overall mass flux of COCs would be significantly reduced.

The objective of the treatability testing is to identify a mix design for in situ solidification/stabilization that would meet the performance criteria identified above throughout the site. Potential difficulties associated with stabilization of intervals of highest NAPL saturation would be reduced through a combination of appropriate reagent mix selection and proper mixing methodology. The in situ mixing would homogenize the soil within an entire soil column, which includes soil layers containing less NAPL and soil layers that have higher NAPL saturations. The characteristic of the mixed soil column would be more uniform and have a lower overall NAPL saturation.

In the event that the treatability testing indicated that certain soils cannot be successfully solidified/stabilized and as a result, that performance criteria is or may not be met, because of the presence of unusually high organic content, or for other possible reasons, then alternative technologies, including but not limited to focused excavation or NAPL recovery, would be implemented to reduce the overall NAPL saturation prior to the implementation of solidification/stabilization activities. Again, the expectation is that in situ solidification/stabilization would successfully meet performance criteria throughout the targeted areas within OU1 without the need for alternative technologies; therefore, the preliminary cost estimates does not include this line item.

It was determined that the available means and methods for solidification/stabilization can achieve the remedial objective of treating source material while also including appropriate health and safety conditions such that ongoing business activities would be able to continue to operate at the 115 River Road during remedy construction. A construction implementation plan was developed to describe the general processes and procedures for implementing future construction activities associated with the remediation of the site (Appendix C).

Solidification/stabilization could be performed through multiple means and methods, including but limited to slurry trench, small-diameter augers, large-diameter augers, jet grouting, or limited excavation with ex situ solidification/stabilization. Assumptions for cost estimates purposes are included in Appendix E; however, final determination of means and methods would be completed during remedial design.

Large-diameter (6 ft or greater) augers (or similar construction equipment) could be advanced to target depths, and upon target depths being reached, reagents would be injected through the augers to treat the material between the ground surface and the target depth. The augers would be advanced and retracted through the treatment area several times in an overlapping pattern to provide for complete mixing. A similar technique could be used with jet grouting where boulders, utilities, or building foundations limit the use of auger mixing. Auger diameter would depend on depth of drilling, consistency and hardness of soil, and soil porosity. Vapor and noise management controls would be put in place to protect workers and the community during construction activities.

For the purpose of FS cost estimating, it was assumed that large-diameter (6 ft or greater) augers would be advanced to the following target depths below ground surface, based on NAPL zone characterization and principal threat criteria: NZ-1 to 11 ft, NZ-2 to 25 ft within

6 to 8 ft of the bulkhead and then to 10 ft bgs further inland, NZ-5 to 25 ft within 6 to 8 ft of the bulkhead, and for the portion of NZ-3 to 23 ft.

Principal-threat NAPL on the Block 93 property could be solidified/stabilized either in situ or ex situ. For the purpose of FS cost estimating, it is assumed that the limited NZ-1 material on Block 93 would be excavated to 10 ft bgs and stabilized ex situ. The stabilized material would be consolidated with principal-threat NAPL soils on the Quanta property and capped as described in Section 4.2.2.3.

For cost-estimating purposes, it was assumed that 15 percent cement by weight would be used to solidify/stabilize the NAPL soils in place and the treated soils would expand by 25 percent. During implementation of the full-scale remedial action, testing would be performed for the purpose of mix optimization, quality assurance, and verification that the remedy is effective. Verification sampling details would be developed during remedial design and may include tests of strength, permeability, and leachability.

The solidification/stabilization areas on the former Celotex property (NZ-5), Block 93, the former Lever Brothers property, and 115 River Road (portion of NZ-1) would be graded and restored to their previous conditions (parking lots). On the Quanta property, stabilized areas would be capped with either fill material or asphalt.

As with the placement of fill on the site, the addition of the mass of stabilizing agent(s) (e.g., Portland cement, fly ash, etc.) would increase the vertical load on the underlying materials and have the potential to displace fluids in subsurface materials. However, the increased load is expected to be nominal, on the order of 100 to 200 psi for a 10- to 20-ft area of soil with an addition of 10 to 15 percent (wt/wt) of portland cement. Engineering controls such as sheet piles or oil booms may be required to address the potential for NAPL migration during implementation.

Settlement caused by the compression of the soils beneath the monolith are expected to be more uniform than those that would result from placement of surface fill because of the stiffness imparted to the monolith by the stabilizing agent(s). This stiffness would distribute the load from the monolith more uniformly than if a more-flexible load (such as soil fill) were placed on the site. The monolith would act to some extent like a raft or mat foundation beneath a structure, distributing the load to stiffer (less compressible) locations in the subsurface and transferring load around softer (more compressible) locations. Thus, the overall settlement resulting from the roughly 100- to 200-pounds-per-square-foot (psf) load added because of stabilization is expected to be less than the settlement that would result from a 100- to 200-psf flexible load, although the difference cannot be quantified. The end result of reduced overall settlement would be a smaller reduction on void volume in the compressible soils, resulting in a reduced volume of fluid displacement required to reach equilibrium after soil solidification/stabilization.

Relocation of occupants in nearby buildings during in situ solidification/stabilization is not anticipated to be required. A construction implementation plan (Appendix C) was developed to describe the general processes and procedures for implementation of future construction activities associated with the remediation of the site, with particular emphasis on in situ solidification/stabilization in and around 115 River Road. The proposed

procedures and processes described would allow for the safe and efficient implementation while mitigating impacts to the community and environment.

4.2.4.2 Arsenic

Principal threat arsenic areas (AA-1 through AA-7) and HCAA would be solidified/stabilized in situ. Figure 4-14 depicts the arsenic areas to be treated with solidification/stabilization as part of this alternative. The objective of in situ solidification/stabilization in these areas is to sequester COCs reducing leaching to groundwater. Figures 4-15 through 4-19 depict in cross-section view the arsenic mitigation measures associated with this alternative.

Due to the presence of an access ramp and parking lots located within the footprint of the HCAA, reagents considered for the treatment of the arsenic under the existing liner were those that maintain or increased the anoxic conditions to immobilize arsenic. The reagents would be injected using either vertical or horizontal wells placed on a grid throughout the target area. The reagent could also be injected at varying depth intervals based on the location of arsenic in the subsurface. Preliminary treatability testing was performed on soils samples collected south of the HCAA. Multiple reagents were evaluated to determine their effectiveness in stabilizing the arsenic in the soil samples, including:

- Portland cement
- Aluminum sulfate ($Al_2(SO_4)_3$)
- Ferrous sulfide—FeS (formed by mixture of $FeSO_4$ and NaHS)
- Ferrous sulfide and portland cement

Treatability results indicated that ferrous sulfide caused the arsenic to precipitate from the water as arsenic-sulfide minerals effectively immobilizing the arsenic. Arsenic-sulfide minerals are insoluble in reducing conditions; therefore, reducing the leaching of arsenic and chemically stabilizing it in place. Additional reagents or physical elimination of permeability could be used to maintain the reducing conditions required. The addition of cement, which may be used to treat coal tar at the site, did not interfere with the ferrous sulfide treatment.

Additional treatability testing is needed to further evaluate ways of preventing oxidation of the soil, limiting oxygenated groundwater flow through the site and other reagents that could effectively stabilize arsenic.

Principal-threat-arsenic-impacted soils on the Block 93 property (AA-2, AA-4, and AA-5) could be either in situ or ex situ solidified/stabilized. For the FS cost estimating, it is assumed that these areas would be excavated and stabilized ex situ. The stabilized material would be consolidated with principal-threat-arsenic-impacted soils on the Quanta property and capped as described in Section 4.2.2.3.

4.2.4.3 HCAA Process Option

If treatability test were to indicate that the in situ stabilization of arsenic is not feasible for the HCAA (e.g., uncertainty of long-term permanence or reagent delivery constraints), it is assumed that hydraulic containment of the groundwater would be implemented as a contingency process option. Hydraulic containment would be implemented as described previously under Alternative 3, Section 4.2.3.4. This HCAA process option is depicted in the

inset of Figure 4-14. In situ solidification/stabilization would be used to address the arsenic areas downgradient of the barrier cutoff wall. Although the final selection of the remedial approach for the HCAA would be contingent on the results of the treatability testing, the more-conservative cost assumptions were used to develop the detailed estimate for Alternative 4a. The Alternative 4a cost estimate presented in Appendix E assumes containment of the HCAA with solidification/stabilization of the Arsenic south of the cutoff wall on the Quanta property and on Block 93.

4.2.4.4 Groundwater

Subaqueous Reactive Barrier. After implementation of the remedial technologies described above, an SRB would be installed within OU2 to address groundwater from OU1 that discharges to the Hudson River, or OU2. The proposed use of the SRB for groundwater is to address uncertainty related to the degree of attenuation of OU1 dissolved-phase constituents and residual NAPL prior to their being discharged to OU2. The installation of the SRB would occur during remediation of OU2 sediments.

The SRB would consist of a permeable subaqueous reactive mat to treat COCs (e.g., benzene, naphthalene, and arsenic, as warranted, pending design phase assessments) as the pore water discharges by advection through the sediments to the surface water of the river. The SRB would be designed to mitigate various sources of constituent loading and NAPL sheens originating from OU1 as well as sources within the OU2 river sediments. SRBs can include geotextiles, liners, and other permeable elements in multiple layers that include the addition of material to attenuate the flux of constituents (e.g., granular activated carbon or organoclay) between the permeable elements (the reactive core). Reactive core materials would be encapsulated between carrier textiles that adhere together to provide integrity. A groundwater model incorporating site-specific conditions would be developed to determine groundwater flow and rate of groundwater flux to OU2. A bench scale testing would be required to predict the expected effectiveness and operations and maintenance (O&M) requirements of the SRB. Bench-scale testing would be performed to assess the sorptive capacity of the core material to address potential NAPL sheens, dissolved phase organics (e.g., naphthalene) and dissolved phase arsenic. Reactive barrier treatment may be reversible if adsorption sites are completely used up, allowing desorption to occur. Therefore, monitoring of the SRB would be conducted to predict when replacement may be required.

A bathymetric survey would be conducted as a predesign activity and after placement to establish a baseline elevation for the area within which the SRB is located. Additional surveys would be performed 6 months and 18 months after placement to identify bathymetric changes in the armoring thickness. Pore water data or surface water samples would be collected to monitor mat effectiveness. Coring and analysis of the SRB would be conducted periodically to determine the vertical profiles of COC concentrations in the SRB. This information would be used to determine when the SRB needs to be replaced.

The final design of the SRB including the size and material would be highly dependent on the upwelling zones and the risk associated with the pore water concentrations. The potential risks associated with the constituents found in the pore water are being assessed as part of the OU2 BERA. The SRB would be secured in place by a layer of sand or sand-gravel mix along with the provision of an armor layer (i.e., rocks) to protect the SRB from hydraulic

scour conditions due to storm surge flows, if deemed necessary based on the results of the OU2 sediment stability study.

The OU2 BERA work plan (CH2M HILL, 2008b) included a description of the mudflat habitat and details related to the Hudson River fish communities in this portion of the river. The habitat value is based on a comparison of the site to reference area conditions. Benthic invertebrate sampling and toxicity testing has been completed. Results of this sampling and testing and a detailed description of the habitat will be included in the OU2 BERA and RI reports. An assessment of habitat value will be made to determine if any mitigation measures are required during SRB installation.

For cost-estimating purposes, it is assumed the SRB would consist of a permeable subaqueous reactive mat placed over approximately 170,000 ft^2 of sediments in OU2 to reduce PAH and arsenic concentrations in groundwater as the pore water discharges by advection through the sediments to the surface water. It is anticipated that a temporary Portadam cofferdam, capable of a 10-ft-high backwater, would be installed to permit uninterrupted access from tidal cycles to the mud flat material for excavation and removal of the proposed first 24 inches of nearsurface materials (approximately 11,000 yd^3 of sediment). Sediment would be excavated via long-reach (85 ft) hydraulic excavators and transported to an OU1 laydown area for initial slack-drying/draining.

The removal of sediments from OU2 or compaction of the sediments may be necessary for the placement of the SBR; however, additional sediment removal or remedial technologies may be selected for the remedial action to address OU2. Therefore, for FS cost estimating, it is assumed that the removal of 2 ft of sediment will be associated with OU1; the cost to dewater and dispose of the sediments will be considered a part of the OU2 remedial costs.

It is anticipated that the SRB would consist of a combination of organoclay, apatite, and activated carbon. Reactive core materials would be encapsulated between carrier textiles that adhere together to provide integrity. The SRB thickness is typically ½ to ¾ inch and is prepared in rolls 15 ft wide and 150 ft long. Layout/installation of the SRB typically requires a 20 percent width overlap between contiguous sections. An 18-inch-thick layer of sand or sand-and-gravel mix mimicking the current sub-bottom conditions of the Hudson River within the OU2 area would be placed over the SRB to limit the ability of the SRB to move, and a 6-inch-thick armor rock layer would be placed to protect the SRB from hydraulic scour conditions due to storm surge flows within the Hudson River.

Design-phase testing would be conducted to determine the relative contribution of drivers of O&M for the SRB, the specific O&M requirements that are related to these drivers, and to predict the expected effectiveness of the SRB. For example, bench-scale testing would be performed to assess the sorptive capacity of the cap material, which would act to decrease constituent flux through the cap. Pending the outcome of design-phase studies, the SRB may be installed as a single sheet, as discrete cells, or other configuration that is best suited to meet the remedial objectives. Monitoring during the early stages of O&M would be used to determine long-term O&M requirements, including the exact location and frequency of replacement, if necessary. It is assumed that certain portions of the SRB may need to be replaced periodically. The SRB would be monitored to predict when potential replacement of particular portions may be required. For FS cost estimating, it was assumed that 30% of the SRB would be replaced every 10 years.

Groundwater Modeling. A groundwater model (Appendix D) was prepared to determine whether groundwater ponding/flooding would occur on site or whether stabilized monolith might adversely impacting groundwater flow direction, such as the potential to channel flow under the 115 RR Building. The groundwater model concluded the following:

- Formation of the monolith is not predicted to cause groundwater elevations to rise. Model predictions shows that groundwater will easily move around and beneath the stabilized material.
- The results of a sensitivity analysis on model input parameters indicate that formation of the monolith will have little adverse impact on groundwater flow direction or elevations.

The groundwater model results confirm that groundwater flow direction and groundwater elevations are not anticipated to significantly change following remedy implementation. Additionally, groundwater gradients at the site are quite flat resulting in small groundwater velocities and are expected to remain small following remedy implementation, including shallow groundwater that would flow between stabilized areas. There is expected to be significant space between the solidified material and the confining layer for groundwater to flow unimpeded.

Natural Attenuation and Groundwater Monitoring. Several primary lines of evidence, including the fate and transport evaluations presented in the final RI (CH2M HILL, 2008) and final SRI (CH2M HILL, 2010), suggest that the attenuation of both the organic constituents and arsenic is occurring within and downgradient of OU1 and that the contaminant plume is not expanding, with the exception of arsenic at the southeastern corner of the former Celotex property (ASA-3). As part of this alternative, monitoring of groundwater would be completed to verify that natural attenuation is occurring and that the footprint of site-related groundwater impacts is not increasing. The groundwater monitoring for Alternative 4 includes postremediation sampling as described in Section 4.2.2.2.

4.2.4.5 Soil and Residual Soil Capping

Areas would be capped where site-related constituents exceed PRGs in surface soil with an asphalt or vegetated engineered cap to prevent direct contact and to minimize erosion by controlling surface water runoff. The cap would be placed over the Quanta property and the remaining remedial areas on the 115 River Road, Block 93 North, Block 93 Central, Block 92.01, and Block 94, replacing existing asphalt or other material (Figure 4-7). Caps are assumed to be composed of materials described in Section 4.2.2.3 for Alternative 2.

4.2.4.6 Vapor

Although vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or do not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008), the basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system as described in Section 4.2.2.4 prior to any additional intrusive activities. Engineering controls will be monitored during and after remedial implementation and modified if necessary.

4.2.4.7 Institutional Controls

The institutional controls for Alternative 4 include land-use restrictions, construction restrictions, liner inspections groundwater use restrictions described in Section 4.2.2.5. In addition, engineering controls would be established to restrict dredging or other activities that could compromise the integrity of the SRB. The placement of the armoring layer would act as an indicator for future dredging operations of the SRB depth and location.

4.2.5 Alternative 4b: NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of 115 River Road Buildings

Alternative 4b (Figure 4-20) includes the same remedial components as Alternative 4a with the exception of the approach applied to the NAPL present under 115 River Road. Alternative 4b would include the temporary relocation of the 115 River Road tenants prior to the start of construction activities. The existing brick building and the parking building (Building 12), including foundations, on the 115 River Road property would be demolished. Following demolition, the NAPL zones underneath the 115 River Road buildings would be accessible for in situ solidification/stabilization similar to the rest of the site. The estimated average target excavation depths are described in Section 1.6.2. Solidification/stabilization under the former building footprints would be conducted as described in Section 4.2.4.1. The 115 River Road buildings would be reconstructed following completion of remedial activities and tenants relocated back to the new buildings.

4.2.6 Alternative 5a: NAPL In Situ Chemical Oxidation, with Arsenic Stabilization

Alternative 5a combines shallow excavation, NAPL recovery and ISCO of the principal threat NAPL areas. Groundwater is contained and then treated through barrier cutoff wall and groundwater extraction and treatment system before discharging to OU2. Principal threat arsenic and the HCAA would be addressed with solidification/stabilization. This alternative would also include capping residual soils and solidified arsenic and maintaining the existing roads and parking surfaces. Institutional controls and vapor mitigation are incorporated into this alternative.

Alternative 5a addresses principal threats identified in Section 1.7 and described below and in Table 4-2:

- Toxicity potential due to direct human contact with principal threat waste at NZ-1, NZ-2, and NZ-5 and from tar boils would be mitigated through NAPL recovery, shallow (0 to 4 ft bgs) excavation, and in situ chemical oxidation.
- Toxicity potential due to direct contact with arsenic principal threat waste (AA-1 through AA-7) is addressed by sequestration of COCs within a solidified/stabilized mass.
- The unoccupied basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system. Other occupied buildings would be sampled periodically and vapor intrusion mitigation would be provided, if warranted.
- Toxicity potential for ecological receptors at OU2 and mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) is reduced through NAPL recovery and the installation of a barrier cutoff wall to protect the Hudson River.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of a barrier cutoff wall with a groundwater extraction and treatment system. Human exposure to contaminated soil and groundwater is restricted through capping and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5.

A summary of the remedial actions taken in this alternative is provided in Table 4-3.

4.2.6.1 Non–Aqueous Phase Liquid

Shallow NAPL present in NZ-1, NZ-2, and the tar boils would be excavated to a depth of 4 ft bgs. Free-phase NAPL would be recovered, to the extent practicable, from recovery wells. The approximate location of excavations, NAPL recovery wells, and NAPL recovery trenches are depicted in Figure 4-21. Figures 4-22 through 4-26 depict in cross-section view the NAPL mitigation measures associated with this alternative.

Free-Phase NAPL Recovery. Free-phase NAPL could be recovered, to the extent practicable, from recovery wells as shown in Figure 4-21. For purposes of this FS, the NAPL recovery system is assumed to be 10 vertical recovery wells installed in OU1 at locations where free-phase NAPL has been identified. NAPL recovery wells and offsite disposal would be implemented as described in Section 4.2.3.1. The exact number of recovery wells and their configuration would be finalized during the design phase of the work, should this alternative be selected. In addition, it is assumed that passive recovery efforts would be performed in three existing monitoring wells screened in NZ-3 and NZ-4 (MW-103, MW-107, and MW-123), as described in Section 4.2.4.1.

Limited Excavation of Shallow NAPL. Soil from locations at which tar boils have been observed and areas of soft, plastic, or hard tars in the vadose zone on the Quanta property would be excavated to a maximum depth of 4 ft bgs. In addition, the soils in NZ-1 and NZ-2, which have been shown to contain shallow NAPL, would be excavated to a depth of 4 ft bgs. Soil underneath the 115 River Road buildings would not be excavated because the exposure pathway can be addressed via institutional and engineering controls. Figure 4-21 depicts the areas to be excavated as part of this alternative.

The typical depth to groundwater onsite is approximately 4 ft bgs, and due to the limited ability to effectively deliver oxidants in the unsaturated zone, these soils would be addressed through excavation. Potential risk associated with soils below 4 ft would be managed through ISCO. Soil underneath the 115 River Road buildings would not be excavated because and potential exposure pathways would be addressed by engineering and institutional controls.

Details of the excavation extents, required excavation stabilization measures, exact volumes of impacted soil to be removed, and any verification sampling would be based on predesign investigation and remedial design. Specific stormwater diversion, soil erosion controls, and air-monitoring requirements would also be assessed during remedial design. The excavation areas would be backfilled with certified clean fill material.

Emissions control techniques such as using dust suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects

on workers and the community from volatile emissions from soil containing NAPL. Air monitoring would be required during excavation activities.

It is anticipated that the excavated soils would not meet TCLP limits because of lead, arsenic, or benzene content and would l need to be disposed of offsite as hazardous waste. Onsite stabilization of soils would be necessary prior to disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

In Situ Chemical Oxidation. ISCO involves the addition of chemical oxidants, such as catalyzed hydrogen peroxide (CHP) (hydrogen peroxide plus ferrous sulfate, previously referred to in the industry as "Fenton's reagent") or catalyzed persulfate, to chemically oxidize organic COCs to carbon dioxide and water. The oxidant would be injected through boreholes or wells across a grid throughout the NZ-1, NZ-2, and NZ-5 areas, at varying depth intervals based on the location of NAPL in the subsurface. A small portion of NZ-3 would also be targeted for treatment (Figure 4-21). This area and rationale are described in Section 4.2.4.1 for in situ solidification/stabilization; however, this same area would be targeted in this alternative for ISCO treatment.

Prior to ISCO injection, the area would be cleared of vegetation and excavated for surface and subsurface debris removal (including large boulders, tank pads, conduits, and concrete), and these materials would be disposed of offsite. It is assumed that the depth of debris removal would primarily be to 4 ft, with some deeper debris removed as necessary. Deeper items of this type, as well as former piping and conduits that may be encountered during injection may need to be excavated, as they could interfere with the injection process. Based on field experience at this site and preliminary geophysical evaluation, several subsurface structures (such as concrete slabs and pads, buried metal, and buried wooden structures) would also have to be excavated prior to implementation.

A bench-scale treatability test using both CHP and sodium persulfate was conducted by Geo-Cleanse® International, Inc. (Kenilworth, N.J.), on site-specific media to

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both
- Determine the relative ability of CHP and sodium persulfate with an alkaline catalysis to oxidize VOCs and SVOCs in soil and groundwater from the site
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO
- Estimate total oxidant demand of the media
- Determine the relative fractions of constituents that are oxidized, volatilized, and leached during the ISCO process
- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard (or benefit) may be created

Treatability testing components included evaluation of baseline soil samples, soil buffering and reactivity tests, peroxide reactivity tests, slurry oxidation tests, soil column tests, and autoclave tests. An evaluation of the performance of the technology on samples from the site and the report of the treatability testing results prepared by Geo-Cleanse® is provided in Appendix B. A summary of key conclusions of the bench test is provided below:

- On the basis of visual observations during the slurry tests, free-phase NAPL was either destroyed or transformed into a nonmobile condition by both oxidants (CHP and catalyzed persulfate) at oxidant-to-contaminant ratios of 10:1.
- CHP was a more efficient oxidant than persulfate for the soils used in the test. CHP yielded 59 to 99 percent oxidation of total mass (total VOCs and total SVOCs) using oxidant-to-contaminant ratios of 10:1 and 20:1, whereas persulfate yielded 3 to 93 percent oxidation using the same oxidant-to-contaminant ratios.
- Concentrations of several metals in the slurries increased, including arsenic, chromium, cadmium, selenium, and lead.

Although constituents in some soil slurries in the bench test were effectively oxidized (up to 99 percent), the effectiveness in other soil slurries was lower. For CHP, the oxidation was as low as 59 percent, and for permanganate, 3 percent. The wide variation in effectiveness among the slurries under ideal laboratory conditions (i.e., completely mixed slurries) suggests that there would be a low likelihood of success of a field application and that results would vary considerably across the site.

The mass of oxidants used in the treatability tests (necessary to treat the very high oxidant demand posed by the large mass of VOCs and SVOCs) may be significantly greater than the amount of oxidant that could be effectively delivered to the subsurface in a field application. Persulfate's limit is from 10 to 15 percent of soil weight (assuming a total soil porosity of between 25 and 30 percent and a maximum weight percent of persulfate in solution of 30 percent), or up to 0.15 of 0.5 kg, or 75 g for the sample volume used in the SS-1 and SS-2 slurries. The sodium persulfate used in the slurry tests for these two samples ranged from 170.0 g (10:1 ratio, SS-2 sample) to 1,435.5 g (40:1 ratio, SS-1 sample). Applying this amount of oxidant in the field would require three to 19 successive applications (spaced from 4 months to 1 year apart). Similar restrictions apply to CHP, since it would not be safe to inject at more than about a 15 percent solution. The high oxidant demand required to appreciably reduce VOC and SVOC concentrations (albeit not to levels low enough to approach preliminary remediation goals) apply to any chemical oxidation technology for the site, not only CHP and persulfate.

Based on the results of the bench-scale treatability test conducted, it is assumed for this FS that CHP reagent would be injected at an oxidant-to-contaminant mass ratio of 20:1 with annual reinjections for 5 years. Although a concentration of 10:1 was effective in the bench-scale test, mixing of the contaminants and oxidant would not occur as ideally in the subsurface environment as in the bench-scale test. Additional details of the bench-scale treatability test conducted can be found in Appendix B. If Alternative 5 were selected, a pilot test would need to be performed to more accurately determine full-scale implementation requirements. Other reagents (such as S-ISCO™ (Surfactant-Enhanced In

Situ Chemical Oxidation), a propriety chemical oxidant/surfactant mixture) could be tested to determine their effectiveness at achieving RAOs.

The results of the testing indicate several potentially significant risks that would need to be addressed during and after implementation:

- Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose potential risks associated with vapor intrusion, which would need to be evaluated and controlled during field implementation. Increases in dissolved arsenic concentrations were observed in the silty sand samples as a result of ISCO. These increases would also need to be monitored and managed during field implementation. In addition, the potential for mobilization of currently residual NAPL as a result of the heat of reaction and the physical injection of reagents would need to be thoroughly evaluated prior to field implementation. Finally, engineering controls would need to be robust enough to mitigate the potential risk of NAPL mobilization, including but not limited to barrier wall and booms in the Hudson River, a planned sequencing of injection locations, and control of the injection rate.
- Relocation of occupants in nearby buildings during oxidation is not anticipated to be required. Implementation of engineering controls to control the generation and migration of vapors during subsurface chemical reactions would be required to protect the community and ecological receptors in the Hudson River. The presence of subsurface features and nearby utility corridors (along River Road) could provide preferential vapor pathways, creating potential vapor intrusion risks and reducing the effectiveness of vapor mitigation measures. These potential risks would require management through engineering controls.
- The potential for structural destabilization as a result of ISCO injection near buildings or other surface features and subsurface utilities is a concern, and additional evaluation during pilot-testing and remedial design would be required if this alternative was selected. Prior to any injection, a barrier cutoff wall would be installed along the shoreline as shown in Figure 4-21 to prevent NAPL migration during implementation and to provide the necessary structure support if the bulkhead is impacted by reactions resulting from ISCO.
- Soils underneath the 115 River Road buildings would not be treated; therefore, the potential exposure pathway under the building to the river would be addressed via angled jet grouting to the confining layer from the sides of the building and vertical jet grouting through the building floor to create a cutoff wall that prevents potential NAPL migration from under the building.

Details of the injection patterns, quantity of injectors, and quantity of reagent would be determined during remedial design following treatability pilot testing. The results of the pilot test would have an impact on the final alternative cost.

4.2.6.2 Arsenic

Principal threat arsenic areas (AA-1 through AA-7) and HCAA would be solidified/stabilized in situ as described in Alternative 4, Section 4.2.4.2. Figure 4-21 depicts the arsenic areas to be treated with solidification/stabilization as part of this alternative. The

objective of in situ solidification/stabilization in these areas is to sequester COCs reducing leaching to groundwater. Figures 4-22 through 4-26 depict in cross-section view the arsenic mitigation measures associated with this alternative.

4.2.6.3 HCAA Process Option

Similar to Alternative 4, a process option has been developed for the HCAA as a contingency if treatability testing indicates that the stabilization of the HCAA is not feasible. The HCAA process option would consist of hydraulic containment of the HCAA and in situ solidification/stabilization of the arsenic areas downgradient of the barrier cutoff wall as described in Alternative 3, Section 4.2.3.4. This HCAA process option is depicted in the inset of Figure 4-21.

4.2.6.4 Soil and Residual Soil Capping

Areas where site-related constituents exceed PRGs in surface soil would be capped with an engineered cap to prevent direct contact and to minimize erosion by controlling surface water runoff. The cap would be placed over the Quanta property and the remaining remedial areas on the 115 River Road, Block 93 North, Block 93 South, Block 92.01, and Block 94 properties, replacing existing asphalt or other material (Figure 4-7). Caps are assumed to be composed of materials described in Section 4.2.2.3 for Alternative 2.

4.2.6.5 Groundwater

Groundwater would be contained through installation of a cutoff wall as described Section 4.2.3.2 and depicted in Figure 4-21. Groundwater would be extracted via a network of extraction wells distributed throughout the areas. All wells would be piped to one centralized ex situ groundwater treatment system.

4.2.6.6 Vapor

Although vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or have been determined not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008a), the basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system as described in Section 4.2.2.4.

4.2.6.7 Institutional Controls

The institutional controls for Alternative 5 include land-use restrictions, construction restrictions, and groundwater use restrictions described in Section 4.2.2.5.

4.2.7 Alternative 5b: NAPL In Situ Chemical Oxidation with Arsenic Solidification/Stabilization with Demolition of 115 River Road Buildings

Alternative 5b (Figure 4-27) includes the same remedial components as Alternative 5a with the exception of the approach applied to the NAPL present under 115 River Road. Alternative 5b would include the temporary relocation of the 115 River Road tenants prior to the start of construction activities. The existing brick building and the parking building (Building 12), including foundations, on the 115 River Road property would be demolished. Following demolition, the NAPL zones underneath the 115 River Road buildings would be accessible for shallow excavation and ISCO treatment similar to the rest of the site. The estimated average target excavation depths are described in Section 1.6.2. Excavation and

ISCO treatment under the former building footprints would be conducted as described in Section 4.2.6.1. The 115 River Road buildings would be reconstructed following completion of remedial activities and tenants relocated back to the new buildings.

4.2.8 Alternative 6a: NAPL and Arsenic Excavation

Alternative 6a combines excavation of principal threat NAPL and arsenic waste with capping of residual soils. In situ treatment of dissolved COCs in groundwater discharging to the Hudson River would be treated by means of an SRB placed in OU2. This alternative also includes the maintenance of existing roads and parking surfaces and implementation of institutional controls and vapor mitigation measures.

Alternative 6a addresses principal threats identified in Section 1.7 as described below and shown in Table 4-2:

- Toxicity potential due to direct human contact with principal threat waste at NZ-1, NZ-2, and NZ-5 and from tar boils would be mitigated through excavation and offsite disposal.
- Toxicity potential due to direct contact with arsenic principal threat waste in AA-1 through AA-7 is addressed through excavation and ex situ stabilization.
- The unoccupied basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system. Other occupied buildings would be sampled periodically and vapor intrusion mitigation would be provided, if warranted.
- Mobility potential for free-phase NAPL (principal threat risk at NZ-2 and NZ-5) and toxicity potential for ecological receptors at OU2 is eliminated through the excavation and offsite disposal of source material.

The potential for COCs in groundwater to migrate to surface water is reduced through the use of a SRB. Human exposure to contaminated soil and groundwater is restricted through physical barriers and institutional controls. Restoration of the groundwater to drinking water quality is considered technically impracticable, as described in Section 2.5.

A summary of the remedial actions taken in this alternative is provided in Table 4-3.

4.2.8.1 Non–Aqueous Phase Liquid and Arsenic Excavation

Soil from locations at which tar boils have been observed and areas of soft, plastic, or hard tars in the vadose zone on the Quanta property would be excavated to a depth of 4 ft bgs. The remaining accessible portions of NAPL zones and arsenic posing a principal threat would be excavated to depths defined in Section 1.6.2 and disposed of offsite. Soil underneath the 115 River Road buildings would not be excavated because the exposure pathway can be addressed via institutional and engineering controls.

Figure 4-28 depicts the areas to be excavated as part of this alternative. Figures 4-29 through 4-33 depict this alternative in cross-section view. Excavations below 4 ft would require dewatering. Water extracted for dewatering would be treated onsite and discharged to the Hudson River. Excavation depths of 20 ft can be achieved with readily available excavation equipment. Deeper excavation and excavation below the water table is possible with more-

specialized equipment. Excavation of soils may require the use of shoring (e.g., sheet piles) to protect utility lines, building foundations, etc.

A small portion of NZ-3 would also be targeted for excavation. This area and rationale are described in Section 4.2.4.1 for in situ solidification/stabilization; however, this same area would be targeted in this alternative for excavation.

Details of the excavation extents, equipment to be used, required excavation stabilization measures, and exact volumes of impacted soil to be removed would be based on predesign investigation or remedial design. A verification sampling plan describing the approach to be used to determine the extent of excavations would be finalized during the design phase. Specific stormwater diversion, soil erosion controls, and air-monitoring requirements would also be assessed during remedial design, as would controls for mitigating the potential risk of NAPL mobilization to the river. The excavation areas would be backfilled and compacted with certified clean fill material.

Large-scale excavations requiring dewatering may result in unforeseen impacts to the site. Such impacts may include additional release of site-related constituents including NAPL into OU2 and potential mobilization of previously stable NAPL. Engineering controls would need to be robust enough to mitigate the potential risk of erosion or NAPL mobilization.

Air monitoring would be important during excavation and to evaluate the appropriate PPE for workers. In addition, emission control techniques such as using dust and odor suppressants and minimizing the open working area of the excavation would be employed as needed to minimize adverse effects on workers and the community from volatile emissions of NAPL. Relocation of occupants in nearby buildings is not anticipated; however, contingency plans would be developed during remedial design in the event that air monitoring suggests temporary relocation is needed. Mitigation measures to reduce adverse impacts to the community from increased truck traffic would need to be evaluated and incorporated into the remedial design.

Residual soils remaining in place on each property after excavation have been assumed for costing purposes to be left in place beneath the backfilled soil cap. Institutional controls would be implemented for all properties to prevent contact with deep residuals left in place following excavation.

Based on a comparison of the NAPL chemical characteristics and soil concentrations, it is anticipated that the excavated soils would be classified as hazardous waste. Onsite stabilization of soils would be necessary prior to their disposal to meet land disposal restrictions. Soil would be stockpiled, stabilized, and then disposed of at an offsite landfill. Details of sampling requirements for excavated soils, required treatment, and disposal options would be finalized during remedial design.

Several hazardous waste landfills in North America receive, stabilize, and dispose of characteristically hazardous soil. These facilities would likely accept the tar- and arsenic-contaminated soil from the site for treatment prior to disposal. Media would be either stabilized onsite then transported and disposed of as nonhazardous waste or directly transported to a hazardous waste landfill for disposal and stabilization on location. It is assumed for this feasibility study that material would be stabilized onsite and disposed of as

nonhazardous. Prequalification samples would be analyzed to determine whether the waste is acceptable for onsite processing and disposal and whether the material can be processed and disposed of in the landfill.

The potential for structural destabilization as a result of excavation near buildings or other surface features and subsurface utilities is a concern, and additional evaluation during remedial design would be required if this component is selected. Prior to any excavation, a temporary barrier of sheet piles would be installed along the shoreline to mitigate NAPL migration during implementation, to act as a turbidity barrier and to provide the necessary structure support if the bulkhead is impacted by the removal of soils behind the bulkhead. The temporary barrier would not be designed for long-term use.

Soils underneath the 115 River Road buildings would not be treated; therefore, the potential exposure pathway under the building to the river would be addressed via barrier wall created to prevent potential NAPL migration from under the building.

4.2.8.2 Soil and Residual Soil Capping

Areas where site-related constituents exceed PRGs in surface soil would be capped with an engineered cap to prevent direct contact and to minimize erosion by controlling surface water runoff. The cap would be placed over the Quanta property and the remaining remedial areas on the 115 River Road, Block 93 North, Block 93 Central, Block 92.01, and Block 94 properties, replacing existing asphalt or other material (Figure 4-7). Caps are assumed to be composed of materials described in Section 4.2.2.3 for Alternative 2.

4.2.8.3 Groundwater

Groundwater that discharges in the Hudson River, or OU2, would be treated by an SRB and monitored as described in Section 4.2.4.4 and depicted in Figure 4-28.

4.2.8.4 Vapor

Although vapor intrusion studies have concluded that vapor intrusion pathways are unlikely to be present or do not to pose an unacceptable human health risk to the occupants of buildings at OU1 under current conditions (CH2M HILL, 2008a), the basements of the 115 River Road building would be equipped with a vapor intrusion mitigation system as described in Section 4.2.2.4.

4.2.8.5 Institutional Controls

The institutional controls for Alternative 6a include land-use restrictions, construction restrictions, and groundwater use restrictions described in Section 4.2.2.5.

4.2.9 Alternative 6b: NAPL and Arsenic Excavation with Demolition of 115 River Road Buildings

Alternative 6b (Figure 4-34) includes the same remedial components as Alternative 6a with the exception of the approach applied to the NAPL present under 115 River Road. Alternative 6b would include the temporary relocation of the 115 River Road tenants prior to the start of construction activities. The existing brick building and the parking building (Building 12), including foundations, on the 115 River Road property would be demolished. Following demolition, the NAPL zones underneath the 115 River Road buildings would be accessible for excavation, disposal, and backfilling similar to the rest of the site. The

estimated average target excavation depths are described in Section 1.6.2. Excavation under the former building footprints would be conducted as described in Section 4.2.8.1. The 115 River Road buildings would be reconstructed following completion of remedial activities, and tenants would be relocated back to the new buildings.

TABLE 4-1
Remedial Alternatives Summary
Quanta Resources Superfund Site,OU1, Edgewater, New Jersey

Technology General Response Actions	Remedial Technologies/ Process Options	Alternative								
		1—No Further Action	2—NAPL and Arsenic Containment	3—NAPL and Arsenic Containment with NAPL Recovery	4—NAPL and Arsenic In Situ Solidification/Stabilization		5—NAPL In Situ Chemical Oxidation, with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
					4a—Preservation of 115 River Road Buildings	4b—Demolition of 115 River Road Buildings	5a—Preservation of 115 River Road Buildings	5b—Demolition of 115 River Road Buildings	6a—Preservation of 115 River Road Buildings	6b—Demolition of 115 River Road Buildings
No action	None	✓	—	—	—		—		—	
Institutional controls	Deed restrictions	✓	✓	✓	✓		✓		✓	
	Monitoring	✓	✓	✓	✓		✓		✓	
Containment	Vertical barriers	—	✓ NAPL, Arsenic & HCAA	✓ NAPL & HCAA	✓ NAPL Process Option: HCAA		✓ NAPL Process Option: HCAA		✓ NAPL	
	Cover or cap	—	✓	✓	✓		✓		✓	
In situ treatment	ISCO	—	—	—	—		✓ NZ-1, NZ-2, NZ-5, portion of NZ-3	✓ NZ-1, NZ-2, NZ-5, portion of NZ-3 and under 115 River Road	—	
	In situ stabilization/solidification	—	—	—	✓ Tar boils, NZ-1, NZ-2, NZ-5, HCAA, AA-1 through AA-7, portion of NZ-3	✓ Tar boils, NZ-1, NZ-2, NZ-5, HCAA, AA-1 through AA-7, portion of NZ-3 and under 115 River Road	✓ Tar boils, NZ-1, NZ-2, NZ-5, HCAA, AA-1 through AA-7, portion of NZ-3	✓ Tar boils, NZ-1, NZ-2, NZ-5, HCAA, AA-1 through AA-7, portion of NZ-3 and under 115 River Road	—	
NAPL extraction	Standard recovery wells	—	—	✓ NZ-1, NZ-2, NZ-5, Limited in NZ-3 & NZ-4	✓ Limited in NZ-3 & NZ-4		✓ NZ-1, NZ-2, NZ-5, Limited in NZ-3 & NZ-4		✓ Limited in NZ-3 & NZ-4	
	Directionally drilled recovery wells	—	—	✓	—		—		—	
Soil removal	Excavation	—	—	—	✓ NZ-1 on Block 93 excavated, surface and subsurface debris		✓ Tar boils, NZ-1 and NZ-2 excavated to 4 ft bgs,		✓ Tar boils, NZ-1, NZ-2, NZ-5 and portion of NZ-3	✓ Tar boils, NZ-1, NZ-2, NZ-5, portion of NZ-3 and under 115 River Road
Vapor intrusion mitigation	Vapor depressurization system	—	✓	✓	✓		✓		✓	
Groundwater treatment	Monitored natural attenuation	—	✓	✓	✓		✓		✓	
	Vertical barriers—sheet pile or slurry/jet grout wall	—	✓	✓ With hydraulic containment	✓ Process option: HCAA Hydraulic Containment		✓ With hydraulic containment Process Option: HCAA Hydraulic Containment		✓	
	In situ passive treatment barriers	—	✓ Funnel-and-gate system	—	✓ SRB		—		✓ SRB	
Disposal	Offsite disposal	—	✓ Debris and material from funnel and gate installation	✓ Debris and material from cutoff wall installation and recovered NAPL	✓ Debris and material from shallow excavation	✓ Debris and material from shallow excavation and demolition	✓ Debris and material from shallow excavation and recovered NAPL	✓ Debris and material from shallow excavation, recovered NAPL and demolition	✓ Debris, material from excavated soils	✓ Debris, material from excavated soils and demolition
	Ex situ treatment (onsite)	—	—	—	✓ portions of NZ-1		—		—	
Sediment transport	Truck	—	—	—	✓		✓		✓	

SRB, subaqueous reactive barrier.

TABLE 4-2
Source Material Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Principal Threat Definition[a]				Alternative							
			Toxicity Potential					4—NAPLand Arsenic In Situ Solidification/ Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
Source Area		**Mobility Potential**	**Accessibility/ Proximity to Receptors**	**Vapor Intrusion**	**Principal Threat Waste?—Summary**	**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Road Buildings**	**4b—Demolition of 115 River Road Buildings**	**5a—Preservation of 115 River Road Buildings**	**5b—Demolition of 115 River Road Buildings**	**6a—Preservation of 115 River Road Buildings**	**6b—Demolition of 115 River Road Buildings**
Principal Threat Waste	**NZ-1**	**Low—**High viscosity and interfacial tension have generally limited the downward vertical migration of NAPL in most locations to a depth of 11 ft bgs. Further migration of NAPL in this zone is not predicted to occur, based on the physical characteristics of the NAPL and the likely age of release(s) that resulted in the presence of NAPL at this location. At an isolated area, NAPL has migrated to the maximum depth of the silty-clay confining unit (approx. 23 ft bgs). At this location, further migration is prevented by the presence of the silty-clay confining unit.	**High**—NAPL containing COCs is present at depths posing a potential risk of direct contact. NAPL under the 115 River Rd. buildings is not accessible under current conditions.	**High**—NAPL containing COCs is present at depths posing a potential risk of vapor intrusion. There is no existing unacceptable risk due to vapor intrusion under current conditions.	**Yes**—Toxicity Potential	**Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Vapor intrusion mitigation would be installed in basements of occupied building (115 River Rd.) and if warranted in other occupied buildings.	**Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Vapor intrusion mitigation would be installed in basements of occupied building (115 River Rd.) and if warranted in other occupied buildings. NAPL would be recovered to the extent possible from standard and directionally drilled recovery wells within NZ-1.	**Toxicity Potential**—The direct contact exposure pathway is addressed through the use of in-situ solidification/stabilization, including shallow excavation for surface and subsurface debris, which mitigates potential risk by sequestering COCs. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion Vapor intrusion mitigation would be installed in basements of occupied building (115 River Rd.) and if warranted in other occupied buildings.	NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity	**Toxicity Potential**—The direct contact exposure pathway is eliminated through shallow excavation (to 4 ft bgs), standard recovery wells, in-situ chemical oxidation and institutional controls. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Vapor intrusion mitigation would be installed in basement of occupied building (115 River Rd.) and if warranted in other occupied buildings.	NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity	**Toxicity Potential**—The direct contact exposure pathway is addressed through the excavation and offsite disposal of principal threat source material in NZ-1, and institutional controls. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Vapor intrusion mitigation would be installed in basements of occupied building (115 River Rd.) and if warranted in other occupied buildings.	NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity

TABLE 4-2
Source Material Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Principal Threat Definition[a]				Alternative							
			Toxicity Potential					4—NAPLand Arsenic In Situ Solidification/ Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
Source Area		**Mobility Potential**	**Accessibility/ Proximity to Receptors**	**Vapor Intrusion**	**Principal Threat Waste?—Summary**	**2—NAPL and Arsenic Containment**	**3—NAPL and Arsenic Containment with NAPL Recovery**	**4a—Preservation of 115 River Road Buildings**	**4b—Demolition of 115 River Road Buildings**	**5a—Preservation of 115 River Road Buildings**	**5b—Demolition of 115 River Road Buildings**	**6a—Preservation of 115 River Road Buildings**	**6b—Demolition of 115 River Road Buildings**
Principal Threat Waste	**NZ-2**	**High—**Nonhomogeneous with varying physical properties, which indicates that portions of the NAPL have limited potential for migration. Migration has been limited to between approx. 4 and 25 ft bgs with the bulk of NAPL at approx. 15 ft bgs. The wooden bulkhead has impeded the flow of NAPL to OU2 causing it to seep laterally beyond the extents of the bulkhead.	**High**—NAPL containing COCs is present at depths posing a potential risk of direct contact, and NAPL is present adjacent to the Hudson River (ecological receptors).	**High**—NAPL containing COCs is present at depths posing a potential risk of vapor intrusion.	**Yes**—Mobility and Toxicity Potential	**Mobility Potential**—Potential NAPL migration to OU2 is prevented through the use of a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) along the shoreline. **Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls. Exposure of ecological receptors in the Hudson River is mitigated through the use of a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) to isolate NZ-2 from the receptors. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	**Mobility Potential**—Potential NAPL migration to OU2 is prevented through the use of NAPL recovery and a barrier cutoff wall along the shoreline. **Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls. Exposure of ecological receptors in the Hudson River is mitigated through the use of a barrier cutoff wall to isolate NZ-2 from the receptors. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	**Mobility Potential**—Potential NAPL migration to OU2 is mitigated through in-situ solidification/stabilization. **Toxicity Potential**—The direct contact exposure pathway is addressed through capping and institutional controls, and through the use of in-situ solidification/stabilization, which mitigates potential risk by sequestering COCs. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Exposure of ecological receptors in the Hudson River is mitigated through the use of an SRB.		**Mobility Potential** —Potential NAPL migration to OU2 is mitigated through shallow excavation, NAPL recovery wells, in-situ chemical treatment (likely chemical oxidation) and the placement of a barrier cutoff wall along the shoreline. **Toxicity Potential** —The direct contact exposure pathway is eliminated through capping, institutional controls, shallow excavation (to 4 ft bgs), and the use of in-situ chemical oxidation. Vapor intrusion would be prevented during in-situ treatment. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Exposure of ecological receptors in the Hudson River is mitigated through the use of a barrier cutoff wall.		**Mobility Potential** —Potential NAPL migration to OU2 is mitigated through the excavation and offsite disposal and the placement of a barrier cutoff wall along the shoreline **Toxicity Potential** —The direct contact exposure pathway at NZ-2 is mitigated through the physical removal and offsite disposal, and institutional controls. Vapor intrusion would be prevented by the removal of NAPL in NZ-2. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion. Exposure of ecological receptors in the Hudson River is mitigated through the use of an SRB.	
								Vapor intrusion would be mitigated by the in-situ solidification/stabilization of NAPL that restricts volatilization and constituent migration.	NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity		NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity		NAPL under the 115 River Rd. footprint would be treated mitigating potential toxicity

TABLE 4-2
Source Material Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Principal Threat Definition[a]				Alternative							
			Toxicity Potential					4—NAPLand Arsenic In Situ Solidification/ Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
	Source Area	Mobility Potential	Accessibility/ Proximity to Receptors	Vapor Intrusion	Principal Threat Waste?—Summary	2—NAPL and Arsenic Containment	3—NAPL and Arsenic Containment with NAPL Recovery	4a— Preservation of 115 River Road Buildings	4b— Demolition of 115 River Road Buildings	5a— Preservation of 115 River Road Buildings	5b— Demolition of 115 River Road Buildings	6a— Preservation of 115 River Road Buildings	6b— Demolition of 115 River Road Buildings
Principal Threat Waste	**NZ-5**	**High—**NAPL is connected to NZ-2 with the majority residing between 20 to 25 ft bgs. Interfacial tension and viscosity of the NAPL indicate the potential for mobility	**Moderate—** NAPL present adjacent to the Hudson River (ecological receptors); however, depth limits potential for direct contact.	**Low—**Depth of NAPL present limits potential for vapor migration.	**Yes—** Mobility and Toxicity Potential	**Mobility Potential**—Potential NAPL migration to OU2 is prevented through the use of a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) along the shoreline. **Toxicity Potential**—Exposure of ecological receptors in the Hudson River is mitigated through the use of a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) barrier to isolate NZ-5 from the receptors. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	**Mobility Potential**—Potential NAPL migration to OU2 is prevented through the use of NAPL recovery and a barrier cutoff wall along the shoreline. **Toxicity Potential**—Exposure of ecological receptors in the Hudson River is mitigated through the use of a barrier cutoff wall to isolate NZ-5 from the receptors. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	**Mobility Potential**—Potential NAPL migration to OU2 is prevented through the use of in-situ solidification/ stabilization at NZ-5. **Toxicity Potential**—Exposure of ecological receptors in the Hudson River is mitigated through the use of in-situ solidification/ stabilization, institutional controls, and an SRB.		**Mobility Potential** —Potential NAPL migration to OU2 is mitigated through NAPL recovery (wells), and application of in-situ treatment and the placement of a barrier cutoff wall. **Toxicity Potential**—Exposure of ecological receptors in the Hudson River is mitigated through the use of NAPL recovery, in-situ chemical oxidation, institutional controls, and the installation of a barrier cutoff wall.		**Mobility Potential** —Potential NAPL migration to OU2 is prevented through the excavation and offsite disposal and the placement of barrier cutoff wall. **Toxicity Potential** —Exposure of ecological receptors in the Hudson River is mitigated through the excavation, offsite disposal, institutional controls, and the installation of an SRB.	
	Tar Boils	**Low—**Solid, taffy-like tar in the near surface vadose zone has been observed to seep through surface cracks in soil or pavement on very hot days. However, this very high viscosity material is not present in quantities sufficient to migrate beyond the immediate vicinity of the tar boil.	**High—**Coal tar is present at the ground surface, posing a risk of direct contact.	**High**—The presence of buildings would prevent the heating caused by sunlight that creates this phenomenon. However, if a building were to be built atop existing tar boils, there would be a potential risk of vapor intrusion	**Yes—** Toxicity Potential	**Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls, including construction requirements, which would establish criteria for future development that would minimize potential for vapor intrusion.	**Toxicity Potential**—NAPL recovery would remove free-phase material and limit the formation of tar boils, while capping reduces the potential risk of direct contact. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	**Toxicity Potential**—The direct contact exposure pathway is addressed through capping and the use of in-situ solidification/stabilization, which mitigates potential risk by sequestering COCs. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.		**Toxicity Potential**—Shallow excavation and NAPL recovery would remove free-phase material and limit the formation of tar boils, while capping reduces the potential risk of direct contact. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.		**Toxicity Potential** —The direct contact exposure pathway for tar boils is mitigated through the physical removal and offsite disposal of shallow NAPL. Institutional controls, including construction requirements, would establish criteria for future development that would minimize potential for vapor intrusion.	

TABLE 4-2
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Principal Threat Definition[a]				Alternative							
			Toxicity Potential					4—NAPLand Arsenic In Situ Solidification/ Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
Source Area		Mobility Potential	Accessibility/ Proximity to Receptors	Vapor Intrusion	Principal Threat Waste?—Summary	2—NAPL and Arsenic Containment	3—NAPL and Arsenic Containment with NAPL Recovery	4a— Preservation of 115 River Road Buildings	4b— Demolition of 115 River Road Buildings	5a— Preservation of 115 River Road Buildings	5b— Demolition of 115 River Road Buildings	6a— Preservation of 115 River Road Buildings	6b— Demolition of 115 River Road Buildings
Principal Threat Waste	**AA-1 through AA-7**	**Low**—Source material (pyritic ore or fill creating geochemical conditions) is not mobile.	**Moderate to High**—Each of the arsenic areas contain soil accessible through either the residential or construction worker exposure scenarios, or both, and concentrations exceeding either 390 mg/kg in shallow soil or 1000 mg/kg for soil from 2-10 ft bgs.	**Low—**Arsenic is not a vapor intrusion concern.	**Yes—** Toxicity Potential	**Toxicity Potential**—The direct contact exposure pathway is eliminated through capping and institutional controls.	**Toxicity Potential**—Same as Alternative 2.	**Toxicity Potential**—The direct contact exposure pathway is eliminated through the stabilization of AA-1 through AA-7		**Toxicity Potential**—Same as Alternative 4.		**Toxicity Potential**—The exposure potential is eliminated through the excavation of AA-1 through AA-7	
Low-Level Threat Waste	**HCAA**	**Low**—Subsurface source material (pyritic ore) is not mobile.	**Low --** The depth of the material limits the potential for direct contact with soil containing concentrations that would otherwise pose a principal threat.	**Low—**Arsenic is not a vapor intrusion concern.	**No**	The potential direct contact exposure pathway controlled through capping and institutional controls. COCs in groundwater from OU1 that discharges in OU2 would be treated through a funnel and gate system.	The potential direct contact exposure pathway controlled through capping and institutional controls. COCs in groundwater from OU1 that discharges in OU2 would be captured by barrier cutoff wall and treated prior to discharge.	The potential direct contact exposure pathway controlled through capping and institutional controls. COCs in groundwater would be reduced through stabilization of the HCAA. HCAA Process Option: COCs in groundwater from OU1 that discharges in OU2 would be captured by barrier cutoff wall and treated prior to discharge.		Same as Alternative 4.		COCs in groundwater from OU1 will be reduced through the excavation of the HCAA.	
	NZ-3	**Low—**NAPL in NZ-3 has low viscosity and has migrated downward and laterally to a natural depression in the top of the silty-clay confining unit at approximately 22 to 25 ft bgs. Beyond the southeastern downgradient edge of NZ-3 the down-sloping silty-clay layer and presence of organic silts along the shoreline would control any future potential migration. If further migration of the NAPL were possible, it would occur along the silty-clay and sand interface to a deeper elevation where the NAPL would again stabilize.	**Low—**NAPL contains COCs; however, depth limits potential for direct contact.	**Low—**Depth of NAPL present limits potential for vapor migration.	**No**	No action is taken to prevent leaching to groundwater from materials below the water table. Restoration of the groundwater to drinking water quality is considered technically impracticable; however, fate and transport evaluation indicates that the contaminant plume is stable. COCs in groundwater from OU1 that discharges in OU2 would be treated through a funnel and gate system.	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 captured by barrier cutoff wall and treated prior to discharge. Passive NAPL recovery in existing monitoring wells.	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 treated through a subaqueous reactive barrier. Passive NAPL recovery and targeted in situ solidification/stabilization		Same as Alternative 3. Targeted in situ chemical oxidation.		Same as Alternative 4 with targeted excavation.	

TABLE 4-2
Principal Threat Mitigation Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

		Principal Threat Definition[a]				Alternative							
			Toxicity Potential					4—NAPLand Arsenic In Situ Solidification/ Stabilization		5—NAPL In Situ Chemical Oxidation with Arsenic Stabilization		6— NAPL and Arsenic Excavation	
Source Area		Mobility Potential	Accessibility/ Proximity to Receptors	Vapor Intrusion	Principal Threat Waste?—Summary	2—NAPL and Arsenic Containment	3—NAPL and Arsenic Containment with NAPL Recovery	4a— Preservation of 115 River Road Buildings	4b— Demolition of 115 River Road Buildings	5a— Preservation of 115 River Road Buildings	5b— Demolition of 115 River Road Buildings	6a— Preservation of 115 River Road Buildings	6b— Demolition of 115 River Road Buildings
Low-Level Threat Waste	**NZ-4**	**Low—**NZ-4 comprises shallow and deeper NAPL (approx. 10 to 15 ft bgs and approx. 20-to 32 ft bgs) beneath Block 93 Central, Block 93 South, and the northwestern portion of the former Lever Brothers property. In all directions along the periphery of NZ-4 a consistent rise in the elevation of the peat and silty clay is present preventing further lateral migration. NAPL under River Rd. addressed by others per AOC II-CERCLA-96-1010	**Low—**NAPL contains COCs; however, depth limits potential for direct contact.	**Low—**Depth of NAPL present limits potential for vapor migration.	**No**	No action is taken to prevent leaching to groundwater from materials below the water table. Restoration of the groundwater to drinking water quality is considered technically impracticable; however, fate and transport evaluation indicates that the contaminant plume is stable. COCs in groundwater from OU1 that discharges in OU2 would be treated through a funnel and gate system. .	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 captured by barrier cutoff wall and treated prior to discharge. Passive NAPL recovery in existing monitoring wells.	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 would be treated through a subaqueous reactive barrier. Passive NAPL recovery		Same as Alternative 3.		Same as Alternative 4.	
	NZ-6	**Low—**Most of the NAPL in NZ-6 is found at 10 ft bgs. Failure for NAPL to accumulate in MW-126 suggests lower NAPL saturation levels.	**Low—**NAPL contains COCs; however, depth limits potential for direct contact.	**Low—**Depth of NAPL present limits potential for vapor migration.	**No**	No action is taken to prevent leaching to groundwater from materials below the water table. Restoration of the groundwater to drinking water quality is considered technically impracticable; however, fate and transport evaluation indicates that the contaminant plume is stable. COCs in groundwater from OU1 that discharges in OU2 would be treated through a funnel and gate system.	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 captured by barrier cutoff wall and treated prior to discharge.	Same as Alternative 2 with COCs in groundwater from OU1 that discharges in OU2 treated through a subaqueous reactive barrier.		Same as Alternative 3.		Same as Alternative 4.	

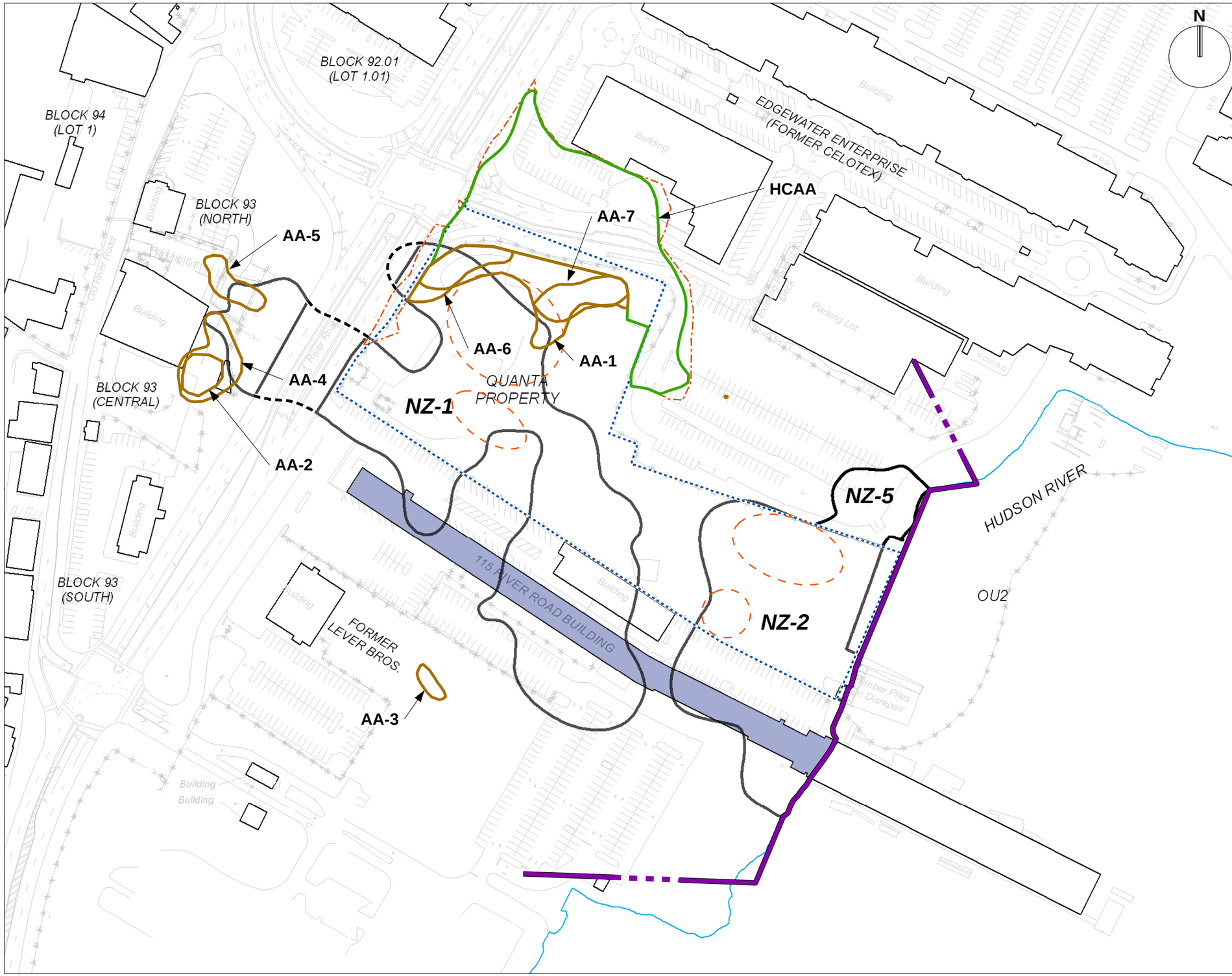
[a] Defining areas as principal threat waste or low-level waste is based on *A Guide to Principal Threat and Low Level Threat Wastes* (EPA, 1991).
[b] As presented in the Draft Human Health Risk Assessment (CH2M HILL, November 2007).
[c] Receptor: future commercial worker.
COC, constituent of concern; ELCR, excess lifetime cancer risk; HCAA, high-concentration arsenic area; AA, arsenic area; HI, hazard index; NAPL, non–aqueous phase liquid; PRB, permeable reactive barrier.

TABLE 4-3
Summary of Feasibility Study Alternatives
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Alternative	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/ Surface Water
2—NAPL and Arsenic Containment	Tar boils at the ground surface throughout the site, NAPL present in NZ-1, NZ-2 and NZ-5 would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place. A funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) would be installed to prevent potential NAPL migration to the Hudson River.	Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta Site, portions of Block 93 (north and central), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd. building. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Site groundwater would be contained and treated with a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) before discharging to the River. Institutional controls restricting groundwater use would be established.
3—NAPL and Arsenic Containment with NAPL Recovery	NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5 and via directionally drilled recovery wells under the 115 River Rd. Building. Capping and institutional controls would be established to document and limit use of areas with COCs remaining in place. Limited NAPL recovery in NZ-3 and NZ-4. A barrier cutoff wall with extraction wells would be installed to prevent potential NAPL migration to the Hudson River.	Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be capped. A cutoff wall would be installed downgradient of the HCAA with extraction wells tied into an ex situ groundwater treatment system.	Same as above	Same as above	Site groundwater would be contained and treated ex situ before discharging to the River. Institutional controls restricting groundwater use would be established.
4a—NAPL and Arsenic In Situ Solidification/Stabilization	In situ solidification/stabilization of tar boils, accessible NAPL present in NZ-1, NZ-2, NZ-5 and portions of NZ-3 with capping. Surface and subsurface debris would be excavated and disposed of offsite. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place. Limited NAPL recovery in NZ-3 and NZ-4.	Principal threat arsenic on Block 93 and the Quanta property and within the HCAA would be solidified/stabilized in situ. **HCAA Process option:** Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be solidified/stabilized. A cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.	Same as above	Same as above	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.
4b—NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of 115 River Rd. Buildings	Same as above with demolition of the 115 River Road buildings and in situ solidification/stabilization of soils beneath the buildings	Same as above	Same as above	Materials under 115 River Road buildings would be treated. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Same as above
5a—NAPL In Situ Chemical Oxidation with Arsenic Stabilization	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for offsite disposal. NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5, to a limited extent in NZ-3 and NZ-4. NAPL collection would be followed by in situ chemical oxidation in NAPL zones NZ-1, NZ-2, and NZ-5, and portions of NZ-3. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline	Same as above	Same as above	Same Alternative 2	Same Alternative 3

TABLE 4-3
Summary of Feasibility Study Alternatives
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Alternative	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/ Surface Water
5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Demolition of 115 River Rd. Buildings	Same as above with demolition of the 115 River Road buildings and chemical treatment of soils beneath the buildings.	Same as above	Same as above	Same as Alternative 4b	Same as above
6a—NAPL and Arsenic Excavation	NAPL present in NZ-1, NZ-2 and NZ-5, tar boils, and portions of NZ-3 would be excavated from accessible areas and disposed of offsite. Excavation would require dewatering to achieve depths greater than 4 ft, and may require shoring near existing structures. Water generated from dewatering activities would be treated onsite prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline. Limited NAPL recovery from NZ-3 and NZ-4	All principal threat arsenic on would be excavated and disposed of offsite. Excavations would require dewatering to achieve depths of greater than 4 ft and may require shoring next existing structures. Water generated from dewatering activities would be treated onsite prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade	Same as above	Same Alternative 2	Same as Alternative 4a
6b—NAPL and Arsenic Excavation with Demolition of 115 River Rd. Buildings	Same as above with demolition of the 115 River Road buildings and excavation of soils beneath the building.	Same as above	Same as above	Same as Alternative 4b	Same as above



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 Principal Threat NAPL Zone
- HCAA High Concentration Arsenic Area
- AA-7 Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Vapor Intrusion Engineering Controls
- Barrier Wall
- Permeable Reactive Barrier

Notes:

1. Alternative also includes capping of residual soils.
2. The final gate size finalized during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

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ALTERNATIVE 2
NAPL AND ARSENIC CONTAINMENT

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-1**

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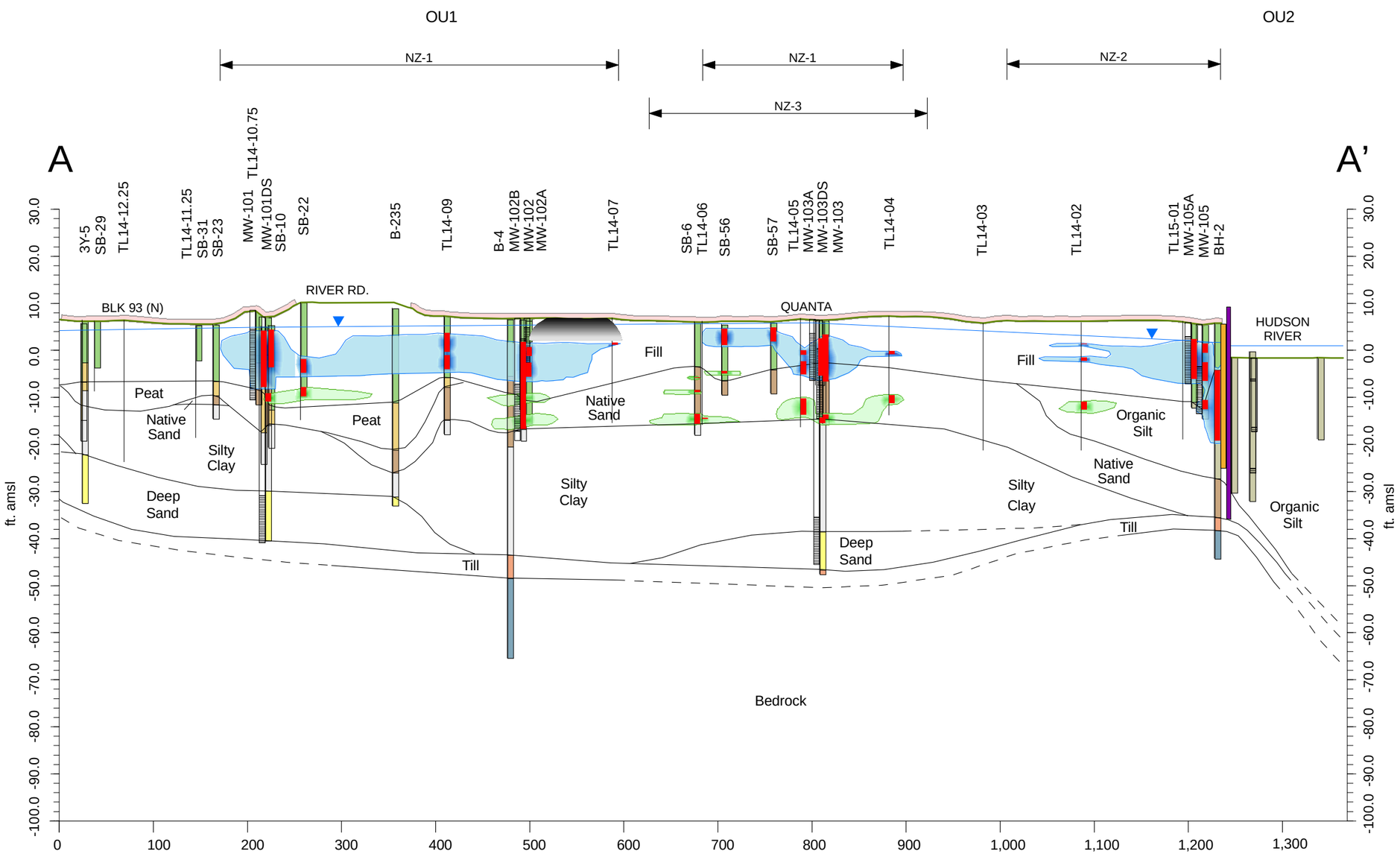
400184



Stratigraphy

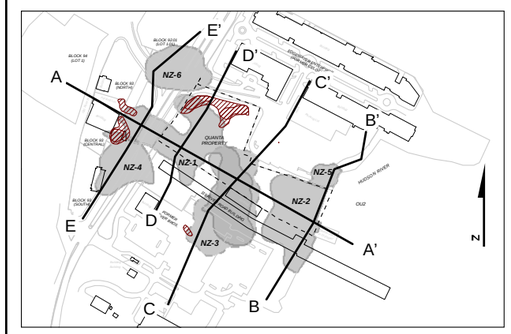
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Engineered Cap
- Tar Boils



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
7. ft. = feet, amsl = above mean sea level

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ALTERNATIVE 2
CROSS-SECTION A - A'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-2**

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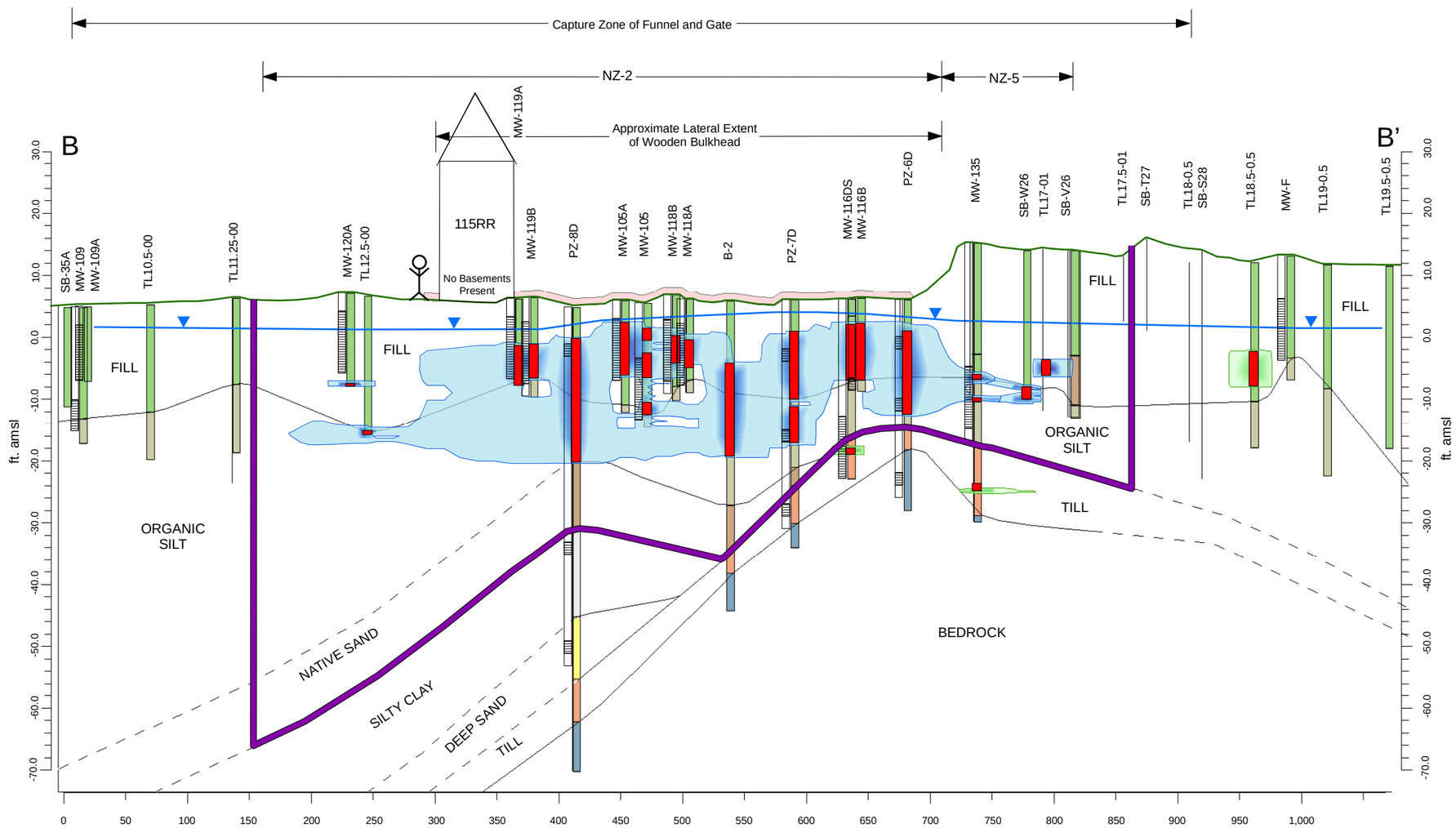
400185



Stratigraphy

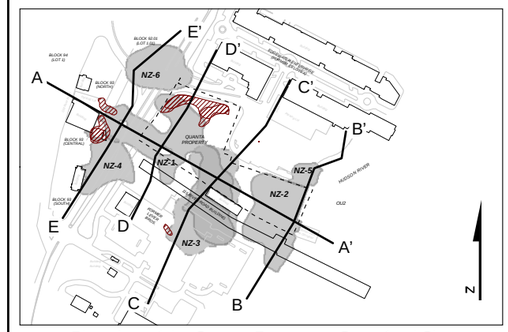
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Barrier Wall
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs,TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
   amsl = above mean sea level
7. Barrier wall and jet grouting shown parallel to cross-section line.
8. 115 River Road dimensions are estimated.
9. Configuration of the barrier wall is approximated for visual depiction and will be determined during remedial design.

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ALTERNATIVE 2
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 4-3

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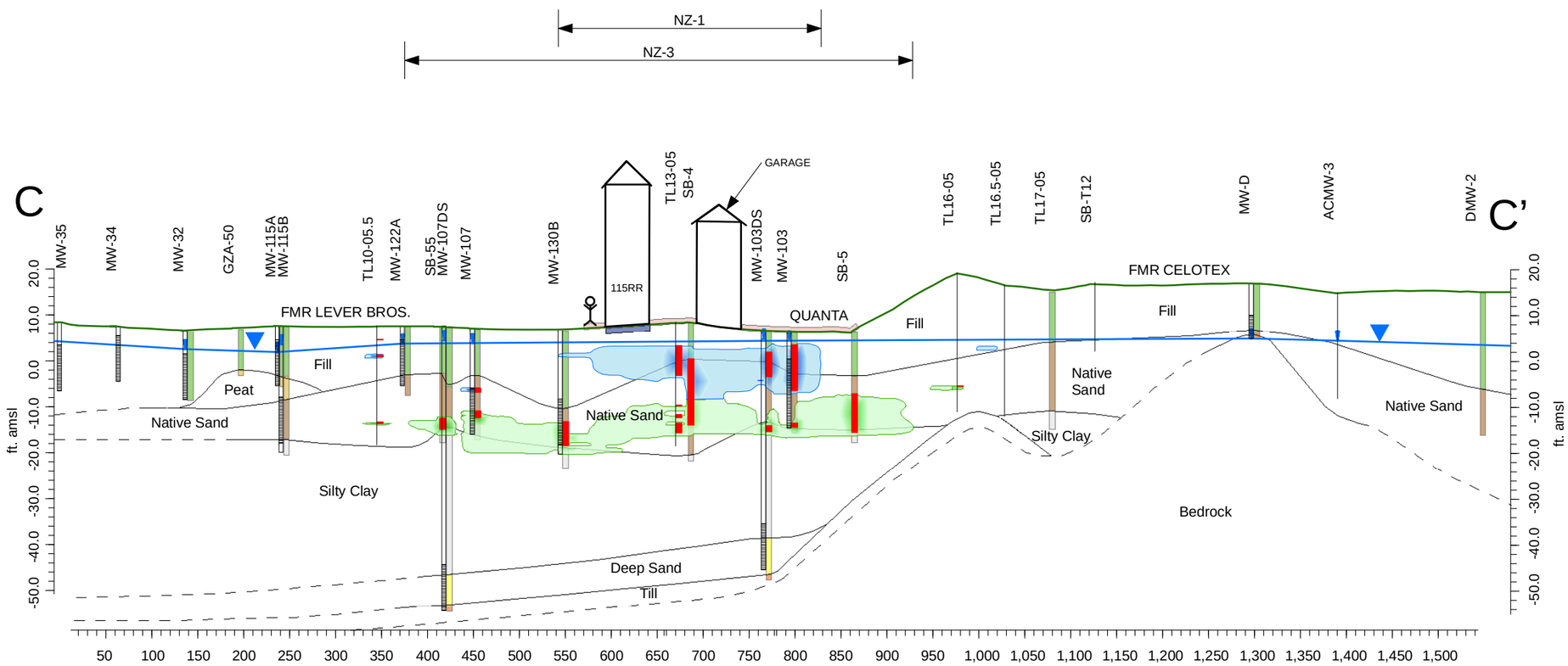
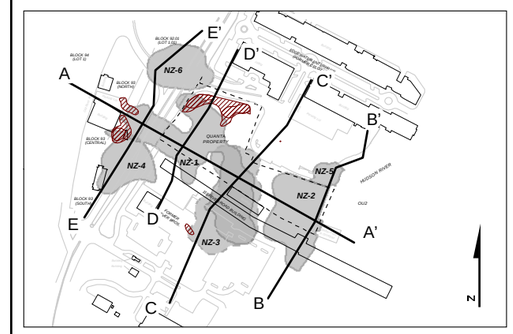
400186



LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Vapor Intrusion Engineering Controls
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs,TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
   amsl = above mean sea level
7. 115 River Road dimensions are estimated.

Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

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ALTERNATIVE 2
CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-4**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT2_CROSSSECTIONS\4-04_NAPL CONTAINMENT ALT 2 OU1 CROSS SECTION C-C.MXD JHANSEN1 7/6/2010 15:05:54

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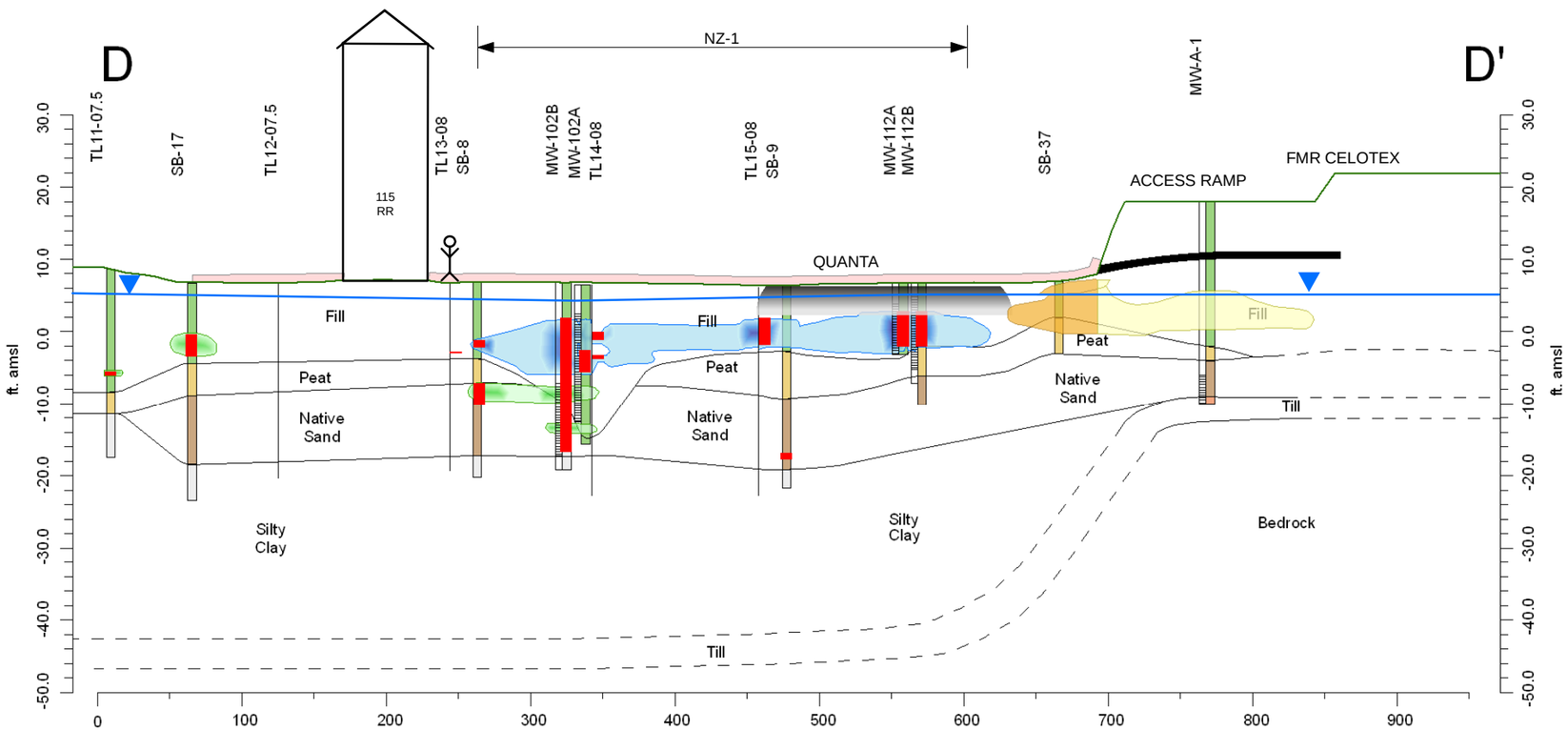


Stratigraphy

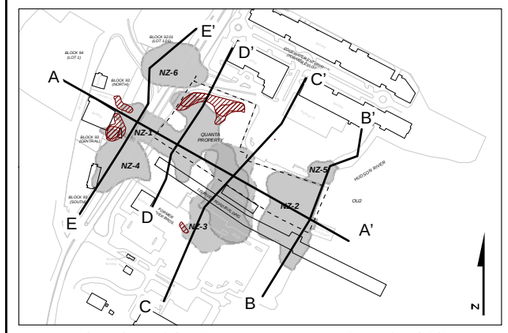
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Area
- Existing Arsenic Liner
- Engineered Cap
- Tar Boils



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs,TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
   amsl = above mean sea level
7. 115 River Road dimensions are estimated.

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ALTERNATIVE 2
CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 4-5

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT2_CROSSSECTIONS\4-05_NAPL CONTAINMENT ALT 2 OU1 CROSS SECTION D-D.MXD JHANSEN1 7/6/2010 15:08:50

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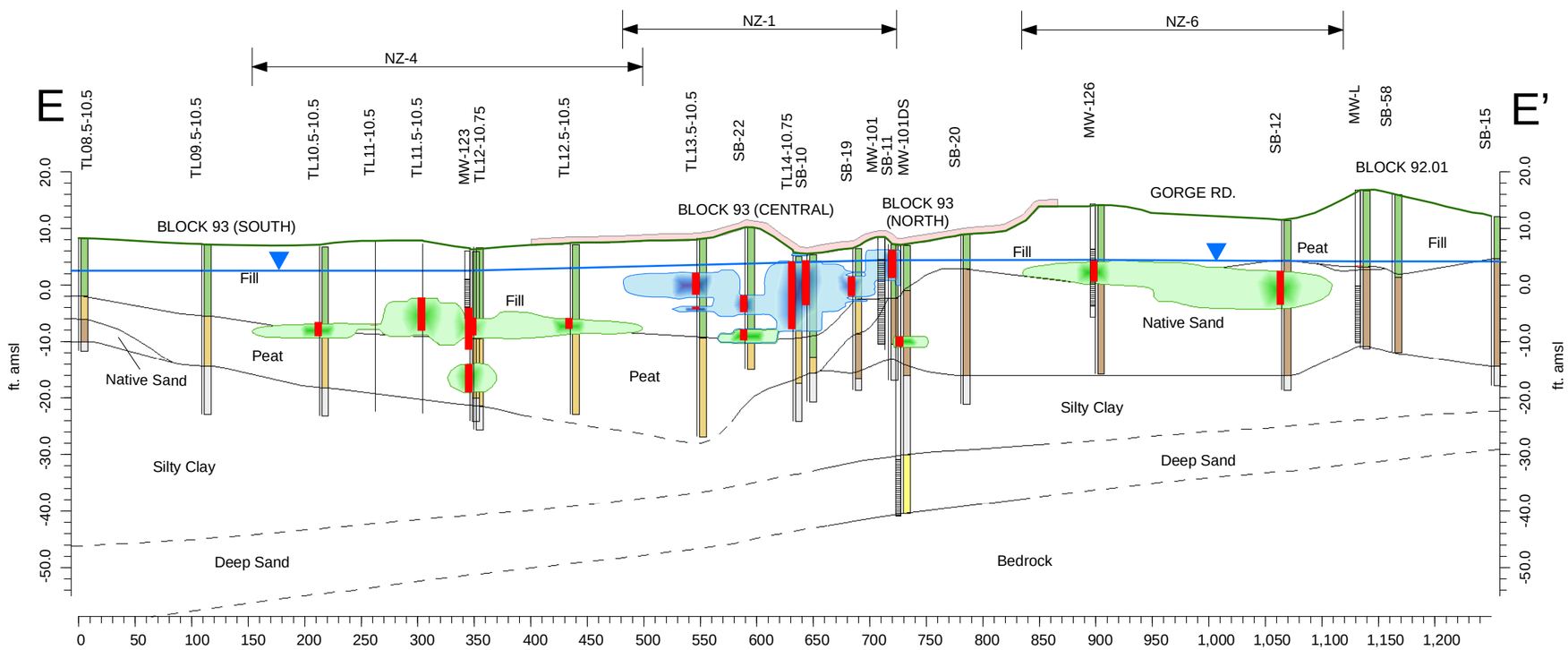


Stratigraphy

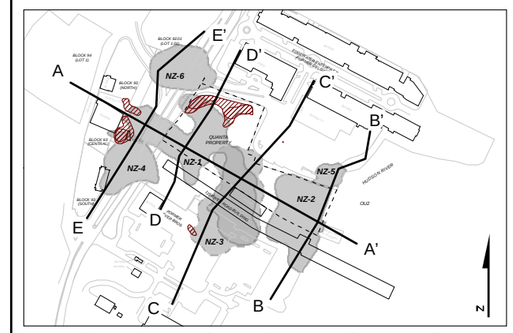
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs,TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet
   amsl = above mean sea level.

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ALTERNATIVE 2
CROSS-SECTION E - E'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-6**

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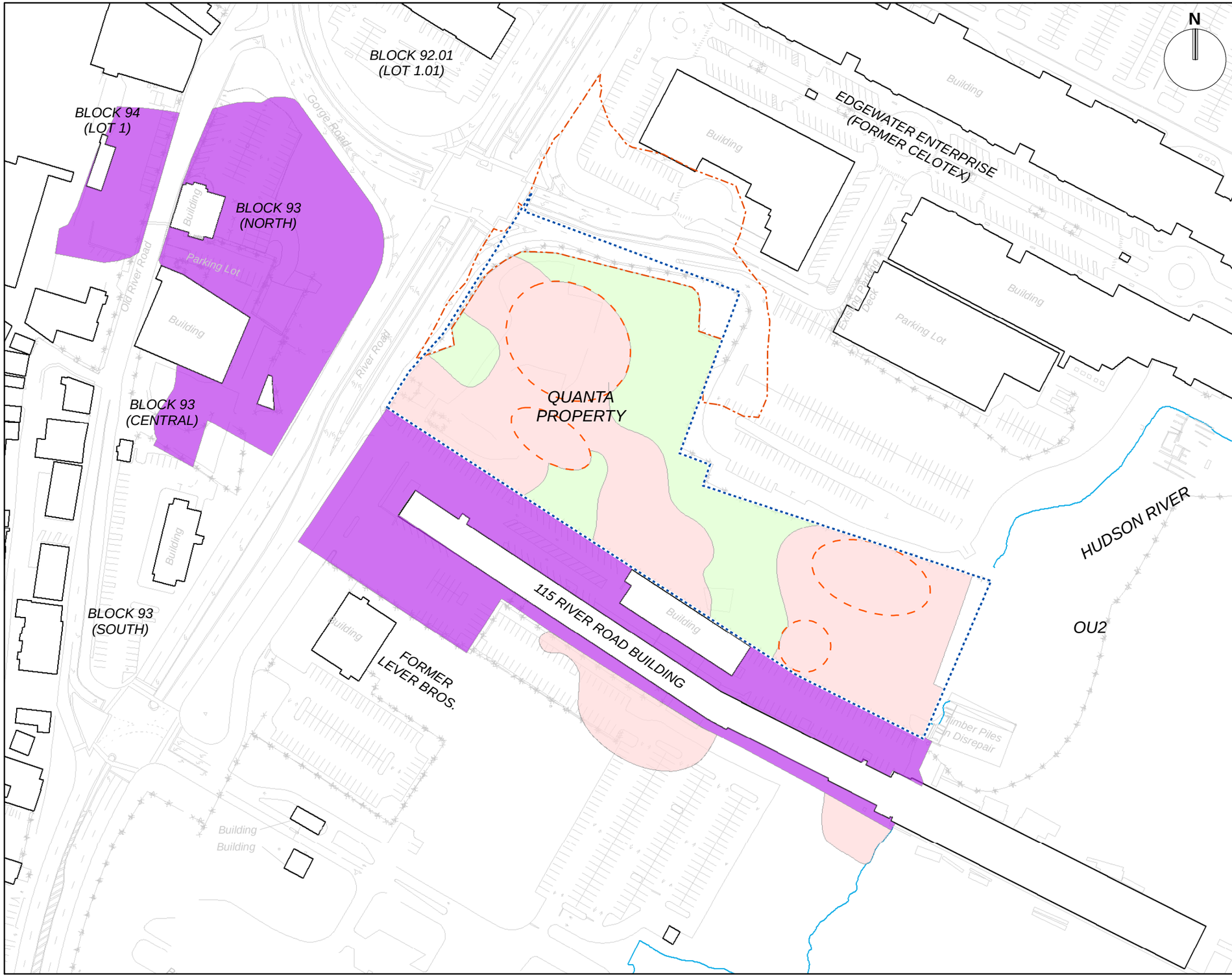

LEGEND

- Hudson River Shoreline
- Quanta Property Boundary
- Existing Arsenic Liner
- Asphalt Cap
- Engineered Cap
- Engineered Cap or Cover Selection based on technology implemented (see note 1)
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Notes:

1. Engineered cap for Alternatives 2 and 3. Soil cover for Alternatives 4, 5, and 6.
2. Existing road surfaces and on-slab grade formations will remain in place and are maintained by others.
3. Arsenic liner remains and is maintained by others.

0 70 140 ft.

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EXTENT OF CAPPING

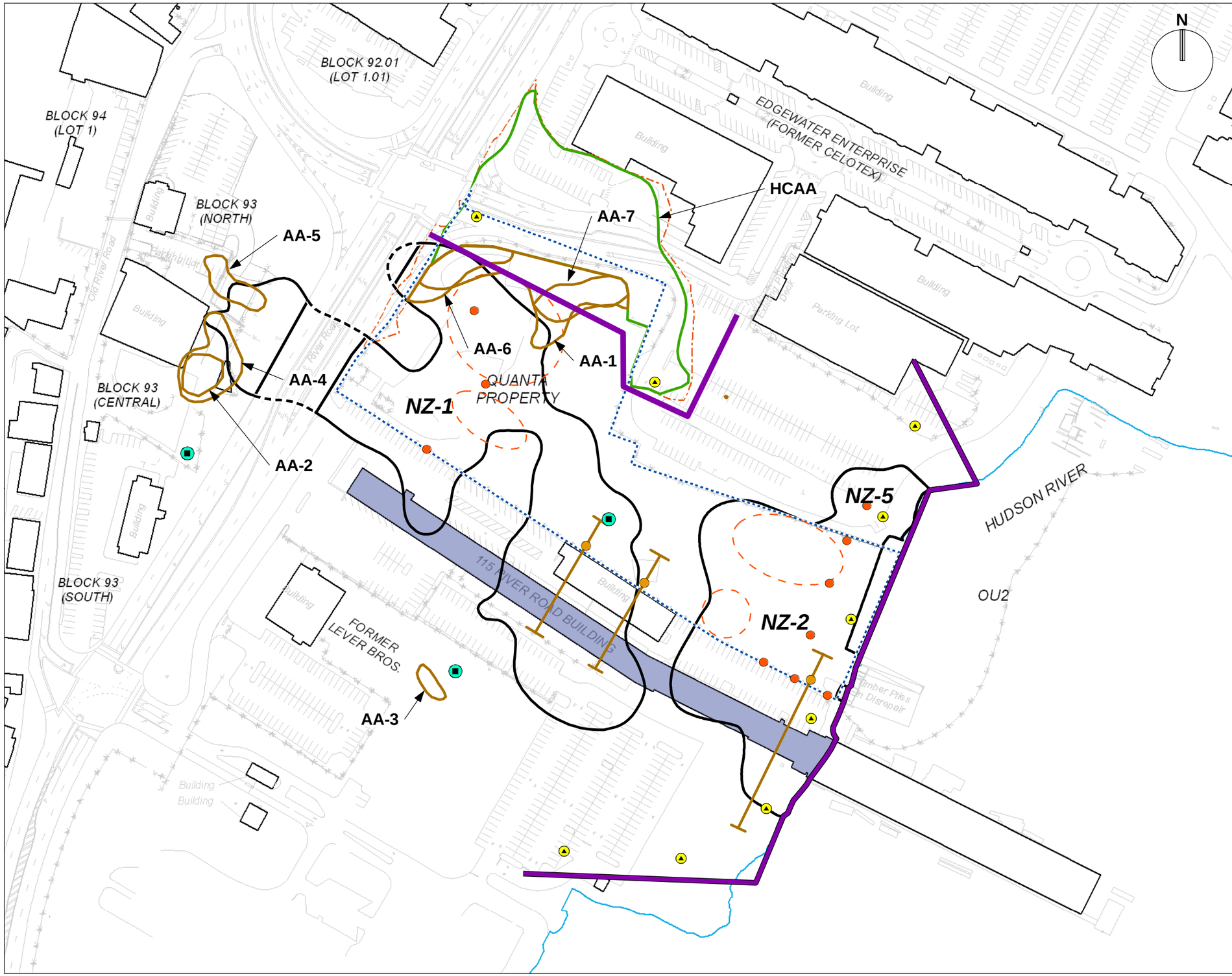
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 4-7

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-07_QUANTAOU1_EXTENT_OF_CAPPING.MXD JHANSEN1 7/6/2010 15:23:14

400190



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 Principal Threat NAPL Zone
- HCAA High Concentration Arsenic Area
- AA-7 Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Vapor Intrusion Engineering Controls
- Barrier Wall
- Horizontal NAPL Recovery Well and Sump
- Groundwater Extraction Well
- NAPL Recovery Wells
- Passive NAPL Recovery

Note:

1. Alternative also includes capping of residual soils
2. Final recovery well layout to be finalized during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

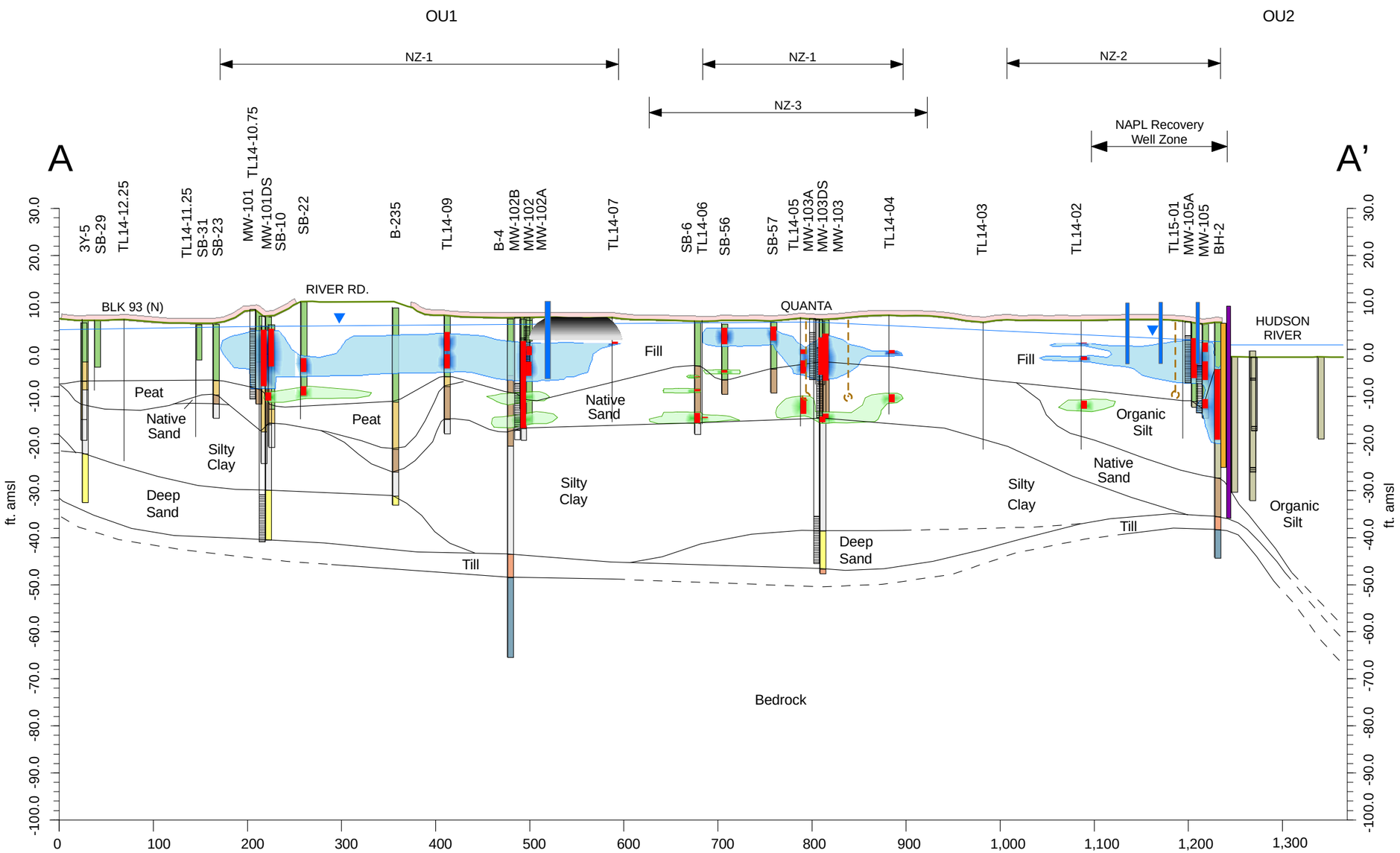
ALTERNATIVE 3 - NAPL AND ARSENIC CONTAINMENT WITH NAPL RECOVERY

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-8**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-08_QUANTAOU1_ALT3_NAPL_AND_ARSENIC_CONTAINMENT_WITH_NAPL_RECOVERY.MXD JHANSEN1 7/7/2010 14:28:35

400191



Stratigraphy

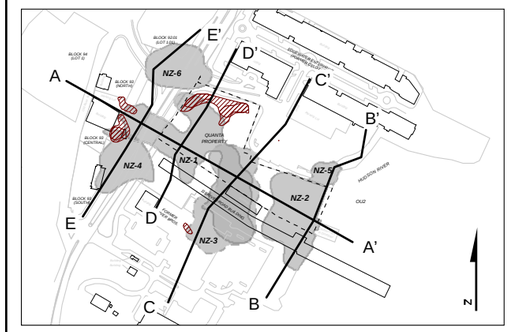
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- NAPL Recovery Well
- Water Table
- Recovery Wells (Perpendicular to Cross-section)
- Engineered Cap
- Tar Boils
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
8. ft. = feet, amsl = above mean sea level

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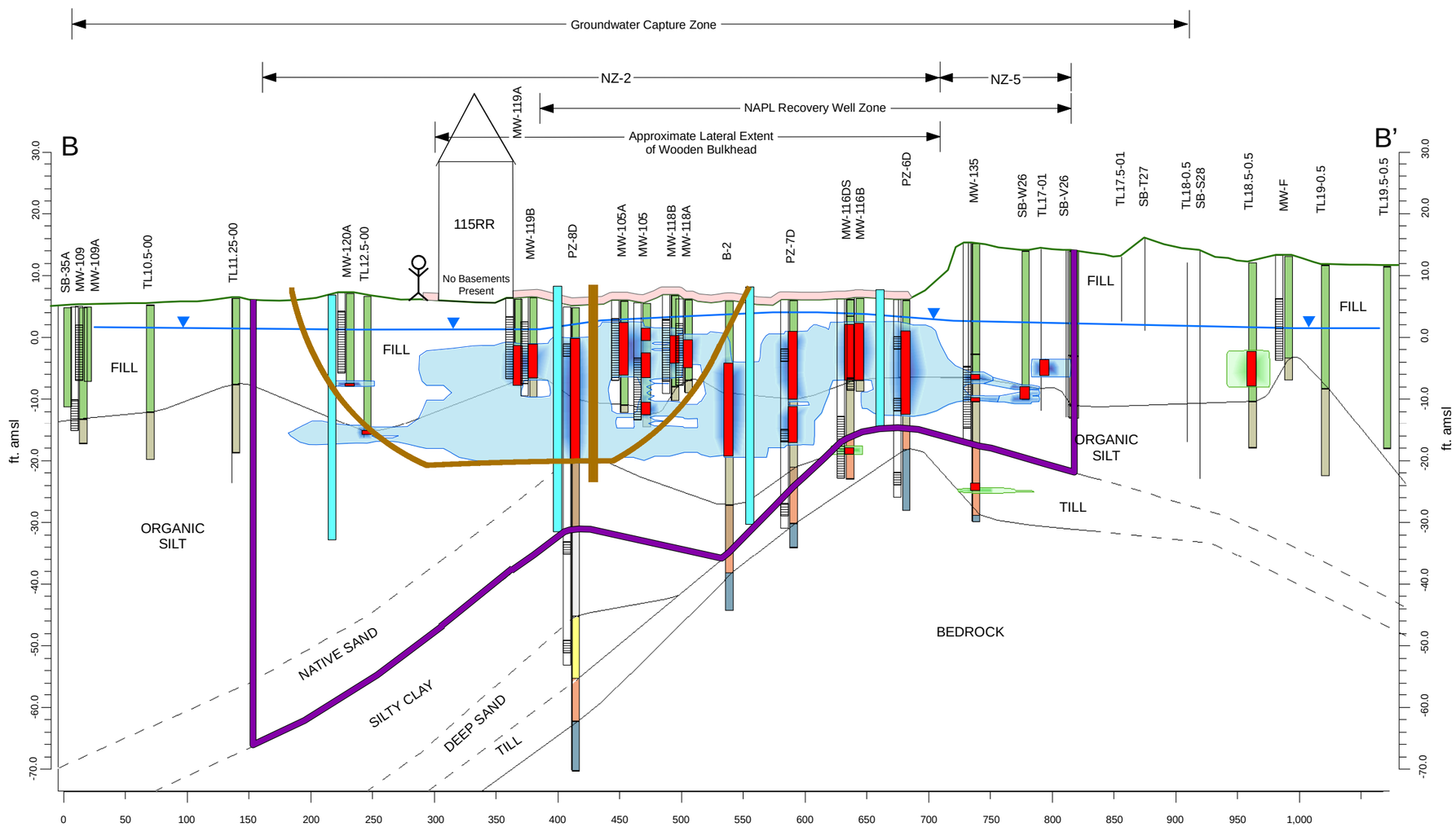
ALTERNATIVE 3
CROSS-SECTION A - A'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-9**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT3_CROSSSECTIONS\4-09_NAPL CONTAINMENT ALT 3 OU1 CROSS SECTION A-A.MXD JHANSEN1 7/6/2010 15:20:37

400192



Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Recovery Sump
- Groundwater Extraction Well
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Barrier Wall
- Engineered Cap
- Passive NAPL Recovery Wells

Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. ft. = feet
   amsl = above mean sea level
8. 115 River Road dimensions are estimated.
9. Configuration of the barrier wall is approximated for visual depiction and will be determined during remedial design.

CH2MHILL

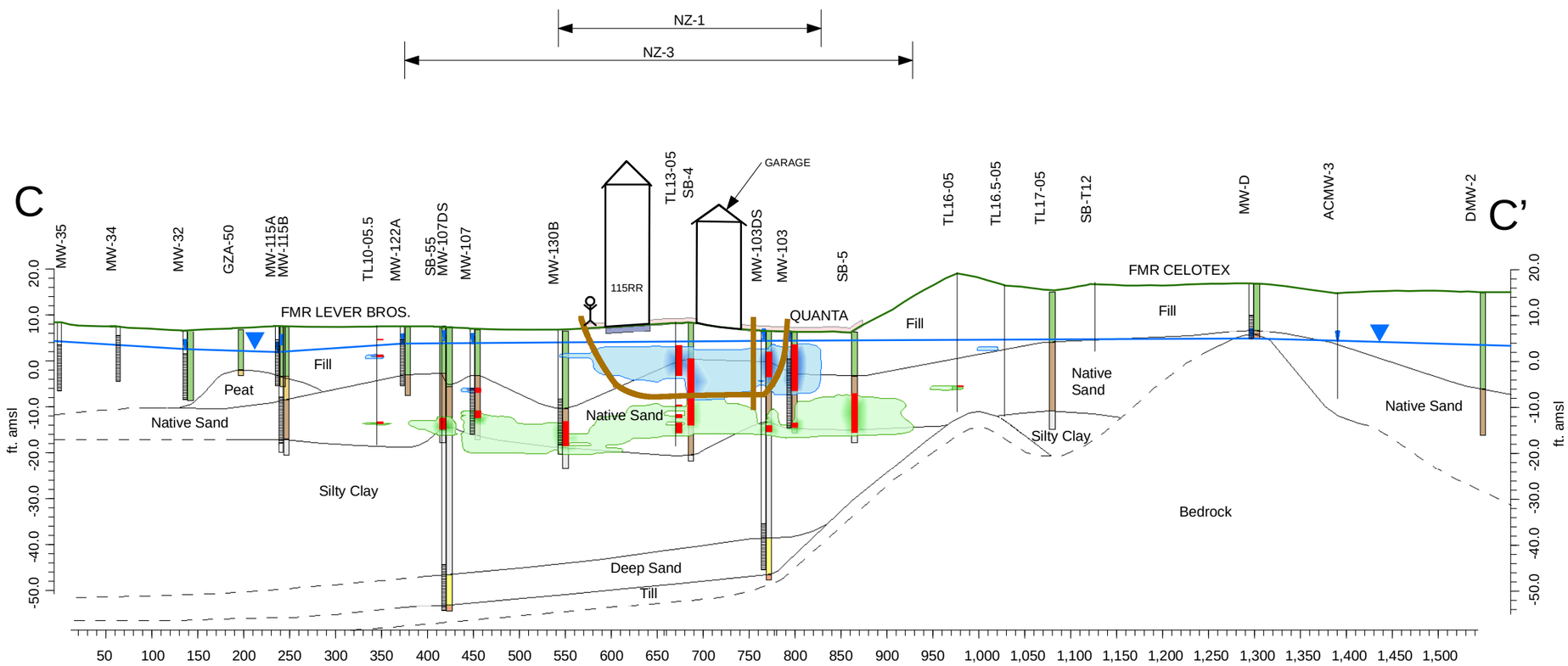
ALTERNATIVE 3
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-10**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT3_CROSSSECTIONS\4-10_NAPL CONTAINMENT ALT 3 OU1 CROSS SECTION B-B.MXD JHANSEN1 7/6/2010 15:27:57

400193



Stratigraphy

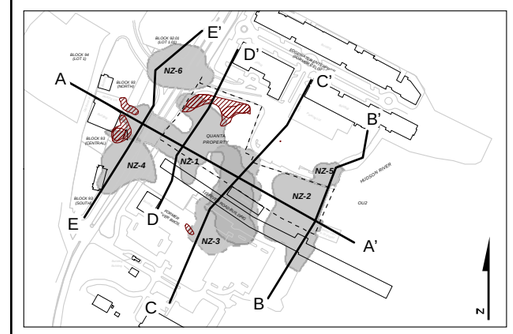
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Water Table
- Recovery Sump
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Engineered Cap
- Vapor Intrusion Engineering Controls
- Passive NAPL Recovery Wells



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOS (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.

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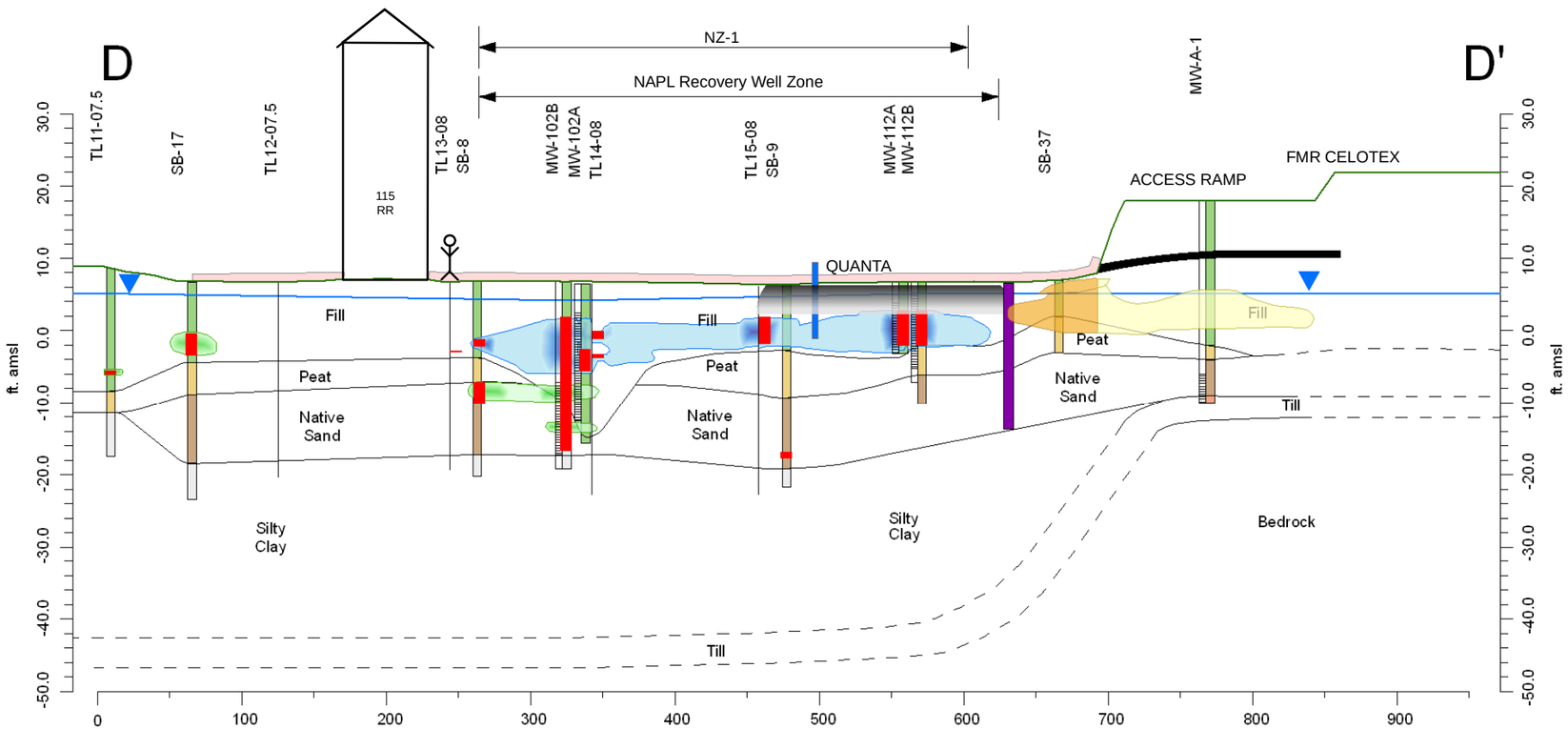
ALTERNATIVE 3
CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-11**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT3_CROSSSECTIONS\4-11_NAPL CONTAINMENT ALT 3 OU1 CROSS SECTION C-C.MXD JHANSEN1 7/6/2010 15:29:07

400194



Stratigraphy

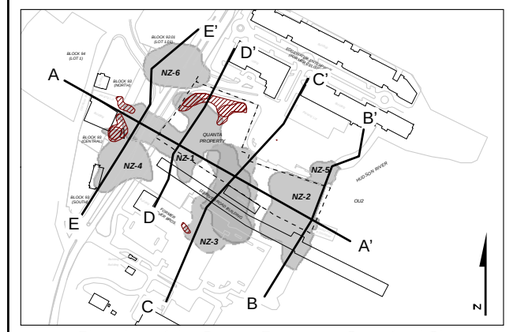
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Recovery Well
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Areas
- Existing Arsenic Liner
- Engineered Cap
- Tar Boils
- Barrier Wall



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. ft. = feet, amsl = above mean sea level
8. 115 River Road dimensions are estimated.

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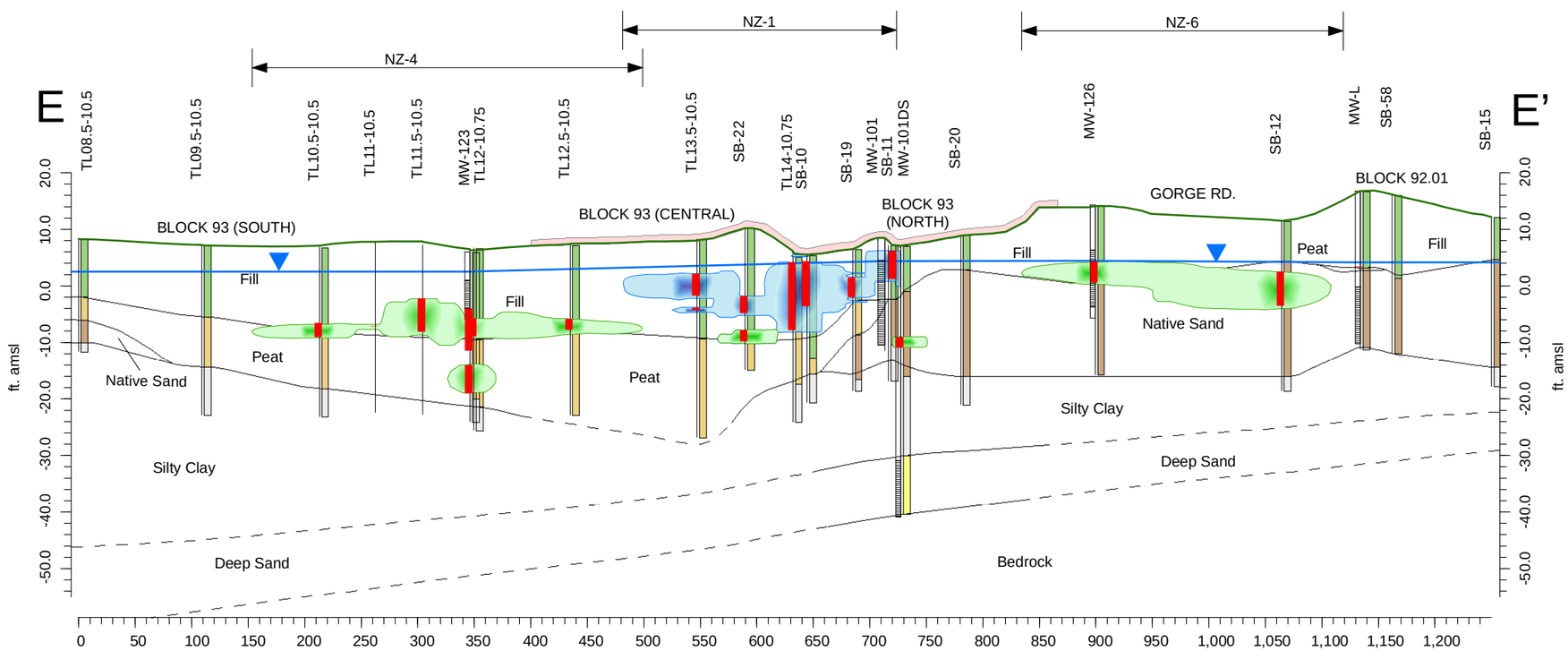
ALTERNATIVE 3
CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-12**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT3_CROSSSECTIONS\4-12_NAPL CONTAINMENT ALT 3 OU1 CROSS SECTION D-D.MXD JHANSEN1 7/6/2010 15:30:48

400195



Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap

Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level

CH2MHILL

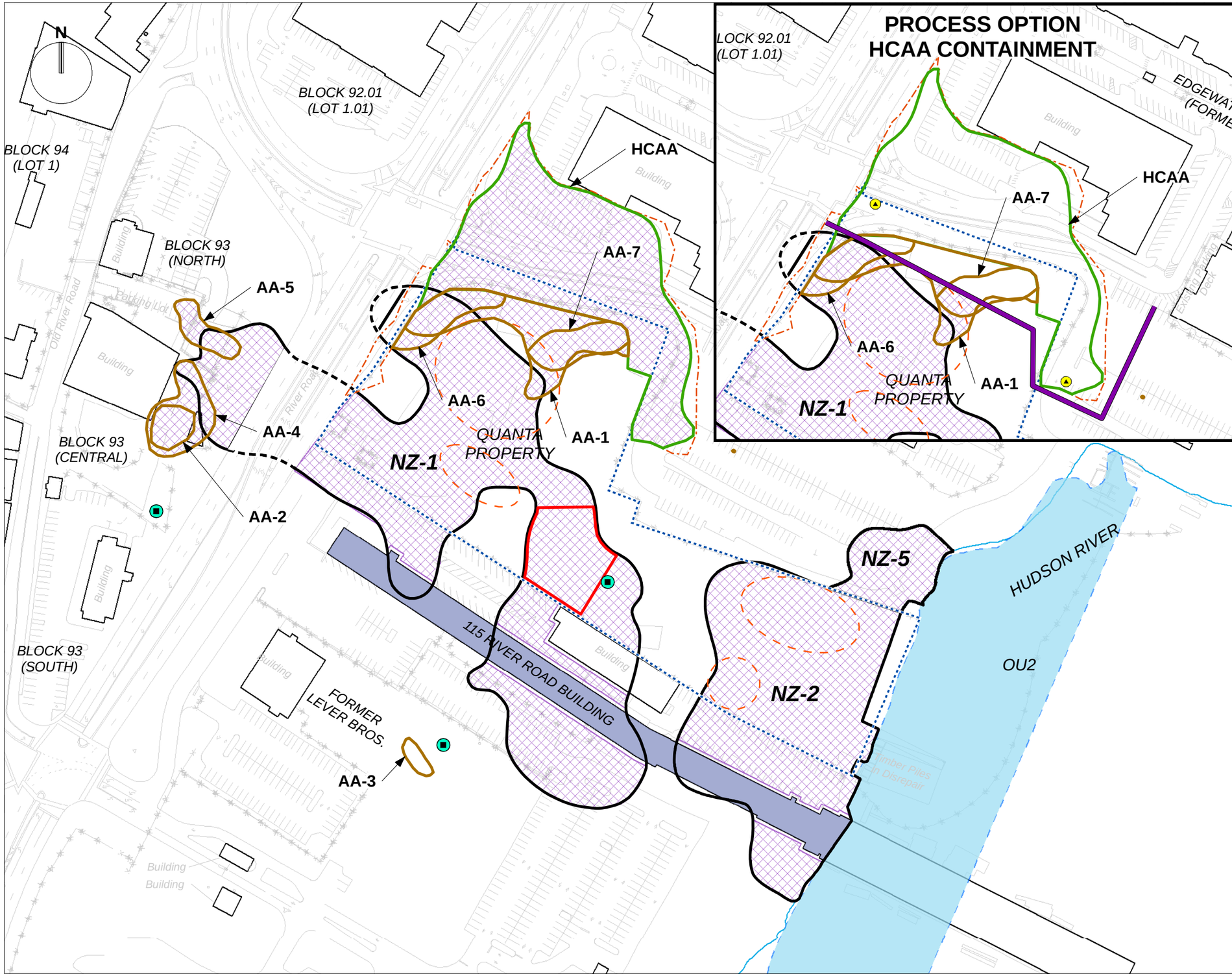
ALTERNATIVE 3
CROSS-SECTION E - E'

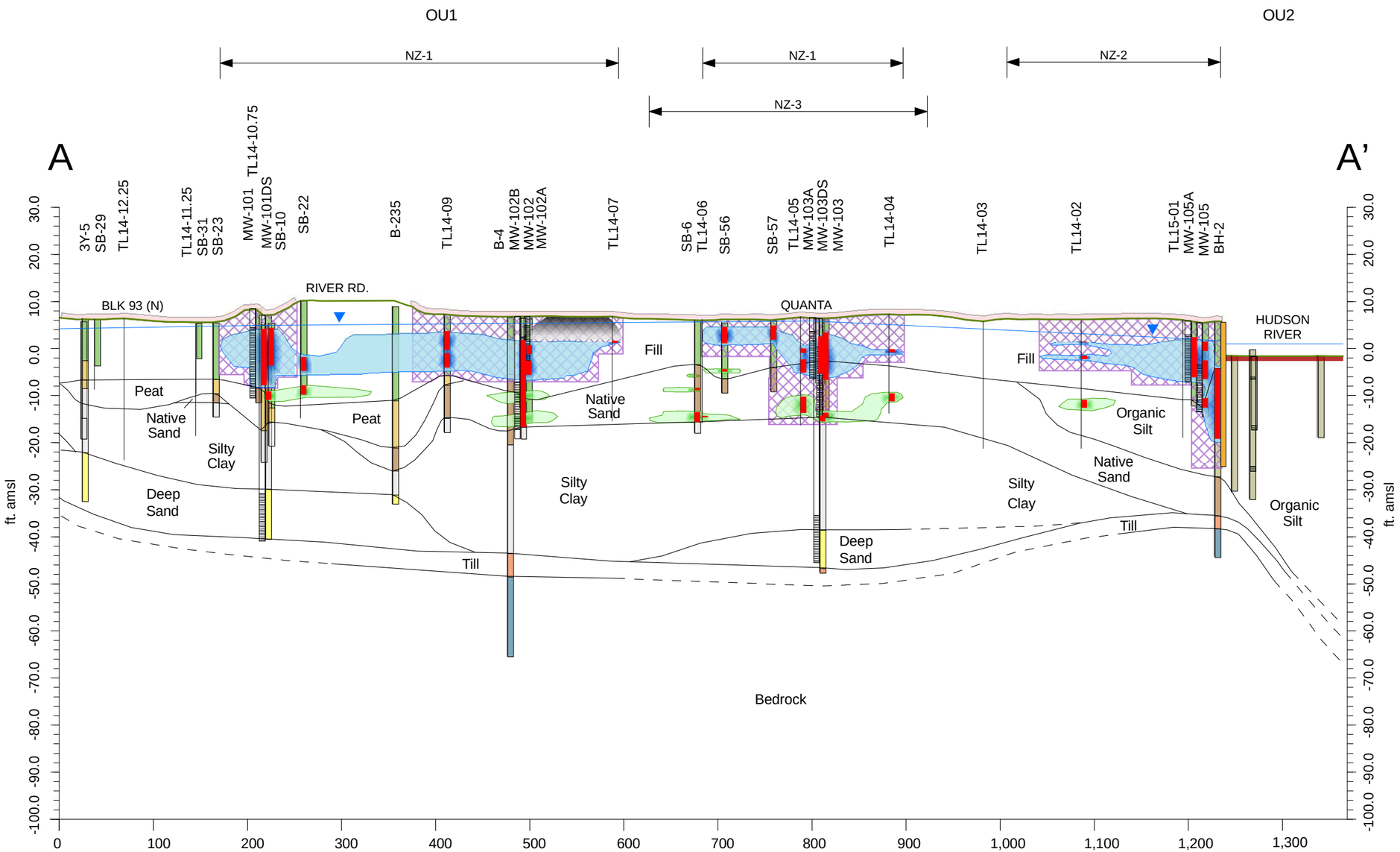
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-13**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT3_CROSSSECTIONS\4-13_NAPL CONTAINMENT ALT 3 OU1 CROSS SECTION E-E.MXD JHANSEN1 7/6/2010 16:38:02

400196


N
BLOCK 94
(LOT 1)
BLOCK 92.01
(LOT 1.01)
BLOCK 93
(NORTH)
BLOCK 93
(CENTRAL)
BLOCK 93
(SOUTH)
Old River Road
River Road
Building
Parking Lot
HCAA
AA-7
AA-5
AA-6
AA-4
AA-1
AA-2
AA-3
NZ-1
QUANTA
PROPERTY
NZ-5
NZ-2
115 RIVER ROAD BUILDING
FORMER
LEVER BROS.
HUDSON RIVER
OU2
Building
Building
Building



Stratigraphy

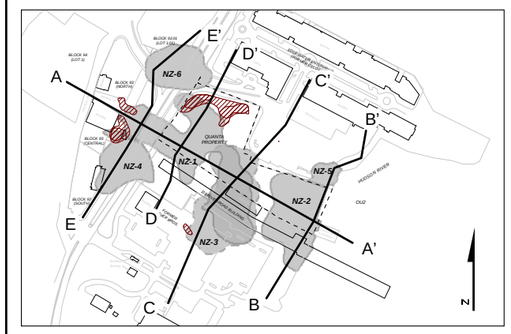
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Solidification/ Stabilization
- Tar Boils
- Engineered Cap
- Subaqueous Reactive Barrier (SRB)



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2
7. ft. = feet, amsl = above mean sea level

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ALTERNATIVE 4a & b
CROSS-SECTION A - A'

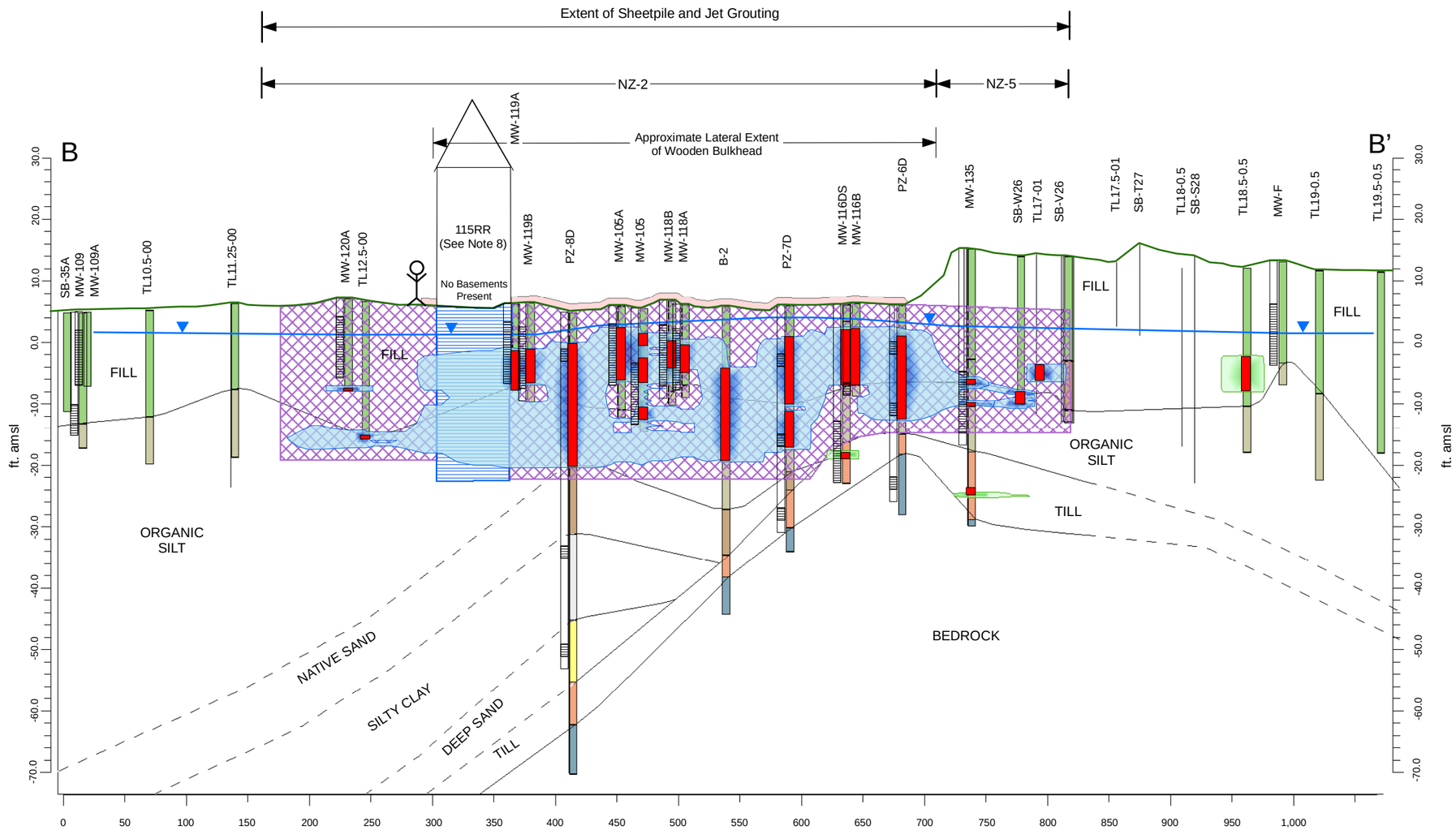
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 4-15

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT4_CROSSSECTIONS\4-15AB_ NAPL CONTAINMENT ALT 4 OU1 CROSS SECTION A-A.MXD JHANSEN1 7/6/2010 15:33:53

400198



Stratigraphy

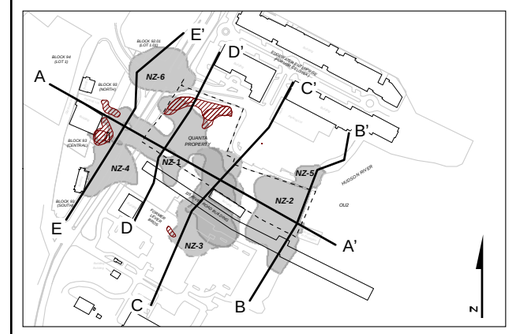
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap
- In Situ Solidification/ Stabilization
- Barrier Wall



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road and garage dimensions are estimated.
8. Alternative 4b includes the demolition of the 115 River Road buildings with in situ solidification/stabilization of NAPL under building.

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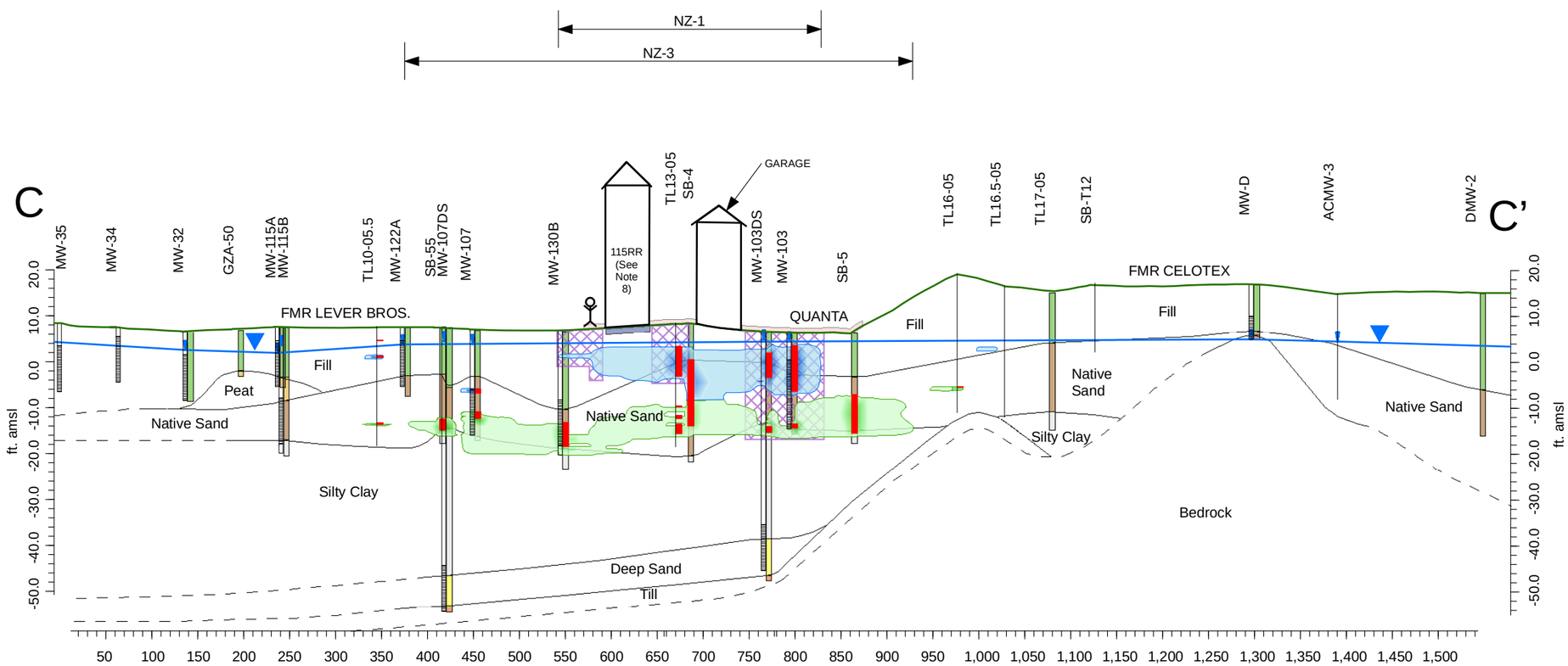
ALTERNATIVE 4a & b
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-16**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT4_CROSSSECTIONS\4-16AB_NAPL CONTAINMENT ALT 4 OU1 CROSS SECTION B-B.MXD JHANSEN1 7/6/2010 15:46:47

400199



Stratigraphy

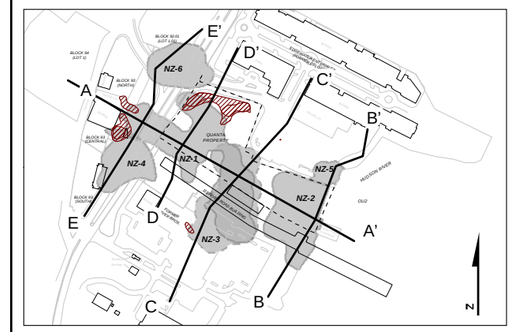
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Interval of Observed NAPL
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Engineered Cap
- Vapor Intrusion Engineering Controls (See Note 8)
- Extent of NAPL Considered Low Level Threat Waste
- In Situ Stabilization/ Solidification



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Alternative 4b includes the demolition of the 115 River Road buildings and in situ stabilization/ solidification of NAPL under the building.

CH2MHILL

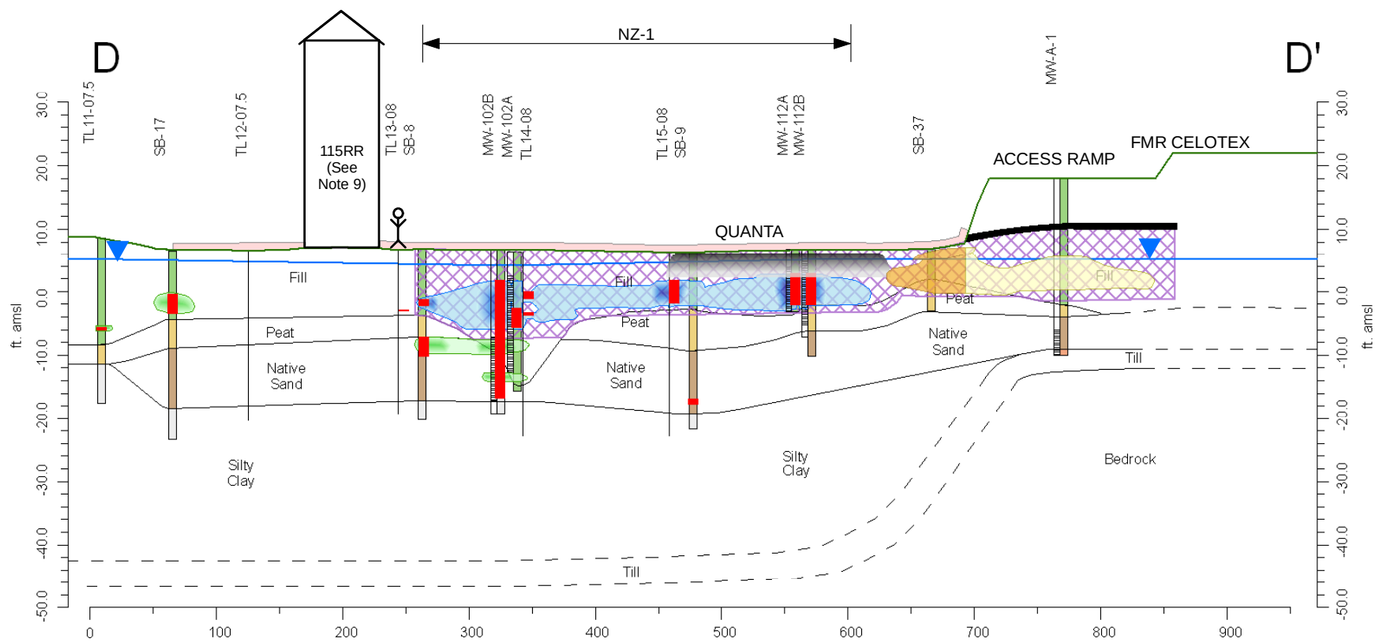
ALTERNATIVE 4a & b
CROSS-SECTION C - C'

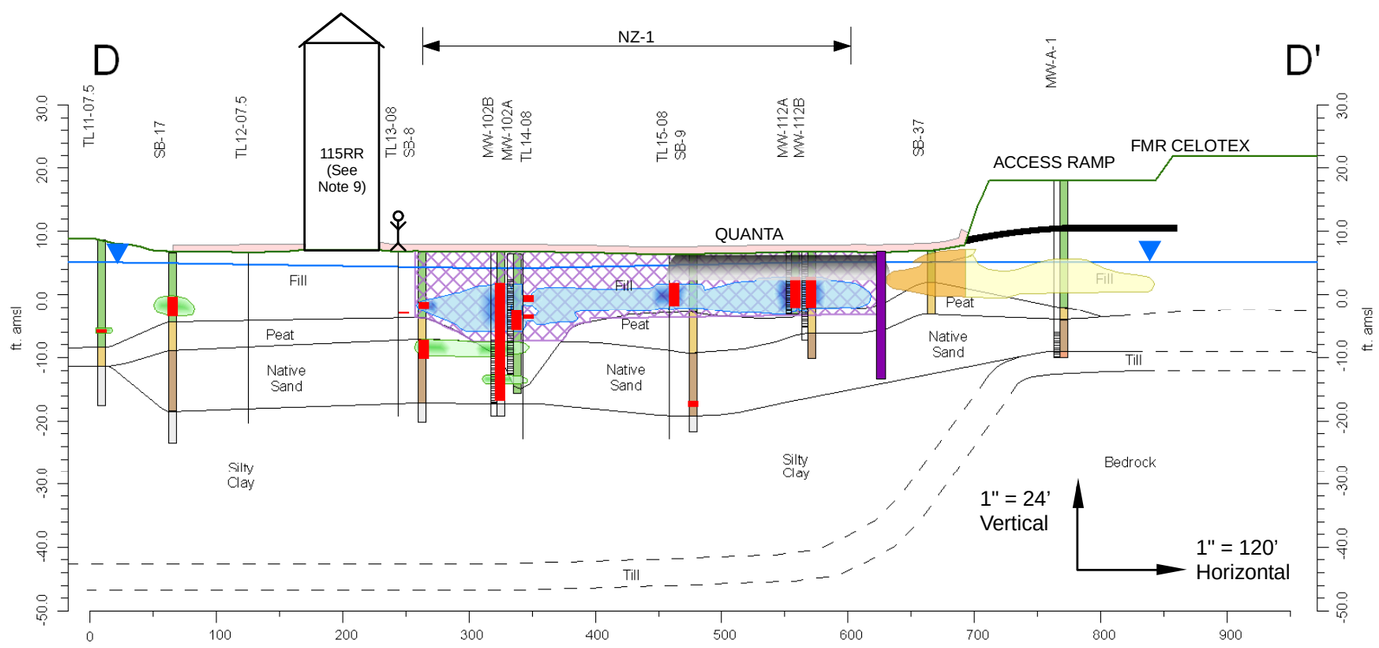
Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-17**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT4_CROSSSECTIONS\4-17AB_NAPL CONTAINMENT ALT 4 OU1 CROSS SECTION C-C.MXD JHANSEN1 7/6/2010 15:58:06

400200





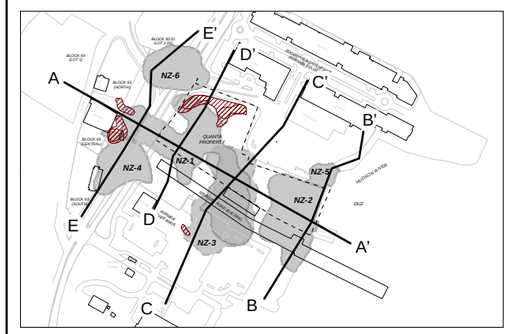
Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

PROCESS OPTION
HCAA CONTAINMENT

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Barrier Wall
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Area
- Existing Arsenic Liner
- Engineered Cap
- Tar Boils
- In Situ Solidification/ Stabilization



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Methods and reagents for solidification and stabilization may vary for the various NAPL and arsenic areas.
9. Alternative 4b includes the demolition of the 115 River Road buildings.

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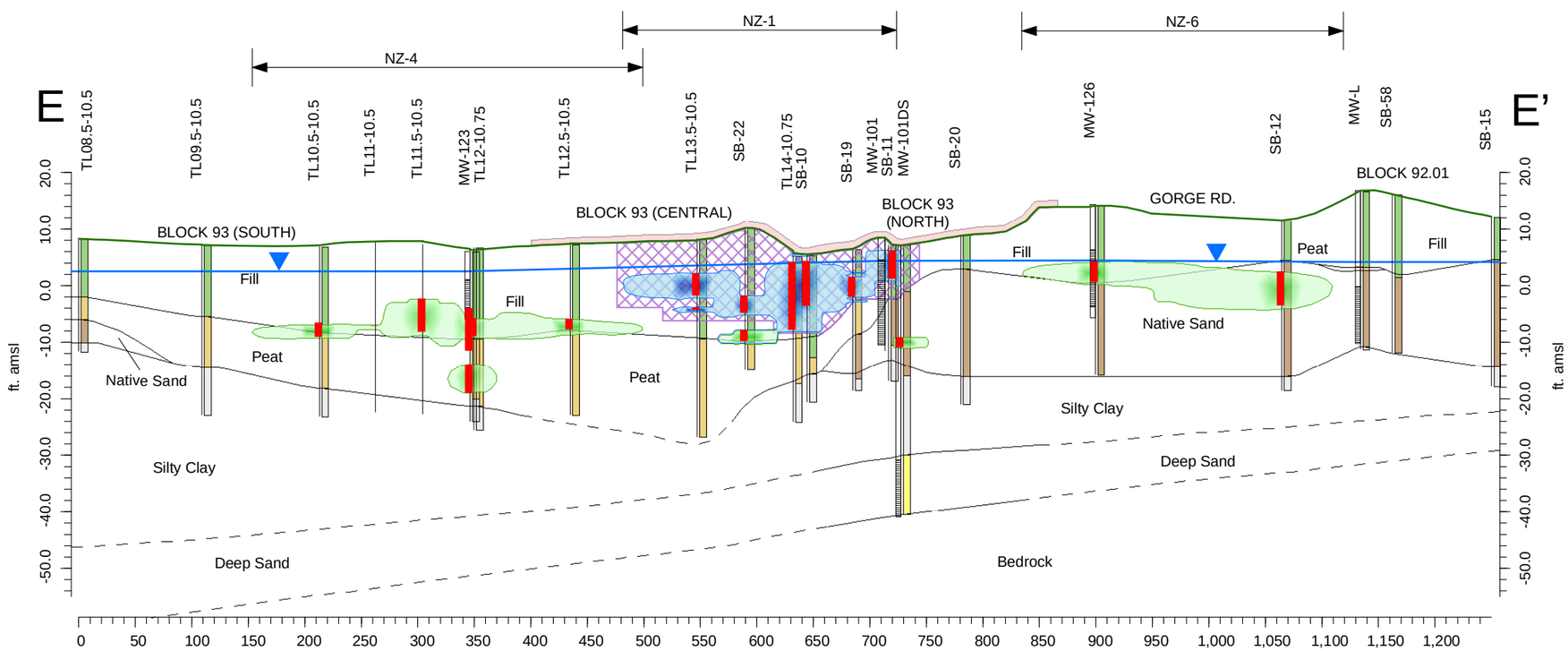
ALTERNATIVE 4a & b
CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-18**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT4_CROSSSECTIONS\4-18AB_NAPL CONTAINMENT ALT 4 OU1 CROSS SECTION D-D.MXD JHANSEN1 7/6/2010 16:02:30

400201



Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- In Situ Stabilization/Solidification
- Engineered Cap

Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level

CH2MHILL

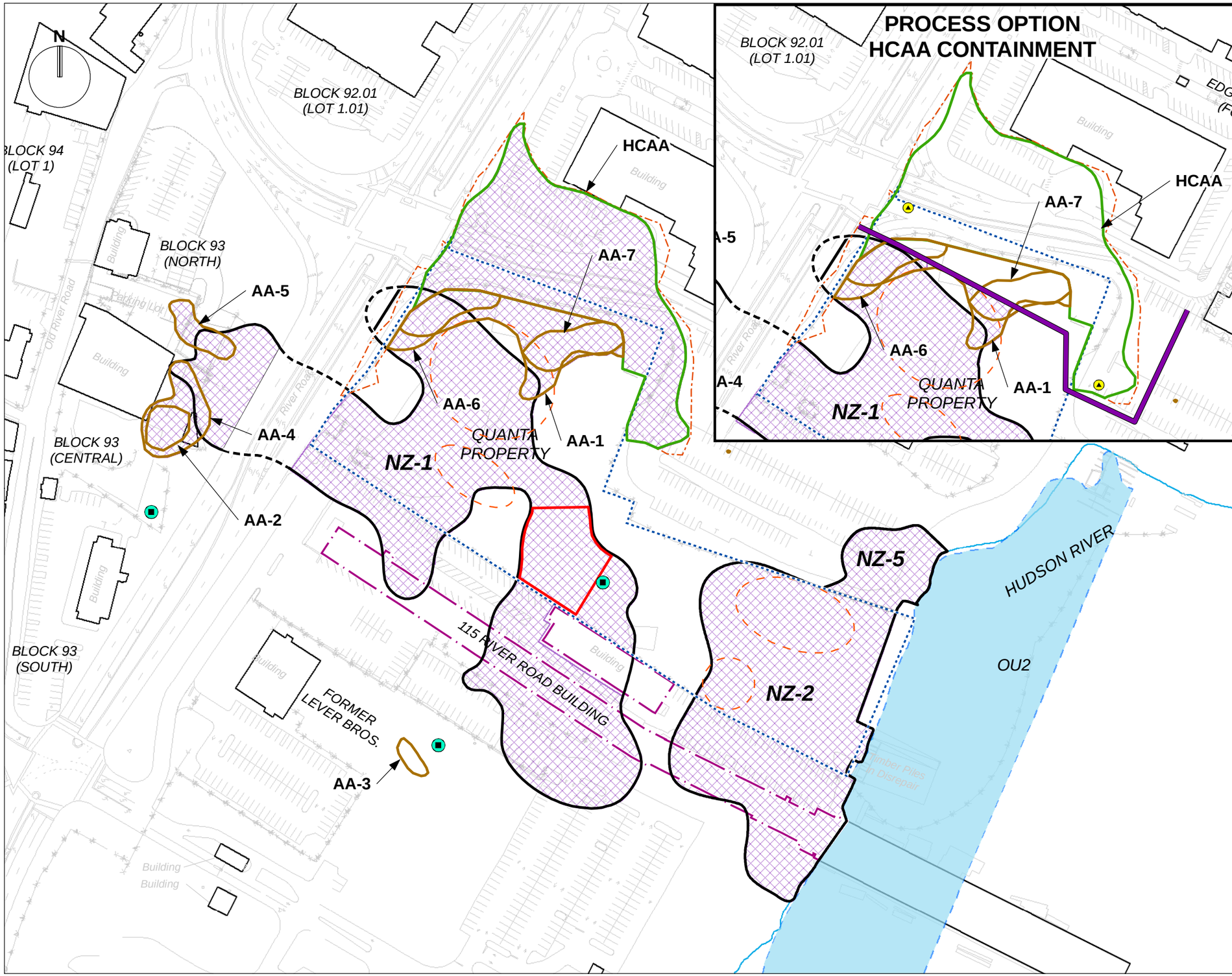
ALTERNATIVE 4a & b
CROSS-SECTION E - E'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-19**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT4_CROSSSECTIONS\4-19AB_NAPL CONTAINMENT ALT 4 OU1 CROSS SECTION E-E.MXD JHANSEN1 7/6/2010 16:01:04

400202



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Demolition
- In Situ Stabilization/Solidification
- Subaqueous Reactive Barrier (SRB)
- Barrier Wall
- Groundwater Extraction Well
- Passive NAPL Recovery

Note:

1. Alternative also includes capping of residual soils.
2. Methods and reagents for solidification and stabilization may vary for the various NAPL and arsenic areas.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

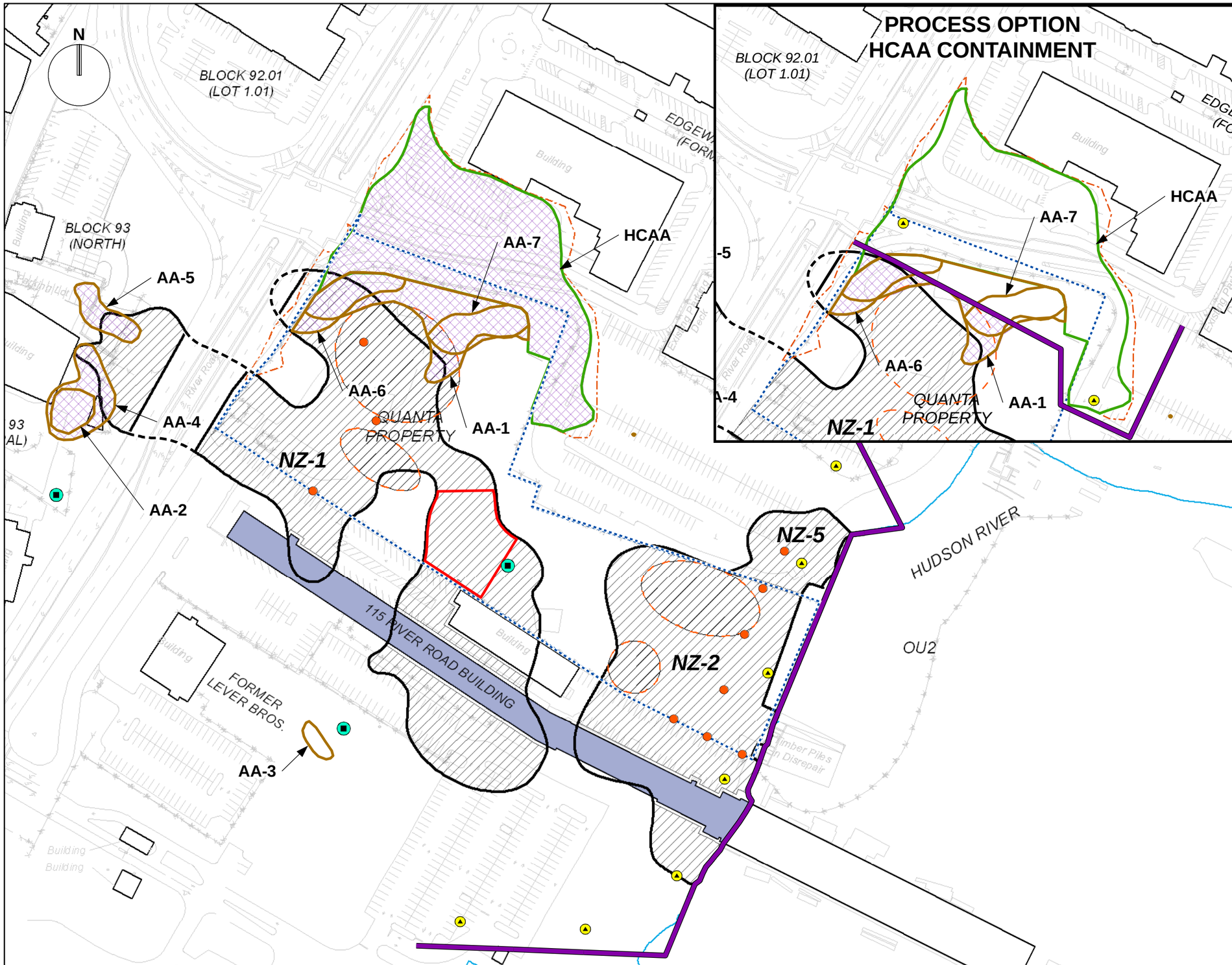
ALTERNATIVE 4B - NAPL AND ARSENIC SOLIDIFICATION/STABILIZATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-20**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-20_QUANTAOU1_ALT4_NAPL_AND_ARSENIC_SOLIDIFICATIONSTABILIZATION_BLDG115_DEMO_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:32:10

400203



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation for NAPL (0 - 4 ft bgs)/ Tar Boils and ISCO
- Stabilization
- Vapor Intrusion Engineering Controls
- Barrier Wall
- NAPL Recovery Wells
- Groundwater Extraction Well
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
3. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

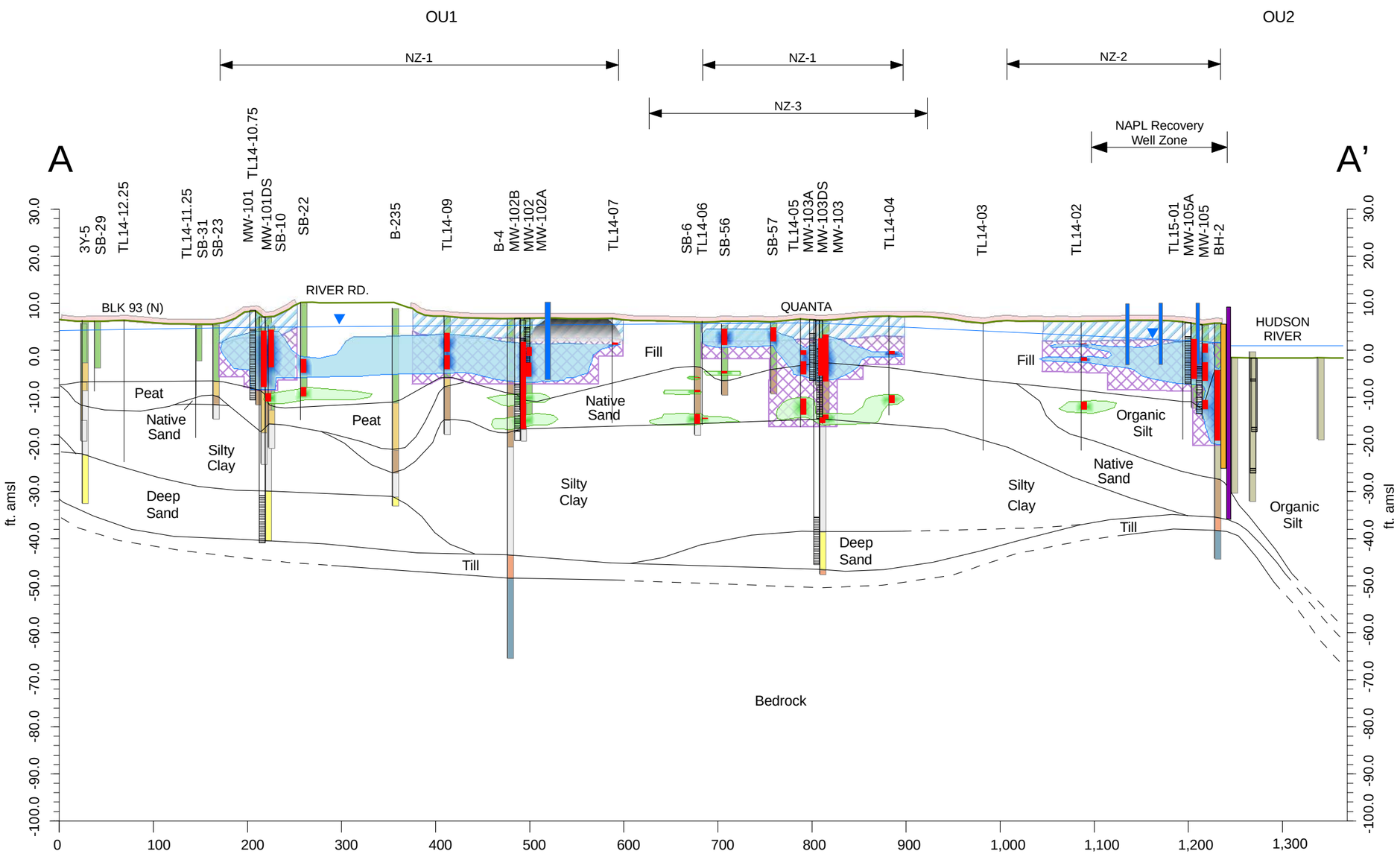
ALTERNATIVE 5A - NAPL IN SITU CHEMICAL OXIDATION WITH ARSENIC STABILIZATION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-21**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-21_QUANTAOU1_ALT5_NAPLINSITUCHEMICALOXIDATION_WITH_ARSENIC_STABILIZATION_WITH_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:34:46

400204



Stratigraphy

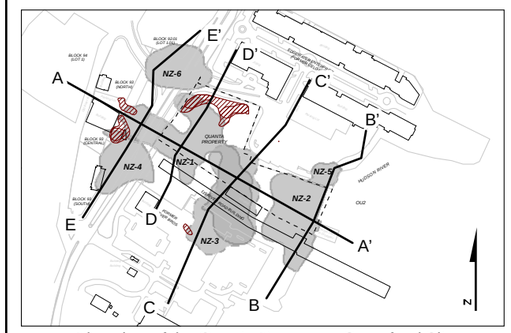
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Barrier Wall
- NAPL Recovery Well
- Water Table
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Tar Boils
- Stabilization
- InSitu Chemical Oxidation
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
8. ft. = feet, amsl = above mean sea level

CH2MHILL

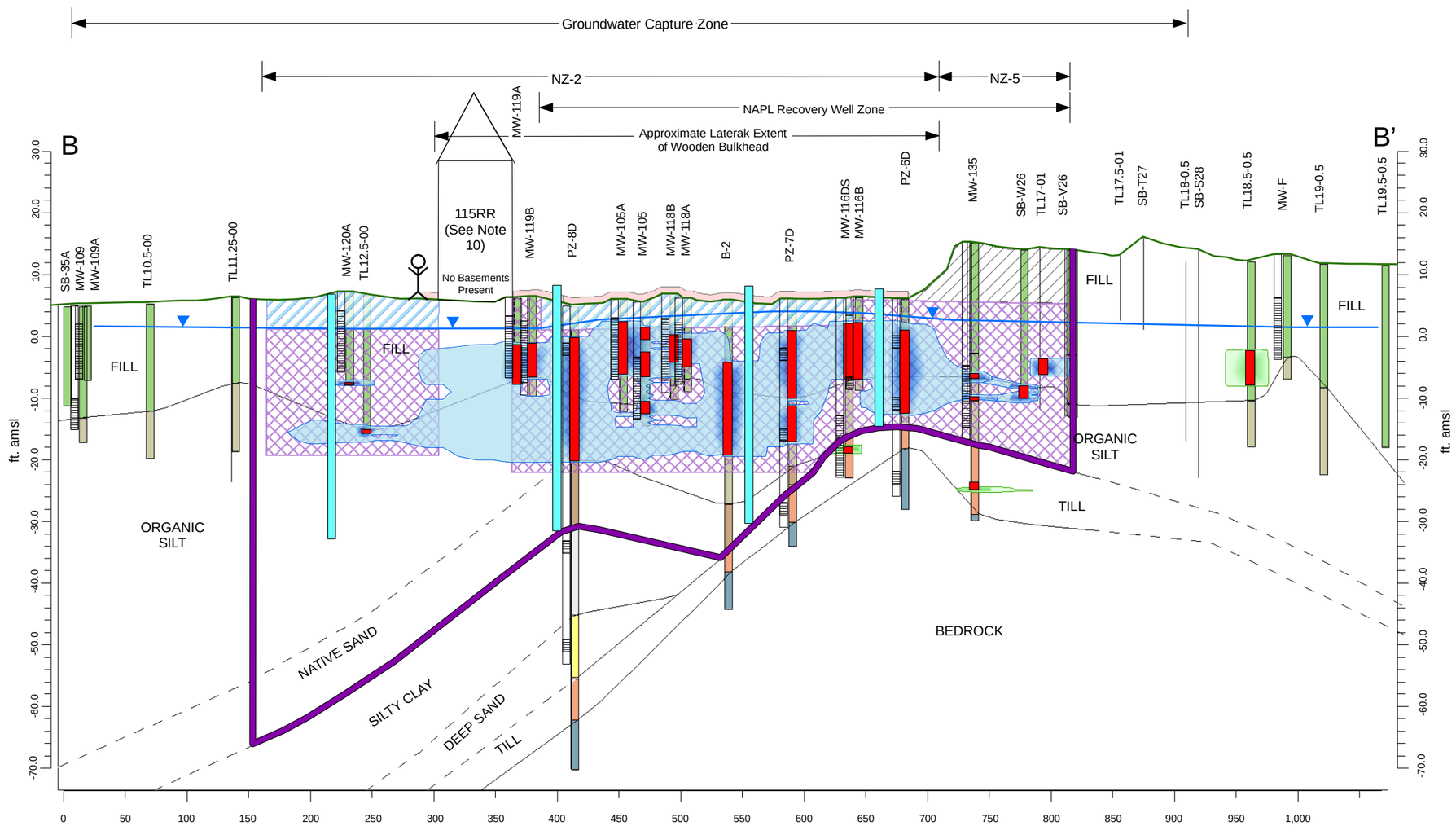
ALTERNATIVE 5a & b
CROSS-SECTION A - A'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-22**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT5_CROSSSECTIONS\4-22_NAPL TREATMENT & CONTAINMENT ALT 5 OU1 CROSS SECTION A-A.MXD JHANSEN1 7/6/2010 16:13:43

400205



Stratigraphy

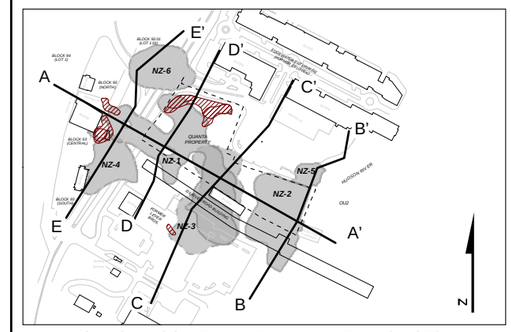
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Barrier Wall
- Groundwater Extraction Wells
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Excavation
- Material to be Removed Prior ISCO
- In Situ Chemical Oxidation (ISCO)
- Engineered Cap



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. ft. = feet, amsl = above mean sea level
8. 115 River Road dimensions are estimated.
9. Configuration of the barrier wall is approximated for visual depiction and will be determined during remedial design.
10. Alternative 5b includes the demolition of the 115 River Road buildings with shallow excavation and ISCO of NAPL beneath the building.

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ALTERNATIVE 5a & b
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE 4-23

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT5_CROSSSECTIONS\4-23_NAPL TREATMENT & CONTAINMENT ALT 5 OU1 CROSS SECTION B-B.MXD JHANSEN1 7/6/2010 16:16:32

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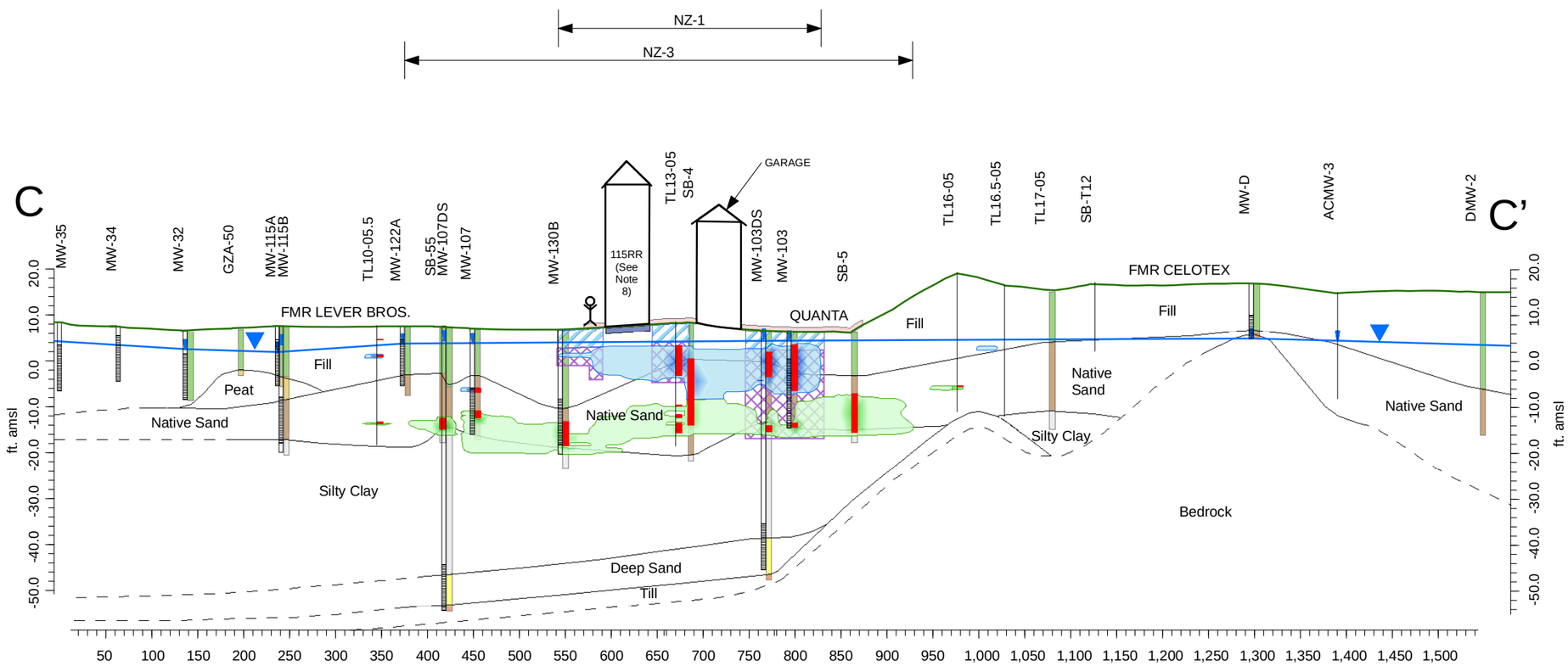


Stratigraphy

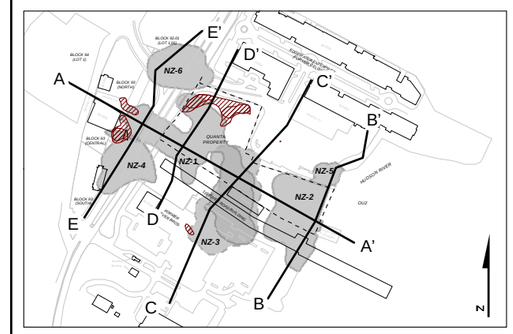
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Excavation
- InSitu Chemical Oxidation
- Engineered Cap
- Vapor Intrusion Engineering Controls (See Note 8)



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Alternative 5b includes the demolition of the 115 River Road building with shallow excavation and ISCO of NAPL beneath the building.

CH2MHILL

ALTERNATIVE 5a & b
CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-24**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT5_CROSSSECTIONS\4-24_NAPL TREATMENT & CONTAINMENT ALT 5 OU1 CROSS SECTION C-C.MXD JHANSEN1 7/6/2010 16:17:24

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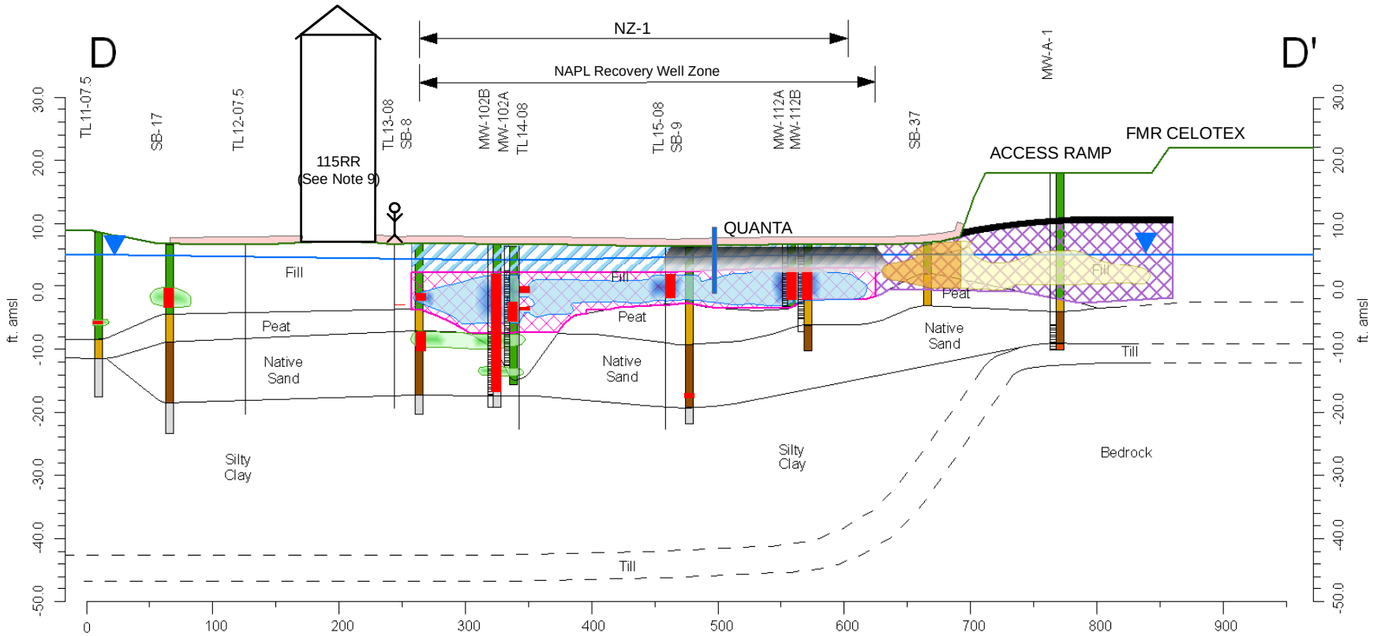
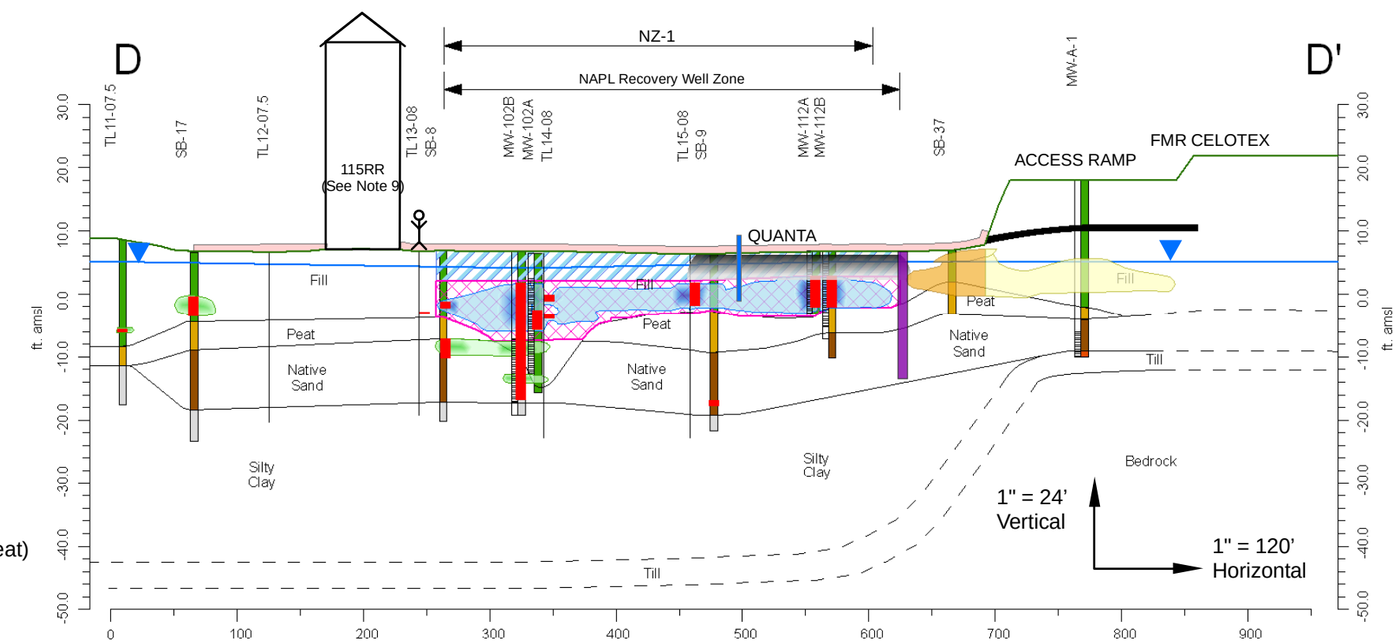




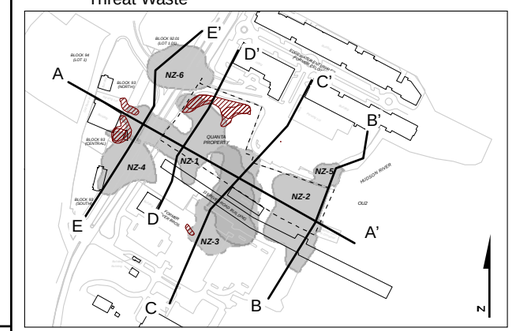
Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

PROCESS OPTION
HCAA CONTAINMENT

LEGEND

- Water Table
- Interval of Observed NAPL
- Recovery Well
- Barrier Wall
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Arsenic Area
- Existing Arsenic Liner
- Engineered Cap
- Tar Boils
- InSitu Chemical Oxidation
- Stabilization
- Excavation



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Recovery wells were located based on highest TarGOST responses and where NAPL was observed in a well.
3. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
4. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
5. Water table elevation depiction based on synoptic measurements taken in March 2009.
6. Dashed lithology lines are inferred from data and observations.
7. ft. = feet, amsl = above mean sea level
8. 115 River Road dimensions are estimated.
9. Alternative 5b includes the demolition of the 115 River Road building.

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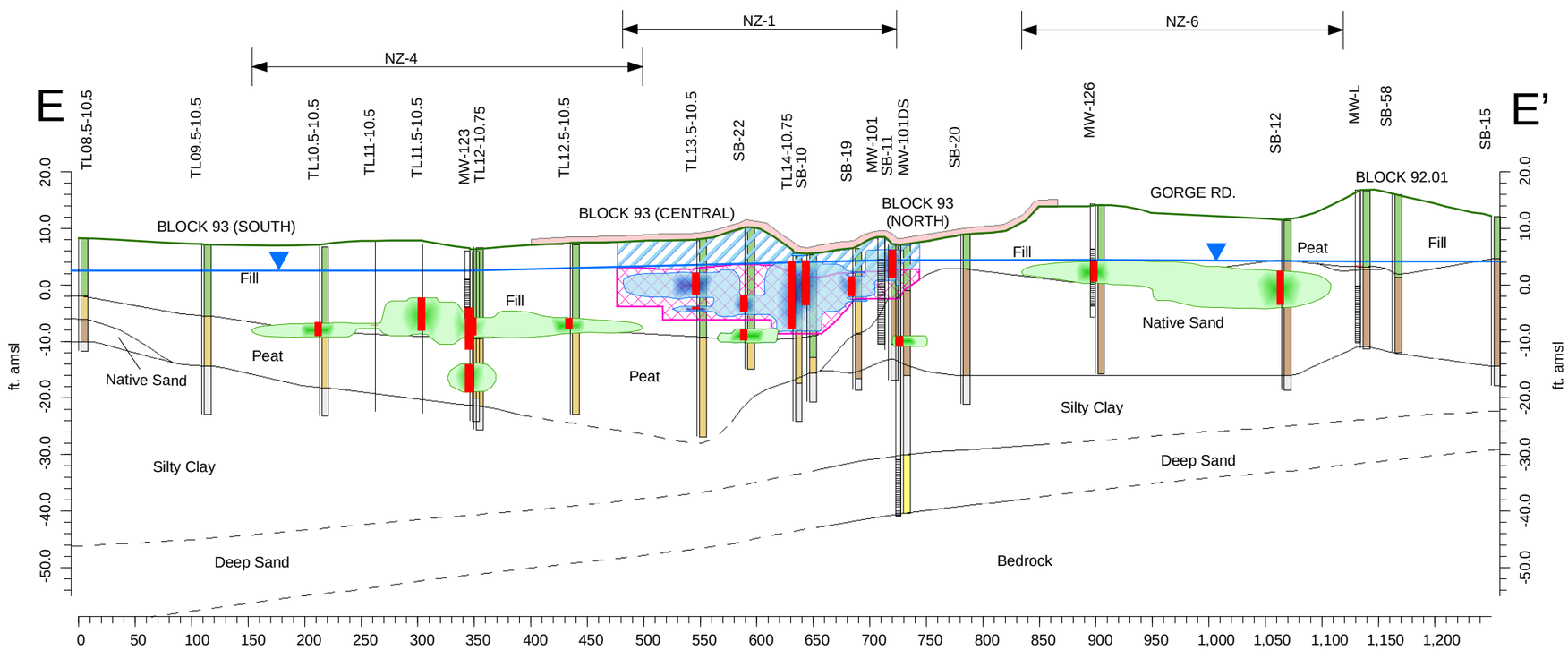
ALTERNATIVE 5a & b
CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-25**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT5_CROSSSECTIONS\4-25_NAPL TREATMENT & CONTAINMENT ALT 5 OU1 CROSS SECTION D-D.MXD JHANSEN1 7/6/2010 16:18:43

400208



Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Engineered Cap
- Excavation
- In Situ Chemical Oxidation

Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level

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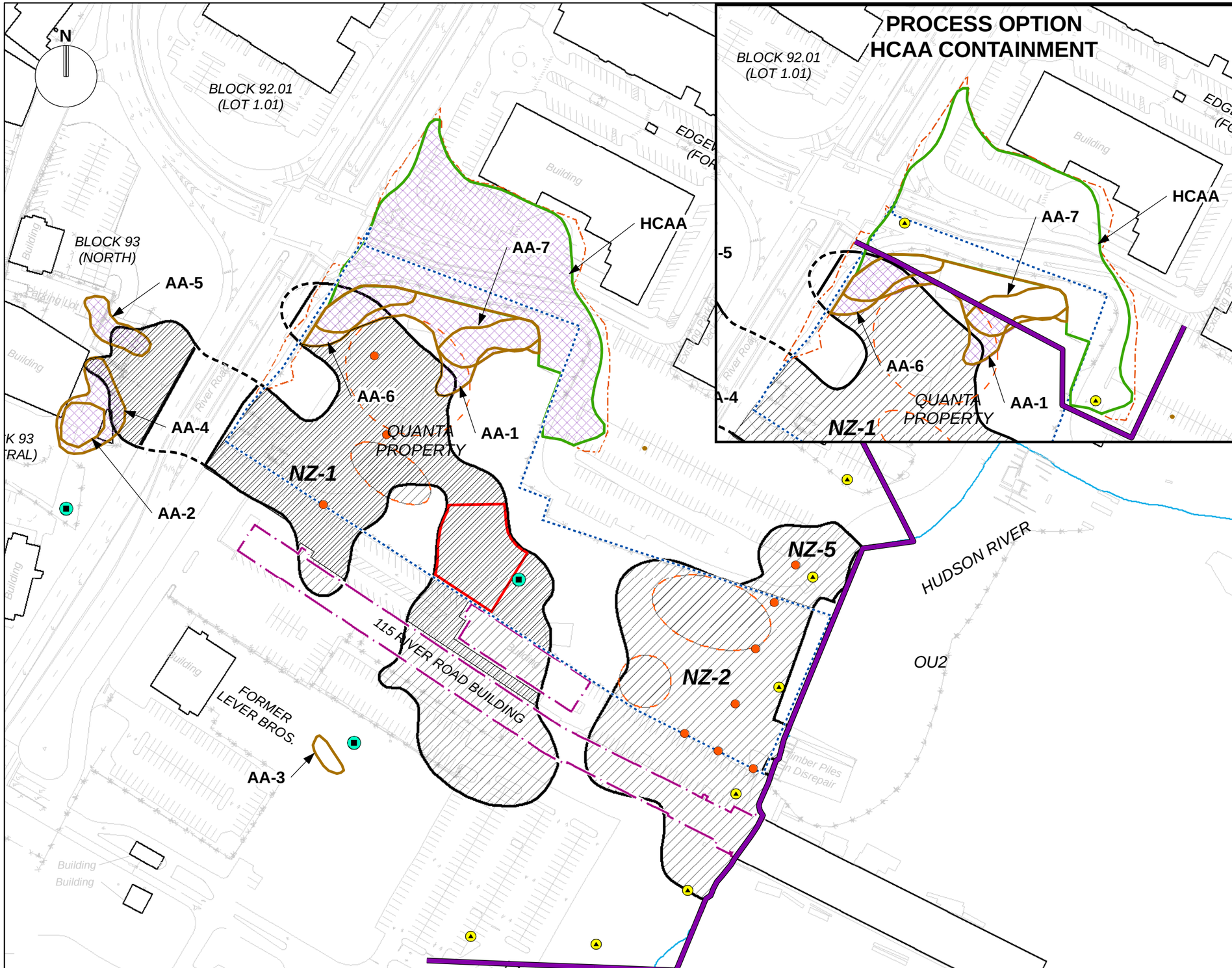
ALTERNATIVE 5a & b
CROSS-SECTION E - E'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-26**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT5_CROSSSECTIONS\4-26_NAPL TREATMENT & CONTAINMENT ALT 5 OU1 CROSS SECTION E-E.MXD JHANSEN1 7/6/2010 16:24:21

400209



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation for NAPL (0 - 4 ft bgs)/ Tar Boils and ISCO
- Stabilization
- Demolition
- Barrier Wall
- NAPL Recovery Wells
- Groundwater Extraction Well
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
3. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

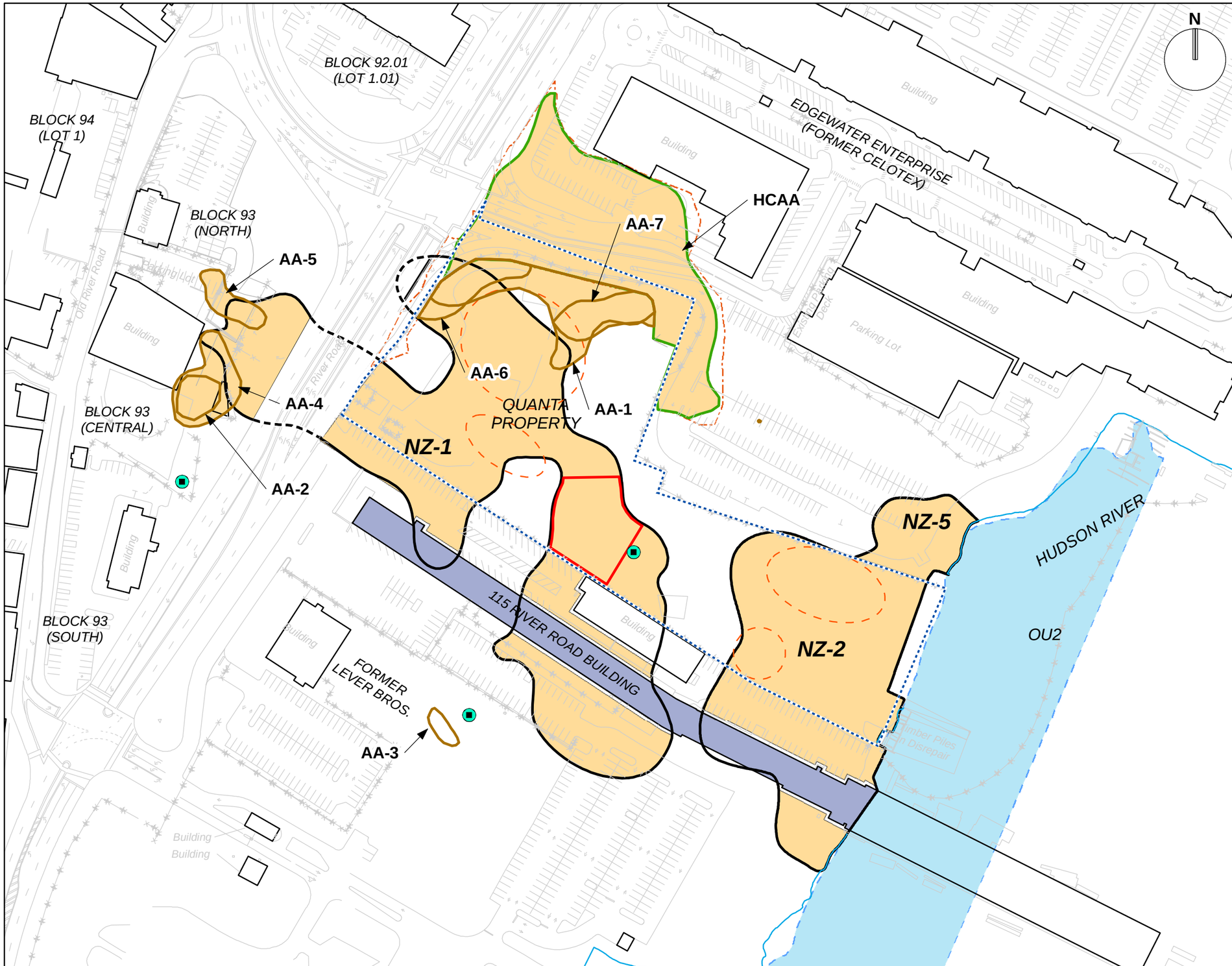
CH2MHILL

ALTERNATIVE 5B - NAPL IN SITU CHEMICAL OXIDATION WITH ARSENIC STABILIZATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-27**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-27_QUANTAOU1_ALT5_NAPLINSITUCHEMICALOXIDATION_WITH_ARSENIC_STABILIZATION_WITH_PROCESSOPTIONHCAACONTAINMENT.MXD JHANSEN1 7/7/2010 14:36:53 400210



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation
- Vapor Intrusion Engineering Controls
- Subaqueous Reactive Barrier (SRB)
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Final excavation depths will be determined during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

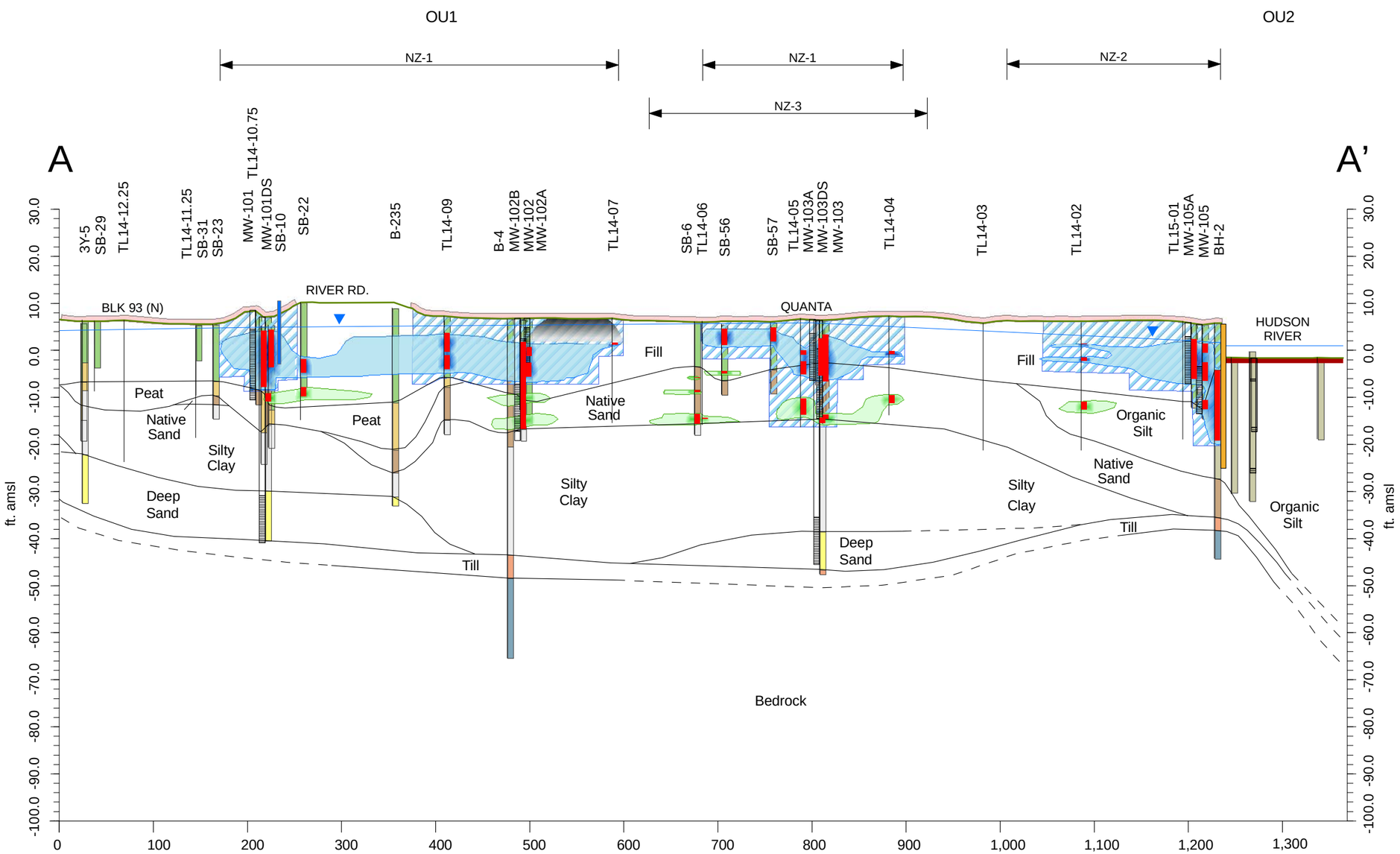
ALTERNATIVE 6A - NAPL AND ARSENIC EXCAVATION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-28**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-28_QUANTAOU1_ALT6_NAPL_AND_ARSENIC_EXCAVATION.MXD JHANSEN1 7/7/2010 14:38:49

400211



Stratigraphy

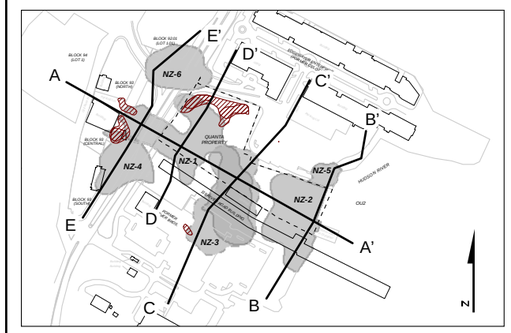
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Wooden Bulkhead
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Engineered Cap
- Subaqueous Reactive Barrier (SRB)
- Excavation
- Tar Boils
- Water Table



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. The NAPL present in river sediment is not addressed in this remedy but will be addressed as part of OU2.
7. ft. = feet, amsl = above mean sea level

CH2MHILL

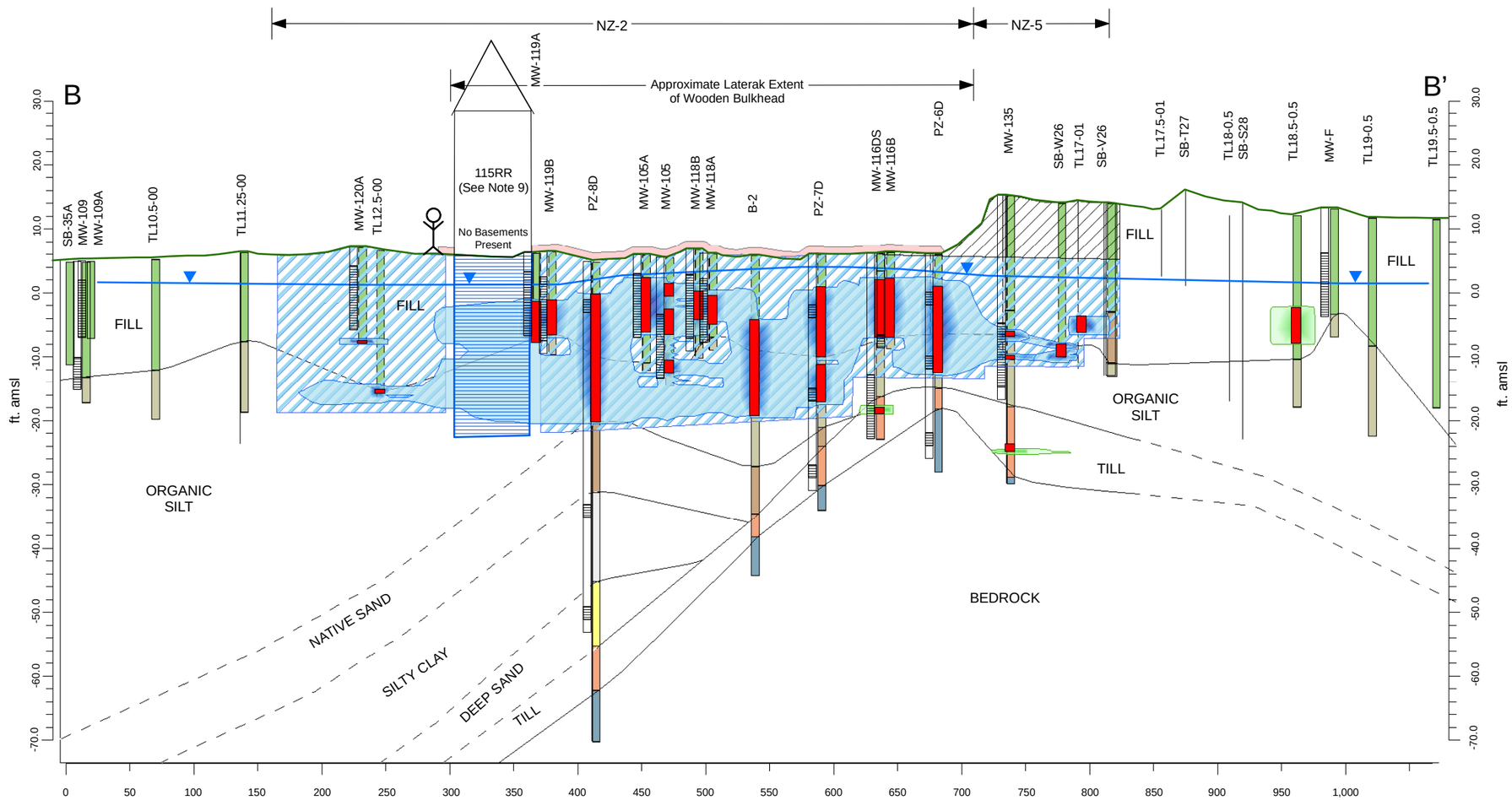
ALTERNATIVE 6a & b
CROSS-SECTION A - A'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-29**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT6_CROSSSECTIONS\4-29_NAPL EXCAVATION ALT 6 OU1 CROSS SECTION A-A.MXD JHANSEN1 7/6/2010 16:30:20

400212



Stratigraphy

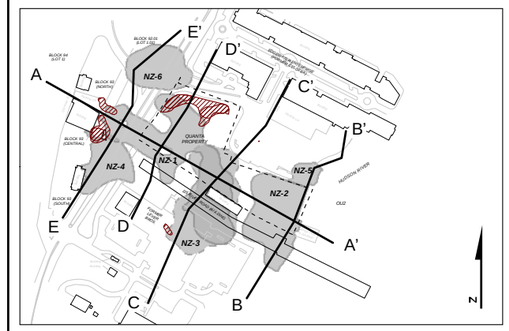
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Water Table
- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Material is Removed but not Disposed
- Excavation
- Engineered Cap
- Barrier Wall



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Configuration of the barrier wall is approximated for visual depiction and will be determined during remedial design.
9. Alternative 6b includes the demolition of the 115 River Road buildings with excavation of NAPL beneath the building.

CH2MHILL

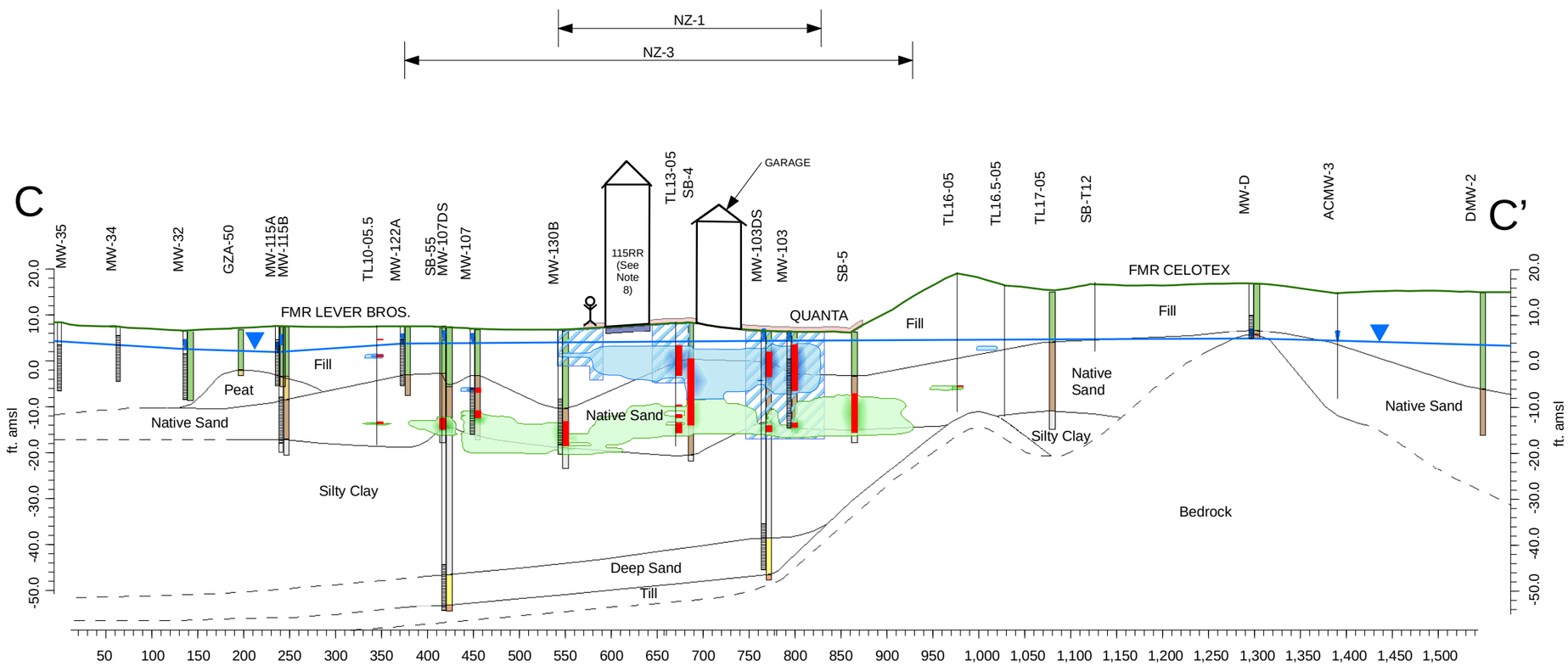
ALTERNATIVE 6a & b
CROSS-SECTION B - B'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-30**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT6_CROSSSECTIONS\4-30_NAPL EXCAVATION ALT 6 OU1 CROSS SECTION B-B.MXD JHANSEN1 7/6/2010 16:32:31

400213



Stratigraphy

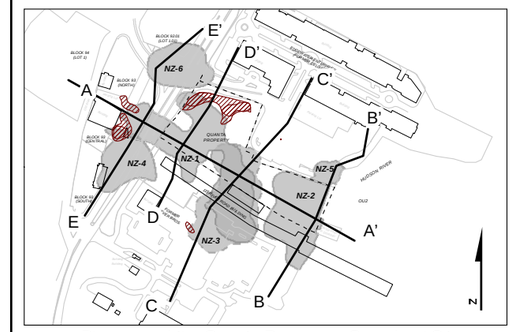
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 28' Vertical

1" = 140' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Excavation
- Water Table
- Engineered Cap
- Vapor Intrusion System (See Note 8)



Plan view of the Quanta Resources Superfund Site

Notes:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of NAPL are based on visual evidence in boring logs, TarGOS (LIF) responses (>49.1% RE), soil screening. and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Alternative 6b includes the demolition of the 115 River Road buildings with excavation of NAPL beneath the building.

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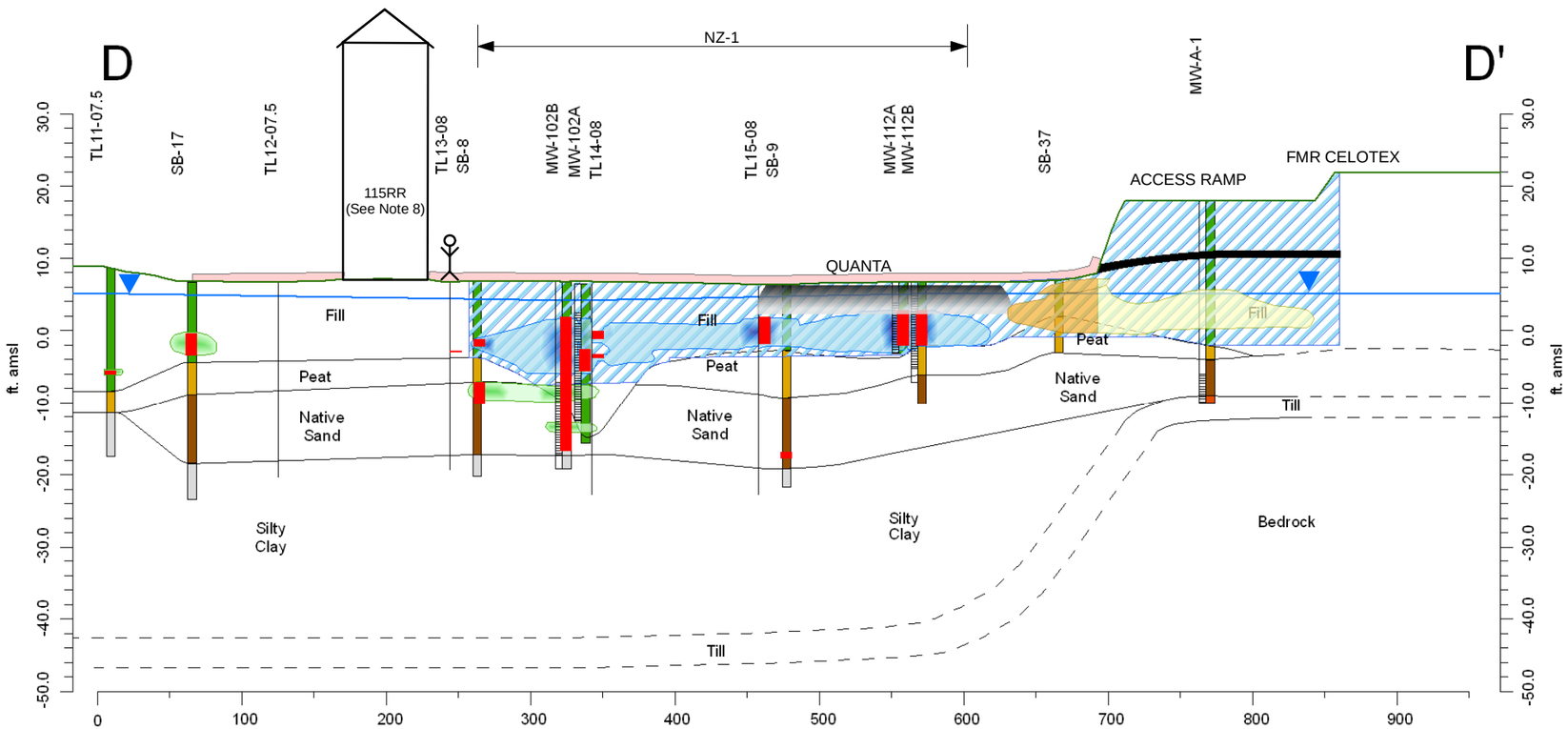
ALTERNATIVE 6a & b
CROSS-SECTION C - C'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-31**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT6_CROSSSECTIONS\4-31_NAPL EXCAVATION ALT 6 OU1 CROSS SECTION C-C.MXD JHANSEN1 7/6/2010 16:33:20

400214



Stratigraphy

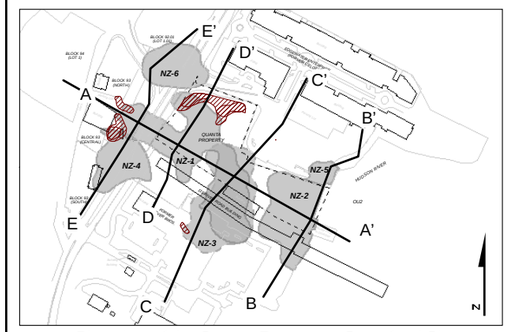
- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 20' Vertical

1" = 100' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Extent of Arsenic Considered Principal Threat Waste
- High Concentration Aresenic Area
- Excavation
- Existing Arsenic Liner
- Engineered Cap
- Tar Boils



Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level
7. 115 River Road dimensions are estimated.
8. Alternative 6b includes the demolition of the 115 River Road building.

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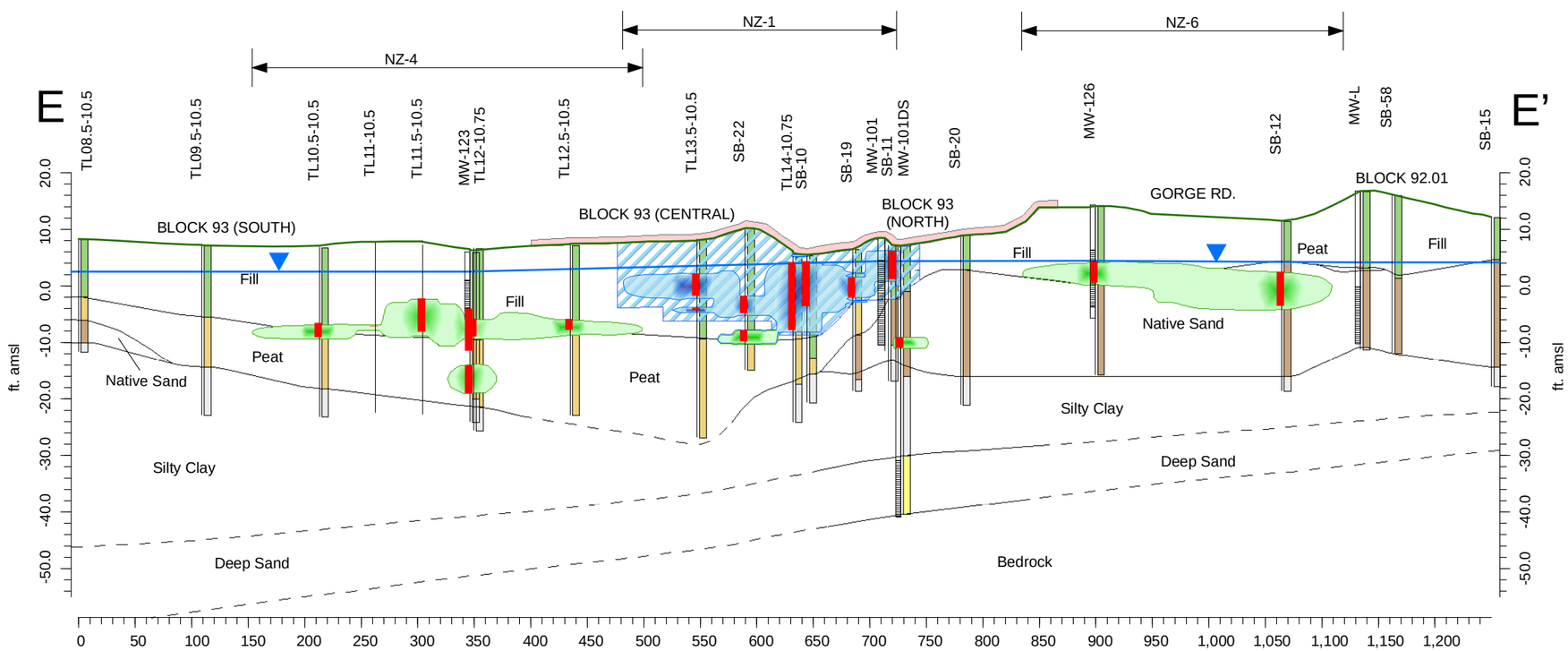
ALTERNATIVE 6a & b
CROSS-SECTION D - D'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 06, 2010 | **FIGURE 4-32**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT6_CROSSSECTIONS\4-32_NAPL EXCAVATION ALT 6 OU1 CROSS SECTION D-D.MXD JHANSEN1 7/6/2010 16:34:47

400215



Stratigraphy

- Fill
- Organic Silt
- Meadow Mat (Peat)
- Native Sand
- Silty-Clay
- Deep Sand
- Till
- Bedrock

1" = 24' Vertical

1" = 120' Horizontal

LEGEND

- Interval of Observed NAPL
- Extent of NAPL Considered Principal Threat Waste
- Extent of NAPL Considered Low Level Threat Waste
- Water Table
- Engineered Cap
- Excavation

Plan view of the Quanta Resources Superfund Site

Note:

1. Extent of NAPL is not representative of recoverable NAPL.
2. Gradation for NAPL and tar boils shading is approximated for visual depiction and does not reflect actual modeling. Only extent of NAPL outline is representative of the modeling.
3. Observed intervals of non-aqueous phase liquid (NAPL) are based on visual evidence in boring logs, TarGOST (LIF) responses (>49.1% RE), soil screening, and laboratory results.
4. Water table elevation depiction based on synoptic measurements taken in March 2009.
5. Dashed lithology lines are inferred from data and observations.
6. ft. = feet, amsl = above mean sea level

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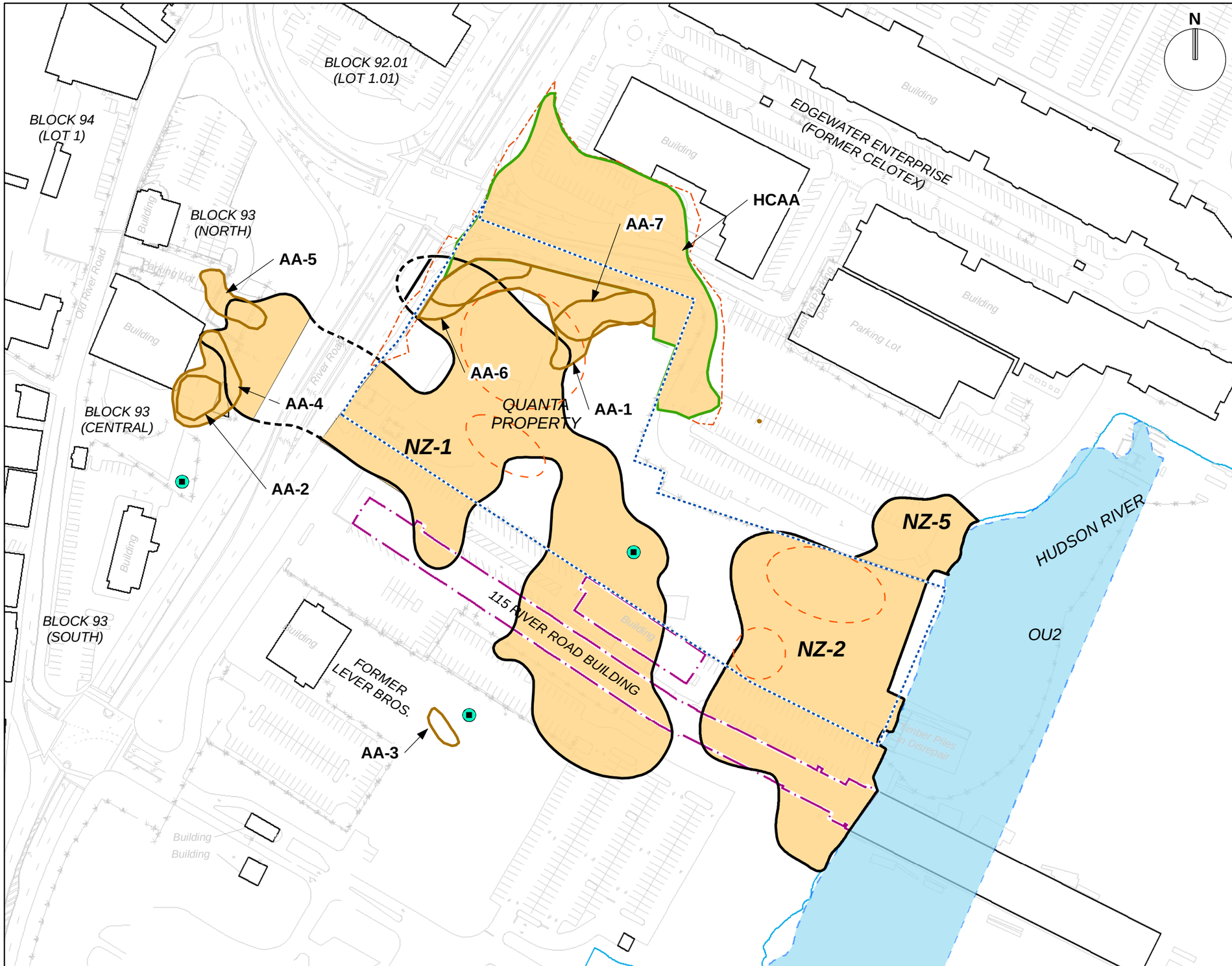
ALTERNATIVE 6a & b
CROSS-SECTION E - E'

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-33**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\ALT6_CROSSSECTIONS\4-33_NAPL EXCAVATION ALT 6 OU1 CROSS SECTION E-E.MXD JHANSEN1 7/6/2010 16:35:23

400216



LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 — Principal Threat NAPL Zone
- HCAA — High Concentration Arsenic Area
- AA-7 — Principal Threat Arsenic Area
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Components

- Excavation
- Demolition
- Subaqueous Reactive Barrier (SRB)
- Passive NAPL Recovery

Notes:

1. Alternative also includes capping of residual soils.
2. Final excavation depths will be determined during remedial design.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 6B - NAPL AND ARSENIC EXCAVATION WITH DEMOLITION OF 115 RIVER ROAD BUILDINGS

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE 4-34**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\SECTION4_PLANVIEW\4-34_QUANTAOU1_ALT6_NAPL_AND_ARSENIC_EXCAVATION.MXD JHANSEN1 7/7/2010 14:39:35

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SECTION 5

Detailed Analysis of Alternatives

The detailed analysis of alternatives presents the relevant information needed to compare the remedial alternatives assembled for OU1. Screening of alternatives was not needed because the number of alternatives was not excessive for detailed evaluation. Detailed analysis of alternatives consists of the following components:

- A detailed evaluation of each alternative against seven of the nine NCP evaluation criteria (the final two criteria, community acceptance and state acceptance, are to be completed later, after public comment)
- A comparative evaluation

The complete detailed evaluation of each alternative is presented in Tables 5-1 through 5-5. The comparative evaluation presented in Section 5.2 highlights the most important factors distinguishing the alternatives.

5.1 Evaluation Criteria

In accordance with the NCP, remedial actions must:

- Be protective of human health and the environment
- Attain ARARs or provide grounds for invoking a waiver of ARARs that cannot be achieved
- Be cost-effective
- Utilize permanent solutions and alternative treatment technologies or resource-recovery technologies to the maximum extent practicable
- Satisfy the preference for treatment that reduces TMV as a principal element

In addition, the NCP emphasizes long-term effectiveness and related considerations, including:

- Long-term uncertainties associated with land disposal
- Goals, objectives, and requirements of the Solid Waste Disposal Act
- Persistence, toxicity, and mobility of hazardous substances and their constituents and their propensity to bioaccumulate
- Short- and long-term potential for adverse health effects from human exposure
- Long-term maintenance costs
- Potential for future remedial action costs if the selected remedial action fails

- Potential threat to human health and the environment associated with excavation, transportation, disposal, or containment

Provisions of the NCP require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9). These criteria were published in the March 8, 1990, *Federal Register* (55 FR 8666) to provide grounds for comparing the relative performance of the alternatives and to identify their advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to select the most appropriate alternative for implementation at the site.

The criteria are divided into three groups: threshold, balancing, and modifying. Threshold criteria must be met for an alternative to be eligible for selection as a remedial action. There is little flexibility in meeting the threshold criteria—either they are met by a particular alternative, or that alternative is not considered acceptable. The two threshold criteria are (1) overall protection of human health and the environment and (2) compliance with ARARs. If ARARs cannot be met, a waiver may be obtained in situations where one or more of the six exceptions listed in the NCP occur (see 40 CFR 300.430 (f)(1)(ii)(C)(1 to 6)).

Unlike the threshold criteria, the five balancing criteria weigh the tradeoffs among alternatives. A low rating on one balancing criterion can be compensated by a high rating on another. The five balancing criteria are

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost

The two modifying criteria—community acceptance and state acceptance—are evaluated following public comment and are used to change (or confirm) the selection of the recommended alternative.

5.1.1 Threshold Criteria

To be eligible for selection, an alternative must meet the two threshold criteria, or if an ARAR is not met, justify that a waiver is appropriate. The performance of each of the alternatives against the threshold criteria is evaluated in Tables 5-1 through 5-5.

Overall Protection of Human Health and the Environment

Protection is the primary requirement that remedial actions must meet under CERCLA. A remedy is protective of human health and the environment if it adequately eliminates, reduces, or controls all current and potential risks posed by the site through exposure pathways. If an exposure pathway is not present, there is no potential for risk. The evaluation of each alternative in consideration of this criterion addresses how the alternative achieves and maintains protection of human health and the environment.

Compliance with ARARs

ARARs are cleanup standards, standards of control, and other substantive environmental statutes or regulations that are either "applicable" or "relevant and appropriate" to the CERCLA cleanup action (42 USC 9621 [d] [2]). ARARs are listed in Appendix A of this report. Applicable requirements directly address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances at a CERCLA site. Relevant and appropriate requirements are those that, while not applicable, address problems or situations sufficiently similar to those encountered at the CERCLA site such that the use of such a requirement is well suited to address the environmental or technical factors that are present at a particular site. The assessment against this criterion describes how the alternative complies with ARARs or presents the rationale for waiving an ARAR. ARARs can be grouped into three categories:

- **Chemical-specific:** ARARs are health- or risk-based numerical values or methodologies that, when applied to site-specific conditions, establish the amount or concentration of a chemical that may remain in or be discharged to the environment.
- **Location-specific:** ARARs restrict the concentration of hazardous substances or the conduct of activities solely because they are in specific locations, such as floodplains, wetlands, historic places, and sensitive ecosystems or habitats.
- **Action-specific:** ARARs include technology- or activity-based requirements that set controls or restrictions on design performance of remedial actions or management of hazardous constituents.

As described in Section 2.5, TI evaluations may be conducted in order to seek waiver of specific ARARs when site-specific conditions make it infeasible to achieve those ARARs within a reasonable timeframe.

5.1.2 Balancing Criteria

The five criteria listed below are used to weigh the tradeoffs between alternatives. The performance of each of the alternatives against the balancing criteria is evaluated in Tables 5-1 through 5-5.

Long-Term Effectiveness and Permanence

This criterion reflects CERCLA's emphasis on implementing remedies that will ensure protection of human health and the environment in the long term as well as in the short term. The assessment of alternatives against this criterion evaluates the potential risk of residual concentrations of COCs at a site after completing a remedial action or enacting a no further action alternative and includes evaluation of the adequacy and reliability of controls.

Reduction of TMV Through Treatment

This criterion addresses the statutory preference for remedies that employ treatment as a principal element. The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies. The criterion is specific to evaluating only how treatment reduces TMV and does not address containment actions such as capping.

Short-Term Effectiveness

This criterion addresses short-term impacts of the alternatives. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment (i.e., minimizing potential risks associated with an alternative) during the construction and implementation of a remedy until the response objectives have been met.

Implementability

The assessment against this criterion evaluates the technical and administrative feasibility of the alternative and the availability of the goods and services needed to implement it.

Cost

Cost encompasses all engineering, construction, and operations and maintenance and monitoring costs incurred over the life of the project. The assessment against this criterion is based on the estimated present worth of these costs for each alternative. Present worth is a method of evaluating expenditures such as construction and operations and maintenance that occur over different lengths of time. This allows costs for remedial alternatives to be compared by discounting all costs to the year that the alternative is implemented. The present worth of a project represents the amount of money, which if invested in the initial year of the remedy and disbursed as needed, would be sufficient to cover all costs associated with the remedial action. As stated in the RI/FS guidance (EPA, 1988a), these estimated costs are expected to provide an accuracy of plus 50 percent to minus 30 percent. The range applies only to the alternatives as they are defined in Section 4 and Appendix E and does not account for changes in the scope of the alternatives. Selection of specific technologies or processes to configure remedial alternatives is not intended to limit flexibility during remedial design but to provide a basis for preparing cost estimates. Appendix E provides a breakdown of the cost estimate for each of the alternatives.

The cost estimates presented have been developed strictly for comparing the alternatives. The final costs of the project and the resulting feasibility will depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, the implementation schedule, the firm selected for final engineering design, and other variables. Therefore, final project costs will vary from the cost estimates. Because of these factors, project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established.

Sustainability

This additional consideration addresses how well or poorly each alternative achieves the five elements for environmental footprint assessments and best practices listed in EPA's (2009) "Principles for Greener Cleanups." The evaluation looks at

- Total energy use and renewable energy use
- Air pollutants and greenhouse gas emissions
- Water use and impacts to water resources
- Materials management and waste reduction
- Land management and ecosystems protection

5.2 Detailed Comparative Analysis of Alternatives

The level of detail required to analyze each alternative against these evaluation criteria depends on the nature and complexity of a site, the types of technologies and alternatives being considered, and other project-specific considerations. The analysis is conducted in sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the evaluation.

5.2.1 Detailed Analysis

The following eight alternatives, with two HCAA process options, were developed and described in Section 4 for media in OU1:

- Alternative 2—NAPL and Arsenic Containment
- Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
- Alternative 4a—NAPL and Arsenic In Situ Solidification/Stabilization
- Alternative 4a (HCAA Process Option)—NAPL and Arsenic In Situ Solidification/Stabilization with Containment of the HCAA
- Alternative 4b—NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of the 115 River Road Buildings
- Alternative 5a—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
- Alternative 5a (HCAA Process Option)—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Containment of the HCAA
- Alternative 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization with Demolition of the 115 River Road Buildings
- Alternative 6a—NAPL and Arsenic Excavation
- Alternative 6b—NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings

All of the remedial action alternatives that are evaluated address the presence of principal threat source material and dissolved-phase COCs by eliminating exposure pathways, thereby eliminating potential risk to human health and the environment. These alternatives were evaluated in detail based on EPA's preference for treatment of principal threat waste and using the seven evaluation criteria described in Section 5.1. The detailed evaluations for these alternatives are presented in Tables 5-1 through 5-5.

5.2.2 Principal Threat Analysis

In Section 1.7, eleven areas were determined to pose a principal threat at OU1: NZ-1, NZ-2, NZ-5, tar boils, and AA-1 through AA-7. Table 4-3 summarizes actions that would be taken for each active alternative to address these principal threats.

NAPL Zone 1: Toxicity Potential

Alternatives 2 and 3 eliminate the direct contact exposure pathway at NZ-1 through capping and institutional controls, and Alternative 3 adds the extraction of recoverable free-phase NAPL. Alternatives 4a and 4b also mitigate potential risk through in situ solidification/ stabilization, and Alternatives 5a and 5b would utilize ISCO treatment following shallow excavation and free-phase NAPL recovery. Alternatives 6a and 6b mitigate potential risk at NZ-1 through the physical removal of principal threat waste. Remedial response actions would be coordinated with Bergen County if future road construction results in exposure of residual NAPL under River Road. Alternatives 2, 3, 4a, 5a, and 6a would include the same vapor intrusion mitigation measures, whereas Alternatives 4b, 5b, and 6b would include treatment of NZ-1 with the potential for vapor intrusion.

NAPL Zone 2: Mobility and Toxicity Potential

Mobility potential at NZ-2 is addressed in Alternatives 2 and 3 through the use of physical containment using a funnel-and-gate system (Alternative 2) or a cutoff wall with free-phase NAPL recovery (Alternative 3). In situ solidification/stabilization would be implemented in Alternative 4a and 4b to physically bind the NAPL within a stabilized mass, eliminating the ability of the material to flow or volatilize. Alternatives 5a and 5b combine shallow excavation and NAPL recovery with ISCO. Alternatives 6a and 6b eliminate the potential for migration by physically removing NZ-2 for offsite disposal. Alternatives 2, 3, 5a, 5b, 6a, and 6b all employ a permanent barrier cutoff between the shoreline and the river, whereas Alternatives 4a and 4b have deep in situ solidification/stabilization along the shoreline wall as a barrier to prevent migration of NAPL to the river.

Alternatives 2 and 3 eliminate the direct-contact exposure pathway at NZ-2 through capping and institutional controls. Alternative 3 would also include free-phase NAPL recovery. Alternatives 4a, 4b, 5a, and 5b incorporate the use of in situ technologies—solidification/stabilization in Alternatives 4a and 4b and ISCO in Alternatives 5a and 5b. Alternatives 5a and 5b also include shallow excavation and free-phase NAPL recovery. Alternatives 6a and 6b mitigate potential risk at NZ-2 through the physical removal of principal threat waste from the zone.

NAPL Zone 5: Mobility and Toxicity Potential

Potential NAPL migration and subsequent potential impacts to ecological receptors in OU2 from NZ-5 are mitigated in Alternative 2 through the use of a funnel-and-gate system; in Alternatives 3, 5a, 5b, 6a, and 6b through the installation of a cutoff wall; and in Alternatives 4a and 4b though in situ solidification/stabilization. Additionally, Alternative 3 includes free-phase NAPL recovery. Potential migration and ecological toxicity are mitigated through in situ solidification/stabilization and the placement of an SRB in Alternatives 4a and 4b and by NAPL recovery, excavation, and ISCO in Alternatives 5a and 5b. Alternatives 6a and 6b eliminate the potential for migration or exposure through the physical removal and offsite disposal of material containing NAPL and the placement of the SRB.

Tar Boils: Toxicity Potential

Capping and institutional controls would be used to reduce the potential risk of direct contact in Alternatives 2 and 3. In Alternatives 4a and 4b, in situ solidification/stabilization would prevent the formation of tar boils by immobilizing the NAPL and solid tar. In

Alternatives 5a and 5b shallow excavation would be used in conjunction with capping and NAPL recovery to limit the formation of tar boils and restrict direct contact. In Alternatives 6a and 6b, material where tar boils have been observed would be excavated and disposed of offsite.

AA-1 through AA-7: Toxicity Potential

In Alternatives 2 and 3, the direct-contact exposure pathway would be eliminated through the implementation of capping and institutional controls. Alternatives 4a, 4b, 5a, and 5b add the solidification/stabilization of principal threat arsenic from on the Quanta and Block 93 properties. Alternatives 6a and 6b include excavation of AA-1 through AA-7.

5.2.3 Detailed Comparative Analysis

EPA's stated program goals and expectations have been carefully considered in developing a range of remedial alternatives for the site. Consideration has been given to identifying according to EPA (1991) guidance appropriate remedial approaches to addressing source materials that may constitute a principal threat owing to toxicity and mobility as well as mitigating potential risks posed by low-level threat source material or residual COCs. Consideration has also been given to the applicability of innovative, emerging, and sustainable source reduction technologies in meeting these goals and expectations. The alternatives are evaluated against the threshold and balancing criteria as discussed in the following subsections.

Overall Protection of Human Health and the Environment

The No Further Action alternative is not protective. The remaining alternatives are protective. The considered alternatives prevent unacceptable human health and ecological risk by eliminating exposure pathways through treatment, removal, or containment of both source material and media containing residual concentrations of COCs. Each active alternative includes capping and institutional controls to prevent exposure to contaminated soil and groundwater and address the risk at the site.

Groundwater at the site is impacted as a result of the leaching of COCs both from the secondary sources that have resulted from operations associated with the Quanta site, as well as from materials that are the result of historic filling activities and non-site-related operations. In addition, offsite sources of groundwater impacts have been documented in previous site investigation reports. The SRI has documented the stability of the impacted groundwater and has demonstrated that contaminants are attenuating naturally. A CEA would be established to serve as an institutional control providing notice that the constituent standards are not or will not be met in a localized area due to natural water quality or anthropogenic influences, and that designated aquifer uses are suspended in the affected area for the term of the CEA. The areas of the site that are not associated with site operations and not determined to be source areas or areas resulting in an unacceptable risk would be left in place for each of the alternatives evaluated but would be capped, and access would be restricted through the implementation of institutional controls. The alternatives evaluated include some degree of containment, source removal, or in situ passive treatment components that would reduce leaching from source materials at the site. Alternatives 3, 5a, and 5b, and to a limited extent Alternatives 4a, 4b, 6a, and 6b, include NAPL recovery. Alternatives 4a, 4b, 5a, and 5b also incorporate technologies to reduce leaching from NAPL

source material, through solidification/stabilization and NAPL recovery with ISCO, respectively. Alternatives 6a and 6b include extensive soil excavation and offsite disposal. Each alternative also includes a component of groundwater control or MNA that addresses dissolved phase constituents that may impact offsite receptors, particularly the Hudson River.

Potential migration of free-phase NAPL in NZ-2 and NZ-5 would be mitigated in each alternative, except Alternative 1. Alternatives 2 and 3 would include a funnel-and-gate and a cutoff wall, respectively, to physically restrict migration. Alternative 4a and 4b would include the solidification/stabilization of these NAPL zones, whereas Alternative 5a and 5b would rely on NAPL recovery and ISCO. Principal threat waste near the shoreline would be excavated and disposed of offsite in Alternative 6a and 6b. Additionally, Alternatives 2, 3, 5a, 5b, 6a, and 6b would include the placement of a permanent barrier cutoff wall to restrict any potential migration of untreated material. A barrier wall is created in Alternative 4a and 4b with the deep solidification/stabilization of material along the shoreline.

Principal threat arsenic is addressed in each alternative by either containment or removal/treatment. Alternative 2 employs capping to limit direct contact with arsenic-impacted soils. Alternatives 3, 4a with the HCAA process option, 4b with the HCAA process option, 5a with the HCAA process option, and 5b with the HCAA process option would include the placement of a cutoff wall downgradient of the HCAA to prevent further leaching and capping of all arsenic-impacted soils. Alternatives 4a, 4b, 5a, and 5b would treat principal threat NAPL on all properties with solidification/stabilization, while under Alternatives 6a and 6b these soils would be excavated.

All alternatives except the No Further Action alternative include measures to prevent the migration of dissolved phase COCs to OU2. Alternative 2 addresses this through the installation of a funnel-and-gate system, while Alternatives 3, 5a, 5b, and the HCAA process options alternatives employ a barrier cutoff wall with upgradient hydraulic control via extraction wells and treatment. Alternatives 4a, 4b, 6a, and 6b prevent migration of dissolved phase COC with the placement of an SRB between discharging groundwater and the river.

Alternatives 2, 3, 4a, 5a, and 6a address the potential risk of vapor intrusion by the construction of a vapor intrusion mitigation system in the basements of the 115 River Road building. Under Alternatives 4b, 5b, and 6b there would be no vapor intrusion into the 115 River Road buildings, as these soils would be treated following the building's being demolished.

Existing road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped with either a single-layer engineered cap or vegetative cap, depending on redevelopment.

Compliance with ARARs

Appendix B presents a compilation of all the state and federal chemical-specific, location-specific, and action-specific ARARs considered for OU1. With the exception of the No Further Action alternative, each alternative satisfies the ARARs except where it is technically impracticable to do so. Some principal threat and low-level threat source material would be left in place because of technological limitations posed by site-specific

conditions. Therefore, technical impracticability is being evaluated as part of a separate document supporting the issuance of a TI waiver for certain ARARs, particularly the reduction of COC concentrations in groundwater to drinking water levels. The waiver would specify which ARARs cannot be achieved. For all alternatives except the No Further Action alternative, exposure to media not meeting ARARs would be prevented, thereby eliminating potential risk.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of alternatives vary largely as a result of the adequacy and reliability of the systems implemented. Alternatives 6a and 6b appear to offer a comparatively higher degree of long-term effectiveness at the site because most principal threat waste would be physically removed; however, as with all of the alternatives, additional source materials that remain a potential risk would be left behind. In addition, for Alternatives 6a and 6b, the material would be disposed of at an offsite landfill and continue to be a potential source and leaching concern there.

The in situ solidification/stabilization used in Alternatives 4a and 4b is considered effective over the long term, and assurance would be ascertained through bench and pilot testing prior to remedy implementation, performance testing during implementation, and long-term monitoring after implementation. This technology would not remove the contaminants but would immobilize them permanently onsite. This technology would permanently sequester principal threat waste and significantly reduce the potential for this material to act as an ongoing source of COCs to groundwater and air.

Alternatives 5a and 5b also incorporate shallow excavation with in situ treatment via ISCO, increasing the long-term effectiveness and permanence of these alternatives if the ISCO is effective. While ISCO would achieve some additional mass removal of these alternatives, there are significant questions as to whether this technology would be completely successful at the site and provide a significant risk reduction. One major concern with ISCO is that its success is based on the contact of the oxidant with the contamination. The low-permeability soils and subsurface debris may impact the delivery of the oxidant, thereby limiting the effectiveness of this technology. In addition, a bench-scale test was performed for the applicability of ISCO at the site, and a number of additional challenges were encountered:

- There was a wide variation in the effectiveness of ISCO on the different soils/wastes tested, even under the ideal laboratory conditions created during the bench-scale testing. Removal effectiveness ranged from 59 to 99 percent. Effectiveness in the field would likely be much less than these values since mixing of the contaminants and oxidant would not occur as ideally in the subsurface environment during full-scale implementation as it had during the bench-scale test.
- High oxidant-to-contaminant ratios, of 10:1 and 20:1, were needed in the bench-scale testing to effectively treat the contaminant. The actual oxidant demand would likely be significantly higher in order to achieve the necessary distribution of oxidant in the subsurface in a field application. Applying this amount of oxidant in the field would require three to 19 successive applications (spaced from 4 months to 1 year apart).
- Increases in dissolved arsenic concentrations were observed in the silty sand samples as a result of ISCO.

Also, during implementation there is a potential for mobilization of currently residual NAPL and increased mobility potential of existing mobile NAPL, especially considering that the injections would not likely treat the majority of NAPL mass with one injection because of the physical injection of reagents and the surfactant like effect that ISCO often has. Depending on the oxidant used and the particular method of application, there is also the potential to increase volatilization of VOCs and SVOCs, and even small amounts of increased volatilization may pose potential risks associated with vapor intrusion, which would need to be evaluated and controlled during field implementation. The 115 River Road foundation is built on timber piles, and injection of large quantities of oxidant adjacent to the building may affect the overall composition of the piles and their structural integrity.

Alternative 2 is the least effective active alternative because it does not meet EPA's preference for removal or treatment of COCs, but rather relies on institutional controls and capping to eliminate exposure pathways. Institutional controls can be effective if they are enforced and would eliminate the exposure pathway; however, the source still remains, and institutional controls require continual enforcement to maintain effectiveness.

Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative 6b offers the greatest potential reduction in TMV at the site because it physically removes the most principal threat waste and uses proven technology; however, the waste material is transferred to another location. The following summarizes for each alternative the waste material removed or treated, thereby reducing TMV at the site.

Alternative 2. Alternative 2 provides the smallest reduction in TMV. Debris, including foundations, piping, and concrete tank pads, present in the location of the funnel-and-gate system would be removed and disposed of to allow for installation. Other surface debris would be removed and disposed of to allow for the placement of the cap.

Alternative 3. Alternative 3 reduces TMV through the recovery and disposal of NAPL; however, the recoverable portion of the NAPL is only a small fraction of the overall NAPL present in the subsurface. Debris, including foundations, piping, and concrete tank pads, present in the location of the barrier cutoff wall and the excavated material for the installation of the ex situ groundwater treatment system would be removed and disposed of offsite. Other surface debris would be removed and disposed of to allow for the placement of the cap.

Alternative 4a. Treatment by in situ solidification/stabilization of principal threat NAPL reduces the mobility and toxicity of the NAPL. In addition, TMV is reduced through the solidification/stabilization of the HCAA and arsenic on the Quanta and Block 93 properties. TMV would also be reduced through passive recover of NAPL at selected wells. Debris, including large boulders, subsurface structures, foundations, piping, and concrete tank pads, present in the in situ solidification/stabilization area would be excavated and disposed of to allow for installation. Other surface debris would be removed and disposed of to allow for the placement of the cap.

Alternative 4a HCAA Process Option. There would be less TMV reduction with the installation of the cutoff wall downgradient of the HCAA, as less material is actually treated.

Alternative 4b. Alternative 4b reduces TMV to a greater extent that Alternative 4a since the NAPL under the 115 River Road buildings would be treated by solidification/stabilization. However, the economic impacts of the demolition to the tenants, building owner, and community would eclipse the minimal benefit of potential source reduction and include more than just the cost of the demolition itself. The removal and temporary relocation of more than 150 employees and tenants would be very costly and would disrupt businesses, cause a loss of revenue to both the tenant businesses and the property owner, and likely result in a loss of jobs. There would be significant negative impacts to the community as well, as some of those businesses might relocate to other areas. Also, the incremental and potential benefit of the source reduction would not improve the overall risk profile at the site. The potential risk associated with the NAPL beneath the building will be addressed through more-cost-effective, less-disruptive options. The potential for the source material located directly beneath the building to act as a source of soil vapor intrusion and a source to groundwater will be addressed by all of the proposed remedial alternatives.

Alternative 4b HCAA Process Option. There would be less TMV reduction with the installation of the cutoff wall downgradient of the HCAA, as less material is actually treated.

Alternative 5a. Treatment of principal threat NAPL by ISCO, excavation of tar boils and soils in NZ-1 and NZ-2, and NAPL recovery reduce the toxicity and volume of NAPL at the site; however, the injection of oxidants may result in a temporary increase in NAPL mobility at the site. TMV is reduced through the solidification/stabilization of the HCAA and arsenic on the Quanta and Block 93 properties. Debris in these areas would also be removed. Other surface debris would be removed and disposed of to allow for the placement of the cap.

Alternative 5a HCAA Process Option. There is less TMV reduction with the installation of the cutoff wall downgradient of the HCAA as less material is actually treated.

Alternative 5b. Alternative 5b reduces TMV to a greater extent that Alternative 5a since the NAPL under the 115 River Road buildings would be treated by ISCO. The same consideration for demolition of the building as described above for Alternative 4b apply to Alternative 5b.

Alternative 5b HCAA Process Option. There is less TMV reduction with the installation of the cutoff wall downgradient of the HCAA as less material is actually treated.

Alternative 6a. Alternative 6a offers a high potential reduction in TMV at the site because it physically removes principal threat waste in accessible areas and uses proven technology; however, the waste material is transferred to another location. The excavation and offsite disposal of the principal threat NAPLs (tar boils and soils in NZ-1, NZ-2, and NZ-5) and the principal threat arsenic would reduce the TMV of the site. Debris in these areas would also be removed and disposed of. Other surface debris would be removed to allow for the placement of the cap.

Alternative 6b. Alternative 6b reduces TMV to a greater extent that Alternative 6a since the NAPL under the 115 River Road buildings would be excavated and disposed offsite.

Alternatives 4a, 4b, 5a, and 5b incorporate testing to verify irreversibility of the remedy. The TMV reduction for Alternatives 2 and 3 is less than for Alternatives 4, 5, and 6, and the

controls are potentially reversible (for example, engineering caps could be removed). The SRB treatment of dissolved-phase COCs (included in all active alternatives) may be reversible if adsorption sites are completely used up, allowing desorption to occur.

Short-Term Effectiveness

Alternatives 2 and 3 have minimal impacts with respect to the protection of workers, the community, and the environment during remedial implementation, assuming adequate monitoring is conducted and mitigating actions are taken. Although there are potential short-term impacts to the worker, community, and environment during the implementation of Alternatives 4a and 4b, procedures and processes described in the construction implementation plan (see Appendix C) can be implemented to mitigate these risks. Alternatives 5a and 5 b have higher potential risks for workers, the community, and the environment due to the potential for mobilizing NAPL and the increased potential for NAPL volatilization. Alternatives 6a and 6b pose high potential risk and would require controls similar to those of Alternatives 4a, 4b, 5a, and 5b and additional controls to mitigate potential risks to the surrounding community from increased odor and vehicular traffic. Alternatives 4b, 5b, and 6b pose the highest potential risk due to the demolition of the 115 River Road buildings and would require additional controls. All alternatives would be conducted in accordance with health and safety plans.

All alternatives would potentially have environmental effects associated with stormwater runoff and potential NAPL mobilization to some degree. The required stormwater controls would be evaluated during predesign of the selected remedy. The potential for mobilization of NAPL during implementation of the active alternatives would be evaluated during predesign, and controls would be selected to mitigate this potential risk.

Air monitoring, appropriate PPE and protective measures for the community would be important for all alternatives. In addition, emission control techniques such as using dust suppressants and minimizing the open working area of excavations would be employed as needed to minimize adverse effects on workers and the community from volatile and dust emissions.

Many of the RAOs for the site would be achieved following completion of the construction activities. The RAOs to prevent unacceptable risk as a result of direct exposure to soils and prevent erosion would be met immediately following cap construction and establishment of institutional controls for each alternative. The RAO to prevent migration of COCs to OU2 would be met immediately after the installation of the funnel-and-gate or SRB and establishment of institutional controls for each alternative. The RAOs to prevent unacceptable risk as a result of exposure to vapors would be immediately met following installation of the vapor intrusion mitigation system for each alternative. The time until the remaining RAOs are achieved was estimated for Alternatives 2 and 3 to be greater than 30 years due to presence of NAPL that would remain. Alternatives 5a and 5b are expected to achieve RAOs within 10–15 years based on the need for NAPL recovery and multiple injection events to reduce the NAPL mass. Alternatives 4a, 4b, 6a, and 6b are anticipated to achieve RAOs most rapidly, on the order of several years.

Implementability

Implementability challenges exist for each of the identified alternatives. Considerations common to all or several alternatives are bundled under subcategories listed below.

Logistics. All alternatives would have access challenges that would have to be addressed with all property owners. For Alternatives 4a, 5a, and 6a, scheduling and sequencing of treatment or removal of NAPL on 115 River Road would be necessary to limit the impacts to the current occupants. Building stability analyses and design of appropriate controls would be required prior to treatment or removal of soils adjacent to the building. For Alternatives 4b, 5b, and 6b, relocation of tenants, demolition, treatment, and reconstruction would be a large logistical challenge.

Subsurface Obstructions. Large boulders and riprap on the former Celotex property at NZ-5 would complicate the implementation of all active remedial technologies in this area. Installation of NAPL recovery wells (Alternatives 3, 5a, and 5b) would require drilling technology able to penetrate bouldery fill. Installation of a funnel-and-gate system (Alternative 2) or cutoff wall (Alternatives 3, 5a, 5b, 6a, and 6b) would require removing overlying bouldery fill prior to barrier placement. In situ solidification/stabilization (Alternatives 4a and 4b) would also require excavation of subsurface boulders prior to mixing. In situ chemical oxidization (Alternatives 5a and 5b) may require either excavating boulders or using drilling technologies able to penetrate the fill material.

Alternatives involving in situ technologies or excavation would require working around utilities. Temporary outages during implementation may be required.

Environmental Testing, Monitoring, and Controls. Alternatives 2–6 would require bench- and pilot-scale testing prior to implementation. Additionally, all alternatives would require stormwater controls and fence line monitoring for dust and emissions.

Temporary controls to prevent mobilization of free-phase NAPL to OU2 would be required during implementation of in situ alternatives or deep excavation (Alternatives 4a, 4b, 5a, 5b, 6a, and 6b) near the shoreline (at NZ-2 and NZ-5).

As part of a predesign task, water flow patterns would need to be modeled for adequate control in alternatives involving placement of barriers to groundwater flow or in situ solidification/stabilization (for all alternatives except no further action).

Businesses located in 115 River Road buildings would need to have air monitoring and engineering controls as well as temporary parking accommodations during implementation of the active alternatives. These controls would be most complicated for Alternatives 4a, 5a, and 6a, which could result in the generation of large amounts of vapor with tenants in close proximity.

Alternatives 4a and 4b pose additional implementability considerations involving soil expansion impacts, and effective distribution of reagent to target treatment areas.

Cost

Estimated costs for each of the groundwater media alternatives are summarized in Table E-1 of Appendix E with an accuracy of plus 50 percent to minus 30 percent. The table breaks

down the estimated capital, O&M, periodic, and present net worth costs. The cost estimates are based on the best available information.

Alternatives 5a, 5b, 6a, and 6b represent the highest present worth cost alternatives, ranging from $206 million and $480 million. These alternatives require extensive capital equipment and labor for construction and operation. The next-highest present worth cost alternatives are Alternative 4a and 4b, at $72 million and $169 million, respectively. Alternatives 2 and 3 are the lowest-cost alternatives, at $41 million and $64million, respectively.

The cost estimates and resulting conclusions have been prepared for guidance in project evaluation and implementation from the information available at the time that the cost estimate was prepared. The final costs of the project and resulting feasibility would depend on actual labor and material costs, competitive market conditions, actual site conditions, final project scope, implementation schedule, and other variable factors. As a result, the final project costs would vary from the cost estimates presented here.

Sustainability

Using sustainable remediation concepts, also called "green" or "greener cleanup" principles, is relatively new to the RI/FS process. In August 2009, EPA's OSWER issued "Principles for Greener Cleanups" (EPA, 2009) as a matter of policy:

OSWER's goal is to evaluate cleanup actions comprehensively to ensure protection of human health and the environment and to reduce the environmental footprint of cleanup activities, to the maximum extent possible.

The OSWER document provides five elements that should be considered when carrying out greener cleanup environmental footprint assessment. These five elements, along with suggestions for how to improve each element, are listed below. They are discussed in Table 5-6 for each alternative. Each element is discussed for the alternatives.

1. **Minimize Total Energy Use and Maximize Use of Renewable Energy**
   - Minimize energy consumption
   - Power cleanup equipment through onsite renewable energy sources
   - Purchase commercial energy from renewable resources
2. **Minimize Air Pollutants and Greenhouse Gas Emissions**
   - Minimize the generation of green house gases
   - Minimize generation and transport of airborne contaminants and dust
   - Use heavy equipment efficiently
   - Maximize use of machinery equipped with advanced emission controls
   - Use cleaner fuels to power machinery and auxiliary equipment
   - Sequester carbon onsite.
3. **Minimize Water Use and Impacts to Water Resources**
   - Minimize water use and depletion of natural water resources
   - Capture, reclaim, and store water for reuse
   - Minimize water demand for revegetation
   - Employ best management practices for stormwater

4. Reduce, Reuse, and Recycle Material and Waste

- Minimize consumption of virgin materials
- Minimize waste generation
- Use recycled products and local materials
- Beneficially reuse waste materials
- Segregate and reuse or recycle materials, products and infrastructure

5. Protect Land and Ecosystems

- Minimize areas requiring activity or use limitations
- Minimize unnecessary soil and habitat disturbances or destruction
- Use native species to support habitat
- Minimize noise and lighting disturbance

Keeping these five elements in mind, Alternative 2 is the "greenest" alternative, and Alternative 3 also achieves many of the sustainability themes. Alternatives 2 and 3 minimize energy use, air pollutants, greenhouse gas emissions, water use, and waste. However, Alternatives 2 and 3 are not the most effective at protecting land and the ecosystems and in returning the site to beneficial reuse.

Of the alternatives that actively treat principal threat arsenic and NAPL, Alternative 4a achieves many of the elements for carrying out a greener cleanup. The ability to have the property ready for beneficial reuse is quickly achieved, compared to other alternatives. No long-term mechanical O&M is required, and there is no, or very limited, waste to transport. There would be substantially less truck traffic than any alternative requiring excavation. Noise, dust, and odor control measures can be taken to minimize impacts to the surrounding community. The two activities that might have a significant environmental footprint for this alternative are the energy required and air emissions from the mixing equipment, and the energy required and the air emission for the manufacture of the stabilization agent (e.g., cement). Based on the results of the bench scale tests, alternative stabilizing agents or reactive media for PRBs could be used which are considered more sustainable. "Green" cement products (e.g., fly ash or slag cement) and red mud are recycled industry waste rather than raw materials, requiring fewer natural resources and less energy and generating less CO_2.

Alternatives 5a has similar impacts to Alternative 4a but is less able to achieve the sustainability themes described above. The duration of implementation is longer than Alternative 4a and community impacts would require higher mitigation planning than Alternatives 2, 3, and 4a. Alternatives 4b, 5b, and 6b require demolishing and reconstructing the 115 River Road buildings, which is not considered sustainable. Alternative 6b is the least sustainable alternative. Demolition and excavation require heavy truck traffic and moving waste from one area to another. In addition, they would require bringing in a substantial amount of fill to the site. It is likely that excavation would require substantial dewatering activities, which involve increased energy consumption and generates waste byproducts resulting from treatment of the groundwater. Although the site may be more quickly ready for beneficial reuse than under alternatives with long-term O&M commitments, and would not have the environmental impacts resulting from long-term mechanical O&M, the benefits

do not offset the substantial human and environmental impacts resulting from the excavation activities.

Each of the alternatives has an opportunity for green remedial design and implementation approaches to be included in the final remedy. Noise, dust, and odor reduction plans, traffic management plans, use of vegetative covers, reduction of truck idling time, the use of biofuels for remediation vehicles, recycling of recovered product, erosion and water management plans, and the incorporation of native vegetation in redevelopment plans are just some items that can be incorporated as desired in the final remedial design/ implementation.

Summary

This FS report presents a range of alternatives developed to address the site ARARs, RAOs, and PRGs and the principal threat and low-level threat wastes identified for the site. While each of the active alternatives satisfies the two threshold criteria, they satisfy the balancing criteria to different degrees: Alternative 4a (in situ solidification/stabilization with 115 River Road building preservation) best satisfies the balancing criteria, whereas Alternative 6b (excavation with 115 River Road buildings demolition) is least favorable.

The following summarizes the performance of each of the alternatives with regard to the balancing criteria:

- Alternative 2 is least disruptive to the community, workers, and environment, and allows for the most rapid redevelopment of the Quanta property. However, this alternative would require the most restrictive institutional controls for future site land use due to the residual COCs that would remain onsite.
- Alternative 3 removes principal threat waste and allows for relatively rapid redevelopment. However, this alternative would also have restrictive future land use due to residual COCs that remain onsite.
- Alternative 4a permanently reduces mobility and toxicity through the solidification/ stabilization of principal threat wastes (and some low-level threat waste where NZ-3 is "stacked" under NZ-1 on the Quanta property) and allows for relatively rapid redevelopment of the site. Short-term impacts can be managed. Large fill debris that could interfere with the mixing process would need to be removed prior to treatment. Treatability studies would be conducted to (1) determine the optimal reagent mix, (2) confirm corresponding cost-effectiveness under full-scale conditions, and (3) confirm compatibility with redevelopment objectives. The HCAA process option for Alternative 4a removes some implementation and treatability challenges; however, long-term operation and maintenance of the system would be required.
- Alternative 4b and its HCAA process option have the same qualities as Alternative 4a except they require the demolition of the 115 River Road buildings, which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.
- Alternative 5a treats principal threat wastes; however, this alternative takes the longest period of time to implement, significantly delaying redevelopment. In addition, excavated contaminated soil must be transported to and disposed of at a landfill.

Chemical oxidation would pose potential risks of NAPL mobilization and vapor intrusion. The HCAA process option for Alternative 5a removes some implementation and treatability challenges; however, long-term operation and maintenance of system would be required.

- Alternative 5b and its HCAA process option have the same qualities as 5a except they require the demolition of the 115 River Road Buildings which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.
- Alternative 6a removes the source material from the site and allows for relatively rapid redevelopment. It is also the least restrictive of future site land uses. However, it is the most disruptive to the site and community in the short term, and significant potential risks are posed by deep excavations adjacent to buildings and roadways. In addition, large volumes of contaminated soil must be transported to and disposed of at a landfill.
- Alternative 6b has the same qualities as 6a except it requires the demolition of the 115 River Road Buildings, which has significant cost and logistical challenges for a building currently in use and is not considered in alignment with sustainability principles.

This FS evaluation also considered sustainability-related elements such as energy and carbon footprint reduction, waste generation reduction, timing, future land use potential, and offsite impacts in addition to the NCP criteria. In particular, due to its prime location, there is a significant benefit to the community in returning the site to productive use as soon as possible, and the alternatives are consistent with future redevelopment. In addition, the groundwater components proposed for Alternatives 2, 4a, 4b, 6a, and 6b (either a funnel-and-gate system or SRBs) are energy-efficient ones that use passive treatment, which reduces the amount of waste produced compared to other, traditional approaches. Each alternative has the opportunity to include techniques during the remedial design that could enhance the overall sustainability of the alternative.

TABLE 5-1
Detailed Evaluation of Alternative 2—NAPL and Arsenic Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
Description of remedy	Tar boils at the ground surface throughout the site, NAPL present in NZ-1, NZ-2 and NZ-5 would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place. A funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) would be installed to prevent potential NAPL migration to the Hudson River.	Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta Site, portions of Block 93 (north, central, and south), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd building. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Site groundwater would be contained and treated with a funnel-and-gate system (barrier cutoff wall with a permeable reactive barrier) before discharging to the River. Institutional controls restricting groundwater use would be established.
1. Overall Protection of Human Health and the Environment					
	Constituents would continue to leach to groundwater. The potential for direct exposure to principal threat waste would be minimized through capping and institutional controls. The containment wall with a funnel and gate would inhibit the potential migration of principal threat material to the Hudson River.	Contaminants would remain in place. Existing liner, additional capping and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact. Existing liner and capping would minimize the infiltration rate; however, groundwater would continue to flow through affected soils, leaching constituents to groundwater. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with principal threat waste.	Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.	Alternative would provide vapor barrier, which reduces inhalation potential. Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements. Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Gates would treat a majority of site constituents prior to discharge. Reactive barrier treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors. Institutional controls would restrict the use of the groundwater.
2. Compliance with ARARs					
	Would not meet soil clean-up standards, but most ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary	Would not meet soil clean-up standards, but most ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.	This alternative would not meet soil clean-up standards. In this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely. ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	The ARARs for vapor intrusion would be met as 115 River Rd. Buildings would undergo remedy to suppress vapor intrusion. 115 River Rd. and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.	The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria. Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.

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Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	Long-term potential risk related to the NAPL would continue indefinitely. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely.	Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls. Soil contamination would remain relatively unchanged since arsenic is not biodegradable. Although leaching would diminish, lateral infiltration would still occur resulting in continued leaching. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged. Although leaching would diminish, lateral infiltration would still occur resulting in continued leaching. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain. Potential risks would be controlled by vapor intrusion mitigation system installed in the basement of Buildings 7 and 8 at 115 River Rd. and maintenance of institutional controls and vapor mitigation. Magnitude of potential risk in buildings would be maintained below appropriate standards. Chosen methods are proven technologies for vapor mitigation.	Potential risks related to groundwater use onsite would remain; however, exposure risk is reduced by groundwater use restrictions. Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment funnel-and-gate system however, residual risk is present if gate fails or is not constructed or maintained correctly.
(b) Adequacy and reliability of controls	Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely. Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.	Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	Permeable reactive barriers are a new technology. Performance monitoring is a critical component of the remedy. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	No treatment used.	No treatment used.	No treatment used.	Vapor intrusion would be mitigated by the vapor intrusion mitigation system installed in the basement of the 115 River Rd building. Vapor intrusion mitigation would be applied to other buildings, if warranted.	Groundwater constituents would be treated/ adsorbed through PRBs before discharging to surface water.
(b) Degree and quantity of TMV reduction	Toxicity and volume of NAPL would remain. Mobility of NAPL would be reduced through the installation of a barrier cutoff wall, however, mobility via leaching to groundwater would continue.	Toxicity and volume of arsenic impacted soil would remain. Mobility of arsenic impacted soils would be reduced through capping; however, mobility via leaching to groundwater would continue.	Toxicity and volume of residual soil contamination would remain. Mobility of residually impacted soils would be reduced through capping and cover however, mobility via leaching to groundwater would continue.	Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Rd. basements. Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain.	Use of the PRBs would reduce groundwater concentrations to acceptable levels to allow for migration to the Hudson River.

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Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
(c) Irreversibility of TMV reduction	Reversible if institutional controls and cap were not maintained	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment of groundwater would be irreversible as long as treatment gates are not compromised or destroyed Permeable reactive barrier treatment may be reversible if barrier is compromised or destroyed or if adsorption sites are saturated up, allowing desorption to occur. Monitoring of the permeable reactive barrier would be conducted to predict when replacement or maintenance may be required.
(d) Type and quantity of treatment residuals	NAPL would remain onsite but access and infiltration would be controlled.	Arsenic contaminated soils would remain onsite but access and infiltration would be controlled.	Impacted soils would remain onsite but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon, organoclay, zero valent iron, GAC, or ion exchange resin.
(e) Statutory preference for treatment	Would not meet NJDEP preference for treatment of NAPL in soil; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of arsenic in soil; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	Potential risk to workers during remedial construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during installation of vapor intrusion mitigation systems.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(b) Protection of community during remedial action	Potential risks to the community during remedial construction include generated vapors, noise and odor during construction activities. These risks would be mitigated during implementation through use of engineering controls.	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the vapor intrusion mitigation system.	Potential risks to the community during remedial construction include generated vapors, noise and odor during construction activities. These risks would be mitigated during implementation through use of engineering controls. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.

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Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
(c) Environmental impacts of remedial action	Potential risk to the environment during barrier or slurry wall installations would be mitigated by implementation engineering controls. Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water. Potential risks to the environment (River habitat) during permeable reactive barrier installation would be mitigated by implementation of adequate erosion controls and proper handling of remediation-generated wastes
(d) Time until RAOs are achieved	Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents would continue.	The RAOs to minimize potential exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be met immediately following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from soils would continue.	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following the installation of the vapor intrusion mitigation system in the basement of Buildings 7 and 8 at 115 River Rd. and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings, if warranted.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the funnel and gate or PRB system Establishment of the institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met inside the containment area.
6. Implementability					
(a) Technical feasibility	Feasible.	Feasible.	Feasible.	Feasible.	Use of permeable reactive barriers is technically feasible pending results of bench- and pilot-scale testing. Permeable reactive barriers are considered an innovative technology.
(b) Administrative feasibility	Administratively feasible; however, access would be needed for cap installation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible; however, access would be needed for cap installation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.

TABLE 5-1
Detailed Evaluation of Alternative 2—NAPL and Arsenic Containment
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.
7. Total Present Worth Cost					
Total present worth cost range[a]	$29,043,000 to $62,235,000				

[a]The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix E.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non–aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound
PRB permeable reactive barrier

TABLE 5-2
Detailed Evaluation of Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
Description of remedy	NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5 and via directionally drilled recovery wells under 115 River Rd. buildings. Capping and institutional controls would be established to document and limit use of areas with COCs remaining in place. Limited NAPL recovery in NZ-3 and NZ-4. A barrier cutoff wall with groundwater extraction and treatment would be installed to prevent potential NAPL migration to the Hudson River.	Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be capped. A cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta Site, portions of Block 93 (north, central, and south), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd building. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Site groundwater would be contained with a barrier cutoff wall and groundwater extraction and treatment prior to discharging to the Hudson River. Institutional controls restricting groundwater use would be established.
1. Overall Protection of Human Health and the Environment					
	The potential for direct exposure to principal threat waste would be minimized through capping and institutional controls. Extraction wells would reduce the amount of free phase NAPL in the subsurface; however, the portion of the total mass that can be removed by this method is limited. Constituents would continue to leach to groundwater. Extracted NAPL would be stored in locked sheds and periodically removed and disposed of offsite. NAPL would be contained in drums and tanks with secondary containment. The containment wall would inhibit the potential migration of principal threat material to the Hudson River.	Contaminants would remain in place. Existing liner, additional capping and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact. The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA. Existing liner and capping would minimize the infiltration rate. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with principal threat waste.	Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.	Alternative would provide vapor barrier, which reduces inhalation potential. Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements. Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.	Groundwater treatment system would treat a majority of site constituents prior to discharge. Treatment system treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors from HCAA. Institutional controls would restrict the use of the groundwater.
2. Compliance with ARARs					
	Would not meet soil clean-up standards, but most ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would not be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.	Would not meet soil clean-up standards, but most ARARs would be met because the alternative reduces the direct exposure to constituents above the cleanup goal. ARARs concerned with leaching to groundwater would be met around the HCAA. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.	This alternative would not meet soil clean-up standards. In this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely. ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	The ARARs for vapor intrusion would be met as the 115 River Rd. buildings would undergo remedy to suppress vapor intrusion. 115 River Rd. and other occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.	The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River to achieve surface water protection criteria. Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.

TABLE 5-2
Detailed Evaluation of Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
3. Long-Term Effectiveness and Permanence					
(a) Magnitude of residual risks	Alternative includes active collection of free phase NAPL; however, long-term potential risk related to the residual NAPL that remains would continue indefinitely. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls. Soil contamination would remain relatively unchanged since arsenic is not biodegradable. Leaching would diminish especially around the HCAA, although lateral infiltration and subsequent leaching would occur in other areas. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged. Leaching would diminish, although lateral infiltration and subsequent leaching would occur. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain. Potential risks would be controlled by a vapor intrusion mitigation system installed in the basement of the115 River Rd. and maintenance of institutional controls and vapor mitigation. Magnitude of potential risk in buildings would be maintained below appropriate standards. Chosen methods are proven technologies for vapor mitigation.	Potential risks related to groundwater use onsite would remain; however, exposure risk is reduced by groundwater use restrictions. Potential risk related to surface water protection from groundwater discharging to river is mitigated by the barrier cutoff wall and groundwater extraction and treatment system however, residual risk is present if system fails or is not constructed or maintained correctly.
(b) Adequacy and reliability of controls	NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply. Performance monitoring is a critical component of the remedy. Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely. Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue.	Capping and soils covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs. The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA. Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	A barrier cutoff wall with a groundwater extraction and treatment system is a reliable, proven technology with multiple vendors for equipment supply. Performance monitoring would be required. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.
4. Reduction of Toxicity, Mobility, or Volume through Treatment					
(a) Treatment process used	Recovered NAPL would be disposed of offsite. Offsite disposal of NAPL is assumed to consist of asphalt batching.	Groundwater constituents associated with the HCAA would be treated through a treatment system before discharging to surface water.	No treatment used.	Vapor intrusion would be mitigated by the vapor intrusion mitigation system installed in the basement of the 115 River Rd. building. Vapor intrusion mitigation would be applied to other buildings, if warranted.	Groundwater constituents would be treated through a treatment system before discharging to surface water.
(b) Degree and quantity of TMV reduction	The volume of free-phase NAPL would be reduced through extraction and/or recovery although significant quantities of NAPL would remain in the subsurface and the total mass of NAPL to be removed is likely a small percent of the overall mass. Toxicity and mobility via leaching to groundwater from remaining NAPL would continue.	Toxicity and volume of arsenic impacted soil would remain. Mobility of arsenic impacted soils would be reduced through capping and containment around the HCAA.	Toxicity and volume of residual soil contamination would remain. Mobility of residually impacted soils would be reduced through capping and cover however, mobility via leaching to groundwater would continue.	Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Rd. basements. Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain.	Use of a barrier cutoff wall with a groundwater extraction and treatment system would reduce groundwater concentrations to acceptable levels to allow for migration to the Hudson River.

TABLE 5-2
Detailed Evaluation of Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
(c) Irreversibility of TMV reduction	NAPL recovery is irreversible. Reversible if institutional controls and cap were not maintained	Treatment of groundwater may be reversible is system is malfunctioning or shut down. Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment may be reversible if system is malfunctioning or shut down. Monitoring of the treatment system would be conducted to predict when maintenance would be required.
(d) Type and quantity of treatment residuals	Recoverable NAPL would be only a small fraction (up to approximately 10 percent) of the total NAPL present at the site. NAPL would remain in the subsurface	Arsenic contaminated soils would remain onsite but access and infiltration would be controlled.	Impacted soils would remain onsite but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Potential for replacement or regeneration of system components could generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue.
(e) Statutory preference for treatment	Preference would be met for removed free-phase NAPL, but not for NAPL remaining in the subsurface. Capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of arsenic in soil; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference met for groundwater because it would be treated before discharging to the river.
5. Short-Term Effectiveness					
(a) Protection of workers during remedial action	Potential risk to workers during remedial construction would be mitigated by adherence to a site-specific health and safety plan and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, cutoff wall and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during the installation of the vapor intrusion mitigation system.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(b) Protection of community during remedial action	Potential risks to the community during remedial construction include generated vapors, odors, and noise during construction activities. Engineering controls would be utilized to protect community from dust, vapors, and noise (silencers, black plastic, odor suppressing foam etc.). Operation and maintenance of NAPL recovery would require periodic transport of NAPL offsite. Appropriate health and safety, storage, and handling procedures must be followed.	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the vapor intrusion mitigation system.	Potential risks to the community during remedial construction include generated vapors, noise and odor during construction activities. These risks would be mitigated during implementation through use of engineering controls. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(c) Environmental impacts of remedial action	Design would include stormwater management. Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and ISCO. These potential risks would be mitigated during implementation through use of engineering controls. Potential risk to the environment during sheet pile or slurry wall installations would be mitigated by implementation engineering controls.	Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls. Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls would be developed to capture NAPL that may be released to surface water (such as containment booms).

TABLE 5-2
Detailed Evaluation of Alternative 3—NAPL and Arsenic Containment with NAPL Recovery
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL	Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor	Groundwater/Surface Water
(d) Time until RAOs are achieved	Anticipated removal of recoverable NAPL would be completed in an estimated 20-30 years from onset of implementation. The RAO to minimize potential exposure through contact, ingestion, and inhalation are achieved when capping is complete. Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from soils would continue.	The RAOs to minimize potential exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be met immediately following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 6 months to 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from soils would continue, although migration and leaching around the HCAA would be reduced.	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following the installation of the vapor intrusion mitigation system in the basement of the 115 River Rd. building and start-up of the ventilation systems. Vapor intrusion mitigation would be applied to other buildings, if warranted.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the barrier cutoff wall and groundwater extraction and treatment system Establishment of the institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met inside the containment area.
6. Implementability					
(a) Technical feasibility	Feasible.	Feasible.	Feasible.	Feasible.	Feasible.
(b) Administrative feasibility	Administratively feasible, however, access to properties would be needed during construction activities and cap installation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established. Rerouting of utilities would need to be coordinated with utility companies.	Administratively feasible; however, access would be needed for cap installation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.	Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials are readily available for installation and operation.
7. Total Cost					
Total present worth cost range [a]	$44,548,000 to $95,460,000				

[a]The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of the engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix E.

ARAR applicable or relevant and appropriate requirement
NAPL non–aqueous phase liquid
OU1 Operable Unit 1
PRG preliminary remediation goal
TMV toxicity, mobility, or volume
COC constituent of concern
NJDEP New Jersey Department of Environmental Protection
OU2 Operable Unit 2
RAO remedial action objective
VOC volatile organic compound

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
Description of Remedy	In situ solidification/stabilization of tar boils, accessible NAPL present in NZ-1, NZ-2, NZ-5 and portions of NZ-3 with capping. Surface and subsurface debris would be excavated and disposed of offsite. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place. Limited NAPL recovery in NZ-3 and NZ-4. NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, buildings are demolished to access NAPL areas below buildings' footprint, and then the buildings are reconstructed.	Principal threat arsenic on Block 93, the Quanta property and within the HCAA would be solidified/stabilized in situ. **HCAA Process option:** Principal threat arsenic on Block 93, the former Celotex and the Quanta properties would be solidified/ stabilized ex situ and a cutoff wall would be installed downgradient of the HCAA with groundwater extraction and treatment.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta Site, portions of Block 93 (north, central, and south), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted. A vapor intrusion mitigation system would be installed in the basements of the 115 River Rd. building.	Materials under 115 River Rd. would be treated.	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established. **HCAA Process Option:** Site groundwater would be contained around the HCAA with a barrier cutoff wall and groundwater extraction and treatment before discharging to the River.
1. Overall Protection of Human Health and the Environment							
	The potential for exposure to the principal threat waste would be minimized through solidification/stabilization, capping, and institutional controls. Constituents remain in place; however, solidification/stabilization would be designed to significantly reduce leaching of constituents from treated soils under normal groundwater geochemical conditions.		The potential for exposure to the principal threat waste and leaching would be minimized through solidification/stabilization, capping, and institutional controls. **HCAA Process Option:** Contaminants associated with the HCAA would remain in place. Existing liner and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact. The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA.	Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.	Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements. Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings. Vapor mitigation systems would be installed in existing buildings, if warranted. Current building slab provides a vapor barrier, which reduces inhalation potential.	Monitoring would be performed in newly constructed buildings.	Reactive barrier treats or adsorbs groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors. Institutional controls would restrict the use of the groundwater. **HCAA Process Option:** Treatment system treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors from HCAA.
2. Compliance with ARARs							
	Must meet substantive requirements for air pollution control using dust and vapor suppression and/or vapor collection. Design would address stormwater management and changed groundwater flow patterns. Complies with the ARAR to treat, remove, or contain NAPL by treating NAPL with solidification/stabilization. Under this alternative, NAPL outside the treatment zones would continue to leach constituents to groundwater and exceedances would persist indefinitely.		Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization. **HCAA Process Option:** Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization, except around the HCAA. ARARs concerned with leaching to groundwater would be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.	This alternative would not meet soil clean-up standards. In this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely. ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	Occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios. The ARARs for vapor intrusion would be met as mitigation measures would be installed in 115 River Rd. buildings to capture potential vapors.	The ARARs for vapor intrusion would be met as the 115 River Road buildings would be rebuilt and monitored.	The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria. Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(a) Magnitude of residual risks	The presence of monoliths resulting from solidification/stabilization would impact groundwater flow. Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely. Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.	Low potential risk due to constituents left in place. All principal threat NAPL would be treated. Infiltration and leaching would be greatly reduced.	Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged. Leaching would diminish, although lateral infiltration and subsequent leaching would occur. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Magnitude of potential risk in buildings would be maintained below appropriate standards. Chosen methods are proven technologies for vapor mitigation. Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain. Potential risks would be controlled by vapor intrusion mitigation system installed in the basement of the 115 River Road building and maintenance of institutional controls and vapor mitigation.	No risk of volatilization as material under buildings is treated. Reconstructed buildings would be monitored and institutional controls maintained.	Potential risks related to groundwater use onsite would remain; however, exposure risk is reduced by groundwater use restrictions. Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.
(b) Adequacy and reliability of controls	Solidified soils and institutional controls are adequate and reliable in preventing direct contact and leaching but would require monitoring indefinitely. NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply.		Solidified soils and institutional controls are adequate and reliable in preventing direct contact and leaching but would require monitoring indefinitely. **HCAA Process Option:** The cutoff wall with extraction wells would minimize leaching to groundwater around the HCAA. Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	Solidified soils are adequate at preventing vapor intrusion.	Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely. **HCAA Process Option:** A barrier cutoff wall and groundwater extraction and treatment system is a reliable, proven technology with multiple vendors for equipment supply. Performance monitoring would be required.

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
4. Reduction of Toxicity, Mobility, or Volume through Treatment							
(a) Treatment process used	NZ-1, NZ-2, NZ-5 and tar boil impacted soils would be solidified /stabilized in situ with reagents mixed in via large diameter augers or jet grouting. Surface and subsurface debris would be excavated and disposed of offsite. Recovered NAPL would be disposed of offsite. Offsite disposal of NAPL is assumed to consist of asphalt batching.		Principal threat arsenic on Block 93, Quanta, and Former Celotex properties would be solidified/stabilized. **HCAA Process Option:** Groundwater constituents associated with the HCAA would be treated through a treatment system before discharging to surface water.	No treatment used.	Vapor intrusion mitigation would be applied to other buildings, if warranted. Monitoring would continue.		Groundwater constituents would be treated/ adsorbed before discharging to surface water through the use of a subaqueous reactive barrier. **HCAA Process Option:** Groundwater constituents would be treated through a treatment system before discharging to surface water
	Materials under 115 River Rd. would not be treated.	NZ-1 and NZ-2 under 115 River Rd. would be solidified/stabilized in situ with reagents.			Vapor intrusion would be mitigated by the vapor intrusion mitigation system installed in the basement of the 115 River Road Building.	No vapor intrusion into 115 River Rd. as soils are treated.	
(b) Degree and quantity of TMV reduction	Toxicity and mobility would be reduced but volume would not be reduced. Leaching of constituents to groundwater would be reduced. The volume of deep free-phase NAPL would be reduced through minimal recovery and minimal in situ solidification/stabilization.		Toxicity and mobility would be reduced but volume would not be reduced. Leaching of constituents to groundwater would be reduced. **HCAA Process Option:** Mobility of arsenic impacted soils would be reduced through solidification/stabilization, capping and containment around the HCAA.	Toxicity and volume of residual soil contamination would remain. Mobility of residually impacted soils would be reduced through capping and cover however, mobility via leaching to groundwater would continue.	Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain. Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Rd. basements.	Toxicity and mobility would be reduced in underlying soils but volume would not be reduced. Vapor intrusion would be reduced.	Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River. **HCAA Process Option:** Use of hydraulic control would reduce groundwater concentrations to acceptable levels to allow for migration to the Hudson River.

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(c) Irreversibility of TMV reduction	Solidification/Stabilization is irreversible. The limited deep NAPL recovery is irreversible.		Solidification/stabilization is irreversible. **HCAA Process Option:** Treatment of groundwater may be reversible is system is malfunctioning or shut down. Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment is irreversible.	Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed. Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required. **HCAA Process Option:** Treatment may be reversible if system is malfunctioning or shut down. Monitoring of the treatment system would be conducted to predict when maintenance would be required.
(d) Type and quantity of treatment residuals	NAPLs stabilized in the soil matrix in-situ would remain onsite.		Arsenic stabilized in the soil matrix would remain onsite. **HCAA Process Option:** Arsenic contaminated soils associated with the HCAA would remain onsite but access and infiltration would be controlled.	Impacted soils would remain onsite but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Sources of vapors would be treated.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin. **HCAA Process Option:** Potential for replacement or regeneration of system components could generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue
(e) Statutory preference for treatment	Would meet NJDEP preference for treatment of NAPLs in the areas treated.	Would meet NJDEP preference for treatment of all principal threat NAPL.	Would meet NJDEP preference for treatment of arsenic contaminated soils in the areas treated. **HCAA Process Option:** Would not meet NJDEP preference for treatment of arsenic in soil in all areas; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference would be met as potential vapor producing material would be treated.	Preference met for groundwater because it would be treated before discharging to the river.

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
5. Short-Term Effectiveness							
(a) Protection of workers during remedial action	Implementation of NAPL and tar boil stabilization could result in the potential for additional risk to workers due to high concentrations of NAPL and COCs expected to be present in the shallow soils within the treatment areas. Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control). Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans. No additional risk.	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.	Implementation of arsenic stabilization could result in the potential for additional risk to workers due to high concentrations of arsenic within the treatment areas. Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control). Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans. **HCAA Process Option:** Minimal potential risk to workers during site clearing and grading, cutoff wall and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of vapor intrusion mitigation system and installation of vapor mitigation in basement.	No additional risk.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water. Potential temporary river habitat destruction during reactive barrier construction. **HCAA Process Option:** Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
(b) Protection of community during remedial action	Potential risks to the community during solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls. Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam). No additional risk.	Potential risk to community from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.	Potential risks to the community during excavation and solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls. Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the vapor intrusion mitigation system.	No additional risk.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier. Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be me prior to reaching the subaqueous reactive barrier. **HCAA Process Option:** Potential risks to the community during remedial construction include generated vapors, noise and odor during construction activities. These risks would be mitigated during implementation through use of engineering controls. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(c) Environmental impacts of remedial action	Design would include storm water management. Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and mixing. These potential risks would be mitigated during implementation through use of engineering controls. Potential risk to the environment during sheet pile or slurry wall installations would be mitigated by implementation engineering controls. No additional impacts.	Potential risk to the environmental from demolition activities would be mitigated through engineering controls.	Design would include storm water management. Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and mixing. These potential risks would be mitigated during implementation through use of engineering controls. Potential risk to the environment during sheet pile or slurry wall installations would be mitigated by implementation engineering controls. **HCAA Process Option:** Minimal potential risks to the environment during cut –off wall assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	No additional impacts.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls would be developed to capture NAPL that may be released to surface water (such as containment booms). Potential temporary River habitat destruction during reactive barrier construction. **HCAA Process Option:** Minimal potential risks to the environment during barrier cutoff wall and groundwater extraction and treatment system assuming implementation of adequate erosion controls.
(d) Time until RAOs are achieved	The treatment of the NAPL through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping area complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than two years). Limited deep NAPL recovery would continue indefinitely. RAOs would not be met in areas outside of the stabilized area.		The treatment of the arsenic through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping area complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than two years). **HCAA Process Option:** Achieve RAOs immediately by treatment of arsenic through solidification/stabilization, except in and around the HCAA.	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.	Vapor intrusion mitigation would be applied to other buildings, if warranted. The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following the installation of the vapor intrusion mitigation system in the basement of the 115 River Road building, and start-up of the ventilation systems.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following solidification/ stabilization and reconstruction of the buildings.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met by use of the in situ passive treatment. Establishment of the institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in groundwater on upgradient portions of the site would not be met. **HCAA Process Option:** The RAOs of preventing migration of arsenic to OU2 (Hudson River) would be met immediately after installation of the barrier cutoff wall and groundwater extraction and treatment system and solidification /stabilization.

TABLE 5-3
Detailed Evaluation of Alternatives 4a and 4b—NAPL and Arsenic In Situ Solidification/Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	4a—Preservation of 115 River Rd. Buildings	**4b—Demolition of 115 River Rd. Buildings**			**4a—Preservation of 115 River Rd. Buildings**	**4b—Demolition of 115 River Rd. Buildings**	
6. Implementability							
(a) Technical feasibility	Solidification/stabilization is technically feasible based on site conditions, pending the results of bench and pilot testing. Implementation would be feasible if large (>12") objects are excavated from the surface and subsurface prior to solidification/stabilization. Feasible.	Demolition is technically feasible and would require detailed planning and coordination.	Solidification/stabilization is technically feasible based on site conditions, pending the results of bench and pilot testing. Horizontal injection under the liner is technically feasible but would require detailed planning, coordination and testing. **HCAA Process Option:** Installation of cutoff wall is feasible	Feasible.	Feasible.		Use of subaqueous reactive barriers is technically feasible pending results of bench- and pilot-scale testing. Subaqueous reactive barriers are considered an innovative technology. **HCAA Process Option:** Feasible.
(b) Administrative feasibility	Administratively feasible; however, access is needed for mixing and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established. Rerouting of utilities would need to be coordinated with utility companies. Impacts to nearby buildings would need to be avoided by measures such as temporary parking and temporarily relocating the entrance of 115 River Rd.	Feasible, however relocation of 115 River Rd. tenants would need to occur and building demolition would have to be coordinated.	Administratively feasible; however, access is needed for implementation and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established. Rerouting of utilities would need to be coordinated with utility companies.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.		Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials are readily available for installation and operation.		Necessary engineering services and materials readily available for installation and operation; however, limited number of contractors have horizontal under a ramp solidification/stabilization.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.		Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.
7. Total Cost							
Total present worth cost range [a]	4a = $50,568,000 to $108,360,000 (Cost assumes implementation of the HCAA process option) 4b = $118,174,000 to $253,230,000 (Cost assumes implementation of the HCAA process option)						

[a]The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of the engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix E.

ARAR applicable or relevant and appropriate requirement
NAPL non–aqueous phase liquid
OU1 Operable Unit 1
PRG preliminary remediation goal
TMV toxicity, mobility, or volume
SRB subaqueous reactive barrier
COC constituent of concern
NJDEP New Jersey Department of Environmental Protection
OU2 Operable Unit 2
RAO remedial action objective
VOC volatile organic compound

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
Description of Remedy	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for offsite disposal. NAPL would be collected via standard recovery wells located in NZ-1, NZ-2, NZ-5, and to a limited extent in NZ-3 and NZ-4. NAPL collection would be followed by in situ chemical oxidation in NAPL zones NZ-1, NZ-2, NZ-5 and a portion of NZ-3. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline.		Principal threat arsenic on Block 93, the Quanta property and within the HCAA would be solidified/stabilized in situ. **HCAA Process option:** A cutoff wall would be installed downgradient of the HCAA with extraction wells tied into an ex situ groundwater treatment system.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, portions of Block 93 (north, central, and south), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.		Site groundwater would be contained with a barrier cutoff wall and groundwater directed through an ex situ groundwater treatment system before discharging to the River. Institutional controls restricting groundwater use would be established. **HCAA Process Option:** Groundwater contained around the HCAA with a barrier cutoff wall would have extraction wells tied into the ex situ groundwater treatment.
	NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, buildings are demolished to access NAPL areas below buildings' footprint, and then the buildings are reconstructed.			A vapor intrusion mitigation system would be installed in the basements of the 115 River Road buildings.	Materials under 115 River Rd. would be treated.	
1. Overall Protection of Human Health and the Environment							
	In situ treatment with ISCO, shallow excavation, NAPL recovery and institutional controls would reduce contaminant mass and minimize exposure to principal threat waste through direct contact, ingestion, and volatilization. ISCO would reduce contaminant mass that is leaching constituents from the soils to surface water or groundwater; however, constituents that do not come in contact with oxidant would remain and continue to leach to groundwater.		The potential for exposure to the principal threat waste and leaching would be minimized through solidification/stabilization, capping, and institutional controls. **HCAA Process Option:** Contaminants associated with the HCAA would remain in place. Existing liner and institutional controls would mitigate the principal threat potential risk of human exposure through direct contact. The barrier cutoff wall and groundwater extraction and treatment system would minimize leaching to groundwater around the HCAA.	Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.	Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements. Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings. Vapor mitigation systems would be installed in existing buildings, if warranted.		A barrier cutoff wall and groundwater extraction and treatment system would treat a majority of site constituents prior to discharge. Treatment system treats or adsorbs contaminated groundwater prior to discharge to the Hudson River, thereby reducing potential exposure to human and ecologic receptors from HCAA. Institutional controls would restrict the use of the groundwater.
					Alternative would provide vapor barrier, which reduces inhalation potential.	Monitoring would be performed in newly constructed buildings.	
2. Compliance with ARARs							
	Complies with the ARAR to treat, remove, or contain NAPL by excavating or chemically oxidizing NAPL, to the extent practicable.		Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization. **HCAA Process Option:** Complies with ARAR to treat, remove or contain principal threat arsenic by solidification/stabilization, except around the HCAA. ARARs concerned with leaching to groundwater would be met. Cap integrity would be maintained through regular inspections and repairs; reporting of the verification of the effectiveness of institutional controls would be conducted, as necessary.	This alternative would not meet soil clean-up standards. In this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely. ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	Occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios.		The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River to achieve surface water protection criteria. Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.
					The ARARs for vapor intrusion would be met as 115 River Rd. buildings would undergo remedy to suppress vapor intrusion.	The ARARs for vapor intrusion would be met as the 115 River Road buildings would be rebuilt and monitored.	

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
3. Long-Term Effectiveness and Permanence							
(a) Magnitude of residual risks	Potential risks due to constituents left in place would be reduced; however, some NAPL would remain and the heat generated during the oxidation reactions and transferred throughout the subsurface could mobilize some of this remaining NAPL. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely.		The presence of monoliths resulting from solidification/stabilization would impact groundwater flow. Solidification/stabilization is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged. Leaching would diminish, although lateral infiltration and subsequent leaching would occur. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Magnitude of potential risk in buildings would be maintained below appropriate standards. Chosen methods are proven technologies for vapor mitigation.		Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions. Potential risk related to surface water protection from groundwater discharging to river is mitigated by the barrier cutoff wall with extraction wells, however residual risk is present if system fails or is not constructed or maintained correctly.
	Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.	Low potential risk due to constituents left in place. All principal threat NAPL would be treated. Infiltration and leaching would be greatly reduced.			Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain. Potential risks would be controlled by vapor intrusion mitigation system installed in the basements of the 115 River Road building and maintenance of institutional controls and vapor mitigation.	No risk of volatilization as material under building sis treated. Reconstructed buildings would be monitored and institutional controls maintained.	
(b) Adequacy and reliability of controls	Treatment of soils and institutional controls are adequate and reliable in preventing direct contact. Treatment of soils reduces leaching. NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply		Solidified soils and institutional controls are adequate and reliable in preventing direct contact and leaching but would require monitoring indefinitely. **HCAA Process Option:** The barrier cutoff wall and groundwater extraction and treatment system would minimize leaching to groundwater around the HCAA. Institutional controls are necessary to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	Treated soils are adequate at preventing vapor intrusion.	A barrier cutoff wall and groundwater extraction and treatment system is a reliable, proven technology with multiple vendors for equipment supply. Performance monitoring would be required. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
4. Reduction of Toxicity, Mobility, or Volume through Treatment							
(a) Treatment process used	Excavated soil and recovered NAPL would be disposed of offsite. NZ-1, NZ-2, and NZ-5 would be treated with ISCO, reagent assumed to be Catalyzed Hydrogen Peroxide (CHP).		Principal threat arsenic on Block 93, Quanta, and Former Celotex properties would be solidified/stabilized. **HCAA Process Option:** Groundwater constituents associated with the HCAA would be treated through a treatment system before discharging to surface water.	No treatment used.	Vapor intrusion mitigation would be applied to other buildings, if warranted. Monitoring would continue.		Groundwater constituents would be treated through a treatment system before discharging to surface water.
	Materials under 115 River Rd. would not be treated.	NZ-1 and NZ-2 under 115 River Rd. would be treated with ISCO			Vapor intrusion would be mitigated by the vapor intrusion mitigation system installed in the basements of the 115 River Road building.	No vapor intrusion into 115 River Rd. as soils are treated.	
(b) Degree and quantity of TMV reduction	Toxicity, mobility, and volume would be reduced by NAPL recovery. ISCO oxidizes the organic compounds that come in contact with the oxidant, which reduces toxicity, mobility, and volume. Pilot-scale testing would be completed to optimize dosages and determine the reduction in concentrations that can be achieved. The volume of deep free-phase NAPL would be reduced through minimal recovery and minimal ISCO treatment.		Toxicity and mobility would be reduced but volume would not be reduced. Leaching of constituents to groundwater would be reduced. **HCAA Process Option:** Mobility of arsenic impacted soils would be reduced through solidification/stabilization, capping and containment around the HCAA.	Toxicity and volume of residual soil contamination would remain. Mobility of residually impacted soils would be reduced through capping and cover however, mobility via leaching to groundwater would continue.	Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain. Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Rd. basements.	Toxicity and mobility would be reduced in underlying soils but volume would not be reduced. Vapor intrusion would be reduced.	Use of a barrier cutoff wall and groundwater extraction and treatment system would reduce groundwater concentrations to acceptable levels to allow for migration to the Hudson River.
(c) Irreversibility of TMV reduction	NAPL recovery and destruction of the organics through ISCO are irreversible.		Solidification/stabilization is irreversible. **HCAA Process Option:** Treatment of groundwater may be reversible is system is malfunctioning or shut down. Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment is irreversible.	Treatment may be reversible if system is malfunctioning or shut down, Monitoring of the treatment system would be conducted to predict when maintenance would be required.
(d) Type and quantity of treatment residuals	Recoverable NAPL would be only a small fraction (up to approximately 10 percent) of the total NAPL present at the site.		Arsenic stabilized in the soil matrix would remain onsite. **HCAA Process Option:** Arsenic contaminated soils associated with the HCAA would remain on site but access and infiltration would be controlled.	Impacted soils would remain on site but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Sources of vapors would be treated.	Potential for replacement or regeneration of system components could generate residuals such as spent carbon, organoclay, GAC, ion exchange resin, or other process residue.

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(e) Statutory preference for treatment	Would meet NJDEP preference for treatment of NAPLs in the areas treated.	Would meet NJDEP preference for treatment of all principal threat NAPL.	Would meet NJDEP preference for treatment of arsenic contaminated soils in the areas treated. **HCAA Process Option:** Would not meet NJDEP preference for treatment of arsenic in soil in all areas; however, capping was approved by NJDEP on adjacent property.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference would be met as potential vapor producing material would be treated.	Preference met for groundwater because it would be treated before discharging to the river.
5. Short-Term Effectiveness							
(a) Protection of workers during remedial action	Implementation of shallow NAPL and tar boil excavation could result in the potential for additional risk to workers due to NAPL and high concentrations of COCs. Implementation of ISCO could result in the potential for additional risk to workers, due to handling of large quantities of chemical required for oxidants. Potential risk to workers during remediation construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, noise control).Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans.		Implementation of arsenic stabilization could result in the potential for additional risk to workers due to high concentrations of arsenic within the treatment areas. Potential risk to workers during solidification/stabilization would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control, and noise control). Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans. **HCAA Process Option:** Minimal potential risk to workers during site clearing and grading, cutoff wall and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of vapor intrusion mitigation system in the basements of the 115 River Road building and installation of vapor mitigation in basement.	No additional risk.	Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
	No additional risk	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.					

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(b) Protection of community during remedial action	Potential risks to the community during remediation construction include generated vapors, dust, noise, and odor during excavation. These potential risks would be mitigated during implementation through use of engineering controls. Heat generated during the oxidation reaction could result in increased NAPL mobility and volatility of constituents that could migrate to 115 River Rd. or other buildings via preferential pathways. Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).		Potential risks to the community during excavation and solidification/stabilization include generated dust, vapors and odor during mixing as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls. Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the vapor intrusion mitigation system.	No additional risk.	Potential risks to the community during remedial construction include generated vapors, noise and odor during construction activities. These risks would be mitigated during implementation through use of engineering controls. Potential risk can be mitigated by adherence to site-specific health and safety plans and operation and maintenance plans.
	No additional risk.	Potential risk to community from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.					
(c) Environmental impacts of remedial action	Design would include storm water management. Heat generated during the oxidation reaction could result in increased mobility and volatility of the residual NAPL. Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and ISCO. These potential risks would be mitigated during implementation through use of engineering controls. Potential risk to the environment during sheet pile or slurry wall installations would be mitigated by implementation engineering controls.		Design would include storm water management. Potential risks to the environment include generated dust, vapors, noise, and odors during excavation and mixing. These potential risks would be mitigated during implementation through use of engineering controls. Potential risk to the environment during sheet pile or slurry wall installations would be mitigated by implementation engineering controls. **HCAA Process Option:** Minimal potential risks to the environment during cut –off wall assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	No additional risk.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls would be developed to capture NAPL that may be released to surface water (such as containment booms). **HCAA Process Option:** Minimal potential risks to the environment during operation of hydraulic containment system assuming implementation of adequate erosion controls.
	No additional impacts	Potential risk to the environmental from demolition activities would be mitigated through engineering controls.					

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	5a—Preservation of 115 River Rd. Buildings	**5b—Demolition of 115 River Rd. Buildings**			**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	
(d) Time until RAOs are achieved	Anticipated NAPL recovery would be completed in an estimated 5-10 years to reduce mass in the subsurface before ISCO is implemented. Limited deep NAPL recovery would continue indefinitely. Oxidation reaction is instantaneous; however, multiple injections events are typically needed. The RAOs to prevent unacceptable risk as a result of exposure to soils would be met following in situ treatment and establishment of institutional controls in the areas treated. RAOs would not be met in areas outside of the treatment areas.		The treatment of the arsenic through solidification/stabilization achieves RAOs immediately after solidification/stabilization and capping area complete and institutional controls are in place. The remedy can be implemented relatively quickly (in less than two years). **HCAA Process Option:** Achieve RAOs immediately by treatment of arsenic through solidification/stabilization, except around the HCAA.	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.	Vapor intrusion mitigation would be applied to other buildings, if warranted. The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following the installation of the vapor intrusion mitigation system in the basements of the 115 River Road and start-up of the ventilation systems.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following solidification/stabilization and reconstruction of the buildings.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the barrier cutoff wall with extraction wells. Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be met inside the containment area.
6. Implementability							
(a) Technical feasibility	ISCO would be technically feasible based on site conditions, pending the results of bench- and pilot-scale testing. Feasible.	Demolition is technically feasible and would require detailed planning and coordination.	Solidification/stabilization is technically feasible based on site conditions, pending the results of bench and pilot testing. Horizontal injection under the liner is technically feasible but would require detailed planning, coordination and testing. **HCAA Process Option:** Installation of cutoff wall is feasible	Feasible.	Feasible.		Feasible.
(b) Administrative feasibility	Administratively feasible; however, access is needed for implementation and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established. Rerouting of utilities would need to be coordinated with utility companies. Impacts to nearby buildings would need to be avoided by measures such as temporary parking and temporarily relocating the entrance of 115 River Rd.	Feasible, however relocation of 115 River Rd. tenants would need to occur and building demolition would have to be coordinated.	Administratively feasible; however, access is needed for implementation and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established. Rerouting of utilities would need to be coordinated with utility companies.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.		Administratively feasible, however, groundwater sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.

TABLE 5-4
Detailed Evaluation of Alternatives 5a and 5b—NAPL In Situ Chemical Oxidation with Arsenic Stabilization
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**5a—Preservation of 115 River Rd. Buildings**	**5b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(c) Availability of services and materials	Necessary engineering services and materials are readily available for installation and operation.		Necessary engineering services and materials readily available for installation and operation; however, limited number of contractors have horizontal under a ramp solidification/stabilization.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.		Necessary engineering services and materials are readily available for installation and operation.
7. Total Cost							
Total present worth cost range [a]	5a = $255,948,000 to $548,460,000 (Cost assumes implementation of the **HCAA** process option) 5b = $336,182,000 to $720,390,000 (Cost assumes implementation of the **HCAA** process option)						

[a]The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of the engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix E.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non–aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
Description of Remedy	NAPL present in NZ-1, NZ-2, NZ-5, tar boils and within portions of NZ-3 would be excavated from accessible areas and disposed of offsite. Excavation would require dewatering to achieve depths greater than 4 ft, and may require shoring near existing structures. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade. A barrier cutoff wall would be installed along NZ-2 and NZ-5 shoreline. Limited NAPL recovery in NZ-3 and NZ-4.		Principal threat arsenic on the former Celotex, Quanta, and Block 93 properties would be excavated, and then backfilled and compacted with clean material to grade.	Existing River/Gorge Rd. surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Soil capping would include light clearing and placement of a cap on the Quanta site, portions of Block 93 (north, central, and south), portions of Block 94, portions of Block 92.01 and portions of 115 River Rd. The cap would be either a single-layer engineered cap or a vegetative cap, depending on redevelopment. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Rd. Vapor intrusion mitigation would be installed in the other occupied buildings, if warranted.		A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.
	NAPL under 115 River Rd. is left in place.	115 River Rd. tenants are relocated, buildings are demolished to access NAPL areas below buildings' footprint, and then the buildings are reconstructed.			A vapor intrusion mitigation system would be installed in the basements of the 115 River Road.	Materials under 115 River Rd. would be removed.	
1. Overall Protection of Human Health and the Environment							
	NAPL zones (NZ-1, NZ-2, and NZ-5) soils and tar boils posing potential risk above acceptable levels would be removed.		The potential for exposure to the principal threat waste and leaching would be eliminated through excavation and institutional controls.	Caps (either existing concrete or asphalt with upgrades and new caps) would prevent direct contact with impacted surface soils and minimize erosion of soils on properties with impacted shallow soils. Institutional controls for all properties would identify the areas of soil constituents left in place exceeding PRGs and minimize the potential for damage to caps and/or direct contact with contaminated subsurface soil. Constituents would remain beneath the cap and groundwater could continue to flow through affected soils, leaching constituents to groundwater.	Institutional controls would establish criteria for future development that would minimize potential for vapor intrusion, including construction requirements. Indoor air monitoring would be performed to identify vapor intrusion concerns within existing buildings. Vapor mitigation systems would be installed in existing buildings, if warranted.		Reactive barrier treats or adsorbs groundwater constituents prior to discharge to the Hudson River, thereby eliminating potential exposure to human and ecologic receptors. Institutional controls would restrict the use of the groundwater.
					Alternative would provide vapor barrier, which reduces inhalation potential.	Monitoring would be performed in newly constructed buildings.	

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings			6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings	
2. Compliance with ARARs							
	Complies with ARAR to treat, remove or contain principal threat NAPL by excavation. Must meet substantive requirements for air pollution control using dust and vapor suppression and vapor collection. Engineering controls such as silt curtains with booms would provide protection to the Hudson River during construction activities. Meets ARAR for controlling potential risk in soil by removing, treating, or containing soil containing NAPL. Transportation and disposal of excavated material would be performed in accordance with applicable federal, state, and local regulations.		Complies with ARAR to treat, remove or contain principal threat arsenic by excavation. Must meet substantive requirements for air pollution control using dust and vapor suppression and vapor collection. Meets ARAR for controlling potential risk in soil by removing, treating, or containing soil containing NAPL. Transportation and disposal of excavated material would be performed in accordance with applicable federal, state, and local regulations.	This alternative would not meet soil clean-up standards. In this alternative, NAPL would continue to leach constituents to groundwater and exceedances would persist indefinitely. ARARs would be met because cap integrity would be maintained through regular inspections and repairs and reporting associated with verification of the effectiveness of institutional controls would be conducted, as necessary.	Occupied buildings would undergo indoor air sampling to monitor for compliance with ARARs. Institutional controls would be used obviate the vapor intrusion pathway under future use scenarios. The ARARs for vapor intrusion would be met as 115 River Rd. buildings would undergo remedy to suppress vapor intrusion.	The ARARs for vapor intrusion would be met as the 115 River Road buildings would be rebuilt and monitored.	The ARAR for surface water discharge would be met as groundwater would be treated prior to discharge to the River achieve surface water protection criteria. Site groundwater would not achieve PRGs; therefore, ARARs would not be achieved. However, institutional controls would be obtained to prevent groundwater use at the site.
3. Long-Term Effectiveness and Permanence							
(a) Magnitude of residual risks	Once excavation is completed, residual risks would remain in soils not excavated. Constituents left in place beneath the excavation depths would be covered by clean backfill. Monitoring of potential NAPL migration at the southern edge of NZ-3 would continue indefinitely. Potential risks due to constituents left in place would be controlled by capping, existing soil cover, and institutional controls.	Low potential risk due to constituents left in place. All principal threat NAPL would be treated. Infiltration and leaching would be greatly reduced.	Once excavation is completed, residual risks would be reduced. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Potential risks due to contamination left in place would be controlled by capping, existing soil cover and institutional controls. Soil constituent concentrations would remain relatively unchanged. Leaching would diminish, although lateral infiltration and subsequent leaching would occur. Capping is a proven technology and effective for eliminating direct exposure to constituents as well reducing infiltration of precipitation to groundwater.	Magnitude of potential risk in buildings would be maintained below appropriate standards. Chosen methods are proven technologies for vapor mitigation. Does not eliminate volatilization of constituents in the subsurface but prevents exposure within buildings. Risk related to potential subsurface volatilization of VOCs would remain. Potential risks would be controlled by vapor intrusion mitigation system installed in the basements of the 115 River Road building and maintenance of institutional controls and vapor mitigation.	No risk of volatilization as material under the buildings is treated. Reconstructed buildings would be monitored and institutional controls maintained.	Potential risks related to groundwater use on site would remain; however, exposure risk is reduced by groundwater use restrictions. Potential risk related to surface water protection from groundwater discharging to river is mitigated by treatment via subaqueous reactive barrier; however, residual risk is present if barrier fails or is not constructed or maintained correctly.

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	6a—Preservation of 115 River Rd. Buildings	**6b—Demolition of 115 River Rd. Buildings**			**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	
(b) Adequacy and reliability of controls	Excavation and institutional controls would be very reliable. NAPL recovery is a reliable, proven technology, with multiple vendors for equipment supply.		Excavation and institutional controls would be very reliable.	Capping and soil covers would be adequate and reliable in preventing direct contact and erosion of surface soils with concentrations exceeding PRGs; however, leaching of constituents to groundwater would continue. Requires reliance on institutional controls to prevent damage to caps, intrusive activities into impacted soils, and spreading of contaminated soil. They are adequate and reliable but would be necessary indefinitely.	Vapor mitigation would be reliable with proper maintenance and access restrictions. Adequacy of the barrier would be tested and augmented if needed to ensure adequacy and reliability of controls.	Solidified soils are adequate at preventing vapor intrusion.	Subaqueous reactive barriers are a new technology. Performance monitoring is a critical component of the remedy. Relies on institutional controls to prevent use of groundwater. These controls would be necessary indefinitely.
4. Reduction of Toxicity, Mobility, or Volume through Treatment							
(a) Treatment process used	Excavated soils would be stabilized prior to disposal offsite, as necessary, to meet land disposal requirements. Recovered NAPL would be disposed of offsite. Offsite disposal of NAPL is assumed to consist of asphalt batching. Materials under 115 River Rd. would not remain in place.	NZ-1 and NZ-2 under 115 River Rd. would be excavated.	Excavated soils would be stabilized prior to disposal offsite, as necessary, to meet land disposal requirements.	No treatment used.	Vapor intrusion mitigation would be applied to other buildings, if warranted. Monitoring would continue. Vapor intrusion would be mitigated by the vapor intrusion mitigation system installed in the basements of the 115 River Road.	No vapor intrusion into 115 River Rd. as soils are treated.	Groundwater constituents would be treated/ adsorbed before discharging to surface water through the use of a subaqueous reactive barrier and PRB.
(b) Degree and quantity of TMV reduction	Toxicity, volume and mobility of NAPL would be reduced by removal of impacted soils. Soils removed during excavation would be stabilized prior to disposal, as necessary, to meet land disposal requirements. The volume of deep free-phase NAPL would be reduced through minimal NAPL recovery and minimal deep excavation.		Toxicity, volume and mobility of arsenic would be reduced by removal of impacted soils. Soils removed during excavation would be stabilized prior to disposal, as necessary, to meet land disposal requirements.	Toxicity and volume of residual soil contamination would remain. Mobility of residually impacted soils would be reduced through capping and cover however, mobility via leaching to groundwater would continue.	Vapor mitigation system(s) would reduce the indoor concentrations to below threshold limits in other buildings, if needed. Toxicity, mobility, and volume of contamination in underlying soils would remain. Intrusion of vapor into buildings would be restricted by the subslabs in the 115 River Rd. basements.	Toxicity and mobility would be reduced in underlying soils but volume would not be reduced. Vapor intrusion would be reduced.	Use of the reactive cap would reduce groundwater concentrations to acceptable levels to allow for surface water discharge to the Hudson River.

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings			6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings	
(c) Irreversibility of TMV reduction	Excavation of soils is irreversible; however, soils must be disposed offsite. The limited deep NAPL recovery is irreversible.		Excavation of soils is irreversible; however, soils must be disposed offsite.	Reversible if institutional controls and cap were not maintained.	Reversible if institutional controls and/or vapor mitigation systems, if needed, were not maintained.	Treatment is irreversible.	Treatment of groundwater would be irreversible as long as subaqueous reactive barrier is not compromised or destroyed. Subaqueous reactive barrier treatment may be reversible if adsorption sites saturated, allowing desorption to occur. Monitoring of the subaqueous reactive barrier would be conducted to predict when replacement or maintenance may be required.
(d) Type and quantity of treatment residuals	This alternative would result in approximately 166,000 cubic yards of treated soils to be disposed offsite.	This alternative would result in approximately 166,000 cubic yards of treated soils to be disposed offsite.	Approximately 33,000 cubic yards of treated arsenic contaminated soils would be removed from Block 93, Quanta, former Lever Bros. and former Celotex properties	Impacted soils would remain on site but access and infiltration would be controlled.	Source of vapors would remain in the subsurface.	Sources of vapors would be treated.	Potential for replacement or regeneration of the barrier could generate residuals such as spent carbon or ion exchange resin.
(e) Statutory preference for treatment	Preference would be met for excavated soils containing NAPL.	Would meet NJDEP preference for removal and disposal of all principal threat NAPL.	Preference would be met for excavated soils containing principal threat arsenic.	Would not meet NJDEP preference for treatment of COCs in soil; however, capping was approved by NJDEP on adjacent property.	Preference would be met for vapor because it would be kept out of occupied buildings.	Preference would be met as potential vapor producing material would be removed.	Preference met for groundwater because it would be treated before discharging to the river.
5. Short-Term Effectiveness							
(a) Protection of workers during remedial action	Excavation of tar and NAPL and related activities would result in additional potential risk to workers, due to the presence of NAPL and high levels of COCs. Potential risk to workers during remediation would be mitigated by adherence to site-specific health and safety plan and engineering controls (e.g., dust suppression, odor control).Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans.		Excavation of arsenic and related activities would result in additional potential risk to workers, due to the presence of arsenic. Use of heavy equipment exposes workers to additional safety risks and would be mitigated by health and safety plans. Potential risk to workers during remediation would be mitigated by adherence to site-specific health and safety plan and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during site clearing and grading, and cap construction would be mitigated by adherence to site-specific health and safety plans and engineering controls (e.g., dust suppression, odor control).	Minimal potential risk to workers during construction of vapor intrusion mitigation system installed in the basement of the 115 River Road and installation of vapor mitigation in basement.	No additional risk.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension. Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls (such as containment booms) would capture NAPL that may be released to surface water. Potential temporary river habitat destruction during reactive barrier construction.
	No additional risk.	Potential risk to workers from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.					

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(b) Protection of community during remedial action	There is the potential for air emissions and airborne particulate dispersion during excavation. Dust suppression and air monitoring would need to be performed during excavation to control potential emissions and protect the community. Active odor control would be required for excavations in NAPL-impacted areas due to the low odor threshold of the waste. Noise control may be needed. Engineering controls would be utilized to protect the community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam). Safety-related risks to the community are associated with the truck traffic to remove excavated soil. Stability of sidewalks, roads, and parking lots to be evaluated to determine safe excavation depth of fill material adjacent to these areas. Potential risks to the community during remedial construction include generated vapors and odor during excavation as well as safety risk to pedestrians walking near deep excavated areas. These potential risks would be mitigated during implementation through use of engineering controls.	No additional risk.	Potential risk to community from demolition activities which would be mitigated by adherence to a site-specific health and safety plans and engineering controls.	There is the potential for air emissions and airborne particulate dispersion during excavation. Dust suppression and air monitoring would need to be performed during excavation to control potential emissions and protect the community. Potential risks to the community during excavation include generated dust, vapors and odor, as well as safety risk to pedestrians walking near remediation areas adjacent to buildings. These potential risks would be mitigated through use of engineering controls. Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam). Safety-related risks to the community are associated with the truck traffic to remove excavated soil. Stability of sidewalks, roads, and parking lots to be evaluated to determine safe excavation depth of fill material adjacent to these areas.	Engineering controls would be used to protect community from dust, vapors, and noise (e.g., silencers, black plastic, odor-suppressing foam).	Best management practices would be used during construction of the vapor intrusion mitigation system.	No additional risk.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met immediately after installation of the subaqueous reactive barrier Establishment of the Institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in site groundwater would not be me prior to reaching the subaqueous reactive barrier.

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

	NAPL				Vapor		
Area	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Arsenic-Contaminated Soil**	**Soil and Residual NAPL**	**6a—Preservation of 115 River Rd. Buildings**	**6b—Demolition of 115 River Rd. Buildings**	**Groundwater/Surface Water**
(c) Environmental impacts of remedial action	Could have significant impacts to the environment when removing large volumes of impacted soils on properties adjacent to the Hudson River. Significant active vapor control would be required at all excavations, along with covering stockpiles and controlling dust.		Potential risks to the environment include generated vapors, noise, and odors during mixing. These potential risks would be mitigated during implementation through use of engineering controls.	Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.	Minimal potential risks to the environment during construction activities.	No additional impacts.	Potential risk of suspending sediment during construction. Potential risks would be addressed via design and construction methods to reduce potential for sediment suspension.
	Mobilization of NAPL during excavation would result in unknown impacts to the environment since the degree of mobilization and the flow directions are unknown. Similarly, dewatering for the purposes of excavation below the water table may mobilize NAPL. These potential risks would be addressed by monitoring and engineering controls.		Minimal potential risks to the environment during cap construction assuming implementation of adequate erosion controls.				Potential risk of release of trapped NAPL during construction, which would be addressed via design and construction methods. In addition, controls would be developed to capture NAPL that may be released to surface water (such as containment booms).
	No additional impacts.	Potential risk to the environmental from demolition activities would be mitigated through engineering controls.					Potential temporary River habitat destruction during reactive barrier construction.
(d) Time until RAOs are achieved	The RAOs to minimize potential exposure through contact, ingestion, and inhalation are achieved as soon as excavation and backfilling are complete and institutional controls are in place. Limited deep NAPL recovery would continue indefinitely.		The RAOs to minimize potential exposure through contact, ingestion, and inhalation are achieved as soon as excavation and backfilling are complete and institutional controls are in place.	The RAOs to prevent unacceptable risk as a result of exposure to soils would be met immediately following cap construction and establishment of institutional controls. The RAO to prevent erosion would be immediately met following cap construction. Cap construction and establishment of institutional controls are expected to be completed within 1 year from initiation of remedial activities. Certain RAOs may not be met since groundwater flow through and leaching of constituents from residual soils would continue.	Vapor intrusion mitigation would be applied to other buildings, if warranted. The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following the installation of the vapor intrusion mitigation system in the basement of the 115 River Road building and start-up of the ventilation systems.	The RAO to prevent unacceptable risk as a result of exposure to vapors would be immediately met following solidification/stabilization and reconstruction of the buildings.	The RAOs of preventing migration of COCs to OU2 (Hudson River) would be met by use of the in situ passive treatment. Establishment of the institutional controls would minimize the potential for contact or ingestion of contaminated groundwater; however, PRGs in groundwater on upgradient portions of the site would not be met.
6. Implementability							
(a) Technical feasibility	Excavation is feasible; however, excavation near structures and utilities would have to be evaluated and structural support provided as needed.		Excavation is feasible; however, excavation near structures and utilities would have to be evaluated and structural support provided as needed.	Feasible.	Feasible.		Use of subaqueous reactive barriers technically feasible pending results of bench- and pilot-scale testing. Subaqueous reactive barriers are considered an innovative technology.
	Feasible.	Demolition is technically feasible and would require detailed planning and coordination.					

TABLE 5-5
Detailed Evaluation of Alternatives 6a and 6b—NAPL and Arsenic Excavation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Area	NAPL		Arsenic-Contaminated Soil	Soil and Residual NAPL	Vapor		Groundwater/Surface Water
	6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings			6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings	
(b) Administrative feasibility	Administratively feasible; however, access is needed for excavation and property owners would need to concur with restriction of usage for each parcel on which institutional controls would be established. Rerouting of utilities would need to be coordinated with utility companies. Impacts to nearby buildings would need to be avoided by measures such as temporary parking and temporarily relocating the entrance of 115 River Rd.	Feasible, however relocation of 115 River Rd. tenants would need to occur and building demolition would have to be coordinated.	Administratively feasible; however, access would be needed for excavation and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established. Rerouting of utilities would need to be coordinated with utility companies.	Administratively feasible; however, access would be needed for cap installation, and property owners would need to concur with restriction of usage for each parcel on which institutional controls are established.	Administratively feasible, however, continued access for vapor monitoring and possible mitigation would be required from building owners, and property owners would need to agree to restrictions of usage for each parcel on which institutional controls would be established.		Administratively feasible, however, sampling would require the consent of the property owner(s) to obtain access. Their concurrence with institutional controls would also be needed.
(c) Availability of services and materials	Necessary engineering services and materials readily available for installation and operation.		Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.	Necessary engineering services and materials readily available for installation and operation.		Necessary engineering services and materials are readily available for installation and operation; however, limited number of contractors with experience necessary for design and installation.
7. Total Cost							
Total present worth cost range [a]	6a = $144,144,000 to $308,880,000 6b = $215,747,000 to 462,315,000						

[a]The information in this preliminary cost estimate is based on the best available information regarding the anticipated scope of potential remedial alternatives. Changes in the cost elements are likely to occur as a result of the engineering design of the remedial alternatives. The range presented is +50 to -30 percent of the order-of-magnitude cost estimate provided in Appendix E.

ARAR applicable or relevant and appropriate requirement
COC constituent of concern
NAPL non–aqueous phase liquid
NJDEP New Jersey Department of Environmental Protection
OU1 Operable Unit 1
OU2 Operable Unit 2
PRG preliminary remediation goal
RAO remedial action objective
TMV toxicity, mobility, or volume
VOC volatile organic compound
SRB subaqueous reactive barrier

TABLE 5-6
Sustainability Evaluation
Quanta Resources Superfund Site, OU1, Edgewater, New Jersey

Elements for Greener Cleanup Environmental Footprint Assessment and Best Practices	Alternative							
			4—NAPL and Arsenic In Situ Solidification/Stabilization		5—NAPL In Situ Chemical Oxidation, with Arsenic Stabilization		6—NAPL and Arsenic Excavation	
	2—NAPL and Arsenic Containment	3—NAPL and Arsenic Containment with NAPL Recovery	4a—Preservation of 115 River Rd. Buildings	4b—Demolition of 115 River Rd. Buildings	5a—Preservation of 115 River Rd. Buildings	5b—Demolition of 115 River Rd. Buildings	6a—Preservation of 115 River Rd. Buildings	6b—Demolition of 115 River Rd. Buildings
Minimize Total Energy Use and Maximizes Use of Renewable Energy	Less energy consumption and need for transportation and disposal of generated waste relative to other alternatives.	Less energy consumption and need for transportation and disposal of generated waste relative to other alternatives. High energy usage for ex situ groundwater treatment system rather than passive processes.	High energy consumption for equipment and trucks during excavation and during production of stabilizing agent; however duration of construction activity is minimized. Minimizes total energy usage using passive groundwater treatment processes rather than mechanical systems.		High energy consumption for equipment and trucks during excavation. Significant energy consumption during production of oxidant. High energy usage for ex situ groundwater treatment system rather than passive processes.		High energy consumption for equipment and trucks during excavation. Minimizes total energy usage using passive groundwater treatment processes rather than mechanical systems.	
			N/A	High energy consumption for equipment and trucks during demolition and building construction.	N/A	High energy consumption for equipment and trucks during demolition and building construction.	N/A	High energy consumption for equipment and trucks during demolition and building construction.
Minimize Air Pollutants and Greenhouse Gas Emissions	Less generation of air pollutants and greenhouse gases relative to other alternatives. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production.	Less generation of air pollutants and greenhouse gases relative to other alternatives. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production.	Greenhouse gas emissions from mixing equipment, however, less than excavation. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production.		High green house gas emissions from production of oxidant and remedy implementation Vegetative cap would minimize greenhouse gas emissions associated with asphalt production.		High green house gas emissions from excavation equipment, waste transportation and transportation of clean fill to the site. Vegetative cap would minimize greenhouse gas emissions associated with asphalt production.	
			N/A	High greenhouse gas emissions from demolition and transportation machinery and from production of materials for building reconstruction	N/A	High greenhouse gas emissions from demolition and transportation machinery and from production of materials for building reconstruction	N/A	High greenhouse gas emissions from demolition and transportation machinery and from production of materials for building reconstruction
Minimize Water Use and Impacts to Water Resources	Capping would effectively reduce the volume of surface water runoff. Unsustainable in that groundwater is not restored to drinking water quality	Capping would effectively reduce the volume of surface water runoff. Unsustainable in that groundwater is not restored to drinking water quality	Capping would effectively reduce the volume of surface water runoff. Unsustainable in that groundwater is not restored to drinking water quality		Capping would effectively reduce the volume of surface water runoff. Unsustainable in that groundwater is not restored to drinking water quality		Capping would effectively reduce the volume of surface water runoff. Unsustainable in that groundwater is not restored to drinking water quality	
Reduce, Reuse, Recycle Material and Waste	Reduces the amount of waste products produced as compared to standard groundwater treatment technologies.	Waste generated which would require offsite disposal. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies	Waste generated which would require offsite disposal. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies		Significant waste generated which would require offsite disposal. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies		Significant waste generated which would require offsite disposal. Reduces the amount of waste products produced as compared to standard groundwater treatment technologies	
Protect Land and Ecosystems	Large areas would remain with restrictions on future activities and use limitations. Soil and habitat disturbance/destruction	Large areas would remain with restrictions on future activities and use limitations. Soil and habitat disturbance/destruction	Areas would remain with restrictions on future activities and use limitations. Beneficial reuse of the property is quickly achieved. Significant soil and habitat disturbance/destruction; however, less then large scale excavation.		There are continued restrictions of future activities and use limitations. Significant soil and habitat disturbance/destruction, however, less then large scale excavation.		Minimizes areas which would require continued restrictions of future activities and use limitations. Maximum noise and light disturbances. Significant soil and habitat disturbance/destruction.	
			N/A	Significant soil and habitat disturbance/ destruction due to buildings' demolition	N/A	Significant soil and habitat disturbance/ destruction due to buildings' demolition	N/A	Significant soil and habitat disturbance/ destruction due to buildings' demolition

SECTION 6

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Appendix A
ARARs

Appendix A
Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Defines those solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 262-265 and 270.	ARAR for wastes or treatment residues which are hazardous as defined by RCRA and are to be disposed of off-site.
Federal Safe Drinking Water Act	National Primary Drinking Water Standards - Maximum Contaminant Level Goals (MCLGs) and Maximum Contaminant Levels (MCLs)	40 CFR 141	Establishes health-based standards for public drinking water systems. Also establishes drinking water quality goals set at levels at which no adverse health effects are anticipated, with an adequate margin of safety. The NCP specifically states that MCLs will be used as ARARs for useable aquifers rather than the more stringent MCLGs.	ARAR because the site groundwater aquifer is classified as a Class IIA Source of Drinking Water. The MCLs have been applied to the remediation of groundwater.
Federal Safe Drinking Water Act	National Secondary Drinking Water Standards-Secondary MCLs	40 CFR 143	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water (secondary MCL).	To Be Considered (TBC). Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBC and will be attained where possible.
Quality Criteria for Water	Water Quality Criteria	40 CFR 131 Quality Criteria for Water, 1976, 1980, and 1986	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	TBC. Water is discharged to surface water, these are used in setting effluent discharge limits.
Federal Clean Water Act; National Pollution Discharge Elimination System (NPDES)	Toxic Pollutant Effluent Standards	40 CFR 129	Establishes effluent standards or prohibitions for certain toxic pollutants; I.e., aldrin/dieldrin, DDT, DDD, DDE, endrin, toxaphene, benzideine, and PCBs.	ARAR if toxic pollutants are in groundwater requiring treatment.
National Ambient Air Quality Standards (NAAQS)	Ambient Air Quality Standards	40 CFR 50	Defines air quality levels adequate to protect public health/welfare. Defines emissions limitations for sulfur oxides, particulate matter, carbon monoxide, ozone, nitrogen oxide, and lead.	Potential ARAR for remedial alternatives resulting in air emissions if these toxic polluntants are present.
Federal Resource Conservation and Recovery Act	Groundwater Protection Standards and Maximum Concentration Limits	40 CFR 264, Subpart F	Establishes standards for groundwater protection for several metals and pesticides.	ARAR. These maximum concentration limits are applicable to RCRA regulated units and are considered relevant and appropriate.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA from a site in Manville, New Jersey (June 2003).

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Potential Chemical-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Sludge Quality Criteria	Criteria for Sludge	N.J.A.C. 7:14-4 Appendix B-1	New Jersey Water Pollution Control Act Contaminant Indicators.	Potential ARAR for remedial alternatives resulting in the generation of sludges during groundwater or soil treatment.
NJDEP Residential Soil Cleanup Standards	Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at residential sites.	ARAR for soil left on site in areas with potential residential use.
NJDEP Non-Residential Soil Cleanup Standards	Non-Residential Soil Cleanup Standards in New Jersey	N.J.A.C. 7-26D	Direct contact cleanup criteria for soils at industrial or commercial sites.	ARAR for soil left on site.
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups.	ARAR for Class IIA aquifers.
Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs)	Maximum Contaminant Levels	A-280 Amendments	Establishes State criteria for drinking water.	Potential ARAR if State MCLs are more stringent than Federal MCLs.
State of New Jersey Statutes and Rules	Drinking Water Standards-Maximum Contaminant Levels (MCLs)	N.J.A.C. 7:10 Safe Drinking Water Act	Establishes MCLs that are generally equal to or more stringent the SDWA MCLs.	ARAR because the site groundwater aquifer is classified as a Class IIA Source of Drinking Water.
State of New Jersey Statutes and Rules	National Secondary Drinking Water Standards-Secondary MCLs	N.J.A.C. 7:10-7 Safe Drinking Water Act	Establishes standards for public drinking water systems for those contaminants which impact the aesthetic qualities of drinking water.	TBC. Secondary MCLs are based on aesthetic criteria and do not reflect public health concerns. They are considered TBCs in that they will be attained where possible.
New Jersey Pollutant Discharge Elimination System (NJPDES)	Surface Water Discharge Criteria	N.J.A.C. 7:14a	Establishes discharge standards when written into permits.	Potential ARAR if treated water is discharged to surface water.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA from a site in Manville, New Jersey (June 2003).

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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Surface Water Criteria	New Jersey Criteria for Surface Water Quality	N.J.A.C. 7:9-4	Criteria for surface water classes	Potential ARAR if treated water is discharged to surface waters.
Prohibition of Air Pollution and Ambient Air Quality Standards	Air Quality Standards	N.J.A.C. 7:27-5 and N.J.A.C.7:27-13	Prohibits air pollution and establishes ambient air quality standards	Potential ARAR for remedial alternatives which include technologies that result in air emissions.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA from a site in Manville, New Jersey (June 2003).

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Discharge of Groundwater or Wastewater				
Federal Clean Water Act	National Pollution Discharge Elimination System (NPDES)	40 CFR 122 and 125	Issues permits for discharge into navigable waters. Establishes criteria and standards for imposing treatment requirements on permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Clean Water Act	General Pretreatment Regulations for Existing and New Sources of Pollution	40 CFR 403	Prohibits discharge of pollutants to a POTW which cause or may cause pass-through or interference with operations of the POTW.	ARAR. Discharge of pollutants including those that could cause fire or explosion or result in toxic vapors or fumes to POTW.
Federal Clean Water Act	Effluent Guidelines and Standards for the Point Source Category	40 CFR 414	Requires specific effluent characteristics for discharge under NPDES permits.	ARAR, although state ARAR takes precedence for discharge permit. Disposal of groundwater to the surface water. NPDES permit may not be required since New Jersey has an approved SPDES permit program (NJDPES).
Federal Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144	Establishes performance standards, well requirements, and permitting requirements for groundwater re-injection wells.	Potential ARAR if remedial alternative includes discharge of treated groundwater to potable water supply aquifer. May also apply to the injection of surfactants or oxidants into the aquifer.
Federal Clean Water Act	Ambient Water Quality Criteria	40 CFR 131.36	Establishes criteria for surface water quality based on toxicity to aquatic organisms and human health.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Federally-approved New Jersey groundwater and surface water standards take precedence over the Federal criteria.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Clean Water Act	Water Quality Criteria Summary		Includes non-promulgated guidance values for surface water based on toxicity to aquatic organisms and human health. Issued by the EPA office of Science and Technology, Health and Ecological Criteria Division.	Potential ARAR if remedial alternative includes groundwater discharge to surface water. Supplements above-referenced Ambient Water Criteria.
Water Pollution Control Act	Protection of water	33 U.S.C. 1251	Protects and maintains the chemical, physical, and biological integrity of the nation's water.	Potential ARAR for remedial actions which may affect water quality.
Water Treatment and Disposal				
Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 301	Technology-based discharge limitations for point sources of conventional, nonconventional, and toxic pollutants.	Potential ARAR for remedial actions which include discharge of wastewater.
Water Quality Related Effluent Limitations	Discharge requirements	33 U.S.C. 1251 Section 302	Protection of intended uses of receiving waters (e.g., public water supply, recreations uses).	Potential ARAR for remedial actions which include discharge of wastewater.
Toxic and Pretreatment Effluent Standards	Pretreatment standards for discharge into POTWs.	33 U.S.C. 1251 Section 307	Establishes list of toxic pollutants and promulgates pretreatment standards for discharge into POTWs.	Potential ARAR for remedial actions which include discharge of wastewater.
National Pollutant Discharge Elimination System (NPDES)	Permitting for discharge into navigable waters.	33 U.S.C. 1251	Issues permits for discharge into navigable waters.	Potential ARAR for remedial actions involving discharge to surface water.
Disposal of Dredged and Fill Material	Requires permitting of discharges of dredged and fill material to navigable waters.	33 U.S.C. 1251 Section 404	Requires permitting of discharges of dredged and fill material to navigable waters.	Potential ARAR for remedial alternatives which require discharge of dredged and fill material to navigable waters.
State of New Jersey Statutes and Rules	The New Jersey Pollutant Discharge Elimination System	N.J.A.C. 7:14A	Establishes standards for discharge of pollutants to surface and groundwaters.	ARAR. New Jersey has a state approved program. Disposal of treated groundwater to surface water.

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Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
State of New Jersey Statutes and Rules	Groundwater Quality Standards	N.J.A.C. 7:9-6 Groundwater Quality Standards	Establishes standards for the protection of ambient groundwater quality. Used as the primary basis for setting numerical criteria for groundwater cleanups and discharges to groundwater.	ARAR. Disposal of treated groundwater by reinjection.
State of New Jersey Statutes and Rules	Surface Water Quality Standards	N.J.A.C. 7:9B Surface Water Quality Standards	Establishes standards for the protection and enhancement of surface water resources.	ARAR. Disposal of treated groundwater by discharge to surface water.
Wastewater Discharge Requirements	Wastewater discharge requirements	N.J.A.C. 7:9-5.1	Minimum treatment requirements and effluent standards for discharge to surface water.	Potential ARAR if waters generated by treatment technology are discharged to surface water.
Worker and Community Right to Know Act	Protects workers and community	P.L. 1983c.315 P.L. 1985c.543 Executive Order #161	Notification of presence of hazardous substances to State Emergency Planning Commissions and to local Emergency Planning Committees.	ARAR. Applies to all on-site treatment alternatives.
Safe Drinking Water	Protects public water supply wells	N.J.S.A. 58:12A	Regulates periodic testing of Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
Interim Safe Drinking Water Testing Schedule	Protects public water supply wells	N.J.A.C. 7:10-14.1 et.seq.	Requires periodic testing, analysis, and reporting for Public Community Water Systems.	ARAR. Periodic water supply monitoring may be part of the remediation alternatives.
New Jersey Safe Drinking Water Act	Protects public water supply wells	N.J.A.C. 7:10	Sets standards for drinking water including MCLs, disinfecting requirements, secondary drinking water regulations, and monitoring requirements.	Potential ARAR if criteria are more stringent than the Federal MCLs.

Appendix A
Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Disposal of Hazardous Waste				
RCRA Criteria for Classification of Solid Waste Disposal Facilities and Practices	Classification of Disposal Facilities	40 CFR 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on heath or the environment and thereby constitute prohibited open dumps.	Potential ARAR for remedial alternatives which include disposal of non-hazardous waste on-site. The current Subtitle D program is principally aimed at municipal and industrial solid waste.
RCRA Hazardous Waste Management Systems, General	General Waste Management Practices	40 CFR 260	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Part 260-265.	Potential ARAR. Establishes general requirements for hazardous waste management.
Federal Resource Conservation and Recovery Act	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes which are subject to regulation as hazardous wastes.	ARAR. Generation of a hazardous waste possibly including spent carbon or contaminated soil. Hazardous waste must be handled and disposed of in accordance with RCRA. Chemical testing and characterization of waste required.
Federal Resource Conservation and Recovery Act	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	ARAR. Waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards which apply to persons transporting manifested hazardous waste within the United States.	ARAR. Transport of waste that is characterized as hazardous.
Federal Resource Conservation and Recovery Act	Standards Applicable to Owners and Operators of Treatment, Storage and Disposal Facilities	40 CFR 264	Establishes the minimum national standards which define acceptable management of hazardous waste.	ARAR. Generation and storage of hazardous waste.

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Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
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Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 265	Establishes minimum national standards that define the periods of interim status and until certification of final closure or if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	Potential ARAR since remedies should be consistent with the more stringent 40 CFR 264 standards, as these represent the ultimate RCRA compliance standards and are consistent with CERCLA's goal of long-term protection of public health and welfare and the environment.
Federal Resource Conservation and Recovery Act	Interim Standards for Owners and Operators	40 CFR 267	Establishes minimum national standards that define acceptable management of hazardous waste for new land disposal facilities.	Potential ARAR. CERCLA actions should be consistent with requirements of 40 CFR 264.
Federal Resource Conservation and Recovery Act	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes which are restricted from land disposal. All listed and characteristic hazardous waste or soil or debris contaminated by a RCRA hazardous waste and removed from a CERCLA site may not be land disposed until treated as required by LDRs.	ARAR. Waste to be disposed as a RCRA waste.
Federal Resource Conservation and Recovery Act	Hazardous Waste Permit Program	40 CFR 270	Establishes provisions covering basic EPA permitting requirements.	Potential ARAR. A permit is not required for on-site CERCLA response actions. Substantive requirements are added in 40 CFR 264.
State of New Jersey Statutes and Rules	Hazardous Waste	N.J.A.C. 7:26C Hazardous Waste	Establishes rules for the operation of hazardous waste facilities in the state of New Jersey	Potential ARAR depending on hazardous waste disposal location.
Federal Resource Conservation and Recovery Act	RCRA	40 CFR 265	Establishes organic air emission standards for tanks, surface impoundments, and containers.	Potential ARAR for hazardous waste treatment, storage, and disposal facilities (TSDFs) that receive new or re-issued permits or Class 3 modifications after 5 January 1995.

Appendix A
Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Federal Hazardous Material Transportation Act	Hazardous Materials Transportation Regulations	49 CFR 107, 171-177	Regulates transportation of hazardous materials.	Potential ARAR since response action may involve transportation of hazardous materials.
General Remediation				
Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and Superfund Amendments and Reauthorization Act of 1986 (SARA)	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	ARAR.
State of New Jersey Statutes and Rules	Technical Requirements for Site Remediation	N.J.A.C. 7:26E	Established minimum regulatory requirements for investigation and remediation of contaminated sites in New Jersey.	ARAR.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Requirements for recording and reporting occupation injuries and illnesses	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
Emergency Response Notice of Release of Hazardous Substance to Atmosphere	Notification of Air Releases	NJSA 7:26, 26:2C-19	Control exposure to air pollution by immediate notification to the department hotline of any air release incident.	Potential ARAR for any remedial alternative having the potential to result in an air release.
Water Pollution Control	Notification of Spills	NJAC 7:21(E)	Immediate notification of any spill of hazardous substances.	Potential ARAR for remedial alternatives having potential for a spill of a hazardous substance.
Noise Control Act	Restrictions of Noise	NJSA 13:1G-1 et.seq.	Prohibits and restricts noise which unnecessarily degrades the quality of life.	Potential ARAR for all remedial action.

Appendix A
Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Disposition of Material Generated During Site Investigations (NJDEP)	Investigation derived waste management	NJDEP's Guidance Document	Provides guidance on the disposition of IDW.	Potential ARAR. To be considered during investigation.
Noise Pollution	Restrictions of Noise	NJAC 7:29-1	Sets maximum limits of sound from any industrial, commercial, public service or community service facility.	Potential ARAR for all remedial actions.
Federal Occupational Safety and Health Act	Worker Protection	29 CFR 1904	Worker Protection	ARAR. Under 40 CFR 300.38, requirements of OSHA apply to all activities which fall under jurisdiction of the National Contingency Plan.
General Requirements for Permitting Wells	Well Permitting	NJAC 7:9-7	Regulates permit procedures, general requirements for drilling and installation of wells, licensing of well driller and pump installer, construction specification, and well casing.	Potential ARAR when installing new wells or if existing wells should require modification.
Sealing of Abandoned Wells	Well Abandonment Procedures	NJAC 7:9-9	General requirements for sealing of all wells (e.g., single cased, multiple cased, hand dug, test wells, boreholes and monitoring wells, abandoned wells).	Potential ARAR if any existing wells need to be abandoned and sealed.
Well Drillers and Pump Installers Act	Drilling Contractor Requirements	NJSA 58:4A-5 et.seq.	Well drillers licensing, supervision, inspection and sampling.	Potential ARAR when additional wells are installed.
Requirement for Groundwater Monitoring	Groundwater Monitoring	N.J.A.C. 7:26-9	Groundwater monitoring system requirements.	Potential ARAR for any remedial alternative requiring groundwater monitoring.

Appendix A
Potential Action-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Off-Gas Management				
Federal Clean Air Act	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes emission limits for six pollutants (SO2, PM10, CO, O3, NO2, and Pb).	Emission of air polluntants may be of concern for some remedial technologies.
Permitting Requirements	Permtting Conditions for air pollution control	N.J.A.C. 7:27-8	Establishes permit conditions for air pollution control apparatus.	ARAR if remedial action includes a technology that would result in air emissions.
Air Pollution Control	Permtting Conditions for air pollution control	N.J.A.C. 7:27-11 and 17	Controls and prohibits air pollution, particle emissions, and toxic VOC emissions.	Potential ARAR if remedial action includes a technology that would result in air emissions.
Operating Standards for Hazardous Waste Incinerators	Incineration Requirements	N.J.A.C. 7:26-10	Specifies maximum air contaminant emissions rates, testing requirements, and minimum design standards.	Potential ARAR if remedial alternative includes incineration.
Interim Standards for Hazardous Waste Incinerators.	Incineration Requirements	N.J.A.C. 7:26-11	Specifies maximum air containment emission rates, testing requirement, and minimum design standards during interim status.	Potential ARAR if remedial alternative includes incineration.
Incinerator Permit Regulations	Incinerator Permitting	N.J.A.C. 7:26-12	Delineates the information needs to be submitted in Part A and B of the permit application.	Potential ARAR if remedial alternative includes incineration.
Federal Clean Air Act	Standards of Performance for New Stationary Sources	40 CFR 60	Provides emissions requirements for new stationary sources.	ARAR.
Federal Clean Air Act	National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Provides emission standards for 8 contaminants including benzene and vinyl chloride. Identifies 25 additional contaminants, as having serious health effects but does not provide emission standards for these contaminants.	ARAR.
State of New Jersey Statutes and Rules	Standards for Hazardous Air Pollutants	N.J.A.C. 7:27 Air Pollution Control	Rule that governs the emitting of, and such activities that result in, the introduction of contaminants into the ambient atmosphere.	ARAR.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Appendix A
Potential Location-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site, OU1
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Executive Order Floodplain Management	Floodplain Management	Exec. Order No. 11988 40 CFR 2 6:302(b) and Appendix A	Requires federal agencies to evaluate the potential effects of actions they may take in a floodplain to avoid, to the maximum extent possible, the adverse impacts associated with direct and indirect development of a floodplain.	Potential ARAR if remedial activities take place in or near a 100-year or 500-year floodplain.
Federal Flood Plains Regulatory Requirements	Regulatory Requirements	(RCRA Location Standards (40 CFR 264.18)	This regulation outlines the requirements for constructing a RCRA facility on a 100-year flood plain.	Potential ARAR if remedial alternatives include construction in or near a 100-year floodplain.
Clean Water Act	Prohibits discharge of dredged or fill material into wetlands	33 U.S.C. 1251 Section 404, 40 CFR 230, 231	Prohibits discharge of dredged or fill material into wetlands without a permit. Preserves and enhances wetlands.	Potential ARAR for remedial alternatives which involve disturbance to wetlands.
Policy Floodplains/Wetlands Assessment	Floodplain assessment	EPA 1985 Statement	Provides federal policy for the assessment of floodplains and wetlands	Potential ARAR for remedial alternatives that affect wetlands and floodplains.
National Historic Preservation Act	Protects historic places	16 U.S.C. 470	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 is eligible for inclusion in the National Register of Historic Places.	ARAR since source areas are included or eligible for inclusion in the National Register of Historic Places.
U.S. Army Corps of Engineers Nationwide Permit Program	Army Corp. of Engineers Permit Program	33 CFR 330	Prohibits activity that adversely affects a wetland if a practical alternative that has less effect is available.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Rivers and Harbors Act of 1899	Army Corp. of Engineers Permit Program	33 CFR 320-330	Establishes a COE permit program for dams, dikes, dredging, and other construction in navigable waters of the U.S.	Potential ARAR if remedial actions occur on Federal Property.

Appendix A
Potential Location-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site, OU1
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Executive Order Protecting Wetlands	Protection of Wetlands	Executive Order No. 11990	Requires Federal agencies to minimize the destruction, loss, or degradation of all wetlands affected by Federal activities.	Potential ARAR for remedial alternatives which have the potential to affect wetlands.
Fish and Wildlife Coordination Act	Requires approval for modification of water body	16 U.S.C. 661 40 CFR 2 6:302(g)	Requires consultation with the U.S. Fish and Wildlife Services when a Federal department or agency proposes or authorizes any modification of any stream or other water body, and adequate provision for protection of fish and wildlife resources.	Potential ARAR since any disturbance and restoration or replacement of wetlands must be coordinated with the Fish and Wildlife Service.
National Ambient Air Quality Standards (NAAQS)	Air Quality Standards	40 CFR 50	Establishes non-attainment zones with respect to health-based criteria.	Potential ARAR for remedial activities which emit restricted contaminants into the atmosphere.
Federal Endangered and Non-Game Species Act	Protection of threatened and endangered species	N.J.S.A. 23:2A-1	Standards for the protection of threatened and endangered species.	Not an ARAR because no listed species identified at the site.
Flood Hazard Area Regulations	Protection of floodplains	N.J.A.C. 7:13	Protects floodplains through permitting requirements for construction and development activities	Potential ARAR if remedial activities are located in or near a 100- or 500-year floodplain.
Flood Hazard Area Control Act	Delineates flood hazard areas	N.J.S.A. 58: 16A-50	Delineates flood hazard areas and regulates use.	Potential ARAR if remedial activities are in or near a 100- or 500-year floodplain.
Wetland Act of 1970	Establishes wetland regulated activities	N.J.S.A. 13:9A-1 et.seq.	Establishes listing and permitting requirements for regulated activities	Potential ARAR. Establishes listing and permitting requirements for regulated activities

Appendix A
Potential Location-Specific Applicable or Relevant and Appropriate Requirements
Quanta Resources Superfund Site, OU1
Edgewater, New Jersey

Act/Authority	Criteria/Issues	Citation	Brief Description	Applicability
Freshwater Wetlands Protection Act	Establishes freshwater wetlands regulated activities	N.J.S.A. 13:9B	Establishes listings and permitting requirements for regulated activities in state freshwater wetlands	Potential ARAR. Establishes listings and permitting requirements for regulated activities in state freshwater wetlands
Open Lands Management	Considers recreational projects during remediation	N.J.A.C. 7:2-12.1 et.seq.	Considers impact of remedial actions on recreational projects funded by Open Lands Management Grants.	Potential ARAR for remedial actions on recreational projects funded by Open Lands Management Grants.
Natural Areas System	Protects natural area sites	N.J.A.C. 7:2-11	Protects natural area sites listed under the Natural Areas Register.	Potential ARAR if remedial actions occur on natural area sites listed under the Natural Areas Register.
State Trails System	Protects state trails	N.J.S.A. 13:8-30 et. seq.	Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.	Potential ARAR. Requires that use of trail does not interfere with nature; maintains natural and scenic qualities.
New Jersey Wild and Scenic Rivers System	Protects Scenic River systems	N.J.S.A. 13:8-45 et. seq.	Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.	Potential ARAR. Governs component river area, flood hazard area, or part of state park, wildlife refuge or similar area.
New Jersey Threatened Plant Species	Lists threatened plant species.	New Jersey's Threatened Plan Species	Lists threatened plant species.	Potential ARAR if remedial actions impact threatened plant species.
Endangered Plant/Animal Species Habitats	Lists threatened habitats where endangered species occur.	New Jersey's Endangered Species Act	Lists threatened habitats where endangered species occur.	Potential ARAR. Lists threatened habitats where endangered species occur.

ARARs are combined from the USEPA Statement of Work (May 1999) and ARARs supplied by USEPA for a site in Manville, New Jersey (June 2003).

Appendix B
ISCO Bench-Scale Treatability Test

In-Situ Chemical Oxidation Treatability Study Results Quanta Resources Superfund Site, Operable Unit 1

PREPARED BY: CH2M HILL

DATE: September 24, 2008

Introduction

As discussed in the November 21, 2006 response to EPA comments on the Draft Candidate Technologies Memorandum for the Quanta Resources Superfund Site ("Site"), EPA's comment letter dated July 28, 2006 requested the submission of a treatability testing work plan for chemical oxidation and other technologies. A work plan to conduct a bench scale treatability test of in-situ chemical oxidation (ISCO) was submitted to EPA on February 6, 2007. Work initiated with the collection of soil and groundwater samples on March 27, 2007. EPA comments on the work plan were received on April 4, 2007 and the analytical suite for the test was modified in response to the comments, including the addition of arsenic speciation analyses. A table providing responses to each of EPA's comments on the work plan is attached to this memorandum.

The bench-scale treatability test was conducted by Geo-Cleanse® International, Inc. (Kenilworth, NJ), and laboratory analysis was conducted by Accutest Laboratories (Dayton, NJ) and Applied Speciation and Consulting, LLC (Tukwila, WA).

The ISCO treatability test was designed to:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both.
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site.
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO.
- Estimate total oxidant demand of the media.
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process.
- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created.

The three general soil types encountered at the site were included in the testing to gain an understanding of how each ISCO reagent would work on the various soils present at the site. The three soil types are:

- Silty sand with visible coal tar (SS-1)

- Silty sand with residual coal tar (SS-2)
- Peat with residual coal tar (P-1)

Soil and groundwater samples were collected on March 27, 2007 in accordance with the Draft In-Situ Chemical Oxidation Treatability Study Work Plan submitted on February 6, 2007. A back hoe was used to excavate the proposed soil sample locations and collect sample material. SS-1 and SS-2 were moved from the locations indicated in the work plan because a concrete pad was encountered at approximately 2 ft bgs. Groundwater was collected with a whale pump from each well selected. The sample locations are described as follows:

- SS-1 – The soil was collected approximately 10 ft northwest of the MW-103 cluster at a depth of 6 – 8 ft bgs. Groundwater was collected from MW-102 which is screened from 4 – 9 ft bgs with the pump set at 6 ft bgs.
- SS-2 – The soil was collected approximately 10 ft northwest of the MW-103 cluster (from the same excavation as SS-1) at a depth of 3 ft bgs. Groundwater was collected from MW-102B which is screened from 14 – 24 ft bgs with the pump set at 14 ft bgs.
- P-1 – The soil was collected approximately 80 ft southwest of the MW-112 cluster at a depth of 9 ft bgs. Groundwater was collected from MW-112B which is screened from 2 – 12 ft bgs with the pump set at 7 ft bgs.

Treatability testing components included evaluation of baseline soil samples, soil buffering and reactivity tests, peroxide reactivity tests, slurry oxidation tests, soil column tests, and autoclave tests. A report of the treatability testing results prepared by Geo-Cleanse® is attached to this memorandum, and includes descriptions of the tests, and presentation and discussion of the results. Preliminary observations based directly on results of the bench-scale test are included in this memorandum.

The total concentrations of VOCs and SVOCs (including tentatively identified compounds) detected in the baseline samples and shown in Tables 4-1, 4-2 and 4-3 of the report are as follows:

Sample	Total VOCs and SVOCs in Groundwater (micrograms per liter)	Total VOCs and SVOCs in Soil (micrograms per kilogram)
SS-1	67,370	71,574,900
SS-2	33,003	33,900,030
P-1	31,873	323,138

Oxidant-to-contaminant ratios of 10:1, 20:1 and 40:1 of Fenton's reagent and base-catalyzed sodium persulfate were evaluated during the treatability test. Permanganate is not capable of oxidizing aromatic ring structures, including BTEX and PAHs (reactions with PAHs predominantly affect alkyl groups and do not involve ring cleavage) and was therefore not included in the treatability test.

Bench-Scale Test Results

The results of the bench-scale test are presented in the attached results report prepared by Geo-Cleanse®. The bench-scale results cannot be used to quantitatively predict pilot or full-scale application results; however qualitative predictions can be made regarding potential remedy effectiveness. A summary of key conclusions of the bench test is provided below.

Based on visual observations during the slurry tests, free-phase NAPL was either destroyed or was transformed to a non-mobile condition by both oxidants at the minimum tested dosage of 10:1.

The slurry tests, soil column tests, and autoclave tests all indicated that Fenton's reagent was a more efficient oxidant than persulfate for the soils used in the test. Fenton's reagent yielded 59-99% oxidation of total contaminant mass depending upon oxidant dosage, whereas persulfate yielded 3-93% oxidation. Persulfate was relatively ineffective for the P-1 sample, achieving 3-35% contaminant mass oxidation.

In the autoclave test, Fenton's reagent was a more efficient oxidant than persulfate. Results for both oxidants indicate that oxidation, rather than leaching or volatilization, were the predominant mechanisms for loss of VOCs and SVOCs from the treated soils. Volatilization and leaching from the soils were negligible relative to oxidation. Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose risks associated with vapor intrusion, which would need to be evaluated and controlled during a pilot-scale or full-scale implementation.

ISCO affected the aqueous concentrations of several inorganic constituents, including arsenic. Sulfate and iron concentrations increased, since these constituents are components of the oxidation reagents. Concentrations of several metals increased, including arsenic, chromium, cadmium, selenium, and lead. These metals may have been either mobilized from the soil or present in the catalyst used during the test. Total arsenic concentrations increased in tests for both SS-1 and SS-2 samples, but almost all of the arsenic was oxidized from As(III) to As(V). The arsenic compounds which contain As(V) are negatively charged and therefore have a greater affinity for adsorption compared to neutrally charged compounds containing As(III). In the peat sample, total arsenic concentrations decreased in the treated slurries, but remained well above the NJ Groundwater Quality Standard for arsenic of 3 micrograms per liter (µg/L).

	Initial Arsenic		Final Arsenic – Fenton's Slurry Test						Final Arsenic – Persulfate Slurry Test					
Sample	Soil (mg/kg)	Ground-water (µg/L)	Soil (mg/kg)			Groundwater (µg/L)			Soil (mg/kg)			Groundwater (µg/L)		
Oxidant-to-Contaminant Ratio			10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
SS-1	20.6	20.6	16.1	14.9	16.0	459	558	590	7.5	4.9	ND	499	683	385
SS-2	9.9	342	6.1	9.2	12.6	583	928	262	7.7	4.2	8.9	480	767	834
P-1	ND	13,500	64.3	59.9	62.6	132	183	2,690	41.1	43.2	37.1	1,370	4,080	2,550

	Initial Arsenic		Final Arsenic – Fenton's Slurry Test						Final Arsenic – Persulfate Slurry Test					
Sample	Soil (mg/kg)	Ground-water (µg/L)	Soil (mg/kg)			Groundwater (µg/L)			Soil (mg/kg)			Groundwater (µg/L)		
Oxidant-to-Contaminant Ratio			10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1	10:1	20:1	40:1
SS-1	20.6	20.6	16.1	14.9	16.0	459	558	590	7.5	4.9	ND	499	683	385
SS-2	9.9	342	6.1	9.2	12.6	583	928	262	7.7	4.2	8.9	480	767	834
P-1	ND	13,500	64.3	59.9	62.6	132	183	2,690	41.1	43.2	37.1	1,370	4,080	2,550

Evaluation of ISCO Effectiveness

Based on the results of the tests as reported by Geo-Cleanse®, ISCO appears to be applicable in general for treatment of VOCs and SVOCs in NAPL-impacted soils from the Site under laboratory conditions. Fenton's appears to be more effective on tested soils while Fenton's and persulfate are about equally effective on tested groundwater. Sodium persulfate applicability appears more limited in peat-rich soil areas at the Site relative to Fenton's reagent at the application concentrations used. Therefore, based on overall mass, the reduction appears better for tests using Fenton's – at the application concentrations used. However, only first order kinetics were taken into account, which may underestimate the overall effectiveness of persulfate due to its anticipated greater longevity in the subsurface compared to Fenton's reagent.

Evaluation of ISCO Implementability

The bench test results have uncertainties which must be considered when evaluating full-scale implementability of ISCO at the Site. Mixing of the contaminants and oxidant will likely not occur as ideally in the subsurface environment as in the bench test. Similarly, oxidant and catalyst will not likely completely mix during full scale implementation. Heat generated during the oxidation reactions and transferred throughout the subsurface will impact NAPL mobility in ways that cannot be evaluated in a bench test. The ability of a relatively small amount of soil and groundwater used in the bench test to accurately represent the subsurface environment in the entire Site is also a considerable uncertainty. However, based on Geo-Cleanse's past experience, the prediction of oxidant demand from the bench test is usually relatively close to the oxidant demand determined during pilot testing for site with contaminants similar to the Site.

The mass of oxidants used in the tests (necessary to treat the very high oxidant demand posed by the large mass of VOCs and SVOCs) may be significantly greater than the amount of oxidant that could be effectively delivered to the subsurface in a field application. Persulfate's limit is from 10 to 15% of soil weight (assuming the total soil porosity is between 25% to 30% and a maximum weight percent of persulfate in solution of 30%), or up to 0.15 of 0.5 kg, or 75 grams for the sample volume used in the SS-1 and SS-2 slurries. The sodium persulfate used in the slurry tests for these two samples ranged from 170.0 grams (10:1 ratio, SS-2 sample) to 1,435.5 grams (40:1 ratio, SS-1 sample). In order to apply this

amount of oxidant in the field would require 3 to 19 successive applications (spaced from 4 months to 1 year apart). Similar restrictions apply to Fenton's since it would not be safe to inject at more than about 15% solution. The high oxidant demand required to appreciably reduce VOC and SVOC concentrations (albeit not to levels low enough to approach preliminary remediation goals) apply to any chemical oxidation technology for the site, not only Fenton's and persulfate.

Although oxidation was the primary mechanism for loss of VOCs and SVOCs, even small amounts of increased volatilization may pose risks associated with vapor intrusion, which would need to be evaluated and controlled during field implementation. The increases in arsenic concentrations observed in the silty sand samples as a result of ISCO would also need to be monitored and managed during field implementation.

Health and safety and transportation issues associated with hydrogen peroxide as a liquid are more serious than those of sodium persulfate as a dry powder. Fenton's application likely requires denser spaced injection locations to distribute the oxidant for maximum contact as fast as possible, in contrast to persulfate. The heat and gas generation associated with Fenton's can pose issues – as observed in the bench-scale tests, gas evolution hinders effective flow, and can impede effective delivery of the oxidant as a fluid during injection. The heat and gas can enhance daylighting, thus slower injection rates can be achieved than with persulfate. The high oxidant demand at the site required to achieve a significant reduction in COC concentrations pose significant technical challenges as discussed above and may render this technology cost-prohibitive in a full-scale application at the site. Even if full scale application was implemented, the bench test indicates that COCs will remain in the soil at concentrations exceeding PRGs.

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
			Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<14)	ND (<980)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<2,400)	ND (<1.4)	ND (<58)	ND (<1.5)	ND (<43)	ND (<1.5)	ND (<4.6)	ND (<1.5)	ND (<1.0)
1,1,2,2-Tetrachloroethane	ND (<14)	ND (<950)	ND (<1.4)	ND (<2,500)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<57)	ND (<4.0)	ND (<33)	ND (<4.0)	ND (<3.6)	ND (<4.0)	ND (<0.79)
1,1,2-Trichloroethane	ND (<16)	ND (<890)	ND (<1.6)	ND (<2,400)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<53)	ND (<2.5)	ND (<33)	ND (<2.5)	ND (<3.6)	ND (<2.5)	ND (<0.79)
1,1-Dichloroethane	ND (<12)	ND (<790)	ND (<1.2)	ND (<2,100)	ND (<1.2)	ND (<1,900)	ND (<1.2)	ND (<47)	ND (<1.0)	ND (<78)	ND (<1.0)	ND (<8.4)	ND (<1.0)	ND (<1.9)
1,1-Dichloroethene	ND (<16)	ND (<1,100)	ND (<1.6)	ND (<3,000)	ND (<1.6)	ND (<2,700)	ND (<1.6)	ND (<68)	ND (<1.4)	ND (<52)	ND (<1.4)	ND (<5.6)	ND (<1.4)	ND (<1.3)
1,2,4-Trichlorobenzene	ND (<8)	ND (<580)	ND (<0.8)	ND (<1,500)	ND (<0.8)	ND (<1,400)	ND (<0.8)	ND (<35)	ND (<2.0)	ND (<40)	ND (<2.0)	ND (<4.3)	ND (<2.0)	ND (<0.95)
1,2-Dibromo-3-chloropropane	ND (<55)	ND (<3,600)	ND (<5.5)	ND (<9,400)	ND (<5.5)	ND (<8,600)	ND (<5.5)	ND (<210)	ND (<4.0)	ND (<110)	ND (<4.0)	ND (<11)	ND (<4.0)	ND (<2.5)
1,2-Dibromoethane	ND (<26)	ND (<930)	ND (<2.6)	ND (<2,500)	ND (<2.6)	ND (<2,300)	ND (<2.6)	ND (<56)	ND (<2.2)	ND (<33)	ND (<2.2)	ND (<3.6)	ND (<2.2)	ND (<0.79)
1,2-Dichlorobenzene	ND (<10)	ND (<750)	ND (<1.0)	ND (<2,000)	ND (<1.0)	ND (<1,800)	ND (<1)	ND (<45)	ND (<0.98)	ND (<31)	ND (<0.98)	ND (<3.4)	ND (<0.98)	ND (<0.75)
1,2-Dichloroethane	ND (<15)	ND (<900)	ND (<1.5)	ND (<2,400)	ND (<1.5)	ND (<2,200)	ND (<1.5)	ND (<54)	ND (<1.4)	ND (<27)	ND (<1.4)	ND (<2.9)	ND (<1.4)	ND (<0.64)
1,2-Dichloropropane	ND (<10)	ND (<920)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,200)	ND (<1)	ND (<55)	ND (<1.2)	ND (<47)	ND (<1.2)	ND (<5.0)	ND (<1.2)	ND (<1.1)
1,3-Dichlorobenzene	ND (<16)	ND (<810)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<1,900)	ND (<1.6)	ND (<48)	ND (<1.0)	ND (<42)	ND (<1.0)	ND (<4.5)	ND (<1.0)	ND (<0.99)
1,4-Dichlorobenzene	ND (<12)	ND (<760)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<1,800)	ND (<1.2)	ND (<45)	ND (<0.84)	ND (<34)	ND (<0.84)	ND (<3.6)	ND (<0.84)	ND (<0.81)
2-Butanone (MEK)	ND (<130)	ND (<4,500)	ND (<13)	ND (<12,000)	ND (<13)	ND (<11,000)	ND (<13)	ND (<270)	ND (<14)	ND (<320)	ND (<14)	ND (<34)	ND (<14)	30.6
2-Hexanone	ND (<63)	ND (<2,200)	ND (<6.3)	ND (<6,000)	ND (<6.3)	ND (<5,400)	ND (<6.3)	ND (<130)	ND (<4.7)	ND (<200)	ND (<4.7)	ND (<21)	ND (<4.7)	ND (<4.7)
4-Methyl-2-pentanone(MIBK)	ND (<53)	ND (<3,300)	ND (<5.3)	ND (<8,700)	ND (<5.3)	ND (<7,900)	ND (<5.3)	ND (<200)	ND (<6.9)	ND (<220)	ND (<6.9)	ND (<24)	ND (<6.9)	ND (<5.3)
Acetone	ND (<120)	ND (<4,700)	ND (<12)	ND (<13,000)	ND (<12)	ND (<11,000)	ND (<12)	ND (<280)	782	1,060 J	371	ND (<50)	133	137
Benzene	5,530	20,800	91.7	14,200	18.9	7,280	3.1 J	1,250	ND (<0.97)	1,020	4.9 J	148	1.6 J	109
Bromodichloromethane	ND (<8.7)	ND (<750)	ND (<0.87)	ND (<2,000)	ND (<0.87)	ND (<1,800)	ND (<0.87)	ND (<45)	ND (<0.74)	ND (<28)	ND (<0.74)	ND (<3.0)	ND (<0.74)	ND (<0.67)
Bromoform	ND (<27)	ND (<720)	ND (<2.7)	ND (<1,900)	ND (<2.7)	ND (<1,700)	ND (<2.7)	ND (<43)	ND (<1.7)	ND (<93)	ND (<1.7)	ND (<10)	ND (<1.7)	ND (<2.2)
Bromomethane	ND (<11)	ND (<610)	ND (<1.1)	ND (<1,600)	ND (<1.1)	ND (<1,500)	ND (<1.1)	ND (<36)	ND (<1.9)	ND (<55)	ND (<1.9)	ND (<5.9)	ND (<1.9)	ND (<1.3)
Carbon disulfide	ND (<10)	ND (<910)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,200)	ND (<1)	ND (<54)	ND (<0.71)	ND (<33)	ND (<0.71)	ND (<3.5)	ND (<0.71)	ND (<0.79)
Carbon tetrachloride	ND (<15)	ND (<1600)	ND (<1.5)	ND (<4,200)	ND (<1.5)	ND (<3,800)	ND (<1.5)	ND (<94)	ND (<0.93)	ND (<28)	ND (<0.93)	ND (<3.0)	ND (<0.93)	ND (<0.67)
Chlorobenzene	ND (<11)	ND (<720)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,700)	ND (<1.1)	ND (<43)	ND (<0.93)	ND (<63)	ND (<0.93)	ND (<6.8)	ND (<0.93)	ND (<1.5)
Chloroethane	ND (<28)	ND (<2,900)	ND (<2.8)	ND (<7,600)	ND (<2.8)	ND (<6,900)	ND (<2.8)	ND (<170)	ND (<3.4)	ND (<59)	ND (<3.4)	ND (<6.3)	ND (<3.4)	ND (<1.4)
Chloroform	ND (<11)	ND (<960)	ND (<1.1)	ND (<2,600)	4.4 J	ND (<2,300)	ND (<1.1)	ND (<57)	ND (<1.3)	ND (<45)	ND (<1.3)	ND (<4.8)	ND (<1.3)	ND (<1.1)
Chloromethane	ND (<17)	ND (<760)	ND (<1.7)	ND (<2,000)	5.6	ND (<1,800)	ND (<1.7)	ND (<45)	ND (<1.5)	ND (<59)	ND (<1.5)	ND (<6.4)	ND (<1.5)	ND (<1.4)
cis-1,2-Dichloroethene	ND (<8.9)	ND (<1,100)	ND (<0.89)	ND (<2,900)	ND (<0.89)	ND (<2,700)	ND (<0.89)	ND (<66)	ND (<1.4)	ND (<22)	ND (<1.4)	ND (<2.3)	ND (<1.4)	ND (<0.52)
cis-1,3-Dichloropropene	ND (<7.4)	ND (<680)	ND (<0.74)	ND (<1,800)	ND (<0.74)	ND (<1,700)	ND (<0.74)	ND (<41)	ND (<0.67)	ND (<57)	ND (<0.67)	ND (<6.1)	ND (<0.67)	ND (<1.4)
Cyclohexane	ND (<25)	ND (<2,100)	ND (<2.5)	ND (<5,600)	ND (<2.5)	ND (<5,100)	ND (<2.5)	ND (<130)	ND (<4.3)	ND (<45)	ND (<4.3)	ND (<4.8)	ND (<4.3)	7.5 J
Dibromochloromethane	ND (<9.4)	ND (<910)	ND (<0.94)	ND (<2,400)	ND (<0.94)	ND (<2,200)	ND (<0.94)	ND (<54)	ND (<1.4)	ND (<24)	ND (<1.4)	ND (<2.6)	ND (<1.4)	ND (<0.57)
Dichlorodifluoromethane	ND (<38)	ND (<1,300)	ND (<3.8)	ND (<3,500)	ND (<3.8)	ND (<3,200)	ND (<3.8)	ND (<78)	ND (<5.2)	ND (<46)	ND (<5.2)	ND (<5.0)	ND (<5.2)	ND (<1.1)
Ethylbenzene	600	113,000	15.5	98,500	ND (<1)	44,100	ND (<1)	11,000	6.1	5,640	1.1 J	93.5	ND (<1.0)	68.5
Freon 113	ND (<34)	ND (<1,400)	ND (<3.4)	ND (<3,800)	ND (<3.4)	ND (<3,400)	ND (<3.4)	ND (<84)	ND (<5.9)	ND (<42)	ND (<5.9)	ND (<4.5)	ND (<5.9)	ND (<1)
Isopropylbenzene	16.6 J	30,800	ND (<1)	17,200 J	ND (<1.0)	7,810 J	ND (<1)	2,130	ND (<2.7)	3,540	ND (<2.7)	18.1 J	ND (<2.7)	12.9 J
m,p-Xylene	954	143,000	4.8 J	142,000	ND (<2.1)	69,900	ND (<2.1)	17,400	15.5	12,600	ND (<1.8)	153	ND (<1.8)	102
Methyl Acetate	ND (<100)	ND (<2,300)	ND (<10)	ND (<6,200)	ND (<10)	ND (<,5600)	ND (<10)	ND (<140)	ND (<7.8)	5,740	ND (<7.8)	ND (<38)	ND (<7.8)	ND (<8.4)
Methyl Tert Butyl Ether	ND (<15)	ND (<920)	ND (<1.5)	ND (<2,500)	ND (<1.5)	ND (<2,200)	ND (<1.5)	ND (<55)	ND (<0.98)	ND (<71)	ND (<0.98)	ND (<7.7)	ND (<0.98)	ND (<1.7)
Methylcyclohexane	ND (<9.1)	ND (<1,100)	ND (<0.91)	ND (<2,800)	ND (<0.91)	ND (<2,600)	ND (<0.91)	ND (<63)	ND (<2.5)	ND (<57)	ND (<2.5)	ND (<6.1)	ND (<2.5)	ND (<1.4)
Methylene chloride	ND (<13)	ND (<1,100)	ND (<1.3)	ND (<3,000)	ND (<1.3)	ND (<2,800)	ND (<1.3)	ND (<68)	ND (<1.1)	ND (<53)	ND (<1.1)	ND (<5.7)	ND (<1.1)	ND (<1.3)
o-Xylene	430	67,900	5.0	66,100	ND (<1.5)	30,700	ND (<1.5)	8,470	9.1	6,000	ND (<1.0)	60.1	ND (<1.0)	26.5
Styrene	ND (<7.9)	ND (<540)	ND (<0.79)	ND (<1,400)	ND (<0.79)	ND (<1,300)	ND (<0.79)	ND (<32)	ND (<1.0)	ND (<26)	ND (<1.0)	ND (<2.8)	ND (<1.0)	8.8 J
Tetrachloroethene	ND (<14)	ND (<1,400)	ND (<1.4)	ND (<3,600)	ND (<1.4)	ND (<3,300)	ND (<1.4)	ND (<81)	ND (<1.4)	ND (<38)	ND (<1.4)	ND (<4.1)	ND (<1.4)	ND (<0.90)
Toluene	2,590	76,200	40.2	63,600	5.5	28,100	ND (<1)	6,160	2.9 J	2,720	3.8 J	189	ND (<1.0)	120
trans-1,2-Dichloroethene	ND (<21)	ND (<1,100)	ND (<2.1)	ND (<3,000)	ND (<2.1)	ND (<2,700)	ND (<2.1)	ND (<67)	ND (<1.6)	ND (<63)	ND (<1.6)	ND (<6.7)	ND (<1.6)	ND (<1.5)
trans-1,3-Dichloropropene	ND (<10)	ND (<650)	ND (<1.0)	ND (<1,700)	ND (<1.0)	ND (<1,600)	ND (<1)	ND (<39)	ND (<0.86)	ND (<91)	ND (<0.86)	ND (<9.8)	ND (<0.86)	ND (<2.2)
Trichloroethene	ND (<14)	ND (<860)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<2,100)	ND (<1.4)	ND (<51)	ND (<1.3)	ND (<37)	ND (<1.3)	ND (<3.9)	ND (<1.3)	ND (<0.87)
Trichlorofluoromethane	ND (<13)	ND (<1,200)	ND (<1.3)	ND (<3,200)	ND (<1.3)	ND (<2,900)	ND (<1.3)	ND (<72)	ND (<1.3)	ND (<53)	ND (<1.3)	ND (<5.7)	ND (<1.3)	ND (<1.3)
Vinyl chloride	ND (<14)	ND (<1,100)	ND (<1.4)	ND (<2,800)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<64)	ND (<1.1)	ND (<63)	ND (<1.1)	ND (<6.8)	ND (<1.1)	ND (<1.5)
Xylene (total)	1,380	211,000	9.9	208,000	ND (<1.5)	101,000	ND (<1.5)	25,900	24.5	18,600	ND (<1.0)	213	ND (<1.0)	128
Total TIC, Volatile	22,900 J	2,951,000 J	1,900 J	8,318,000	170 J	4,300,000	88 J	365,000	1,385 J	203,700 J	49 J	16,170 J	ND J	2,468 J
Total Volatiles (Target)	*11,501*	*662,700*	*167*	*609,600*	*34*	*288,890*	*3*	*72,310*	*840*	*56,920*	*381*	*875*	*135*	*751*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
			Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	144 J	1,110,000	26.6	400,000	7.5	373,000	13	84,700	58.4	502,000	17.0	120,000	5.6	110,000
2,4,5-Trichlorophenol	ND (<1.9)	ND (<4,600)	ND (<1.9)	ND (<410)	ND (<1.9)	ND (<390)	ND (<1.9)	ND (<74)	ND (<1.9)	ND (<4,800)	ND (<1.9)	ND (<2,300)	ND (<1.9)	ND (<480)
2,4,6-Trichlorophenol	ND (<1.3)	ND (<2,600)	ND (<1.3)	ND (<230)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<42)	ND (<1.3)	ND (<2,700)	ND (<1.3)	ND (<1,300)	ND (<1.3)	ND (<270)
2,4-Dichlorophenol	ND (<1.6)	ND (<5,100)	ND (<1.6)	ND (<460)	ND (<1.6)	ND (<430)	ND (<1.6)	ND (<83)	ND (<1.6)	ND (<5,400)	ND (<1.6)	ND (<2,600)	ND (<1.6)	ND (<540)
2,4-Dimethylphenol	5,350	145,000	ND (<1.6)	ND (<710)	ND (<1.6)	ND (<660)	ND (<1.6)	ND (<130)	ND (<1.6)	ND (<8,200)	3.7 J	ND (<4,000)	ND (<1.6)	2,370
2,4-Dinitrophenol	ND (<0.89)	ND (<4,700)	ND (<0.89)	ND (<420)	ND (<0.89)	ND (<390)	ND (<0.89)	ND (<75)	ND (<0.89)	ND (<4,900)	ND (<0.89)	ND (<2,300)	ND (<0.89)	ND (<490)
2,4-Dinitrotoluene	ND (<0.86)	ND (<3,600)	ND (<0.86)	ND (<320)	ND (<0.86)	ND (<300)	ND (<0.86)	ND (<57)	ND (<0.86)	ND (<3,700)	ND (<0.86)	ND (<1,800)	ND (<0.86)	ND (<1,700)
2,6-Dinitrotoluene	ND (<0.56)	ND (<3,500)	ND (<0.56)	ND (<310)	ND (<0.56)	ND (<300)	ND (<0.56)	ND (<56)	ND (<0.56)	ND (<3,700)	ND (<0.56)	ND (<1,800)	ND (<0.56)	ND (<1,700)
2-Chloronaphthalene	ND (<0.98)	ND (<4,300)	ND (<0.98)	ND (<390)	ND (<0.98)	ND (<360)	ND (<0.98)	ND (<69)	ND (<0.98)	ND (<4,500)	ND (<0.98)	ND (<2,200)	ND (<0.98)	ND (<2,100)
2-Chlorophenol	ND (<0.95)	ND (<2,600)	ND (<0.95)	ND (<240)	ND (<0.95)	ND (<220)	ND (<0.95)	ND (<42)	ND (<0.95)	ND (<2,700)	ND (<0.95)	ND (<1,300)	ND (<0.95)	ND (<270)
2-Methylnaphthalene	983	5,720,000	29.9	2,450,000	9.6	2,080,000	16.4	486,000	231	1,730,000	17.8	232,000	2.7	61,300
2-Methylphenol	3,290	26,200	ND (<1.4)	ND (<270)	ND (<1.4)	ND (<250)	ND (<1.4)	ND (<49)	ND (<1.4)	ND (<3,100)	5.0	1,660 J	ND (<1.4)	1,600
2-Nitroaniline	ND (<0.66)	ND (<1,900)	ND (<0.66)	ND (<170)	ND (<0.66)	ND (<160)	ND (<0.66)	ND (<31)	ND (<0.66)	ND (<2,000)	ND (<0.66)	ND (<980)	ND (<0.66)	ND (<940)
2-Nitrophenol	ND (<1.8)	ND (<3,800)	ND (<1.8)	ND (<340)	ND (<1.8)	ND (<320)	ND (<1.8)	ND (<61)	ND (<1.8)	ND (<4,000)	ND (<1.8)	ND (<1,900)	ND (<1.8)	ND (<400)
3&4-Methylphenol	3,990	ND (<4,400)	ND (<1.3)	ND (<390)	ND (<1.3)	ND (<370)	ND (<1.3)	ND (<71)	ND (<1.3)	ND (<4,600)	12.8	3,780 J	2.0 J	4,640
3,3'-Dichlorobenzidine	ND (<1.2)	ND (<2,900)	ND (<1.2)	ND (<260)	ND (<1.2)	ND (<250)	ND (<1.2)	ND (<47)	ND (<1.2)	ND (<3,100)	ND (<1.2)	ND (<1,500)	ND (<1.2)	ND (<1,400)
3-Nitroaniline	ND (<1.3)	ND (<2,400)	ND (<1.3)	ND (<210)	ND (<1.3)	ND (<200)	ND (<1.3)	ND (<38)	ND (<1.3)	ND (<2,500)	ND (<1.3)	ND (<1,200)	ND (<1.3)	ND (<1,200)
4,6-Dinitro-o-cresol	ND (<0.72)	ND (<2,700)	ND (<0.72)	ND (<240)	ND (<0.72)	ND (<230)	ND (<0.72)	ND (<43)	ND (<0.72)	ND (<2,800)	ND (<0.72)	ND (<1,300)	ND (<0.72)	ND (<280)
4-Bromophenyl phenyl ether	ND (<0.3)	ND (<1,600)	ND (<0.3)	ND (<140)	ND (<0.3)	ND (<130)	ND (<0.30)	ND (<25)	ND (<0.30)	ND (<1,600)	ND (<0.30)	ND (<790)	ND (<0.3)	ND (<750)
4-Chloro-3-methyl phenol	ND (<1.2)	ND (<3,900)	ND (<1.2)	ND (<350)	ND (<1.2)	ND (<330)	ND (<1.2)	ND (<63)	ND (<1.2)	ND (<4,100)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<410)
4-Chloroaniline	ND (<0.4)	ND (<1,900)	ND (<0.4)	ND (<170)	ND (<0.4)	ND (<160)	ND (<0.40)	ND (<31)	ND (<0.40)	ND (<2,000)	ND (<0.40)	ND (<960)	ND (<0.4)	ND (<920)
4-Chlorophenyl phenyl ether	ND (<0.43)	ND (<1,400)	ND (<0.43)	ND (<130)	ND (<0.43)	ND (<120)	ND (<0.43)	ND (<23)	ND (<0.43)	ND (<1,500)	ND (<0.43)	ND (<730)	ND (<0.43)	ND (<700)
4-Nitroaniline	ND (<0.72)	ND (<2,100)	ND (<0.72)	ND (<190)	ND (<0.72)	ND (<180)	ND (<0.72)	ND (<34)	ND (<0.72)	ND (<2,200)	ND (<0.72)	ND (<1,100)	ND (<0.72)	ND (<1,000)
4-Nitrophenol	ND (<0.84)	ND (<4,200)	ND (<0.84)	ND (<370)	ND (<0.84)	ND (<350)	ND (<0.84)	ND (<67)	ND (<0.84)	ND (<4,400)	ND (<0.84)	ND (<2,100)	ND (<0.84)	ND (<440)
Acenaphthene	299	3,300,000	1.3 J	1,070,000	4.3	829,000	3	181,000	94.1	1,260,000	31.5	412,000	3.61	120,000
Acenaphthylene	168 J	155,000	7.9	29,600	0.63 J	30,700	1.1 J	8,850	4.0	77,500	1.73	57,700	0.936	84,200
Acetophenone	ND (<0.37)	ND (<1,900)	19.9	ND (<170)	2.7 J	ND (<160)	7	ND (<31)	3.4 J	ND (<2,000)	ND (<0.37)	ND (<980)	ND (<0.37)	1,500 J
Anthracene	252	2,330,000	7.4	757,000	2.9	527,000	2.8	76,200	15.5	889,000	8.6	335,000	1.64	97,300 J
Atrazine	ND (<0.16)	ND (<2,700)	ND (<0.16)	ND (<240)	ND (<0.16)	ND (<220)	ND (<0.16)	ND (<43)	ND (<0.16)	ND (<2,800)	ND (<0.16)	ND (<1,300)	ND (<0.16)	ND (<1,300)
Benzaldehyde	ND (<0.27)	ND (<3,400)	13.1	ND (<300)	3.9 J	ND (<290)	6.7	ND (<54)	ND (<0.27)	ND (<3,500)	5.5	ND (<1,700)	ND (<0.27)	ND (<1,600)
Benzo(a)anthracene	147 J	1,560,000	14.6	541,000	4.2	506,000	10.4	90,800	22.0	863,000	26.2	1,190,000	6.2	627,000
Benzo(a)pyrene	102 J	1,110,000	3.2	432,000	2.4	357,000	3.9	48,900	12.8	689,000	15.6	733,000	1.96	258,000
Benzo(b)fluoranthene	97.1	970,000	13.7	452,000	3.7	341,000	10.1	68,100	17.5	640,000	20.7	971,000	3.36	619,000
Benzo(g,h,i)perylene	85.5	618,000	7.1	157,000	2.3	176,000	5.5	34,500	5.1	288,000	9.7	437,000	1.23	179,000
Benzo(k)fluoranthene	88.4 J	733,000	12	206,000	2.9	246,000	9.1	40,200	16.9	599,000	14.7	664,000	3.4	368,000
bis(2-Chloroethoxy)methane	ND (<0.65)	ND (<2,000)	ND (<0.65)	ND (<180)	ND (<0.65)	ND (<170)	ND (<0.65)	ND (<32)	ND (<0.65)	ND (<2,100)	ND (<0.65)	ND (<1,000)	ND (<0.65)	ND (<960)
bis(2-Chloroethyl)ether	ND (<0.53)	ND (<1,500)	ND (<0.53)	ND (<140)	ND (<0.53)	ND (<130)	ND (<0.53)	ND (<25)	ND (<0.53)	ND (<1,600)	ND (<0.53)	ND (<770)	ND (<0.53)	ND (<740)
bis(2-Chloroisopropyl)ether	ND (<0.74)	ND (<2,300)	ND (<0.74)	ND (<210)	ND (<0.74)	ND (<190)	ND (<0.74)	ND (<37)	ND (<0.74)	ND (<2,400)	ND (<0.74)	ND (<1,200)	ND (<0.74)	ND (<1,100)
bis(2-Ethylhexyl)phthalate	ND (<0.66)	ND (<3,900)	ND (<0.66)	ND (<350)	1.3 J	ND (<330)	ND (<0.66)	931	ND (<0.66)	ND (<4,100)	ND (<0.66)	ND (<2,000)	ND (<0.66)	4,940
Butyl benzyl phthalate	ND (<0.59)	ND (<2,300)	ND (<0.59)	ND (<210)	ND (<0.59)	ND (<200)	ND (<0.59)	ND (<37)	ND (<0.59)	ND (<2,400)	ND (<0.59)	ND (<1,200)	ND (<0.59)	ND (<1,100)
Caprolactam	ND (<0.32)	ND (<3,000)	ND (<0.32)	ND (<270)	ND (<0.32)	ND (<250)	ND (<0.32)	ND (<48)	ND (<0.32)	ND (<3,100)	ND (<0.32)	ND (<1,500)	ND (<0.32)	ND (<1,400)
Carbazole	297	831,000	10.2	104,000	0.54 J	29,300	1.5 J	4,320	36.4	188,000	4.1	35,300	0.51 J	25,900
Chrysene	139 J	1,670,000	25.8	549,000	5.4	524,000	15.1	95,300	27.4	963,000	28.5	1,280,000	8.5	888,000
Dibenzo(a,h)anthracene	23.5	159,000	2.3	68,600	ND (<0.54)	72,700	1.4 J	14,300	2.2	135,000	4.4	130,000	0.868	109,000
Dibenzofuran	297 J	2,360,000	51.5	907,000	14.4	808,000	28.6	178,000	88.2	1,100,000	42.8	553,000	11.0	262,000
Diethyl phthalate	ND (<0.39)	ND (<1,300)	ND (<0.39)	ND (<120)	ND (<0.39)	ND (<110)	ND (<0.39)	ND (<21)	ND (<0.39)	ND (<1,400)	ND (<0.39)	ND (<660)	ND (<0.39)	ND (<640)
Dimethyl phthalate	ND (<0.33)	ND (<1,300)	ND (<0.33)	ND (<120)	ND (<0.33)	ND (<110)	ND (<0.33)	ND (<21)	ND (<0.33)	ND (<1,400)	ND (<0.33)	ND (<660)	ND (<0.33)	ND (<640)
Di-n-butyl phthalate	ND (<0.59)	ND (<2,000)	ND (<0.59)	ND (<180)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<32)	ND (<0.59)	ND (<2,000)	ND (<0.59)	ND (<980)	ND (<0.59)	ND (<940)
Di-n-octyl phthalate	ND (<0.57)	ND (<2,600)	ND (<0.57)	ND (<240)	ND (<0.57)	ND (<220)	ND (<0.57)	ND (<42)	ND (<0.57)	ND (<2,700)	ND (<0.57)	ND (<1,300)	ND (<0.57)	ND (<1,300)
Fluoranthene	509	4,820,000	65.8	1,620,000	15.3	1,460,000	43.5	281,000	78.3	2,610,000	87.4	3,530,000	21.7	1,930,000
Fluorene	320	2,680,000	7.5	892,000	4.7	641,000	12.1	147,000	135	1,560,000	96.6	1,360,000	23.4	673,000
Hexachlorobenzene	ND (<0.54)	ND (<1,800)	ND (<0.54)	ND (<160)	ND (<0.54)	ND (<150)	ND (<0.54)	ND (<28)	ND (<0.54)	ND (<1,800)	ND (<0.02)	ND (<890)	ND (<0.02)	ND (<850)
Hexachlorobutadiene	ND (<0.18)	ND (<2,000)	ND (<0.18)	ND (<180)	ND (<0.18)	ND (<170)	ND (<0.18)	ND (<33)	ND (<0.18)	ND (<2,100)	ND (<0.18)	ND (<1,000)	ND (<0.18)	ND (<980)
Hexachlorocyclopentadiene	ND (<0.41)	ND (<2,200)	ND (<0.41)	ND (<200)	ND (<0.41)	ND (<190)	ND (<0.41)	ND (<36)	ND (<0.41)	ND (<2,300)	ND (<0.41)	ND (<1,100)	ND (<0.41)	ND (<1,100)
Hexachloroethane	ND (<0.28)	ND (<1,500)	ND (<0.28)	ND (<140)	ND (<0.28)	ND (<130)	ND (<0.28)	ND (<25)	ND (<0.28)	ND (<1,600)	ND (<0.28)	ND (<770)	ND (<0.28)	ND (<740)
Indeno(1,2,3-cd)pyrene	71.8	542,000	6.1	193,000	1.9 J	210,000	5.2	40,600	5.5	299,000	10.1	466,000	1.62	198,000
Isophorone	ND (<0.59)	ND (<1,500)	ND (<0.59)	ND (<140)	ND (<0.59)	ND (<130)	ND (<0.59)	ND (<25)	ND (<0.59)	ND (<1,600)	ND (<0.59)	ND (<770)	ND (<0.59)	ND (<740)
Naphthalene	9,940	21,200,000	380	8,360,000	45.6	6,660,000	195	1,660,000	492	1,660,000	25.8	145,000	2.86	50,500
Nitrobenzene	ND (<0.42)	ND (<2,100)	ND (<0.42)	ND (<190)	ND (<0.42)	ND (<180)	ND (<0.42)	ND (<35)	ND (<0.42)	ND (<2,200)	ND (<0.42)	ND (<1,100)	ND (<0.42)	ND (<1,000)
N-Nitroso-di-n-propylamine	ND (<0.47)	ND (<2,000)	ND (<0.47)	ND (<180)	ND (<0.47)	ND (<170)	ND (<0.47)	ND (<32)	ND (<0.47)	ND (<2,100)	ND (<0.47)	ND (<990)	ND (<0.47)	ND (<950)
N-Nitrosodiphenylamine	ND (<0.52)	ND (<1,300)	ND (<0.52)	ND (<110)	ND (<0.52)	ND (<110)	ND (<0.52)	ND (<20)	ND (<0.52)	ND (<1,300)	ND (<0.52)	ND (<640)	ND (<0.52)	ND (<610)
Pentachlorophenol	ND (<1.9)	ND (<3,400)	ND (<1.9)	ND (<310)	ND (<1.9)	ND (<290)	ND (<1.9)	ND (<55)	ND (<1.9)	ND (<3,600)	ND (<0.30)	ND (<1,700)	ND (<0.3)	ND (<360)
Phenanthrene	1,050	9,240,000	217	3,240,000	32.6	2,970,000	72.7	613,000	206	4,240,000	216	4,800,000	42.7	2,890,000
Phenol	1,770	ND (<3,800)	ND (<0.5)	ND (<340)	ND (<0.50)	ND (<320)	ND (<0.50)	ND (<61)	1.2 J	ND (<4,000)	34.9	3,420 J	6.1	4,160
Pyrene	389	3,490,000	31.7	1,230,000	9.2	1,100,000	22.1	218,000	48.3	1,870,000	60.1	2,520,000	12.5	1,360,000
Total TIC, Semivolatile	3,167 J	3,192,000 J	391.2 J	301,600 J	164.9 J	216,300 J	444.7 J	27,940 J	568 J	9,710,000 J	376.7 J	2,736,000 J	93.3 J	2,553,000 J
Total Semivolatiles (target)	*29,802*	*64,769,200*	*955*	*23,658,200*	*178*	*19,940,700*	*486*	*4,371,701*	*1,601*	*22,162,500*	*801*	*19,979,860*	*164*	*10,929,410*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Baseline Data		SS-1 Slurry Test Data											
			Persulfate 10:1 (SS1-P-10)		Persulfate 20:1 (SS1-P-20)		Persulfate 40:1 (SS1-P-40)		Fenton 10:1 (SS1-F-10)		Fenton 20:1 (SS1-F-20)		Fenton 40:1 (SS1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry														
(mg/L unless noted)														
Solids, Percent		81.5		72.6		77.0		67.3		62.3		64.7		61.2
Chromium, Hexavalent	ND (<0.010)				ND (<0.10) c						0.071			
Iron, Ferrous	0.36				0.11						101			
Nitrogen, Nitrate[a]	ND (<0.11)				51.6						1.4			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				51.7						1.4			
Nitrogen, Nitrite	ND (<0.010)				0.11						ND (<0.010)			
Petroleum Hydrocarbons	5.3	1,970		3,620	ND (<0.53) d	2,210		347		4,430	0.51	2,360		291
Phosphorus, Total	0.32				ND (<0.050) d						50.8			
Sulfate	ND (<10)				62,100						1,750			
Total Organic Carbon	92.9	537,000	414	303,000	808	192,000	2,020	24,700	1,060	471,000	1,070	554,000	898	519,000
pH, standard units	7.20 b		13.18 b		13.42 b		12.94 b		2.14 b		2.19 b		2.21 b	
As(III) (ug/L)	7.5				ND (<0.56)						ND (<1.23)			
As(V) (ug/L)	3.0				658						752			
Metals (ug/L or mg/kg)														
Arsenic	20.6	20.6	499	7.5	683	4.9	385	ND (<3.0)	459	16.1	558	14.9	590	16.0
Barium	ND (<200)	89.8	ND (<2,000) c	37.0	ND (<2,000) c	25.8	ND (<400) c	ND (<30)	364	79.7	456	95.5	191 B	97.5
Cadmium	ND (<4.0)	1.4	ND (<40) c	ND (<0.68)	ND (<40) c	ND (<0.62)	ND (<8.0) c	ND (<0.74)	25.5	ND (<0.77)	31.8	ND (<0.22)	58.8	ND (<0.22)
Chromium	ND (<10)	11.7	128	3.7	193	2.3	90.2	ND (<1.5)	140	7.9	4,690	1,420	6,990	1,710
Iron	1,280	19,600	ND (<1,000) c	6,820	1,260	5,470	292	704	557,000	9,590	833,000	16,300	900,000	18200
Lead	ND (<3.0)	91.1	1,700	51.0	5,600	25.5	2,690	8.4	2,920	106	3,070	139	5,280	272
Manganese	79.8		ND (<150) c	53.0	ND (<150) c	38.9	ND (<30) c	8.3	3,890	55.7	6,270	209	9,320	236
Mercury	ND (<0.40) c	0.17	ND (<0.20)	0.087	0.95	0.045	0.92	0.051	ND (<0.20)	0.47	ND (<0.20)	0.92	0.065 B	0.88
Selenium	ND (<10)	3.3	ND (<100) c	ND (<2.7)	160	ND (<2.5)	36.1	ND (<3.0)	57.2	ND (<3.1)	93.0	1.6 B	123	ND (<1.2)
Silver	ND (<10)	ND (<1.2)	ND (<100) c	ND (<1.4)	ND (<100) c	ND (<1.2)	ND (<20) c	ND (<1.5)	ND (<10)	ND (<1.5)	12.9	ND (<0.23)	2.4 B	0.47 B
Thallium	ND (<10)	ND (<1.2)	ND (<100) c	ND (<1.4)	ND (<100) c	ND (<1.2)	ND (<20) c	ND (<1.5)	ND (<10)	ND (<1.5)	ND (<10)	ND (<1.2)	10.5	ND (<1.3)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data							
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave			
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Silica Gel	Carbon
Volatiles (ug/L or ug/kg)										
1,1,1-Trichloroethane	ND (<2,800)	ND (<2,800)	ND (<0.3)	ND (<2.8)	2.8 J	104 J	ND (<3.0)	ND (<360)	3.1 J	101 J
1,1,2,2-Tetrachloroethane	ND (<2,200)	ND (<2,200)	ND (<0.8)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<8.0)	ND (<280)	ND (<0.34)	ND (<35)
1,1,2-Trichloroethane	ND (<2,200)	ND (<2,200)	ND (<0.49)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<4.9)	ND (<280)	ND (<0.34)	ND (<35)
1,1-Dichloroethane	ND (<5,100)	ND (<5,100)	ND (<0.2)	ND (<5.2)	ND (<0.81)	ND (<79)	ND (<2.0)	ND (<660)	ND (<0.79)	ND (<83)
1,1-Dichloroethene	ND (<3,400)	ND (<3,400)	ND (<0.28)	ND (<3.5)	0.71 J	ND (<53)	ND (<2.8)	ND (<440)	0.92 J	ND (<56)
1,2,4-Trichlorobenzene	ND (<2,600)	ND (<2,600)	ND (<0.41)	ND (<2.7)	ND (<0.41)	ND (<41)	ND (<4.1)	ND (<340)	ND (<0.41)	ND (<42)
1,2-Dibromo-3-chloropropane	ND (<6,900)	ND (<6,900)	ND (<0.8)	ND (<7)	ND (<1.1)	ND (<110)	ND (<8.0)	ND (<900)	ND (<1.1)	ND (<110)
1,2-Dibromoethane	ND (<2,100)	ND (<2,100)	ND (<0.45)	ND (<2.2)	ND (<0.34)	ND (<34)	ND (<4.5)	ND (<280)	ND (<0.34)	ND (<35)
1,2-Dichlorobenzene	ND (<2,000)	ND (<2,000)	ND (<0.2)	ND (<2.1)	ND (<0.32)	ND (<32)	ND (<2.0)	ND (<270)	ND (<0.32)	ND (<33)
1,2-Dichloroethane	ND (<1,700)	ND (<1,700)	ND (<0.29)	ND (<1.8)	ND (<0.28)	74 J	ND (<2.9)	ND (<230)	ND (<0.27)	70 J
1,2-Dichloropropane	ND (<3,000)	ND (<3,000)	ND (<0.24)	ND (<3.1)	ND (<0.48)	ND (<47)	ND (<2.4)	ND (<400)	ND (<0.47)	ND (<49)
1,3-Dichlorobenzene	ND (<2,700)	ND (<2,700)	ND (<0.21)	ND (<2.8)	ND (<0.43)	ND (<42)	ND (<2.1)	ND (<350)	ND (<0.42)	ND (<44)
1,4-Dichlorobenzene	ND (<2,200)	ND (<2,200)	ND (<0.17)	ND (<2.3)	ND (<0.35)	ND (<34)	ND (<1.7)	ND (<290)	ND (<0.34)	ND (<36)
2-Butanone (MEK)	ND (<21,000)	ND (<21,000)	ND (<2.7)	ND (<21)	ND (<3.3)	ND (<320)	38.5 J	ND (<2,700)	ND (<3.2)	ND (<340)
2-Hexanone	ND (<13,000)	ND (<13,000)	ND (<0.94)	ND (<13)	ND (<2)	ND (<200)	ND (<9.4)	ND (<1,700)	ND (<2)	ND (<210)
4-Methyl-2-pentanone(MIBK)	ND (<15,000)	ND (<15,000)	ND (<1.4)	ND (<15)	ND (<2.3)	ND (<230)	ND (<14)	ND (<1,900)	ND (<2.3)	ND (<240)
Acetone	ND (<30,000)	ND (<30,000)	117	ND (<31)	94.4	ND (<470)	1140	ND (<3,900)	72.9	ND (<490)
Benzene	6,540	ND (<5,400)	1.6	14.8	5.4	ND (<83)	12.8	2,730	9.8	ND (<87)
Bromodichloromethane	ND (<1,800)	ND (<1,800)	ND (<0.15)	ND (<1.9)	ND (<0.29)	ND (<29)	ND (<1.5)	ND (<240)	ND (<0.29)	ND (<30)
Bromoform	ND (<6,000)	ND (<6,000)	ND (<0.34)	ND (<6.2)	ND (<0.95)	ND (<94)	ND (<3.4)	ND (<790)	ND (<0.94)	ND (<98)
Bromomethane	ND (<3,600)	ND (<3,600)	ND (<0.38)	ND (<3.7)	ND (<0.57)	ND (<56)	ND (<3.8)	ND (<470)	ND (<0.56)	ND (<58)
Carbon disulfide	ND (<2,100)	ND (<2,100)	0.58 J	ND (<2.2)	ND (<0.34)	ND (<33)	16.5 J	ND (<280)	ND (<0.33)	ND (<35)
Carbon tetrachloride	ND (<1,800)	ND (<1,800)	ND (<0.19)	ND (<1.9)	ND (<0.29)	ND (<29)	ND (<1.9)	ND (<240)	ND (<0.29)	ND (<30)
Chlorobenzene	ND (<4,100)	ND (<4,100)	ND (<0.19)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<1.9)	ND (<540)	ND (<0.64)	ND (<67)
Chloroethane	ND (<3,800)	ND (<3,800)	ND (<0.67)	ND (<3.9)	ND (<0.61)	ND (<60)	ND (<6.7)	ND (<500)	ND (<0.6)	ND (<62)
Chloroform	ND (<2,900)	ND (<2,900)	ND (<0.25)	ND (<3)	0.89 J	296 J	ND (<2.5)	ND (<380)	0.96 J	268 J
Chloromethane	ND (<3,900)	ND (<3,900)	ND (<0.3)	ND (<4)	ND (<0.61)	ND (<60)	50.5	ND (<500)	ND (<0.6)	ND (<63)
cis-1,2-Dichloroethene	ND (<1,400)	ND (<1,400)	ND (<0.27)	ND (<1.4)	ND (<0.22)	ND (<22)	ND (<2.7)	ND (<180)	ND (<0.22)	ND (<23)
cis-1,3-Dichloropropene	ND (<3,700)	ND (<3,700)	ND (<0.13)	ND (<3.8)	ND (<0.58)	ND (<58)	ND (<1.3)	ND (<480)	ND (<0.58)	ND (<60)
Cyclohexane	ND (<2,900)	ND (<2,900)	ND (<0.85)	ND (<3)	ND (<0.46)	ND (<45)	ND (<8.5)	ND (<380)	ND (<0.45)	ND (<47)
Dibromochloromethane	ND (<1,500)	ND (<1,500)	ND (<0.28)	ND (<1.6)	ND (<0.24)	ND (<24)	ND (<2.8)	ND (<200)	ND (<0.24)	ND (<25)
Dichlorodifluoromethane	ND (<3,000)	ND (<3,000)	ND (<1)	ND (<3.1)	ND (<0.47)	ND (<47)	ND (<10)	ND (<390)	ND (<0.47)	ND (<49)
Ethylbenzene	81,000	8,250	0.54 J	23.9	2.1	ND (<56)	ND (<2.1)	20,800	9.5	ND (<58)
Freon 113	ND (<2,700)	ND (<2,700)	ND (<1.2)	ND (<2.8)	ND (<0.43)	101 J	ND (<12)	ND (<360)	4.5 J	ND (<45)
Isopropylbenzene	24,600	3,670	ND (<0.54)	3.9 J	ND (<0.35)	ND (<34)	ND (<5.4)	4,470 J	0.65 J	ND (<36)
m,p-Xylene	275,000	31,500	1.4	74.7	8.3	ND (<56)	ND (<3.5)	70,500	35.7	ND (<59)
Methyl Acetate	ND (<23,000)	ND (<23,000)	ND (<1.6)	ND (<23)	ND (<3.6)	ND (<360)	ND (<16)	ND (<3,000)	ND (<3.6)	ND (<370)
Methyl Tert Butyl Ether	ND (<4,600)	ND (<4,700)	ND (<0.2)	ND (<4.7)	2.0	ND (<72)	ND (<2.0)	ND (<600)	2.1	ND (<76)
Methylcyclohexane	ND (<3,700)	ND (<3,700)	ND (<0.5)	ND (<3.8)	0.91 J	ND (<58)	ND (<5.0)	ND (<480)	1.5 J	ND (<60)
Methylene chloride	ND (<3,500)	ND (<3,500)	ND (<0.21)	ND (<3.5)	11.3	1,070	ND (<2.1)	ND (<450)	13.8	946
o-Xylene	136,000	14,900	0.50 J	35	3.0	ND (<30)	ND (<2.0)	37,600	9.4	ND (<31)
Styrene	ND (<1,700)	ND (<1,700)	ND (<0.2)	ND (<1.7)	ND (<0.27)	ND (<26)	ND (<2.0)	ND (<220)	ND (<0.26)	ND (<27)
Tetrachloroethene	ND (<2,400)	ND (<2,500)	ND (<0.28)	ND (<2.5)	2.2 J	ND (<38)	ND (<2.8)	ND (<320)	2.6 J	ND (<40)
Toluene	57,500	ND (<3,100)	2.3	34.2	20.4	ND (<48)	ND (<2.1)	19,100	34.4	ND (<50)
trans-1,2-Dichloroethene	ND (<4,100)	ND (<4,100)	ND (<0.32)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<3.2)	ND (<530)	ND (<0.64)	ND (<66)
trans-1,3-Dichloropropene	ND (<5,900)	ND (<6,000)	ND (<0.17)	ND (<6.1)	ND (<0.94)	ND (<93)	ND (<1.7)	ND (<770)	ND (<0.93)	ND (<97)
Trichloroethene	ND (<2,400)	ND (<2,400)	ND (<0.26)	ND (<2.4)	1.9 J	ND (<37)	ND (<2.6)	ND (<310)	2.1 J	ND (<39)
Trichlorofluoromethane	ND (<3,400)	ND (<3,500)	ND (<0.26)	ND (<3.5)	17.6	168 J	ND (<2.6)	ND (<450)	20.1	155 J
Vinyl chloride	ND (<4,100)	ND (<4,100)	ND (<0.22)	ND (<4.2)	ND (<0.65)	ND (<64)	ND (<2.2)	ND (<530)	ND (<0.64)	ND (<67)
Xylene (total)	410,000	46,400	1.9	110	11.3	ND (<30)	ND (<2.0)	108,000	45.1	ND (<31)
Total TIC, Volatile	7,210,000	1,104,000	21 J	2,355 J	37.9 J	1,220 J	ND	1,736,000 J	433.1 J	1,230 J
Total Volatiles (Target)	*990,640*	*104,720*	*125.82*	*296.5*	*185.21*	*1,813*	*1258.3*	*263,200*	*269.13*	*1,540*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data							
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave			
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Silica Gel	Carbon
Semivolatiles (ug/L or ug/kg)										
1,1'-Biphenyl	443,000	142,000	6.2	10,000	ND (<100)	ND (<100)	28.3	415,000	ND (<100)	ND (<260)
2,4,5-Trichlorophenol	ND (<1,900)	ND (<1,900)	ND (<1.9)	ND (<360)	ND (<320)	ND (<310)	ND (<1.9)	ND (<940)	ND (<320)	ND (<810)
2,4,6-Trichlorophenol	ND (<1,100)	ND (<1,000)	ND (<1.3)	ND (<200)	ND (<180)	ND (<180)	ND (<1.3)	ND (<520)	ND (<180)	ND (<460)
2,4-Dichlorophenol	ND (<2,100)	ND (<2,100)	ND (<1.6)	ND (<400)	ND (<360)	ND (<350)	ND (<1.6)	ND (<1,000)	ND (<350)	ND (<910)
2,4-Dimethylphenol	ND (<3,300)	ND (<3,200)	1.9 J	ND (<610)	ND (<550)	ND (<540)	ND (<1.6)	ND (<1,600)	ND (<540)	ND (<1,400)
2,4-Dinitrophenol	ND (<1,900)	ND (<1,900)	ND (<0.89)	ND (<360)	ND (<330)	ND (<320)	ND (<0.89)	ND (<950)	ND (<320)	ND (<820)
2,4-Dinitrotoluene	ND (<1,500)	ND (<1,400)	ND (<0.86)	ND (<280)	ND (<250)	ND (<240)	ND (<0.86)	ND (<720)	ND (<250)	ND (<630)
2,6-Dinitrotoluene	ND (<1,500)	ND (<1,400)	ND (<0.56)	ND (<270)	ND (<240)	ND (<240)	ND (<0.56)	ND (<710)	ND (<240)	ND (<620)
2-Chloronaphthalene	ND (<1,800)	ND (<1,700)	ND (<0.98)	ND (<330)	ND (<300)	ND (<290)	ND (<0.98)	ND (<870)	ND (<300)	ND (<760)
2-Chlorophenol	ND (<1,100)	ND (<1,100)	ND (<0.95)	ND (<200)	ND (<180)	ND (<180)	ND (<0.95)	ND (<530)	ND (<180)	ND (<460)
2-Methylnaphthalene	2,670,000	982,000	11.4	39,900	ND (<140)	ND (<140)	119	1,880,000	551	ND (<350)
2-Methylphenol	ND (<1,300)	ND (<1,200)	2.6 J	ND (<230)	ND (<210)	ND (<210)	ND (<1.4)	ND (<610)	ND (<210)	ND (<530)
2-Nitroaniline	ND (<810)	ND (<780)	ND (<0.66)	ND (<150)	ND (<140)	ND (<130)	ND (<0.66)	ND (<390)	ND (<130)	ND (<340)
2-Nitrophenol	ND (<1,600)	ND (<1,500)	ND (<1.8)	ND (<300)	ND (<270)	ND (<260)	ND (<1.8)	ND (<770)	ND (<260)	ND (<670)
3&4-Methylphenol	ND (<1,800)	ND (<1,800)	6.3	ND (<340)	ND (<310)	ND (<300)	ND (<1.3)	ND (<890)	ND (<300)	ND (<780)
3,3'-Dichlorobenzidine	ND (<1,200)	ND (<1,200)	ND (<1.2)	ND (<230)	ND (<200)	ND (<200)	ND (<1.2)	ND (<600)	ND (<200)	ND (<520)
3-Nitroaniline	ND (<990)	ND (<960)	ND (<1.3)	ND (<190)	ND (<170)	ND (<160)	ND (<1.3)	ND (<480)	ND (<160)	ND (<420)
4,6-Dinitro-o-cresol	ND (<1,100)	ND (<1,100)	ND (<0.72)	ND (<210)	ND (<190)	ND (<180)	ND (<0.72)	ND (<540)	ND (<180)	ND (<470)
4-Bromophenyl phenyl ether	ND (<650)	ND (<630)	ND (<0.3)	ND (<120)	ND (<110)	ND (<110)	ND (<0.3)	ND (<320)	ND (<110)	ND (<280)
4-Chloro-3-methyl phenol	ND (<1,600)	ND (<1,600)	ND (<1.2)	ND (<300)	ND (<270)	ND (<270)	ND (<1.2)	ND (<790)	ND (<270)	ND (<690)
4-Chloroaniline	ND (<790)	ND (<770)	ND (<0.4)	ND (<150)	ND (<130)	ND (<130)	ND (<0.4)	ND (<390)	ND (<130)	ND (<340)
4-Chlorophenyl phenyl ether	ND (<600)	ND (<580)	ND (<0.43)	ND (<110)	ND (<100)	ND (<98)	ND (<0.43)	ND (<290)	ND (<99)	ND (<250)
4-Nitroaniline	ND (<880)	ND (<850)	ND (<0.72)	ND (<160)	ND (<150)	ND (<140)	ND (<0.72)	ND (<430)	ND (<150)	ND (<370)
4-Nitrophenol	ND (<1,700)	ND (<1,700)	ND (<0.84)	ND (<330)	ND (<290)	ND (<280)	ND (<0.84)	ND (<850)	ND (<290)	ND (<740)
Acenaphthene	1,520,000	719,000	13.4	32,900	ND (<110)	ND (<110)	2.02	1,120,000	296 J	ND (<280)
Acenaphthylene	74,200	39,900	1.5	4,460	ND (<87)	ND (<85)	2.27	75,100	ND (<86)	ND (<220)
Acetophenone	ND (<810)	ND (<780)	2.7 J	ND (<150)	ND (<130)	ND (<130)	60.3	ND (<390)	ND (<130)	ND (<340)
Anthracene	1,040,000	461,000	10.2	28,700	ND (<83)	ND (<81)	6.70	693,000	ND (<82)	ND (<210)
Atrazine	ND (<1,100)	ND (<1,100)	ND (<0.16)	ND (<210)	ND (<180)	ND (<180)	ND (<0.16)	ND (<540)	ND (<180)	ND (<470)
Benzaldehyde	ND (<1,400)	ND (<1,400)	3.0 J	ND (<260)	ND (<240)	ND (<230)	43.7	ND (<690)	ND (<230)	ND (<600)
Benzo(a)anthracene	732,000	369,000	35.8	55,300	ND (<100)	ND (<100)	21.9	542,000	ND (<100)	ND (<260)
Benzo(a)pyrene	552,000	270,000	17.0	39,600	ND (<74)	ND (<73)	3.90	374,000	ND (<74)	ND (<190)
Benzo(b)fluoranthene	545,000	256,000	21.4	41,700	ND (<98)	ND (<95)	25.9	305,000	ND (<96)	ND (<250)
Benzo(g,h,i)perylene	215,000	122,000	7.7	20,900	ND (<120)	ND (<110)	11.8	290,000	ND (<120)	ND (<300)
Benzo(k)fluoranthene	499,000	269,000	18.7	23,400	ND (<160)	ND (<160)	22.1	400,000	ND (<160)	ND (<410)
bis(2-Chloroethoxy)methane	ND (<830)	ND (<800)	ND (<0.65)	ND (<150)	ND (<140)	ND (<130)	ND (<0.65)	ND (<400)	ND (<140)	ND (<350)
bis(2-Chloroethyl)ether	ND (<640)	ND (<620)	ND (<0.53)	ND (<120)	ND (<110)	ND (<100)	ND (<0.53)	ND (<310)	ND (<110)	ND (<270)
bis(2-Chloroisopropyl)ether	ND (<960)	ND (<930)	ND (<0.74)	ND (<180)	ND (<160)	ND (<160)	ND (<0.74)	ND (<470)	ND (<160)	ND (<410)
bis(2-Ethylhexyl)phthalate	6,570	ND (<1,600)	ND (<0.66)	ND (<310)	592	ND (<270)	ND (<0.66)	2,030	ND (<270)	788 J
Butyl benzyl phthalate	ND (<970)	ND (<930)	ND (<0.59)	ND (<180)	ND (<160)	ND (<160)	ND (<0.59)	ND (<470)	ND (<160)	ND (<410)
Caprolactam	ND (<1,200)	ND (<1,200)	ND (<0.32)	ND (<230)	ND (<210)	ND (<200)	ND (<0.32)	ND (<600)	ND (<200)	ND (<520)
Carbazole	192,000	80,400	2.1	5,460	ND (<86)	ND (<85)	6.70	160,000	ND (<85)	ND (<220)
Chrysene	732,000	375,000	41.2	58,700	ND (<79)	ND (<77)	42.8	511,000	ND (<78)	ND (<200)
Dibenzo(a,h)anthracene	114,000	58,900	2.93	10,500	ND (<110)	ND (<110)	3.50	115,000	ND (<110)	ND (<280)
Dibenzofuran	1,270,000	586,000	15.6	24,100	ND (<99)	ND (<97)	110	777,000	393 J	ND (<250)
Diethyl phthalate	ND (<550)	ND (<530)	ND (<0.39)	ND (<100)	ND (<92)	ND (<90)	ND (<0.39)	ND (<270)	ND (<90)	ND (<230)
Dimethyl phthalate	ND (<550)	ND (<530)	ND (<0.33)	ND (<100)	ND (<92)	ND (<90)	ND (<0.33)	ND (<270)	ND (<91)	ND (<230)
Di-n-butyl phthalate	ND (<820)	ND (<790)	ND (<0.59)	ND (<150)	ND (<140)	ND (<130)	ND (<0.59)	ND (<400)	ND (<130)	ND (<340)
Di-n-octyl phthalate	ND (<1,100)	ND (<1,100)	ND (<0.57)	ND (<200)	ND (<180)	ND (<180)	ND (<0.57)	ND (<530)	ND (<180)	ND (<460)
Fluoranthene	1,970,000	1,020,000	117 E	154,000	ND (<76)	ND (<74)	144	1,650,000	117 J	676 J
Fluorene	1,460,000	781,000	55.3	51,800	ND (<86)	ND (<84)	60.3	956,000	276 J	ND (<220)
Hexachlorobenzene	ND (<740)	ND (<710)	ND (<0.02)	ND (<140)	ND (<120)	ND (<120)	ND (<0.02)	ND (<360)	ND (<120)	ND (<310)
Hexachlorobutadiene	ND (<840)	ND (<810)	ND (<0.18)	ND (<160)	ND (<140)	ND (<140)	ND (<0.18)	ND (<410)	ND (<140)	ND (<360)
Hexachlorocyclopentadiene	ND (<920)	ND (<890)	ND (<0.41)	ND (<170)	ND (<150)	ND (<150)	ND (<0.41)	ND (<450)	ND (<150)	ND (<390)
Hexachloroethane	ND (<640)	ND (<620)	ND (<0.28)	ND (<120)	ND (<110)	ND (<100)	ND (<0.28)	ND (<310)	ND (<110)	ND (<270)
Indeno(1,2,3-cd)pyrene	280,000	143,000	8.3	20,700	ND (<140)	ND (<130)	11.8	291,000	ND (<130)	ND (<340)
Isophorone	ND (<640)	ND (<610)	ND (<0.59)	ND (<120)	ND (<110)	ND (<100)	ND (<0.59)	ND (<310)	ND (<100)	ND (<270)
Naphthalene	6,080,000	1,200,000	23.9	75,700	ND (<120)	ND (<120)	1050	4,560,000	ND (<120)	ND (<310)
Nitrobenzene	ND (<890)	ND (<860)	ND (<0.42)	ND (<170)	ND (<150)	ND (<150)	ND (<0.42)	ND (<440)	ND (<150)	ND (<380)
N-Nitroso-di-n-propylamine	ND (<820)	ND (<790)	ND (<0.47)	ND (<150)	ND (<140)	ND (<130)	ND (<0.47)	ND (<400)	ND (<140)	ND (<350)
N-Nitrosodiphenylamine	ND (<530)	ND (<510)	ND (<0.52)	ND (<99)	ND (<88)	ND (<86)	ND (<0.52)	ND (<260)	ND (<87)	ND (<220)
Pentachlorophenol	ND (<1,400)	ND (<1,400)	ND (<0.3)	ND (<270)	ND (<240)	ND (<230)	ND (<0.3)	ND (<700)	ND (<240)	ND (<610)
Phenanthrene	4,090,000	2,080,000	139	179,000	ND (<94)	ND (<92)	302	3,000,000	630	ND (<240)
Phenol	ND (<1,600)	ND (<1,500)	9.0	ND (<300)	ND (<270)	ND (<260)	ND (<0.5)	ND (<770)	ND (<260)	ND (<670)
Pyrene	2,370,000	1,210,000	81.9	108,000	ND (<74)	ND (<72)	31.8	1,180,000	ND (<73)	504 J
Total TIC, Semivolatile	884,400 J	693,800 J	370.4 J	504,300 J	4,900 J	ND	778 J	367,200 J	ND	234,800 J
Total Semivolatiles (target)	*26,854,770*	*11,164,200*	*656.03*	*984,820*	*592*	*ND*	*2110.79*	*19,296,130*	*2,263*	*1,968*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-1. SS-1 Laboratory Analytical Results

Analyte	SS-1 Column Test Data		SS-1 Autoclave Test Data							
	Persulfate	Fenton	Fenton Autoclave				Persulfate Autoclave			
	Soil	Soil	Leachate	Soil	Silica Gel	Carbon	Leachate	Soil	Silica Gel	Carbon
General Chemistry										
(mg/L unless noted)										
Solids, Percent	76.5	79.3		82.0	93.5	93.7		69.6	92.8	92.2
Chromium, Hexavalent										
Iron, Ferrous										
Nitrogen, Nitrate[a]										
Nitrogen, Nitrate + Nitrite										
Nitrogen, Nitrite										
Petroleum Hydrocarbons										
Phosphorus, Total										
Sulfate										
Total Organic Carbon										
pH, standard units										
As(III) (ug/L)										
As(V) (ug/L)										
Metals (ug/L or mg/kg)										
Arsenic										
Barium										
Cadmium										
Chromium										
Iron										
Lead										
Manganese										
Mercury										
Selenium										
Silver										
Thallium										

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
			Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<2.8)	ND (<1,100)	ND (<1.4)	ND (<3,100)	ND (<1.4)	ND (<2,600)	ND (<1.4)	ND (<2,500)	ND (<0.28)	ND (<5,700)	ND (<0.28)	ND (<1,000)	ND (<1.4)	ND (<230)
1,1,2,2-Tetrachloroethane	ND (<2.8)	ND (<1,000)	ND (<1.4)	ND (<3,000)	ND (<1.4)	ND (<2,500)	ND (<1.4)	ND (<2,400)	ND (<0.28)	ND (<5,500)	ND (<0.28)	ND (<1,000)	ND (<1.4)	ND (<230)
1,1,2-Trichloroethane	ND (<3.2)	ND (<980)	ND (<1.6)	ND (<2,800)	ND (<1.6)	ND (<2,400)	ND (<1.6)	ND (<2,300)	ND (<0.32)	ND (<5,100)	ND (<0.32)	ND (<940)	ND (<1.6)	ND (<210)
1,1-Dichloroethane	ND (<2.3)	ND (<870)	ND (<1.2)	ND (<2,500)	ND (<1.2)	ND (<2,100)	ND (<1.2)	ND (<2,000)	ND (<0.23)	ND (<4,600)	ND (<0.23)	ND (<840)	ND (<1.2)	ND (<190)
1,1-Dichloroethene	ND (<3.3)	ND (<1,300)	ND (<1.6)	ND (<3,600)	ND (<1.6)	ND (<3,000)	ND (<1.6)	ND (<2,900)	ND (<0.33)	ND (<6,600)	ND (<0.33)	ND (<1,200)	ND (<1.6)	ND (<270)
1,2,4-Trichlorobenzene	ND (<1.6)	ND (<640)	ND (<0.8)	ND (<1,800)	ND (<0.8)	ND (<1,500)	ND (<0.8)	ND (<1,500)	ND (<0.16)	ND (<3,400)	ND (<0.16)	ND (<610)	ND (<0.8)	ND (<140)
1,2-Dibromo-3-chloropropane	ND (<11)	ND (<3,900)	ND (<5.5)	ND (<11,000)	ND (<5.5)	ND (<9,400)	ND (<5.5)	ND (<9,100)	ND (<1.1)	ND (<21,000)	ND (<1.1)	ND (<3,800)	ND (<5.5)	ND (<840)
1,2-Dibromoethane	ND (<5.2)	ND (<1,000)	ND (<2.6)	ND (<3,000)	ND (<2.6)	ND (<2,500)	ND (<2.6)	ND (<2,400)	ND (<0.52)	ND (<5,400)	ND (<0.52)	ND (<990)	ND (<2.6)	ND (<220)
1,2-Dichlorobenzene	ND (<2.0)	ND (<830)	ND (<1)	ND (<2,400)	ND (<1)	ND (<2,000)	ND (<1.0)	ND (<1,900)	ND (<0.20)	ND (<4,400)	ND (<0.2)	ND (<790)	ND (<1.0)	ND (<180)
1,2-Dichloroethane	ND (<2.9)	ND (<990)	ND (<1.5)	ND (<2,800)	ND (<1.5)	ND (<2,400)	ND (<1.5)	ND (<2,300)	ND (<0.29)	ND (<5,200)	ND (<0.29)	ND (<950)	ND (<1.5)	ND (<210)
1,2-Dichloropropane	ND (<2.0)	ND (<1,000)	ND (<1.0)	ND (<2,900)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,400)	ND (<0.20)	ND (<5,300)	ND (<0.2)	ND (<970)	ND (<1)	ND (<220)
1,3-Dichlorobenzene	ND (<3.2)	ND (<890)	ND (<1.6)	ND (<2,600)	ND (<1.6)	ND (<2,100)	ND (<1.6)	ND (<2,100)	ND (<0.32)	ND (<4,700)	ND (<0.32)	ND (<850)	ND (<1.6)	ND (<190)
1,4-Dichlorobenzene	ND (<2.4)	ND (<840)	ND (<1.2)	ND (<2,400)	ND (<1.2)	ND (<2,000)	ND (<1.2)	ND (<2,000)	ND (<0.24)	ND (<4,400)	ND (<0.24)	ND (<800)	ND (<1.2)	ND (<180)
2-Butanone (MEK)	ND (<26)	ND (<5,000)	29.4 J	ND (<14,000)	ND (<13)	ND (<12,000)	ND (<13)	ND (<12,000)	26.3	ND (<26,000)	42.8	ND (<4,800)	ND (<13)	ND (<1,100)
2-Hexanone	ND (<13)	ND (<2,500)	ND (<6.3)	ND (<7,100)	ND (<6.3)	ND (<6,000)	ND (<6.3)	ND (<5,800)	ND (<1.3)	ND (<13,000)	ND (<1.3)	ND (<2,400)	ND (<6.3)	ND (<530)
4-Methyl-2-pentanone(MIBK)	ND (<11)	ND (<3,600)	ND (<5.3)	ND (<10,000)	ND (<5.3)	ND (<8,700)	ND (<5.3)	ND (<8,500)	ND (<1.1)	ND (<19,000)	ND (<1.1)	ND (<3,500)	ND (<5.3)	ND (<780)
Acetone	ND (<24)	ND (<5,200)	485	ND (<15,000)	ND (<12)	ND (<13,000)	ND (<12)	ND (<12,000)	1,600	ND (<27,000)	2,100	ND (<5,000)	905	ND (<1100)
Benzene	1,670	20,000	34.9	4,700 J	33.4	3,990 J	7.0	5,530	13.7	ND (<4,600)	11.7	2,180	9.3	2,430
Bromodichloromethane	ND (<1.7)	ND (<830)	ND (<0.87)	ND (<2,400)	ND (<0.87)	ND (<2,000)	ND (<0.87)	ND (<1,900)	ND (<0.17)	ND (<4,400)	ND (<0.17)	ND (<800)	ND (<0.87)	ND (<180)
Bromoform	ND (<5.4)	ND (<790)	ND (<2.7)	ND (<2,300)	ND (<2.7)	ND (<1,900)	ND (<2.7)	ND (<1,800)	ND (<0.54)	ND (<4,200)	ND (<0.54)	ND (<760)	ND (<2.7)	ND (<170)
Bromomethane	ND (<2.2)	ND (<670)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,600)	ND (<1.1)	ND (<1,600)	ND (<0.22)	ND (<3,500)	ND (<0.22)	ND (<640)	ND (<1.1)	ND (<140)
Carbon disulfide	ND (<2.1)	ND (<1,000)	ND (<1.0)	ND (<2,900)	ND (<1)	ND (<2,400)	ND (<1.0)	ND (<2,300)	2.1	ND (<5,300)	0.94	ND (<960)	ND (<1.0)	ND (<220)
Carbon tetrachloride	ND (<2.9)	ND (<1,700)	ND (<1.5)	ND (<5,000)	ND (<1.5)	ND (<4,200)	ND (<1.5)	ND (<4,000)	ND (<0.29)	ND (<9,100)	ND (<0.29)	ND (<1,700)	ND (<1.5)	ND (<370)
Chlorobenzene	ND (<2.2)	ND (<790)	ND (<1.1)	ND (<2,300)	ND (<1.1)	ND (<1,900)	ND (<1.1)	ND (<1,800)	ND (<0.22)	ND (<4,200)	ND (<0.22)	ND (<760)	ND (<1.1)	ND (<170)
Chloroethane	ND (<5.6)	ND (<3,200)	ND (<2.8)	ND (<9,100)	ND (<2.8)	ND (<7,600)	ND (<2.8)	ND (<7,400)	ND (<0.56)	ND (<17,000)	ND (<0.56)	ND (<3,000)	ND (<2.8)	ND (<680)
Chloroform	ND (<2.2)	ND (<1,100)	ND (<1.1)	ND (<3,000)	ND (<1.1)	ND (<2,600)	5.4	ND (<2,500)	ND (<0.22)	ND (<5,600)	ND (<0.22)	ND (<1,000)	ND (<1.1)	ND (<230)
Chloromethane	ND (<3.5)	ND (<840)	ND (<1.7)	ND (<2,400)	ND (<1.7)	ND (<2,000)	ND (<1.7)	ND (<2,000)	ND (<0.35)	ND (<4,400)	ND (<0.35)	ND (<810)	ND (<1.7)	ND (<180)
cis-1,2-Dichloroethene	ND (<1.8)	ND (<1,200)	ND (<0.89)	ND (<3,500)	ND (<0.89)	ND (<2,900)	ND (<0.89)	ND (<2,900)	ND (<0.18)	ND (<6,400)	ND (<0.18)	ND (<1,200)	ND (<0.89)	ND (<260)
cis-1,3-Dichloropropene	ND (<1.5)	ND (<760)	ND (<0.74)	ND (<2,200)	ND (<0.74)	ND (<1,800)	ND (<0.74)	ND (<1,800)	ND (<0.15)	ND (<4,000)	ND (<0.15)	ND (<720)	ND (<0.74)	ND (<160)
Cyclohexane	ND (<5)	ND (<2,300)	ND (<2.5)	ND (<6,700)	ND (<2.5)	ND (<5,600)	ND (<2.5)	ND (<5,400)	ND (<0.50)	ND (<12,000)	ND (<0.5)	ND (<2,200)	ND (<2.5)	ND (<500)
Dibromochloromethane	ND (<1.9)	ND (<1,000)	ND (<0.94)	ND (<2,900)	ND (<0.94)	ND (<2,400)	ND (<0.94)	ND (<2,300)	ND (<0.19)	ND (<5,300)	ND (<0.19)	ND (<960)	ND (<0.94)	ND (<220)
Dichlorodifluoromethane	ND (<7.5)	ND (<1,400)	ND (<3.8)	ND (<4,200)	ND (<3.8)	ND (<3,500)	ND (<3.8)	ND (<3,400)	ND (<0.75)	ND (<7,600)	ND (<0.75)	ND (<1,400)	ND (<3.8)	ND (<310)
Ethylbenzene	718	153,000	4.4 J	82,600	34.9	74,700	ND (<1.0)	68,800	25.3	17,800	5.0	2,850	3.3 J	2,120
Freon 113	ND (<6.9)	ND (<1,600)	ND (<3.4)	ND (<4,500)	ND (<3.4)	ND (<3,800)	ND (<3.4)	ND (<3,600)	ND (<0.69)	ND (<8,200)	ND (<0.69)	ND (<1,500)	ND (<3.4)	ND (<340)
Isopropylbenzene	39.5	32,500	ND (<1.0)	16,500 J	3.0 J	16,900 J	ND (<1.0)	16,000	4.5	5,360 J	0.91	ND (<810)	ND (<1.0)	209 J
m,p-Xylene	729	196,000	ND (<2.1)	103,000	32.0	93,800	ND (<2.1)	85,900	48.2	27,600	9.1	3,640	4.4 J	2,450
Methyl Acetate	ND (<21)	ND (<2,600)	ND (<10)	ND (<7,400)	ND (<10)	ND (<6,200)	ND (<10)	ND (<6,000)	ND (<2.1)	ND (<14,000)	ND (<2.1)	6,420 J	ND (<10)	14,000
Methyl Tert Butyl Ether	ND (<3.1)	ND (<1,000)	ND (<1.5)	ND (<2,900)	ND (<1.5)	ND (<2,500)	ND (<1.5)	ND (<2,400)	ND (<0.31)	ND (<5,400)	ND (<0.31)	ND (<980)	ND (<1.5)	ND (<220)
Methylcyclohexane	ND (<1.8)	ND (<1,200)	ND (<0.91)	ND (<3,400)	ND (<0.91)	ND (<2,800)	ND (<0.91)	ND (<2,700)	ND (<0.18)	ND (<6,200)	ND (<0.18)	ND (<1,100)	ND (<0.91)	ND (<250)
Methylene chloride	ND (<2.7)	ND (<1,300)	ND (<1.3)	ND (<3,600)	ND (<1.3)	ND (<3,000)	ND (<1.3)	ND (<2,900)	ND (<0.27)	ND (<6,600)	ND (<0.27)	ND (<1,200)	ND (<1.3)	ND (<270)
o-Xylene	442	97,300	2.4 J	50,600	22.3	44,700	ND (<1.5)	41,300	31.1	12,000	5.8	1,320 J	2.1 J	563
Styrene	ND (<1.6)	ND (<600)	ND (<0.79)	ND (<1,700)	ND (<0.79)	ND (<1,400)	ND (<0.79)	ND (<1,400)	ND (<0.16)	ND (<3,100)	ND (<0.16)	ND (<570)	ND (<0.79)	187 J
Tetrachloroethene	ND (<2.8)	ND (<1,500)	ND (<1.4)	ND (<4,300)	ND (<1.4)	ND (<3,600)	ND (<1.4)	ND (<3,500)	ND (<0.28)	ND (<7,900)	ND (<0.28)	ND (<1,400)	ND (<1.4)	ND (<320)
Toluene	452	81,800	14.5	30,500	41.5	25,600	2.7 J	23,100	19.6	5,340 J	8.6	3,110	7.6	3,480
trans-1,2-Dichloroethene	ND (<4.2)	ND (<1,200)	ND (<2.1)	ND (<3,600)	ND (<2.1)	ND (<3,000)	ND (<2.1)	ND (<2,900)	ND (<0.42)	ND (<6,600)	ND (<0.42)	ND (<1,200)	ND (<2.1)	ND (<270)
trans-1,3-Dichloropropene	ND (<2)	ND (<720)	ND (<1.0)	ND (<2,100)	ND (<1)	ND (<1,700)	ND (<1.0)	ND (<1,700)	ND (<0.2)	ND (<3,800)	ND (<0.20)	ND (<680)	ND (<1.0)	ND (<150)
Trichloroethene	ND (<2.9)	ND (<950)	ND (<1.4)	ND (<2,700)	ND (<1.4)	ND (<2,300)	ND (<1.4)	ND (<2,200)	ND (<0.29)	ND (<5,000)	ND (<0.29)	ND (<910)	ND (<1.4)	ND (<200)
Trichlorofluoromethane	ND (<2.5)	ND (<1,300)	ND (<1.3)	ND (<3,800)	ND (<1.3)	ND (<3,200)	ND (<1.3)	ND (<3,100)	ND (<0.25)	ND (<7,000)	ND (<0.25)	ND (<1,300)	ND (<1.3)	ND (<290)
Vinyl chloride	ND (<2.9)	ND (<1,200)	ND (<1.4)	ND (<3,400)	ND (<1.4)	ND (<2,800)	ND (<1.4)	ND (<2,700)	ND (<0.29)	ND (<6,200)	ND (<0.29)	ND (<1,100)	ND (<1.4)	ND (<250)
Xylene (total)	1,170	293,000	4.5 J	154,000	54.3	138,000	ND (<1.5)	127,000	79.3	39,500	14.9	4,970	6.5	3,010
Total TIC, Volatile	17,317 J	4,246,000 J	310 J	6,558,000	4,279 J	8,577,000 J	25 J	8,548,000 J	1,969 J	3,041,000 J	1,230 J	625,000 J	304 J	136,800 J
Total Volatiles (Target)	*5,221*	*873,600*	*575*	*441,900*	*221*	*397,690*	*15*	*367,630*	*1,850*	*107,600*	*2,200*	*24,490*	*938*	*28,449*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
			Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	48.8	614,000	25.7	276,000	21.5	306,000	ND (<6.5)	366,000	94.7	345,000	142	145,000	26.6	46,400 J
2,4,5-Trichlorophenol	ND (<2.2)	ND (<930)	ND (<1.9)	ND (<760)	ND (<1.9)	ND (<340)	ND (<39)	ND (<340)	ND (<1.9)	ND (<430)	ND (<1.9)	ND (<400)	ND (<1.9)	ND (<360)
2,4,6-Trichlorophenol	ND (<1.4)	ND (<520)	ND (<1.3)	ND (<430)	ND (<1.3)	ND (<190)	ND (<25)	ND (<190)	ND (<1.3)	ND (<240)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<200)
2,4-Dichlorophenol	ND (<1.8)	ND (<1,000)	ND (<1.6)	ND (<850)	ND (<1.6)	ND (<380)	ND (<31)	ND (<370)	ND (<1.6)	ND (<480)	ND (<1.6)	ND (<440)	ND (<1.6)	ND (<410)
2,4-Dimethylphenol	396 J	41,100	ND (<1.6)	ND (<1300)	ND (<1.6)	ND (<580)	ND (<33)	ND (<570)	37.3	ND (<730)	26.5	ND (<680)	8.7	781 J
2,4-Dinitrophenol	ND (<1)	ND (<940)	ND (<0.89)	ND (<770)	ND (<0.89)	ND (<350)	ND (<18)	ND (<340)	ND (<0.89)	ND (<440)	ND (<0.89)	ND (<400)	ND (<0.89)	ND (<370)
2,4-Dinitrotoluene	ND (<0.98)	ND (<720)	ND (<0.86)	ND (<590)	ND (<0.86)	ND (<260)	ND (<17)	ND (<260)	ND (<0.86)	ND (<330)	ND (<0.86)	ND (<310)	ND (<0.86)	ND (<280)
2,6-Dinitrotoluene	ND (<0.64)	ND (<710)	ND (<0.56)	ND (<580)	ND (<0.56)	ND (<260)	ND (<11)	ND (<260)	ND (<0.56)	ND (<330)	ND (<0.56)	ND (<300)	ND (<0.56)	ND (<280)
2-Chloronaphthalene	ND (<1.1)	ND (<870)	ND (<0.98)	ND (<710)	ND (<0.98)	ND (<320)	ND (<20)	ND (<310)	ND (<0.98)	ND (<400)	ND (<0.98)	ND (<370)	ND (<0.98)	ND (<340)
2-Chlorophenol	ND (<1.1)	ND (<530)	ND (<0.95)	ND (<440)	ND (<0.95)	ND (<190)	ND (<19)	ND (<190)	ND (<0.95)	ND (<250)	ND (<0.95)	ND (<230)	ND (<0.95)	ND (<210)
2-Methylnaphthalene	319	3,070,000	113	1,300,000	30	1,050,000	ND (<8.2)	1,720,000	416	1,110,000	345 B	266,000	50.7	61,400
2-Methylphenol	60.8	5,590	ND (<1.4)	ND (<500)	ND (<1.4)	ND (<220)	ND (<27)	ND (<220)	ND (<1.4)	ND (<280)	19.8	ND (<260)	9.4	ND (<240)
2-Nitroaniline	ND (<0.75)	ND (<390)	ND (<0.66)	ND (<320)	ND (<0.66)	ND (<140)	ND (<13)	ND (<140)	ND (<0.66)	ND (<180)	ND (<0.66)	ND (<170)	ND (<0.66)	ND (<150)
2-Nitrophenol	ND (<2.1)	ND (<770)	ND (<1.8)	ND (<630)	ND (<1.8)	ND (<280)	ND (<36)	ND (<280)	ND (<1.8)	ND (<350)	ND (<1.8)	ND (<330)	ND (<1.8)	ND (<300)
3&4-Methylphenol	210 J	ND (<880)	ND (<1.3)	ND (<730)	ND (<1.3)	ND (<330)	ND (<25)	ND (<320)	24.3	ND (<410)	48.2	ND (<380)	25.1	ND (<350)
3,3'-Dichlorobenzidine	ND (<1.4)	ND (<590)	ND (<1.2)	ND (<490)	ND (<1.2)	ND (<220)	ND (<24)	ND (<210)	ND (<1.2)	ND (<270)	ND (<1.2)	ND (<250)	ND (<1.2)	ND (<230)
3-Nitroaniline	ND (<1.4)	ND (<480)	ND (<1.3)	ND (<390)	ND (<1.3)	ND (<180)	ND (<25)	ND (<170)	ND (<1.3)	ND (<220)	ND (<1.3)	ND (<200)	ND (<1.3)	ND (<190)
4,6-Dinitro-o-cresol	ND (<0.82)	ND (<540)	ND (<0.72)	ND (<440)	ND (<0.72)	ND (<200)	ND (<14)	ND (<200)	ND (<0.72)	ND (<250)	ND (<0.72)	ND (<230)	ND (<0.72)	ND (<210)
4-Bromophenyl phenyl ether	ND (<0.34)	ND (<310)	ND (<0.3)	ND (<260)	ND (<0.3)	ND (<120)	ND (<6.0)	ND (<110)	ND (<0.30)	ND (<150)	ND (<0.3)	ND (<130)	ND (<0.3)	ND (<120)
4-Chloro-3-methyl phenol	ND (<1.3)	ND (<790)	ND (<1.2)	ND (<650)	ND (<1.2)	ND (<290)	ND (<24)	ND (<280)	ND (<1.2)	ND (<360)	ND (<1.2)	ND (<340)	ND (<1.2)	ND (<310)
4-Chloroaniline	ND (<0.45)	ND (<380)	ND (<0.4)	ND (<320)	ND (<0.40)	ND (<140)	ND (<7.9)	ND (<140)	ND (<0.40)	ND (<180)	ND (<0.4)	ND (<160)	ND (<0.4)	ND (<150)
4-Chlorophenyl phenyl ether	ND (<0.49)	ND (<290)	ND (<0.43)	ND (<240)	ND (<0.43)	ND (<110)	ND (<8.6)	ND (<110)	ND (<0.43)	ND (<130)	ND (<0.43)	ND (<120)	ND (<0.43)	ND (<110)
4-Nitroaniline	ND (<0.82)	ND (<430)	ND (<0.72)	ND (<350)	ND (<0.72)	ND (<160)	ND (<14)	ND (<150)	ND (<0.72)	ND (<200)	ND (<0.72)	ND (<180)	ND (<0.72)	ND (<170)
4-Nitrophenol	ND (<0.96)	ND (<840)	ND (<0.84)	ND (<690)	ND (<0.84)	ND (<310)	ND (<17)	ND (<300)	ND (<0.84)	ND (<390)	ND (<0.84)	ND (<360)	ND (<0.84)	ND (<330)
Acenaphthene	112 J	2,200,000	7.8	780,000	30.8	656,000	ND (<7.0)	935,000	216	898,000	279	301,000	37.1	82,700
Acenaphthylene	15	111,000	3.5	38,700	ND (<0.38)	39,100	ND (<7.6)	44,500	14.9	48,100 J	12.2	20,100 J	ND (<0.38)	20,200
Acetophenone	ND (<0.42)	ND (<390)	28.1	ND (<320)	19.8	ND (<140)	ND (<7.5)	ND (<140)	46.6	ND (<180)	45.5	ND (<170)	25	ND (<150)
Anthracene	12	2,320,000	ND (<0.4)	444,000	ND (<0.40)	418,000	ND (<8.0)	379,000	10.8	602,000	11.9	356,000	7.8	112,000
Atrazine	ND (<0.19)	ND (<530)	ND (<0.16)	ND (<440)	ND (<0.16)	ND (<200)	ND (<3.3)	ND (<190)	ND (<0.16)	ND (<250)	ND (<0.16)	ND (<230)	ND (<0.16)	ND (<210)
Benzaldehyde	ND (<0.3)	ND (<680)	ND (<0.27)	ND (<560)	ND (<0.27)	ND (<250)	ND (<5.3)	ND (<250)	ND (<0.27)	ND (<310)	ND (<0.27)	ND (<290)	ND (<0.27)	ND (<270)
Benzo(a)anthracene	1.5 J	457,000	1.3 J	218,000	ND (<0.36)	246,000	ND (<7.1)	285,000	ND (<0.36)	425,000	ND (<0.36)	223,000	2.4	136,000
Benzo(a)pyrene	1 J	273,000	0.8 J	133,000	ND (<0.37)	132,000	ND (<7.3)	134,000	ND (<0.37)	251,000	ND (<0.37)	122,000	1 J	68,100
Benzo(b)fluoranthene	ND (<0.67)	229,000	ND (<0.59)	119,000	ND (<0.59)	147,000	ND (<12)	177,000	ND (<0.59)	299,000	ND (<0.59)	113,000	1.2 J	109,000
Benzo(g,h,i)perylene	0.77 J	161,000	ND (<0.42)	67,200	ND (<0.42)	73,800	ND (<8.4)	90,600	ND (<0.42)	127,000	ND (<0.42)	61,400	0.69 J	39,400 J
Benzo(k)fluoranthene	0.88 J	202,000	0.71 J	106,000	ND (<0.42)	112,000	ND (<8.4)	139,000	ND (<0.42)	158,000	ND (<0.42)	129,000	1.5 J	58,800
bis(2-Chloroethoxy)methane	ND (<0.74)	ND (<400)	ND (<0.65)	ND (<330)	ND (<0.65)	ND (<150)	ND (<13)	ND (<140)	ND (<0.65)	ND (<180)	ND (<0.65)	ND (<170)	ND (<0.65)	ND (<160)
bis(2-Chloroethyl)ether	ND (<0.6)	ND (<310)	ND (<0.53)	ND (<250)	ND (<0.53)	ND (<110)	ND (<11)	ND (<110)	ND (<0.53)	ND (<140)	ND (<0.53)	ND (<130)	ND (<0.53)	ND (<120)
bis(2-Chloroisopropyl)ether	ND (<0.84)	ND (<460)	ND (<0.74)	ND (<380)	ND (<0.74)	ND (<170)	ND (<15)	ND (<170)	ND (<0.74)	ND (<210)	ND (<0.74)	ND (<200)	ND (<0.74)	ND (<180)
bis(2-Ethylhexyl)phthalate	ND (<0.75)	ND (<790)	ND (<0.66)	ND (<650)	ND (<0.66)	1,390	ND (<13)	1,560	ND (<0.66)	ND (<370)	ND (<0.66)	ND (<340)	ND (<0.66)	ND (<310)
Butyl benzyl phthalate	ND (<0.67)	ND (<470)	ND (<0.59)	ND (<380)	ND (<0.59)	ND (<170)	ND (<12)	ND (<170)	ND (<0.59)	ND (<220)	ND (<0.59)	ND (<200)	ND (<0.59)	ND (<180)
Caprolactam	ND (<0.36)	ND (<600)	ND (<0.32)	ND (<490)	ND (<0.32)	ND (<220)	ND (<6.3)	ND (<220)	ND (<0.32)	ND (<280)	ND (<0.32)	ND (<250)	ND (<0.32)	ND (<230)
Carbazole	157 J	719,000	3.1	47,600	0.57 J	26,900	ND (<7.3)	21,400	92.4	143,000	63.8	80,100	23.5	20,400
Chrysene	1.5 J	465,000	1.3 J	195,000	ND (<0.25)	229,000	ND (<5.0)	273,000	ND (<0.25)	410,000	ND (<0.25)	235,000	2.8	166,000
Dibenzo(a,h)anthracene	ND (<0.62)	38,200	ND (<0.54)	23,100	ND (<0.54)	23,100	ND (<11)	30,000	ND (<0.54)	34,600 J	ND (<0.54)	21,000 J	ND (<0.54)	18,000 J
Dibenzofuran	82.9	1,570,000	58.6	616,000	35.6	557,000	ND (<6.9)	874,000	155 J	762,000	201	330,000	34.9	93,700
Diethyl phthalate	ND (<0.44)	ND (<260)	ND (<0.39)	ND (<220)	ND (<0.39)	ND (<97)	ND (<7.8)	ND (<96)	ND (<0.39)	ND (<120)	ND (<0.39)	ND (<110)	ND (<0.39)	ND (<100)
Dimethyl phthalate	ND (<0.37)	ND (<270)	ND (<0.33)	ND (<220)	ND (<0.33)	ND (<98)	ND (<6.6)	ND (<96)	ND (<0.33)	ND (<120)	ND (<0.33)	ND (<110)	ND (<0.33)	ND (<100)
Di-n-butyl phthalate	ND (<0.67)	ND (<390)	ND (<0.59)	ND (<320)	ND (<0.59)	ND (<140)	ND (<12)	ND (<140)	1.3 J	ND (<180)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<150)
Di-n-octyl phthalate	ND (<0.65)	ND (<530)	ND (<0.57)	ND (<440)	ND (<0.57)	ND (<190)	ND (<11)	ND (<190)	ND (<0.57)	ND (<240)	ND (<0.57)	ND (<230)	ND (<0.57)	ND (<210)
Fluoranthene	11	2,010,000	4.7	955,000	ND (<0.25)	1,160,000	ND (<5.0)	1,420,000	2.8	1,500,000	4.4	837,000	15.6	487,000
Fluorene	63.1	1,860,000	20.7	629,000	3.2	563,000	ND (<9.0)	716,000	190	1,090,000	280	540,000	76.5	210,000
Hexachlorobenzene	ND (<0.61)	ND (<360)	ND (<0.54)	ND (<290)	ND (<0.54)	ND (<130)	ND (<11)	ND (<130)	ND (<0.54)	ND (<160)	ND (<0.54)	ND (<150)	ND (<0.54)	ND (<140)
Hexachlorobutadiene	ND (<0.2)	ND (<410)	ND (<0.18)	ND (<340)	ND (<0.18)	ND (<150)	ND (<3.5)	ND (<150)	ND (<0.18)	ND (<190)	ND (<0.18)	ND (<170)	ND (<0.18)	ND (<160)
Hexachlorocyclopentadiene	ND (<0.46)	ND (<440)	ND (<0.41)	ND (<370)	ND (<0.41)	ND (<160)	ND (<8.1)	ND (<160)	ND (<0.41)	ND (<210)	ND (<0.41)	ND (<190)	ND (<0.41)	ND (<170)
Hexachloroethane	ND (<0.32)	ND (<310)	ND (<0.28)	ND (<250)	ND (<0.28)	ND (<110)	ND (<5.7)	ND (<110)	ND (<0.28)	ND (<140)	ND (<0.28)	ND (<130)	ND (<0.28)	ND (<120)
Indeno(1,2,3-cd)pyrene	0.47 J	127,000	3.2	61,100	ND (<0.30)	71,000	ND (<6.1)	86,100	ND (<0.3)	110,000	ND (<0.3)	63,700	ND (<0.30)	37,700 J
Isophorone	ND (<0.67)	ND (<310)	ND (<0.59)	ND (<250)	ND (<0.59)	ND (<110)	ND (<12)	ND (<110)	ND (<0.59)	ND (<140)	ND (<0.59)	ND (<130)	ND (<0.59)	ND (<120)
Naphthalene	6,120	10,600,000	1930	4,310,000	1,960	3,280,000	91.9	5,850,000	2,780	1,530,000	780 B	197,000	244 B	72,300
Nitrobenzene	ND (<0.48)	ND (<430)	ND (<0.42)	ND (<350)	ND (<0.42)	ND (<160)	ND (<8.4)	ND (<160)	ND (<0.42)	ND (<200)	ND (<0.42)	ND (<180)	ND (<0.42)	ND (<170)
N-Nitroso-di-n-propylamine	ND (<0.53)	ND (<400)	ND (<0.47)	ND (<330)	ND (<0.47)	ND (<150)	ND (<9.4)	ND (<140)	ND (<0.47)	ND (<180)	ND (<0.47)	ND (<170)	ND (<0.47)	ND (<160)
N-Nitrosodiphenylamine	ND (<0.59)	ND (<250)	ND (<0.52)	ND (<210)	ND (<0.52)	ND (<94)	ND (<10)	ND (<92)	ND (<0.52)	ND (<120)	ND (<0.52)	ND (<110)	ND (<0.52)	ND (<100)
Pentachlorophenol	ND (<2.2)	ND (<690)	ND (<1.9)	ND (<570)	ND (<1.9)	ND (<250)	ND (<38)	ND (<250)	ND (<1.9)	ND (<320)	ND (<1.9)	ND (<300)	ND (<1.9)	ND (<270)
Phenanthrene	84.8	5,620,000	50.7	2,180,000	4.4	2,290,000	ND (<7.3)	3,150,000	137	3,150,000	194	1,660,000	88.3	725,000
Phenol	ND (<0.56)	ND (<770)	ND (<0.5)	ND (<630)	ND (<0.50)	ND (<280)	ND (<9.9)	ND (<280)	18.8	ND (<350)	52.3	ND (<330)	37.1	ND (<300)
Pyrene	7.9	1,370,000	ND (<0.34)	739,000	ND (<0.34)	943,000	ND (<6.7)	1,130,000	2.0	1,130,000	3.4	605,000	11.1	335,000
Total TIC, Semivolatile	2,759 J	951,600 J	1,224 J	2,021,000 J	593 J	197,600 J	140 J	205,500 J	1,223 J	152,700 J	1,152 J	752,000 J	595 J	134,100 J
Total Semivolatiles (target)	*7,706*	*34,062,890*	*2,253*	*13,237,700*	*2,106*	*12,324,290*	*92*	*17,822,160*	*4,240*	*14,122,700*	*2,509*	*6,305,300*	*731*	*2,899,881*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-2. SS-2 Laboratory Analytical Results

Analyte	SS-2 Baseline Data		SS-2 Slurry Test Data											
			Persulfate 10:1 (SS2-P-10)		Persulfate 20:1 (SS2-P-20)		Persulfate 40:1 (SS2-P-40)		Fenton 10:1 (SS2-F-10)		Fenton 20:1 (SS2-F-20)		Fenton 40:1 (SS2-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry														
(mg/L unless noted)														
Solids, Percent		80.8		64.6		72.6		74.1		68.5		72.8		77.8
Chromium, Hexavalent	ND (<0.010)				0.034						0.069			
Iron, Ferrous	36.1				0.98						249			
Nitrogen, Nitrate[a]	ND (<0.11)				4.5						2.0			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				4.6						2.0			
Nitrogen, Nitrite	ND (<0.010)				0.12						ND (<0.010)			
Petroleum Hydrocarbons	2.5	7,270		5,440	ND (<0.62)	1,550		3,360		4,140	ND (<0.51)	1,990		657
Phosphorus, Total	0.11				4.8						ND (<0.050)			
Sulfate	414				50,600						4,520			
Total Organic Carbon	20.7	297,000	516	248,000	546	321,000	845	208,000	1,340	251,000	1,790	228,000	1,430	364,000
pH, standard units	6.34 b		10.21		13.06		13.42		2.31		2.21		2.31	
As(III) (ug/L)	110				ND (<0.56)						6.53			
As(V) (ug/L)	15.9				729						1,090			
Metals (ug/L or mg/kg)														
Arsenic	342	9.9	480	7.7	767	4.2	834	8.9	583	6.1	928	9.2	262	12.6
Barium	236	92.2	ND (<400) c	62.8	ND (<400) c	43.1	ND (<1,000) c	38.9	265	53.9	317	54.6	290	85.1
Cadmium	ND (<4.0)	ND (<0.63)	ND (<8.0) c	ND (<0.74)	ND (<8.0) c	ND (<0.72)	ND (<20) c	ND (<0.70)	40.4	ND (<0.72)	36.0	ND (<0.72)	36.3	ND (<0.66)
Chromium	ND (<10)	9.0	137	5.9	192	5.2	310	3.2	363	5.4	463	87.9	636	101
Iron	41,800	10,700	707	8,940	ND (<200) c	9,010	ND (<500) c	7,450	1,100,000	6,900	1,550,000	5,910	1,540,000	8,490
Lead	3.9	116	6.2	132	395	64.6	4,280	42.5	3,490	65.7	2,900	80.4	3,060	101
Manganese	3,650		ND (<30) c	149	ND (<30) c	88.5	ND (<75) c	55.0	7,300	40.6	9,070	46.5	8,130	56.5
Mercury	ND (<0.20)	2.1	ND (<0.40) c	1.7	ND (<0.40) c	0.83	2.4	1.7	ND (<0.20)	0.23	ND (<0.20)	1.8	ND (<0.20)	0.61
Selenium	ND (<10)	ND (<2.5)	134	ND (<3.0)	164	ND (<2.9)	211	ND (<2.8)	74.3	ND (<2.9)	93.1	ND (<2.9)	137	ND (<2.6)
Silver	ND (<10)	ND (<1.3)	ND (<20) c	ND (<1.5)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<10)	ND (<1.4)	ND (<10)	ND (<1.4)	ND (<10)	ND (<1.3)
Thallium	ND (<10)	ND (<1.3)	ND (<20) c	ND (<1.5)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<20) c	ND (<1.4)	ND (<50) c	ND (<1.4)	ND (<50) c	ND (<1.3)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-3. P-1 Laboratory Analytical Results

Analyte	P-1 Baseline Data		P-1 Slurry Test Data											
			Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Volatiles (ug/L or ug/kg)														
1,1,1-Trichloroethane	ND (<5.5)	ND (<180)	ND (<6.9)	ND (<1,300)	ND (<14)	ND (<1,200)	ND (<14)	ND (<1,400)	ND (<0.28)	ND (<3.7)	ND (<0.28)	ND (<2.7)	ND (<0.28)	ND (<1.8)
1,1,2,2-Tetrachloroethane	ND (<5.5)	ND (<180)	ND (<6.9)	ND (<1,300)	ND (<14)	ND (<1,200)	ND (<14)	ND (<1,300)	ND (<0.28)	ND (<3.6)	ND (<0.28)	ND (<2.6)	ND (<0.28)	ND (<1.7)
1,1,2-Trichloroethane	ND (<6.3)	ND (<160)	ND (<7.9)	ND (<1,200)	ND (<16)	ND (<1,100)	ND (<16)	ND (<1,200)	ND (<0.32)	ND (<3.4)	ND (<0.32)	ND (<2.4)	ND (<0.32)	ND (<1.6)
1,1-Dichloroethane	ND (<4.7)	ND (<150)	ND (<5.8)	ND (<1,100)	ND (<12)	ND (<980)	ND (<12)	ND (<1,100)	ND (<0.23)	ND (<3.0)	ND (<0.23)	ND (<2.2)	ND (<0.23)	ND (<1.4)
1,1-Dichloroethene	ND (<6.5)	ND (<210)	ND (<8.1)	ND (<1,600)	ND (<16)	ND (<1,400)	ND (<16)	ND (<1,600)	ND (<0.33)	ND (<4.3)	ND (<0.33)	ND (<3.1)	ND (<0.33)	ND (<2.0)
1,2,4-Trichlorobenzene	ND (<3.2)	ND (<110)	ND (<4)	ND (<800)	ND (<8.0)	ND (<720)	ND (<8)	ND (<810)	ND (<0.16)	ND (<2.2)	ND (<0.16)	ND (<1.6)	ND (<0.16)	ND (<1.0)
1,2-Dibromo-3-chloropropane	ND (<22)	ND (<660)	ND (<27)	ND (<4,900)	ND (<55)	ND (<4,400)	ND (<55)	ND (<4,900)	ND (<1.1)	ND (<13)	ND (<1.1)	ND (<9.7)	ND (<1.1)	ND (<6.4)
1,2-Dibromoethane	ND (<10)	ND (<170)	ND (<13)	ND (<1,300)	ND (<26)	ND (<1,200)	ND (<26)	ND (<1,300)	ND (<0.52)	ND (<3.5)	ND (<0.52)	ND (<2.5)	ND (<0.52)	ND (<1.7)
1,2-Dichlorobenzene	ND (<4.1)	ND (<140)	ND (<5.1)	ND (<1,000)	ND (<10)	ND (<930)	ND (<10)	ND (<1,000)	ND (<0.2)	ND (<2.8)	ND (<0.20)	ND (<2)	ND (<0.20)	ND (<1.4)
1,2-Dichloroethane	ND (<5.9)	ND (<170)	ND (<7.3)	ND (<1,200)	ND (<15)	ND (<1,100)	ND (<15)	ND (<1,200)	ND (<0.29)	ND (<3.4)	ND (<0.29)	ND (<2.4)	ND (<0.29)	ND (<1.6)
1,2-Dichloropropane	ND (<4.0)	ND (<170)	ND (<5)	ND (<1,300)	ND (<10)	ND (<1,100)	ND (<10)	ND (<1,300)	ND (<0.20)	ND (<3.5)	ND (<0.20)	ND (<2.5)	ND (<0.20)	ND (<1.6)
1,3-Dichlorobenzene	ND (<6.3)	ND (<150)	ND (<7.9)	ND (<1,100)	ND (<16)	ND (<1,000)	ND (<16)	ND (<1,100)	ND (<0.32)	ND (<3.1)	ND (<0.32)	ND (<2.2)	ND (<0.32)	ND (<1.4)
1,4-Dichlorobenzene	ND (<4.8)	ND (<140)	ND (<6)	ND (<1,000)	ND (<12)	ND (<940)	ND (<12)	ND (<1,100)	ND (<0.24)	ND (<2.9)	ND (<0.24)	ND (<2.1)	ND (<0.24)	ND (<1.4)
2-Butanone (MEK)	ND (<52)	ND (<840)	ND (<65)	ND (<6,200)	ND (<130)	ND (<5,600)	ND (<130)	ND (<6,300)	44	237	50.9	147	172	192
2-Hexanone	ND (<25)	ND (<420)	ND (<32)	ND (<3,100)	ND (<63)	ND (<2,800)	ND (<63)	ND (<3,100)	ND (<1.3)	ND (<8.5)	ND (<1.3)	ND (<6.1)	ND (<1.3)	ND (<4)
4-Methyl-2-pentanone (MIBK)	ND (<21)	ND (<610)	ND (<27)	ND (<4,500)	ND (<53)	ND (<4,100)	ND (<53)	ND (<4,600)	ND (<1.1)	ND (<12)	ND (<1.1)	ND (<9)	ND (<1.1)	ND (<5.9)
Acetone	ND (<48)	ND (<880)	554	ND (<6,500)	806	ND (<5,800)	757	ND (<6,600)	597	1,590	528	982	2,340	2,100
Benzene	1,500	9,210	325	2,310	277	2,090	239	2,360	5.7	78	1.3	24.9	3.4	9.4
Bromodichloromethane	ND (<3.5)	ND (<140)	ND (<4.4)	ND (<1,000)	ND (<8.7)	ND (<930)	ND (<8.7)	ND (<1,000)	ND (<0.17)	ND (<2.9)	ND (<0.17)	ND (<2.1)	ND (<0.17)	ND (<1.4)
Bromoform	ND (<11)	ND (<130)	ND (<13)	ND (<990)	ND (<27)	ND (<890)	ND (<27)	ND (<1,000)	ND (<0.54)	ND (<2.7)	ND (<0.54)	ND (<2.0)	ND (<0.54)	ND (<1.3)
Bromomethane	ND (<4.5)	ND (<110)	ND (<5.6)	ND (<840)	ND (<11)	ND (<750)	ND (<11)	ND (<850)	ND (<0.22)	ND (<2.3)	ND (<0.22)	ND (<1.7)	ND (<0.22)	ND (<1.1)
Carbon disulfide	ND (<4.1)	ND (<170)	17.2 J	ND (<1,300)	51.4 J	ND (<1,100)	52.6 J	ND (<1,300)	28.9	788	5.8	269	14.9	120
Carbon tetrachloride	ND (<5.8)	ND (<290)	ND (<7.3)	ND (<2,200)	ND (<15)	ND (<1,900)	ND (<15)	ND (<2,200)	ND (<0.29)	ND (<5.9)	ND (<0.29)	ND (<4.3)	ND (<0.29)	ND (<2.8)
Chlorobenzene	ND (<4.5)	ND (<130)	ND (<5.6)	ND (<990)	ND (<11)	ND (<880)	ND (<11)	ND (<1,000)	ND (<0.22)	ND (<2.7)	ND (<0.22)	ND (<2.0)	ND (<0.22)	ND (<1.3)
Chloroethane	ND (<11)	ND (<530)	ND (<14)	ND (<4,000)	ND (<28)	ND (<3,600)	ND (<28)	ND (<4,000)	ND (<0.56)	ND (<11)	ND (<0.56)	ND (<7.8)	ND (<0.56)	ND (<5.2)
Chloroform	ND (<4.3)	ND (<180)	7.1 J	ND (<1,300)	ND (<11)	ND (<1,200)	ND (<11)	ND (<1,300)	ND (<0.22)	ND (<3.6)	ND (<0.22)	ND (<2.6)	ND (<0.22)	ND (<1.7)
Chloromethane	ND (<7)	ND (<140)	ND (<8.7)	ND (<1,000)	ND (<17)	ND (<940)	ND (<17)	ND (<1,100)	2.3	ND (<2.9)	ND (<0.35)	ND (<2.1)	1.0	ND (<1.4)
cis-1,2-Dichloroethene	ND (<3.6)	ND (<210)	ND (<4.5)	ND (<1,500)	ND (<8.9)	ND (<1,400)	ND (<8.9)	ND (<1,500)	ND (<0.18)	ND (<4.2)	ND (<0.18)	ND (<3)	ND (<0.18)	ND (<2.0)
cis-1,3-Dichloropropene	ND (<3)	ND (<130)	ND (<3.7)	ND (<940)	ND (<7.4)	ND (<850)	ND (<7.4)	ND (<950)	ND (<0.15)	ND (<2.6)	ND (<0.15)	ND (<1.9)	ND (<0.15)	ND (<1.2)
Cyclohexane	ND (<9.9)	ND (<390)	ND (<12)	ND (<2,900)	ND (<25)	ND (<2,600)	ND (<25)	ND (<2,900)	ND (<0.50)	41.9	ND (<0.50)	6.1 J	ND (<0.50)	ND (<3.8)
Dibromochloromethane	ND (<3.8)	ND (<170)	ND (<4.7)	ND (<1,200)	ND (<9.4)	ND (<1,100)	ND (<9.4)	ND (<1,300)	ND (<0.19)	ND (<3.4)	ND (<0.19)	ND (<2.5)	ND (<0.19)	ND (<1.6)
Dichlorodifluoromethane	ND (<15)	ND (<240)	ND (<19)	ND (<1,800)	ND (<38)	ND (<1,600)	ND (<38)	ND (<1,800)	ND (<0.75)	ND (<5.0)	ND (<0.75)	ND (<3.6)	ND (<0.75)	ND (<2.4)
Ethylbenzene	817	2,520	56.7	1,560 J	62.3	1,280 J	59.3	1,380 J	2	84	ND (<0.20)	16.0	0.45 J	5.5
Freon 113	ND (<14)	ND (<260)	ND (<17)	ND (<1,900)	ND (<34)	ND (<1,700)	ND (<34)	ND (<2,000)	ND (<0.69)	11 J	ND (<0.69)	5.3 J	ND (<0.69)	3.9 J
Isopropylbenzene	23.6 J	601 J	ND (<5)	ND (<1,100)	ND (<10)	ND (<950)	ND (<10)	ND (<1,100)	ND (<0.20)	11 J	ND (<0.2)	ND (<2.1)	ND (<0.20)	ND (<1.4)
m,p-Xylene	1260	7,050	87.0	3,000 J	108	2,420 J	109	2,890 J	3.7	165	0.49 J	34.3	0.91 J	12.5
Methyl Acetate	ND (<42)	ND (<430)	ND (<52)	20,500	ND (<100)	10,300	ND (<100)	17,300	ND (<2.1)	ND (<8.8)	ND (<2.1)	ND (<6.4)	13.2	ND (<4.2)
Methyl Tert Butyl Ether	ND (<6.1)	ND (<170)	ND (<7.6)	ND (<1,300)	ND (<15)	ND (<1,100)	ND (<15)	ND (<1300)	ND (<0.31)	ND (<3.5)	ND (<0.31)	ND (<2.5)	ND (<0.31)	ND (<1.7)
Methylcyclohexane	ND (<3.6)	ND (<200)	ND (<4.6)	ND (<1,500)	ND (<9.1)	ND (<1,300)	ND (<9.1)	ND (<1500)	ND (<0.18)	ND (<4.0)	ND (<0.18)	ND (<2.9)	ND (<0.18)	ND (<1.9)
Methylene chloride	ND (<5.3)	ND (<210)	ND (<6.6)	ND (<1,600)	ND (<13)	ND (<1,400)	ND (<13)	ND (<1600)	ND (<0.27)	ND (<4.3)	ND (<0.27)	ND (<3.1)	ND (<0.27)	ND (<2.1)
o-Xylene	633	2,790	51.6	1,330 J	59.0	1,130 J	60.6	1,210 J	1.8	65.2	ND (<0.31)	13.1	0.36 J	4.0
Styrene	ND (<3.2)	ND (<100)	ND (<4)	ND (<740)	ND (<7.9)	ND (<670)	ND (<7.9)	ND (<750)	ND (<0.16)	ND (<2)	ND (<0.16)	ND (<1.5)	ND (<0.16)	ND (<0.97)
Tetrachloroethene	ND (<5.5)	ND (<250)	ND (<6.9)	ND (<1,900)	ND (<14)	ND (<1,700)	ND (<14)	ND (<1900)	ND (<0.28)	ND (<5.1)	ND (<0.28)	ND (<3.7)	ND (<0.28)	ND (<2.4)
Toluene	490	445	41.0	ND (<1,200)	39.7 J	ND (<1,100)	38.2 J	ND (<1200)	1.4	31	ND (<0.20)	8.4	ND (<0.20)	ND (<1.6)
trans-1,2-Dichloroethene	ND (<8.4)	ND (<210)	ND (<11)	ND (<1,600)	ND (<21)	ND (<1,400)	ND (<21)	ND (<1600)	ND (<0.42)	ND (<4.3)	ND (<0.42)	ND (<3.1)	ND (<0.42)	ND (<2.0)
trans-1,3-Dichloropropene	ND (<4.0)	ND (<120)	ND (<5)	ND (<890)	ND (<10)	ND (<800)	ND (<10)	ND (<900)	ND (<0.2)	ND (<2.5)	ND (<0.20)	ND (<1.8)	ND (<0.20)	ND (<1.2)
Trichloroethene	ND (<5.8)	ND (<160)	ND (<7.2)	ND (<1,200)	ND (<14)	ND (<1,100)	ND (<14)	ND (<1200)	ND (<0.29)	ND (<3.3)	ND (<0.29)	ND (<2.3)	ND (<0.29)	ND (<1.5)
Trichlorofluoromethane	ND (<5.1)	ND (<220)	ND (<6.3)	ND (<1,700)	ND (<13)	ND (<1,500)	ND (<13)	ND (<1700)	ND (<0.25)	ND (<4.6)	ND (<0.25)	ND (<3.3)	ND (<0.25)	ND (<2.2)
Vinyl chloride	ND (<5.8)	ND (<200)	ND (<7.2)	ND (<1,500)	ND (<14)	ND (<1,300)	ND (<14)	ND (<1500)	ND (<0.29)	ND (<4.0)	ND (<0.29)	ND (<2.9)	ND (<0.29)	ND (<1.9)
Xylene (total)	1,890	9,840	139	4,340 J	167	3,550 J	169	4,100 J	5.5	230	0.49 J	47.4	1.3	16.5
Total TIC, Volatile	13,250 J	85,300 J	270 J	22,000 J	1,300 J	19,000 J	650 J	25,000 J	53 J	870 J	64 J	970 J	148.7 J	179 J
Total Volatiles (Target)	*6,614*	*32,456*	*1,279*	*33,040*	*1,570*	*20,770*	*1,485*	*29,240*	*692*	*3,331*	*587*	*1,554*	*2,548*	*2,464*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-3. P-1 Laboratory Analytical Results

Analyte	P-1 Baseline Data		P-1 Slurry Test Data											
			Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
Semivolatiles (ug/L or ug/kg)														
1,1'-Biphenyl	79.9	416 J	ND (<65)	659 J	ND (<65)	896 J	ND (<65)	613 J	ND (<0.33)	134 J	2.7	180 J	1.3 J	83.7 J
2,4,5-Trichlorophenol	ND (<2.2)	ND (<860)	ND (<390)	ND (<1,500)	ND (<390)	ND (<1,400)	ND (<390)	ND (<1,500)	ND (<1.9)	ND (<340)	ND (<1.9)	ND (<230)	ND (<1.9)	ND (<150)
2,4,6-Trichlorophenol	ND (<1.4)	ND (<480)	ND (<250)	ND (<850)	ND (<250)	ND (<770)	ND (<250)	ND (<860)	ND (<1.3)	ND (<190)	ND (<1.3)	ND (<130)	ND (<1.3)	ND (<83)
2,4-Dichlorophenol	ND (<1.8)	ND (<960)	ND (<310)	ND (<1,700)	ND (<310)	ND (<1,500)	ND (<310)	ND (<1,700)	ND (<1.6)	ND (<370)	ND (<1.6)	ND (<250)	ND (<1.6)	ND (<170)
2,4-Dimethylphenol	93 J	3,400	ND (<330)	ND (<2,600)	ND (<330)	ND (<2,300)	ND (<330)	ND (<2,600)	4.3 J	ND (<570)	3.6 J	ND (<380)	3.2 J	ND (<250)
2,4-Dinitrophenol	ND (<1)	ND (<870)	ND (<180)	ND (<1,500)	ND (<180)	ND (<1,400)	ND (<180)	ND (<1,600)	ND (<0.89)	ND (<340)	ND (<0.89)	ND (<230)	ND (<0.89)	ND (<150)
2,4-Dinitrotoluene	ND (<0.97)	ND (<670)	ND (<170)	ND (<1,200)	ND (<170)	ND (<1,100)	ND (<170)	ND (<1,200)	ND (<0.86)	ND (<260)	ND (<0.86)	ND (<170)	ND (<0.86)	ND (<110)
2,6-Dinitrotoluene	ND (<0.63)	ND (<650)	ND (<110)	ND (<1,200)	ND (<110)	ND (<1,000)	ND (<110)	ND (<1,200)	ND (<0.56)	ND (<260)	ND (<0.56)	ND (<170)	ND (<0.56)	ND (<110)
2-Chloronaphthalene	ND (<1.1)	ND (<800)	ND (<200)	ND (<1,400)	ND (<200)	ND (<1,300)	ND (<200)	ND (<1,400)	ND (<0.98)	ND (<310)	ND (<0.98)	ND (<210)	ND (<0.98)	ND (<140)
2-Chlorophenol	ND (<1.1)	ND (<490)	ND (<190)	ND (<860)	ND (<190)	ND (<790)	ND (<190)	ND (<870)	ND (<0.95)	ND (<190)	ND (<0.95)	ND (<130)	ND (<0.95)	ND (<85)
2-Methylnaphthalene	591	1,800	ND (<82)	4,910	155 J	6,190	ND (<82)	4,370	2.4	770	13.1	716	4.7	260
2-Methylphenol	15.8	ND (<560)	ND (<270)	ND (<990)	ND (<270)	ND (<900)	ND (<270)	ND (<1,000)	ND (<1.4)	ND (<220)	ND (<1.4)	ND (<150)	ND (<1.4)	ND (<97)
2-Nitroaniline	ND (<0.74)	ND (<360)	ND (<130)	ND (<640)	ND (<130)	ND (<580)	ND (<130)	ND (<640)	ND (<0.66)	ND (<140)	ND (<0.66)	ND (<95)	ND (<0.66)	ND (<63)
2-Nitrophenol	ND (<2)	ND (<710)	ND (<360)	ND (<1,300)	ND (<360)	ND (<1,100)	ND (<360)	ND (<1,300)	ND (<1.8)	ND (<280)	ND (<1.8)	ND (<190)	ND (<1.8)	ND (<120)
3&4-Methylphenol	14.6	ND (<820)	ND (<250)	ND (<1,400)	ND (<250)	ND (<1,300)	ND (<250)	ND (<1,500)	ND (<1.3)	ND (<320)	ND (<1.3)	ND (<210)	ND (<1.3)	ND (<140)
3,3'-Dichlorobenzidine	ND (<1.4)	ND (<550)	ND (<240)	ND (<960)	ND (<240)	ND (<870)	ND (<240)	ND (<970)	ND (<1.2)	ND (<210)	ND (<1.2)	ND (<140)	ND (<1.2)	ND (<94)
3-Nitroaniline	ND (<1.4)	ND (<440)	ND (<250)	ND (<780)	ND (<250)	ND (<710)	ND (<250)	ND (<790)	ND (<1.3)	ND (<170)	ND (<1.3)	ND (<120)	ND (<1.3)	ND (<77)
4,6-Dinitro-o-cresol	ND (<0.81)	ND (<500)	ND (<140)	ND (<880)	ND (<140)	ND (<800)	ND (<140)	ND (<890)	ND (<0.72)	ND (<200)	ND (<0.72)	ND (<130)	ND (<0.72)	ND (<86)
4-Bromophenyl phenyl ether	ND (<0.34)	ND (<290)	ND (<60)	ND (<510)	ND (<60)	ND (<470)	ND (<60)	ND (<520)	ND (<0.3)	ND (<110)	ND (<0.3)	ND (<76)	ND (<0.30)	ND (<50)
4-Chloro-3-methyl phenol	ND (<1.3)	ND (<730)	ND (<240)	ND (<1,300)	ND (<240)	ND (<1,200)	ND (<240)	ND (<1,300)	ND (<1.2)	ND (<290)	ND (<1.2)	ND (<190)	ND (<1.2)	ND (<130)
4-Chloroaniline	ND (<0.45)	ND (<360)	ND (<79)	ND (<630)	ND (<79)	ND (<570)	ND (<79)	ND (<630)	ND (<0.4)	ND (<140)	ND (<0.4)	ND (<93)	ND (<0.40)	ND (<61)
4-Chlorophenyl phenyl ether	ND (<0.48)	ND (<270)	ND (<86)	ND (<470)	ND (<86)	ND (<430)	ND (<86)	ND (<480)	ND (<0.43)	ND (<110)	ND (<0.43)	ND (<71)	ND (<0.43)	ND (<46)
4-Nitroaniline	ND (<0.81)	ND (<400)	ND (<140)	ND (<700)	ND (<140)	ND (<630)	ND (<140)	ND (<700)	ND (<0.72)	ND (<150)	ND (<0.72)	ND (<100)	ND (<0.72)	ND (<68)
4-Nitrophenol	ND (<0.95)	ND (<780)	ND (<170)	ND (<1,400)	ND (<170)	ND (<1,200)	ND (<170)	ND (<1,400)	ND (<0.84)	ND (<310)	ND (<0.84)	ND (<200)	ND (<0.84)	ND (<130)
Acenaphthene	141 J	2,930	ND (<70)	2,790	ND (<70)	3,940	ND (<70)	3,080	0.56 J	532	3.1	373	0.82 J	91.9 J
Acenaphthylene	148 J	ND (<230)	ND (<76)	ND (<410)	ND (<76)	921 J	ND (<76)	ND (<410)	ND (<0.38)	202 J	ND (<0.38)	141 J	ND (<0.38)	76.8 J
Acetophenone	ND (<0.42)	ND (<360)	ND (<75)	ND (<640)	ND (<75)	ND (<580)	ND (<75)	ND (<640)	2.2 J	ND (<140)	1.7 J	ND (<95)	0.85 J	ND (<62)
Anthracene	106 J	5,260	ND (<80)	3,550	ND (<80)	6,110	ND (<80)	6,250	ND (<0.4)	1,340	1.0 J	607	ND (<0.40)	152 J
Atrazine	ND (<0.18)	ND (<500)	ND (<33)	ND (<870)	ND (<33)	ND (<790)	ND (<33)	ND (<880)	ND (<0.16)	ND (<190)	ND (<0.16)	ND (<130)	ND (<0.16)	ND (<85)
Benzaldehyde	ND (<0.3)	ND (<630)	ND (<53)	ND (<1,100)	ND (<53)	ND (<1,000)	ND (<53)	ND (<1,100)	9.0	ND (<250)	12.5	ND (<170)	24.3	ND (<110)
Benzo(a)anthracene	67.6	7,120	ND (<71)	4,980	ND (<71)	10,900	ND (<71)	11,300	ND (<0.36)	1,890	0.93 J	1,080	0.55 J	361
Benzo(a)pyrene	45	5,750	ND (<73)	4,510	ND (<73)	9,120	ND (<73)	8,790	ND (<0.37)	1,560	0.49 J	949	ND (<0.37)	320
Benzo(b)fluoranthene	24.1	4,180	ND (<120)	3,610	ND (<120)	8,050	ND (<120)	6,720	ND (<0.59)	1,260	ND (<0.59)	725	ND (<0.59)	255
Benzo(g,h,i)perylene	22	1,760	ND (<84)	2,500	ND (<84)	4,760	ND (<84)	4,340	ND (<0.42)	738	ND (<0.42)	453	ND (<0.42)	154 J
Benzo(k)fluoranthene	29.6	5,380	ND (<84)	2,690	ND (<84)	5,170	ND (<84)	6,020	ND (<0.42)	1,180	0.45 J	673	ND (<0.42)	220
bis(2-Chloroethoxy)methane	ND (<0.73)	ND (<370)	ND (<130)	ND (<650)	ND (<130)	ND (<590)	ND (<130)	ND (<660)	ND (<0.65)	ND (<140)	ND (<0.65)	ND (<97)	ND (<0.65)	ND (<64)
bis(2-Chloroethyl)ether	ND (<0.6)	ND (<290)	ND (<110)	ND (<500)	ND (<110)	ND (<460)	ND (<110)	ND (<510)	ND (<0.53)	ND (<110)	ND (<0.53)	ND (<75)	ND (<0.53)	ND (<49)
bis(2-Chloroisopropyl)ether	ND (<0.83)	ND (<430)	ND (<150)	ND (<760)	ND (<150)	ND (<690)	ND (<150)	ND (<760)	ND (<0.74)	ND (<170)	ND (<0.74)	ND (<110)	ND (<0.74)	ND (<74)
bis(2-Ethylhexyl)phthalate	ND (<0.74)	ND (<730)	ND (<130)	1,340 J	ND (<130)	ND (<1,200)	220 J	ND (<1,300)	ND (<0.66)	438 J	ND (<0.66)	ND (<190)	2.3	ND (<130)
Butyl benzyl phthalate	ND (<0.67)	ND (<430)	ND (<120)	ND (<760)	ND (<120)	ND (<690)	ND (<120)	ND (<770)	ND (<0.59)	ND (<170)	ND (<0.59)	ND (<110)	ND (<0.59)	ND (<75)
Caprolactam	ND (<0.35)	ND (<550)	ND (<63)	ND (<970)	ND (<63)	ND (<880)	ND (<63)	ND (<980)	ND (<0.32)	ND (<220)	ND (<0.32)	ND (<140)	ND (<0.32)	ND (<95)
Carbazole	81.8 J	3,570	ND (<73)	2,600	ND (<73)	3,650	ND (<73)	4,100	ND (<0.36)	870	1.4 J	353	0.47 J	90.5 J
Chrysene	64.3	7,420	ND (<50)	5,310	ND (<50)	11,200	ND (<50)	11,700	ND (<0.25)	1,950	1.0 J	1,110	0.51 J	383
Dibenzo(a,h)anthracene	9.3	416 J	ND (<110)	868 J	ND (<110)	1,510 J	ND (<110)	1,250 J	ND (<0.54)	320 J	ND (<0.54)	165 J	ND (<0.54)	54.2 J
Dibenzofuran	80.3 J	2,140	ND (<69)	1,960 J	ND (<69)	2,880	ND (<69)	2,150	ND (<0.34)	525	3.3 J	458	1.5 J	167 J
Diethyl phthalate	ND (<0.44)	ND (<250)	ND (<78)	ND (<430)	ND (<78)	ND (<390)	ND (<78)	ND (<440)	ND (<0.39)	ND (<96)	ND (<0.39)	ND (<64)	ND (<0.39)	ND (<42)
Dimethyl phthalate	ND (<0.37)	ND (<250)	ND (<66)	ND (<430)	ND (<66)	ND (<390)	ND (<66)	ND (<440)	ND (<0.33)	ND (<96)	ND (<0.33)	ND (<64)	ND (<0.33)	ND (<42)
Di-n-butyl phthalate	ND (<0.67)	ND (<370)	ND (<120)	ND (<640)	ND (<120)	ND (<580)	ND (<120)	ND (<650)	ND (<0.59)	ND (<140)	ND (<0.59)	ND (<95)	ND (<0.59)	ND (<63)
Di-n-octyl phthalate	ND (<0.64)	ND (<490)	ND (<110)	ND (<860)	ND (<110)	ND (<780)	ND (<110)	ND (<870)	ND (<0.57)	ND (<190)	ND (<0.57)	ND (<130)	ND (<0.57)	ND (<85)
Fluoranthene	155 J	18,900	ND (<50)	12,300	ND (<50)	25,600	ND (<50)	27,000	0.47 J	4,640	3.2	2,490	1.6 J	733
Fluorene	153 J	3,010	ND (<90)	3,100	ND (<90)	4,790	ND (<90)	3,780	0.53 J	788	5.7	754	2.4	260
Hexachlorobenzene	ND (<0.6)	ND (<330)	ND (<110)	ND (<580)	ND (<110)	ND (<530)	ND (<110)	ND (<590)	ND (<0.54)	ND (<130)	ND (<0.54)	ND (<86)	ND (<0.54)	ND (<57)
Hexachlorobutadiene	ND (<0.2)	ND (<380)	ND (<35)	ND (<670)	ND (<35)	ND (<600)	ND (<35)	ND (<670)	ND (<0.18)	ND (<150)	ND (<0.18)	ND (<99)	ND (<0.18)	ND (<65)
Hexachlorocyclopentadiene	ND (<0.46)	ND (<410)	ND (<81)	ND (<730)	ND (<81)	ND (<660)	ND (<81)	ND (<730)	ND (<0.41)	ND (<160)	ND (<0.41)	ND (<110)	ND (<0.41)	ND (<71)
Hexachloroethane	ND (<0.32)	ND (<290)	ND (<57)	ND (<510)	ND (<57)	ND (<460)	ND (<57)	ND (<510)	ND (<0.28)	ND (<110)	ND (<0.28)	ND (<75)	ND (<0.28)	ND (<49)
Indeno(1,2,3-cd)pyrene	18.5	1,830	ND (<61)	2,070	ND (<61)	4,200	ND (<61)	3,890	ND (<0.3)	693	ND (<0.30)	415	ND (<0.30)	145 J
Isophorone	ND (<0.66)	ND (<280)	ND (<120)	ND (<500)	ND (<120)	ND (<460)	ND (<120)	ND (<510)	ND (<0.59)	ND (<110)	ND (<0.59)	ND (<74)	ND (<0.59)	ND (<49)
Naphthalene	5,180	10,500	745	33,400	1,280	33,400	720	32,900	21.1	2,990	26.6	747	12.8	358
Nitrobenzene	ND (<0.47)	ND (<400)	ND (<84)	ND (<700)	ND (<84)	ND (<640)	ND (<84)	ND (<710)	ND (<0.42)	ND (<160)	ND (<0.42)	ND (<100)	ND (<0.42)	ND (<69)
N-Nitroso-di-n-propylamine	ND (<0.53)	ND (<370)	ND (<94)	ND (<650)	ND (<94)	ND (<590)	ND (<94)	ND (<660)	ND (<0.47)	ND (<140)	ND (<0.47)	ND (<96)	ND (<0.47)	ND (<64)
N-Nitrosodiphenylamine	ND (<0.58)	ND (<240)	ND (<100)	ND (<420)	ND (<100)	ND (<380)	ND (<100)	ND (<420)	ND (<0.52)	ND (<92)	ND (<0.52)	ND (<62)	ND (<0.52)	ND (<41)
Pentachlorophenol	ND (<2.1)	ND (<640)	ND (<380)	ND (<1,100)	ND (<380)	ND (<1,000)	ND (<380)	ND (<1,100)	ND (<1.9)	ND (<250)	ND (<1.9)	ND (<170)	ND (<1.9)	ND (<110)
Phenanthrene	540	26,700	ND (<73)	17,000	153 J	32,100	ND (<73)	31,400	0.80 J	5,640	10.1	3,690	4.7	1,090
Phenol	ND (<0.56)	ND (<710)	388 J	9,000	ND (<99)	ND (<1,100)	ND (<99)	ND (<1300)	ND (<0.5)	ND (<280)	ND (<0.5)	ND (<190)	2.0 J	ND (<120)
Pyrene	145 J	16,700	ND (<67)	14,700	ND (<67)	30,200	ND (<67)	31,700	0.46 J	4,100	2.9	2,290	1.4 J	705
Total TIC, Semivolatile	4,205 J	76,200 J	2,500 J	377,400 J	2,900 J	289,400 J	2,100 J	313,300 J	106.8 J	8,730 J	295.9 J	6,010 J	541.7 J	8,550 J
Total Semivolatiles (target)	*7,805*	*129,182*	*1,133*	*133,847*	*1,588*	*205,587*	*940*	*201,353*	*42*	*32,560*	*94*	*18,369*	*65*	*5,960*

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Table 4-3. P-1 Laboratory Analytical Results

Analyte	P-1 Baseline Data		P-1 Slurry Test Data											
			Persulfate 10:1 (P1-P-10)		Persulfate 20:1 (P1-P-20)		Persulfate 40:1 (P1-P-40)		Fenton 10:1 (P1-F-10)		Fenton 20:1 (P1-F-20)		Fenton 40:1 (P1-F-40)	
	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry														
(mg/L or mg/kg unless noted)														
Solids, Percent		33.5		19.8		21.8		19.6		14.8		22.2		33.7
Chromium, Hexavalent	ND (<0.010)				ND (<1.0) c						ND (<0.010)			
Iron, Ferrous	766				146						308			
Nitrogen, Nitrate[a]	ND (<0.11)				ND (<2.1)						0.14			
Nitrogen, Nitrate + Nitrite	ND (<0.10)				ND (<0.10)						0.14			
Nitrogen, Nitrite	ND (<0.010)				ND (<2.0)						ND (<0.010)			
Petroleum Hydrocarbons	27.8	309		ND (<130)	ND (<0.53)	ND (<110)		ND (<120)		384	ND (<0.53)	266		355
Phosphorus, Total	0.86				15.4						0.14			
Sulfate	2,510				3,440						4,770			
Total Organic Carbon	42.9	162,000	6,660	153,000	8,700	116,000	8,230	137,000	184	205,000	473	187,000	1,170	139,000
pH, standard units	6.23 b		10.12 b		10.17 b		10.20 b		3.10		2.89		2.57	
As(III) (ug/L)	5,880				132						6.86			
As(V) (ug/L)	14,900				767						288			
Metals (ug/L or mg/kg)														
Arsenic	13,500	ND (<6.4)	1,370	41.1	4,080	43.2	2,550	37.1	132	64.3	183	59.9	2,690	62.6
Barium	ND (<200)	ND (<64)	ND (<1,000) c	ND (<50)	ND (<1,000) c	ND (<45)	ND (<1,000) c	ND (<51)	ND (<200)	28.0	ND (<200)	25.5	ND (<400) c	ND (<30)
Cadmium	11.9	ND (<1.6)	ND (<20) c	ND (<1.3)	ND (<20) c	ND (<1.1)	ND (<20) c	ND (<1.3)	4.4	ND (<0.66)	4.4	ND (<0.56)	ND (<8.0) c	ND (<0.74)
Chromium	ND (<10)	24.1	389	19.1	778	17.9	644	18.6	10.8	17.6	21.1	19.8	188	16.4
Iron	535,000	18,500	28,600	21,500	159,000	19,100	154,000	18,700	262,000	16,400	241,000	14,900	430,000	12,900
Lead	92.4	10.3	22.0	12.1	106	9.8	126	11.0	16.5	9.2	28.1	8.3	74.7	8.9
Manganese	397		86.8	87.6	956	79.9	986	82.1	1,980	54.9	1,880	49.1	2,160	47.4
Mercury	0.93	ND (<0.054)	ND (<8.0) c	ND (<0.16)	ND (<8.0)	ND (<0.15)	ND (<8.0) c	ND (<0.16)	ND (<0.40) c	ND (<0.095)	ND (<0.40) c	ND (<0.075)	ND (<0.40) c	ND (<0.055)
Selenium	48.8	ND (<6.4)	ND (<50) c	ND (<5.0)	ND (<50) c	ND (<4.5)	ND (<50) c	ND (<5.1)	ND (<10)	ND (<2.6)	ND (<10)	ND (<2.2)	ND (<20) c	ND (<3.0)
Silver	ND (<10)	ND (<3.2)	ND (<50) c	ND (<2.5)	ND (<50) c	ND (<2.3)	ND (<50) c	ND (<2.5)	ND (<10)	ND (<1.3)	ND (<10)	ND (<1.1)	ND (<20) c	ND (<1.5)
Thallium	ND (<10)	ND (<3.2)	ND (<50) c	ND (<2.5)	ND (<50) c	ND (<2.3)	ND (<50) c	ND (<2.5)	ND (<10)	ND (<1.3)	ND (<10)	ND (<1.1)	ND (<20) c	ND (<1.5)

Notes:
J: Estimated value
ND: Not detected at quoted Method Detection Limit
B: Analyte detected in method blank.
a: Calculated as (Nitrogen, Nitrate + Nitrite) - (Nitrogen, Nitrite)
b: Sample received out of holding time for pH analysis
c: Elevated detection limit due to difficult sample matrix
d: Sample pH preservative >2 upon receipt at lab

Response to EPA Comments

Response to April 4, 2007 Agency Comments (via e-mail)
Scope of Work for Treatability Study

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	Agency Comment	Response
1.	Objectives of the study include an evaluation of ISCO as a treatment option in source zones and impacted soils at the Site and an evaluation of whether the use of ISCO might have an impact on other contaminants at the Site. The plan seems to emphasize arsenic which is appropriate. However, other inorganic contaminants have been observed at the site. EPA recommends adding other contaminants of concern to the list of analytes, in particular lead and thallium. It is worth noting that other contaminants have been detected in SPLP tests on soil samples collected from the site, such as cadmium, barium, selenium, mercury, benzene, and chloroform.	Comment noted. Groundwater and soil samples (baseline and final) were analyzed for RCRA metals (arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver) plus thallium. The groundwater and soil samples (baseline and final) were also analyzed for VOCs which included benzene and chloroform.
2.	The selected sampling areas interestingly coincide with a region where soil arsenic concentrations (at depths >4 feet) are atypically low for the site. Because of this it may be difficult to accurately assess the impact of ISCO treatment on arsenic behavior. EPA recommends selecting soils from a region where arsenic values are >100 mg/kg and more typical for site concentrations of arsenic in soil.	P -1 was collected from approximately 9' below grade (bg), within an area of soil arsenic concentrations estimated to be above 100 mg/kg according to contoured soil concentrations below 4 ft bgs. A soil sample to the north of the P-1 location contained 498 mg/kg total arsenic, and a soil sample to the east contained 34.2 mg/kg total arsenic. SS-1 and SS-2 were moved from the location indicated in the work plan because a concrete pad was encountered at approximately 2 ft bgs. The samples were collected from approximately 6 – 8' bg and approximately 3' bg, respectively, near the MW-103 well cluster. The arsenic concentrations in soil at similar depths collected from nearby soil boring SB-103DS are: 2.5 mg/kg (0-0.16 ft) 2.5 mg/kg (1.4-1.9 ft) 5.1 mg/kg (5-6 ft) These soil locations were selected to provide the most appropriate sample containing visible and residual coal tar, the target contaminants for the bench test. Since the presence of tar in the areas of highest arsenic contamination is limited, ISCO would likely be applied to areas with moderate arsenic contamination, such as those selected for the bench test samples. It is unlikely that ISCO would be applied to the area of highest arsenic concentrations due to the limited distribution of tar in this area. Please see response to Comment 4 for additional information regarding sample location selection and TarGOST™ results.

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	Agency Comment	Response
3.	As part of the planned analyses, it is proposed that both As(III) and As(V) concentrations will be determined. EPA recommends that, in addition to these fractions, total arsenic be measured. This will ensure that all forms of soluble arsenic are being captured in the As(III) and As(V) determinations.	See response to comment #1. Groundwater and soil samples (baseline and final) were analyzed for total arsenic. Groundwater samples (baseline and 20:1) were analyzed for As(III) and As(V).
4.	Please clarify the depth intervals for the SS-1, SS-2, and P-1 material samples, and how these targeted depths correspond to the contamination observed during the OU1 Supplemental Investigation TarGOST™ study conducted in October 2006.	The soil boring logs from the OU1 SI were used to develop the soil sample collection locations. The exact depths were not specified because the field team was to determine the exact sample depth based on field observations of targeted soil types, selecting a peat and residual tar sample from P-1, a sample with free phase tar for SS-1, and a sample with residual tar for SS-2. P -1 was collected from approximately 9' below grade (bg), SS-1 from approximately 6 – 8' bg, and SS-2 from approximately 3' bg. TarGOST™ responses from corresponding depths at nearby TarGOST™ boring locations are provided below. A TarGOST™ response greater than 49% RE was determined to coincide with the presence of coal tar at the Site. The P-1 sample is located between TL-15-09 and TL-15-08. The max TarGOST™ response of 75.9% RE at TL-15-09 was observed between 8 and 9 ft bgs. The max TarGOST™ response of 133.3% RE at TL-15-09 was observed at approximately 8 ft bgs. The SS-1 and SS-2 samples are located between TL-15-05 and TL-14-05. A TarGOST™ response of approximately 75% RE was observed at approximately 2-3 ft bgs in TL-15-05. A TarGOST™ response to approximately 100% RE was observed between 7 and 8 ft bgs in TL-14-05.

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	Agency Comment	Response
5.	Please provide the monitoring well screen intervals for MW-102A, MW-102, MW-112A and MW-112B, and confirm that the selected wells are screened closest to the targeted SS-1, SS-2, and P-1 material intervals.	For SS-1 groundwater was collected from MW-102. MW-102 is screened from 4 – 19 ft bg and the pump was set at approximately 6 ft bg. Soil for SS-1 was collected at approximately 6 – 8 ft bg. For SS-2 groundwater was collected from MW-102B instead of MW-102A due to the presence of NAPL in MW-102A. MW-102 is screened from 14 – 24 ft bg and the pump was set at approximately 14 ft bg. Soil for SS-2 was collected at approximately 3 ft bg. It was not possible to collect soil and groundwater samples at similar depth intervals for SS-2 due to the presence of NAPL in the shallow well MW-102A. For P-1 groundwater was collected from MW-112A. MW-112B is screened from 2 – 12 ft bg and the pump was set at approximately 7 ft bg. Soil for P-1 was collected at approximately 9 ft bg.
6.	EPA recommends also doing TOC, grain-size, TPH, and metals analyses on the baseline and final soil samples from SS-1, SS-2, and P-1 to have a better understanding of the site characteristics, as well as the potential competition for oxidant.	Groundwater and soil samples (baseline and final) were analyzed for TOC, TPH and RCRA metals (see response to comment #1). Baseline soil samples were analyzed for grain size. Analysis of final soil samples for grain size was not possible due to required sample volume and is not necessary because grain size will not be affected by oxidation.
7.	Please record the groundwater sample temperatures at the time of collection to qualify the approximate formation temperature. Will the groundwater be kept on ice until test preparation? Will the slurries be kept at room temperature during the 8 to 16 hour equilibration period during the mixture preparation stage?	Sample temperatures were not recorded at the time of collection. Adequate formation temperature data exists from the quarterly groundwater sampling for the OU1 RI. Groundwater samples were kept on ice in the field and refrigerated in the lab until used for testing. Slurries will be operated at room temperature.
8.	Sample homogenization will disturb VOC concentrations in the soil samples, even if plastic sealable bags are used for the actual mixing. Please confirm that the SS-1, SS-2, and P-1 sample locations have previous VOC concentration data from the OU1 Supplemental Investigation that can be used to corroborate the VOC sample results obtained during this treatability study.	Comment is acknowledged; however homogenization was necessary. The oxidation kinetics of the VOCs are well known already, and the VOCs are a relatively small proportion of the total organic mass. Therefore although disturbance did occur it had a nominal effect regarding the overall bench test objectives.
9.	Please include a discussion of the ISCO reagent selection process and why Fenton's and sodium persulfate were selected for coal tar constituents over alternate reagents such as permanganate.	Permanganate is not capable of oxidizing aromatic ring structures, including BTEX and PAHs (reactions with PAHs predominantly affect alkyl groups and do not involve ring cleavage). However, both Fenton's and persulfate are powerful enough to cleave rings and thus were utilized.

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	Agency Comment	Response
10.	Clarify the purpose of the soil buffering test and the targeted pH range of 4 to 5. Is it to evaluate the possibility of introducing acidic solution to the formation to enhance the in-situ remediation, or to evaluate the potential effects of in-situ remedy by-products? Also clarify whether the soil buffering test mixtures will be at 50% slurries. Also clarify the purpose of the reactivity test and whether any additional measurements besides visual observations will be taken during this test (i.e. temperature).	Soil buffering tests were performed to ensure that optimal pH conditions could be achieved in the slurries for oxidation. An acidic pH, less than 4, is optimal for Fenton's reagent oxidation, while a basic pH, greater than 11, is required for base-catalyzed persulfate oxidation. The hydrogen peroxide reactivity test was performed to determine if the amount of transition metals (primarily iron) released as a result of acidification of the slurries is sufficient to initiate and sustain a reaction with dilute hydrogen peroxide. Once the hydrogen peroxide was added to the acidified slurries evidence of reaction was determined by visual observation and measurement of peroxide and iron concentrations, pH, temperature and PID headspace readings.
11.	Clarify the catalyst that will be added for solution pH and iron concentration adjustment during the slurry testing. Will iron catalyst be used for both the Fenton's and persulfate tests, or will another catalyst be used to activate the persulfate reaction, such as heat?	For the Fenton's tests sulfuric acid was used to achieve a pH less than 4 in the slurries. For the persulfate tests NaOH was used to achieve a pH greater than 11 in the slurries. The results of the reactivity test indicated that the addition of an iron catalyst was not necessary for the Fenton's tests due to the native presence of iron in the slurries. Heat is not generally used in field applications because it is typically not economically feasible.
12.	For the Fenton's reagent testing, will the slurry mixture pH be lowered as required for standard Fenton's reagent reactions, or is a "modified" Fenton's reagent proposed? The work plan discusses lowering pH only during the soil buffering test.	See response above to comment #11. Sulfuric acid was used to achieve a pH less than 4 in the slurries for the Fenton's tests.
13.	Please monitor sample temperatures during the slurry tests, as it is a function of the reaction speed for both reagents.	Comment noted. Temperatures were monitored during the slurry tests.
14.	The work plan describes that slurry testing will be performed until residual peroxide or persulfate has been consumed in the test reactors. How will this be determined and what is the estimated duration for these tests? Has any additional mid-test sampling been considered to supplement the baseline and final sample data?	Residual peroxide was measured with peroxide strips. Persulfate was measured by collecting a very small aliquot of liquid, then adding a couple drops of permanganate; if the permanganate disappears, then active persulfate is still present.

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Quanta Resources Superfund Site – Operable Unit 1

	Agency Comment	Response
15.	Is there any additional rationale for the 50%-50% slurry mixture composition and have any other mixtures been considered?	This was primarily driven by the need to analyze multiple parameters in water samples, balanced with sample volumes that can be reasonable handled in the lab. Geo-Cleanse® wanted to maximize the soil, as it has the bulk of the contaminant mass, oxidant demand, and largest impact on ISCO. However, Geo-Cleanse® needed a "water space" above the soil to collect sufficient water to analyze all of the target analytes. Thus the 50% slurry is the best balance of these factors.
16.	For the autoclave test, will the temperature and pressure selections be modified to account for anticipated field conditions as mentioned, and if so, how will this determination be made? Describe any measurements to be taken to adjust these parameters for the bench test, or whether 80-100 degrees F and 20-25 psi will be used.	These parameters were measured during the tests, and oxidant delivery rates were modified to stay within the desired ranges.
17.	Page 2-1, last paragraph—EPA went to the Geocleanse website to look at their performance in using oxidation for coal tar. Their experience in New Jersey is limited to two sites (one in Jersey City). In both cases, they only performed a bench study, and the technology was never scaled up to a full-scale system. Please supply more information on why this technology did not make it to full-scale application. There is a full-scale system listed in Rochester, but the geology would be quite different there.	Geo-Cleanse® has considerable previous experience with coal tar sites, and points to case studies of field applications (pilot and full-scale) in Savannah, Augusta, and Americus, Georgia; Saginaw and Charlotte, Michigan; Charleston, SC; and Somersworth, NH. At the two NJ sites, the bench tests were successful in demonstrating potential effectiveness.
18.	Page 2-2, first paragraph after bullets—It states that there will be testing for only arsenic (III) and arsenic (V). CH2M Hill performed arsenic speciation analyses, but have not supplied the EPA with those results. If you only test for arsenic (III) and arsenic (V) then you need to provide the EPA with the speciation results so that we can be assured that there are no other inorganic or organic forms at the site. The behavior of all forms of arsenic during the treatability testing is an important part of the test.	Arsenic speciation data will be provided to EPA in the OU1 Remedial Investigation Report.
19.	The Work Plan needs a detailed description of the treatment technology being evaluated. Please provide a flow diagram showing the different components of the treatment system.	Detailed descriptions of the bench test systems are provided in the results report. Schematics of the soil column and autoclave tests are also included in the report.

Response to April 4, 2007 Agency Comments (via e-mail)
Scope of Work for Treatability Study

Quanta Resources Superfund Site – Operable Unit 1

	Agency Comment	Response
20.	Section 2.2, Pages 2-2 to 2-3 – The descriptions of the different tests that will be performed on the contaminated materials should include an explanation of how these tests will be used to evaluate the efficacy of the In-Situ Chemical Oxidation technology for this site. The methods used to calculate buffering capacity, reactivity of the soil to hydrogen peroxide, and the results of the slurry, autoclave and residual saturation tests should be delineated. The criteria to be used to determine whether the study accomplished the stated goals needs to be discussed.	The bench test results' applicability to the evaluation of full-scale effectiveness of ISCO at the Quanta Resources Superfund Site will be discussed in the Draft FS Report.
21.	Section 4 – The procedures for recording, storing and transmitting the data generated during the study needs to be described. Provide the procedures that will be used to analyze and interpret this data, including methods of data presentation and statistical interpretation. This section should also discuss any status or interim reports that will be produced during the study. Identify the person responsible for preparing each report as well as explain internal and external review and approval procedures, including individual roles and responsibilities.	Data and methods of evaluation are presented in the results report for the bench test. Geo-Cleanse® will prepare a report of the bench test results, and CH2M HILL will prepare a cover letter to accompany the report. A full discussion of the bench test results in the context of technology evaluation will be included in the Draft FS Report for OU1.
22.	The Work Plan needs to provide estimates of the types and quantities of materials that will be generated during the study. Types of waste generated may include: unused waste not being treated; treated waste; treatment residuals; laboratory samples and extracts; used containers; contaminated debris, etc. Provide a description of the applicable regulations and an explanation of the procedures that will be used to comply with them.	Volumes of wastes generated include up to 86 kg of soil and 39 liters of water. The waste sample material will be returned to the site and disposed of as IDW. Used containers will be disposed in non-hazardous waste as per 40 CFR 261.7, "Empty Containers" provision in RCRA.
23.	Appendix B – The laboratory performing the analyses described here should be identified and a list of the analytical SOPs that will be used should be provided. Also, if this work will be performed under the approved CH2MHill QAPP and FSP, these documents should be referenced; otherwise a QAPP should be prepared and submitted for this work.	Accutest and Applied Speciation performed the analyses. Figure 1-1 of QAPP has the labs utilized in the treatability study identified. Section 3 of the work plan specifies that the work will be performed under the approved CH2M HILL QAPP and the FSP addendum which was Attachment A.

Geo-Cleanse® Treatment Program
Bench Test Report

400308

Geo-Cleanse®
INTERNATIONAL, INC.

Geo-Cleanse® Treatment Program

Bench Test Report

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, NJ

Prepared for:

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October 25, 2007

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400309

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1. Introduction

CH2M HILL is currently performing a remedial investigation / feasibility study (RI/FS) for Operable Unit (OU) 1 at the Quanta Resources Superfund Site in Edgewater, New Jersey. The RI/FS is being performed in accordance with the U.S. Environmental Protection Agency Administrative Order on Consent II-Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)-2003-2012.

In-situ chemical oxidation (ISCO) has been identified as a potential remedial technology for the Site. CH2M HILL contracted Geo-Cleanse International, Inc. (GCI) of Kenilworth, New Jersey to conduct laboratory-scale bench tests with ISCO to determine the applicability of this technology at the site.

1.1. Site Information

Site characterization data provided by CH2M HILL and baseline sampling data (Section 4) indicate that the predominant organic contaminants are volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), primarily polynuclear aromatic hydrocarbons (PAHs). The VOC compounds are benzene, toluene, ethylbenzene, xylenes (collectively known as BTEX), and isopropylbenzene. Representative PAH compounds of interest include naphthalene, phenanthrene, acenaphthylene, anthracene, and pyrene.

1.2. Treatability Study Objectives

The overall objective of the bench test was to evaluate Fenton's reagent and sodium persulfate chemical oxidation, and to estimate oxidant demand, with different types of soils and different levels of contaminant impact at the site. Two types of soil (silty sand and peat) and associated groundwater present at the site were tested. The levels of contaminant impact ranged from residual sorbed-phase constituents to NAPL-phase impact. In addition, the study was also intended to evaluate the potential impact of ISCO on constituents of concern at the site other than VOCs and SVOCs (e.g., arsenic).

Specific objectives of the bench test were:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both.
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site.
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO.
- Estimate total oxidant demand of the media.
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process.

- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created.

2. Oxidation Chemistry

2.1. Fenton's Reagent

Fenton's reagent is a solution of hydrogen peroxide and a ferrous iron catalyst, which together generate a hydroxyl free radical that acts as the active oxidizing agent (Haber and Weiss, 1934). The basic radical-producing mechanism is characterized as:

$$H_2O_2 + Fe^{+2} \rightarrow OH\cdot + OH^- + Fe^{+3} \quad (1)$$

where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, OH· is hydroxyl free radical, OH^- is hydroxyl ion, and Fe^{+3} is ferric iron. Fenton's reagent chemistry is complex, involving a number of additional reactions producing both oxidants and reductants that contribute to contaminant destruction (e.g., Watts et al., 1999a):

$$OH\cdot + Fe^{+2} \rightarrow OH^- + Fe^{+3} \quad (2)$$

$$Fe^{+3} + H_2O_2 \rightarrow H^+ + HO_2\cdot + Fe^{+2} \quad (3)$$

$$Fe^{+2} + HO_2\cdot \rightarrow Fe^{+3} + HO_2^- \quad (4)$$

$$Fe^{+3} + HO_2\cdot \rightarrow Fe^{+2} + O_2 + H^+ \quad (5)$$

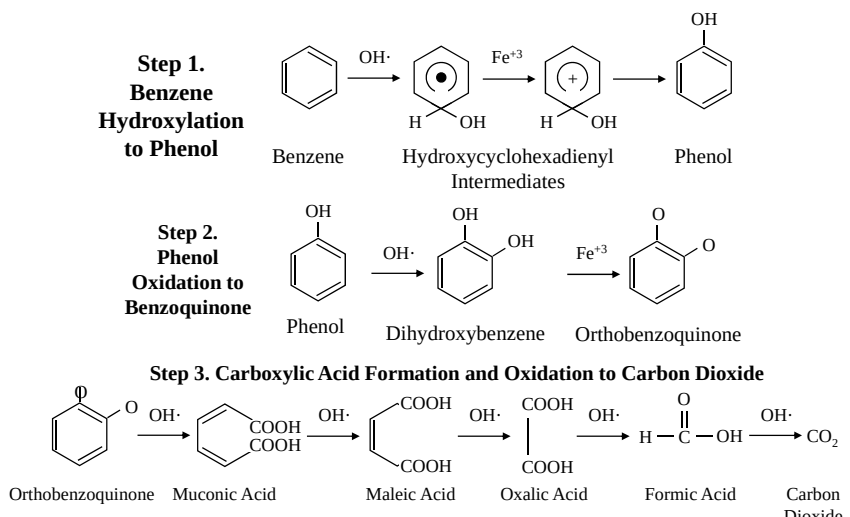
$$OH\cdot + H_2O_2 \rightarrow H_2O + HO_2\cdot \quad (6)$$

where $HO_2\cdot$ is hydroperoxyl radical, HO_2^- is hydroperoxyl anion, O_2 is molecular oxygen, H^+ is hydronium ion, and H_2O is water. Additional reactions occur with organic compounds. The suite of reactions associated with Fenton's reagent is complex, but very effective at destroying many organic compounds dissolved in groundwater, sorbed to soil, or existing as non-aqueous phase liquids in subsurface environments. Fenton's reagent is generally most efficient under acidic pH conditions (pH <5) because oxidation of iron (from Fe^{+2} to Fe^{+3}) by other reactions is minimized, hydrous ferric iron oxides are less likely to precipitate and remove iron from solution, and bicarbonate (which competes with the organic compounds for hydroxyl radicals) is absent. However, an effective (although not chemically optimal) Fenton's reagent system can be established at a pH >6 (e.g., Watts et al., 1999b; Lindsey and Tarr, 2000).

The hydroxyl free radical generated by Fenton's reagent is a powerful, non-selective oxidant. Oxidation of an organic compound by Fenton's reagent is a rapid and exothermic (heat-producing) reaction. Rate constants for reactions of hydroxyl free radical with common environmental pollutants are typically in the range of 10^7 to 10^{10} $M^{-1}s^{-1}$ (e.g., Buxton et al., 1988; Haag and Yao, 1992), and 100% mineralization is generally complete in minutes. Intermediate compounds are primarily naturally occurring carboxylic acids. The end products of oxidation are primarily carbon dioxide and water. None of the injected reagents pose an environmental hazard. Unconsumed H_2O_2 naturally degrades to oxygen and water after injection.

The structure of the VOCs and PAHs at the site is similar in that all are composed of one or more benzene-type (aromatic) ring structures. The oxidation pathway of benzene is well known (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975; Edwards and Curci, 1992; Scheck and Frimmel, 1995) and provides a model for the oxidation pathway of BTEX and isopropylbenzene. The rate constant for oxidation of benzene by OH· is reported as 7.8 x 10^9 $M^{-1}s^{-1}$ (Buxton et al., 1988). Reaction of benzene with OH· produces short-lived and highly reactive aromatic intermediates. The initial attack is by hydroxylation to phenol with subsequent oxidation to orthobenzoquinone (Figure 2-1). Once orthobenzoquinone is formed, ring tension and oxidizing agents rapidly force fission of the aromatic ring to produce muconic acid, a linear carboxylic acid. The pathway then proceeds through a series of intermediate carboxylic acids to carbon dioxide. Hydroxyl radicals do not readily oxidize certain carboxylic acids produced as intermediate oxidation products from organic compounds, thus mineralization may be incomplete although no hazardous intermediate compounds are formed. For example, oxalic acid produced as an intermediate product from benzene is not readily oxidized in the absence of light (e.g., Karpel vel Leitner, 1997). A similar series of intermediate products, possibly also including benzoic acid, is reported for toluene (Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975).

Figure 2-1. Fenton's Reagent Benzene Oxidation Pathway



References: Edwards and Curci 1992; Scheck and Frimmel, 1995

Fenton's reagent oxidation of PAHs is well demonstrated, although the oxidation pathway is not as well known. Lee et al. (2001) and Lee and Hosomi (2001a) reported that oxidation of several PAHs, including anthracene, acenaphthylene, fluorene, benzo(a)anthracene, and benzo(a)pyrene, all produced quinones as oxidation products. The fate of the quinones during Fenton's reagent was not further determined in these studies, although quinones are also susceptible to Fenton's reagent oxidation (Chen and

Pignatello, 1997). A more detailed study of benzo(a)pyrene oxidation identified diones (the -1,6-, -3,6-, and -6,12- diones of benzo(a)pyrene) as intermediates, but that final products amounting to approximately 65% of the initial benzo(a)pyrene mass could not be identified (Lee and Hosomi, 2001b). Lee and Hosomi (2001b) confirmed that the diones are much less toxic and more readily biodegraded than the parent benzo(a)pyrene. Reisen and Arey (2002) determined that hydroxyl radicals oxidized acenaphthene and acenaphthylene in gas phase reactions rapidly to an unidentified ten carbon ring-opened product and a dialdehyde, respectively. Many other studies have concluded that PAHs are susceptible to at least partial oxidation (if not complete mineralization to carbon dioxide and water), and that the oxidation products are much more susceptible to natural degradation and are less toxic than the parent PAH compounds (Martens and Frankenberger, 1995; Kelley et al., 1997; Allen and Reardon, 2000; Nam and Kukor, 2000; Zeng et al., 2000; Lee and Hosomi, 2001a; Zappi et al., 2002). Although Fenton's reagent does temporarily reduce microbial activity, aquifer materials are not sterilized even by aggressive treatment and natural degradation processes return quickly (e.g., Chapelle, 2001; Büyüksönmez et al., 1998, 1999).

In addition to phenols, diones, and other compounds that are known to form as oxidation intermediates with Fenton's reagent, acetone and 2-butanone are often detected at both laboratory and field-scale applications of Fenton's reagent. Once formed, ketones react very slowly with hydroxyl radicals (Stefan and Bolton, 1999) and are generally recalcitrant to chemical oxidation, but are typically degraded rapidly by other (biological) processes following the ISCO treatment. The origin of the ketones in ISCO applications has not been documented. Acetone is a known oxidation byproduct of methyl tert-butyl ether (MTBE), but acetone is often detected at sites with no known MTBE impact. Ketones and phenol can be formed by hydrogen peroxide oxidation of isopropylbenzene (which is present at the site), which is the basis for a number of industrial phenol and acetone production processes. In addition, reaction of hydroxyl radicals with alkyl groups associated with the organic contaminants can produce alkoxyl radicals, which may undergo spontaneous fission to produce acetone (e.g., Cederbaum et al., 1983).

2.2. Persulfate

Persulfate is a strong oxidant that has recently gained attention for ISCO applications. Persulfate exists in a number of salts, of which sodium persulfate is most commonly applied. Sodium persulfate dissolves in solution to release the persulfate anion, which is a strong oxidant:

$$S_2O_8^{-2} + 2e^- \rightarrow 2SO_4^{-2} \tag{7}$$

where $S_2O_8^{-2}$ is persulfate anion and SO_4^{-2} is sulfate anion. Persulfate can be catalyzed, however, to generate persulfate radicals and hydroxyl radicals, which are more powerful oxidant than the persulfate anion:

$$S_2O_8^{-2} + \text{catalyst} \rightarrow SO_4\cdot^- + (SO_4\cdot^- \text{ or } SO_4^{-2}) \tag{8}$$

$$SO_4\cdot^- + H_2O \rightarrow OH\cdot + SO_4^{-2} + H^+ \tag{9}$$

where $SO_4^{\cdot -}$ is the persulfate radical. Potential catalysts include ferrous iron and hydrogen peroxide; elevated temperatures and elevated pH (above approximately 10) can also initiate radical formation (Block et al., 2004). Because a hydroxyl radical is formed, other associated oxidants and reductants (as shown in equations 2-6) are likely also involved.

For this bench test, base-catalyzed (also called elevated pH or alkaline catalysis) was utilized for several reasons:

(1) In general, base-catalyzed systems are more efficient with respect to oxidant utilization, resulting in lower oxidant demand.
(2) At elevated pH, a superoxide radical may be generated by the persulfate system. The superoxide radical may be responsible for penetrating NAPL phases and enhance oxidation (Watts et al., 1999a).
(3) High pH imparts detergent properties that may enhance dissolution of NAPLs and enhance contact with the oxidant (Block, 2007).
(4) Titration bench tests (Section 4.2.2) indicated the soil had relatively low buffering capacity, hence achieving a high pH condition was possible.

Persulfate oxidation of BTEX and PAHs has been demonstrated (e.g., Nadim et al., 2006; Crimi and Taylor, 2007), however the oxidation pathways and associated reactions or mechanisms have not been elucidated as well as with Fenton's reagent. Gosetti et al. (2005) found that persulfate radical-assisted oxidation of 1,5-naphthalenedisulfonate (an aromatic compound with a structure very similar to naphthalene) proceeded via a hydroxylation and ring-fission pathway similar to that of hydroxyl radical oxidation of benzene or PAHs (Figure 2-1), indicating that the intermediate products may also be similar.

3. Materials and Methods

3.1. Soil and Groundwater Collection

Soil samples were collected on March 27, 2007 by CH2M HILL representatives from three different locations using an excavator. The samples and a brief description of the soil type and anticipated level of contaminant impact for each sample are as follows:

- SS-1: Silty sand with visible NAPL.
- SS-2: Silty sand with residual contaminant impact (no visible NAPL).
- P-1: Peat with residual contaminant impact (no visible NAPL).

Immediately upon collection, GCI personnel collected baseline samples (see Section 3.2), and then transferred the remaining bulk soil into plastic-lined polyethylene buckets. The plastic liners were sealed with a tie-wrap, a lid was sealed on the bucket, and then the buckets were placed on ice. The buckets were kept sealed (other than the short time the buckets were periodically opened to prepare bench test samples) and on ice or refrigerated throughout the bench test program.

Three groundwater samples were also collected on March 27, 2007 from monitoring wells adjacent to each of the three soil sample locations. The samples were collected by CH2M HILL personnel using a dedicated polyethylene bailer. Immediately upon collection, GCI personnel collected baseline samples (see Section 2.2), and then transferred the remaining bulk water into 1-L amber glass bottles. The bottles were placed on ice at the time of collection. Upon delivery to the GCI laboratory on the same day of collection, the bottles were transferred to a refrigerator (approximately 4°C) for storage.

3.2. Baseline Sampling

Baseline samples of soil and groundwater were collected at the time the bulk soil and groundwater samples for the bench test were collected in the field. Samples were submitted to Accutest Laboratories, Inc. (Dayton, New Jersey) and to Applied Speciation and Consulting, LLC (Tukwila, Washington) for analysis (see Section 4.3.1). The analytical sample matrix, by test and analyte, are summarized in Table 4-1. The baseline soil samples were analyzed for VOCs, SVOCs, percent solids, petroleum hydrocarbons, total organic carbon, and metals. The baseline water samples were analyzed for VOCs, SVOCs, nitrite, nitrate, petroleum hydrocarbons, phosphorus, sulfate, total organic carbon, pH, arsenic speciation (As(III) / As(V)), and metals. The metals analyzed in both the soil and water samples were arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, silver, and thallium.

Table 3-1. Laboratory Analytical Sampling Matrix

Analyte and Phase	Bench Test Phase							
	Baseline		10:1 Slurries		20:1 Slurries		40:1 Slurries	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Volatile Organic Compounds	x	x	x	x	x	x	x	x
Semivolatile Organic Compounds	x	x	x	x	x	x	x	x
Percent Solids	x		x		x		x	
Hexavalent Chromium		x				x		
Ferrous Iron		x				x		
Nitrogen, Nitrate + Nitrite		x				x		
Nitrogen, Nitrite		x				x		
Nitrate (by difference)		x				x		
Petroleum Hydrocarbons	x	x	x		x	x	x	
Phosphorus		x				x		
Sulfate		x				x		
Total Organic Carbon	x	x	x	x	x	x	x	x
pH		x		x		x		x
As(III) / As(V) Speciation		x				x		
Metals[1]	x	x	x	x	x	x	x	x

Analyte and Phase	Bench Test Phase				
	Soil Columns	Autoclave Tests			
	Soil	Soil	Water	Silica Gel	Carbon
Volatile Organic Compounds	x	x	x	x	x
Semivolatile Organic Compounds	x	x	x	x	x
Percent Solids					
Hexavalent Chromium					
Ferrous Iron					
Nitrogen, Nitrate + Nitrite					
Nitrogen, Nitrite					
Nitrate (by difference)					
Petroleum Hydrocarbons					
Phosphorus					
Sulfate					
Total Organic Carbon					
pH					
As(III) / As(V) Speciation					
Metals[1]					

[1]Metals = arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, silver, thallium

3.3. Laboratory Methods

3.3.1. Analytical Laboratory Methods

All of the laboratory analytical samples except the arsenic speciation samples were submitted to Accutest Laboratories (Dayton, New Jersey). The arsenic speciation samples were submitted to Applied Speciation and Consulting, LLC (Tukwila, Washington). The analytes and analytical methods utilized are summarized in Table 3-2.

Table 3-2. Laboratory Analytical Methods

Analyte	Method	Laboratory
Soil		
Volatile Organic Compounds	SW-846 8260b	Accutest
Semivolatile Organic Compounds	SW-846 8270c	Accutest
Percent Solids	EPA 160.3 M	Accutest
Petroleum Hydrocarbons	EPA 418.1 M	Accutest
Total Organic Carbon	SW-846 9060 M	Accutest
Mercury	SW-846 7471A	Accutest
Other Metals[1] (except mercury)	SW-846 6010B	Accutest
Water		
Volatile Organic Compounds	SW-846 8260b	Accutest
Semivolatile Organic Compounds	SW-846 8270c	Accutest
Nitrogen, Nitrate + Nitrite	EPA 353.2	Accutest
Nitrogen, Nitrite	SM 19 4500NO2B	Accutest
Nitrogen, Nitrate	By difference	Accutest
Petroleum Hydrocarbons	EPA 418.1	Accutest
Phosphorus, Total	EPA 365.3	Accutest
Sulfate	EPA 300 / SW-846 9056	Accutest
Total Organic Carbon	EPA 415.1 / SW-846 9060 M / SW-846 5310B	Accutest
pH	EPA 150.1	Accutest
Chromium, Hexavalent	SW-846 7196A	Accutest
Iron, Ferrous	SM 18 3500FED	Accutest
As(III) / As(V) Speciation	Proprietary IC-ICPMS Method	Applied Speciation
Arsenic	SW-846 6020	Accutest
Mercury	SW-846 7470A	Accutest
Other Metals[1]	SW-846 6010B	Accutest

[1]Metals = arsenic, barium, cadmium, chromium, iron, lead, manganese, mercury, selenium, silver, thallium

3.3.2. Soil Buffering Tests

Soil buffering tests were performed to determine the amount of acid and the amount of base that would need to be added to the slurries to achieve a pH less than 4 and a pH greater than 11, respectively. An acidic pH is optimal for Fenton's reagent oxidation, while a basic pH is required for base-catalyzed persulfate oxidation. For the acid buffering tests, a 50% solids slurry was prepared in a 100-mL Pyrex beaker using 50 g of soil and 50 mL of groundwater. The baseline pH and iron concentration were measured with a calibrated pH meter and a field test kit, respectively. A 0.5-mL aliquot of 10% sulfuric acid was added and the slurry was mixed for five minutes. For all three samples, the resulting slurry pH was less than the target pH of 4.0. The pH was then measured periodically over a three-hour period to evaluate pH buffering, and the iron concentration was determined after four hours of reaction. The experiment was conducted in triplicate for each of the three samples.

For the base buffering tests, a 50% solids slurry was prepared in a 250-mL Pyrex beaker using 150 g of soil and 150 mL of groundwater. A larger volume was utilized for the base tests to increase volume and simplify pH measurement, because the high pH resulted in disaggregation and "fluffing" of the soil in the P-1 sample. The baseline pH was measured with a calibrated pH meter. Aliquots of 10% sodium hydroxide ranging from 0.1 to 2.0 mL were added periodically; the slurry was mixed for five minutes and then allowed to settle for two minutes. The pH was then measured after each addition. The additions continued until the slurry pH was greater than 11.

3.3.3. Hydrogen Peroxide Reactivity Tests

The hydrogen peroxide reactivity test is conducted to evaluate if transition metals (primarily iron) from the soil and/or groundwater released into the acidified slurry samples is sufficient to initiate and sustain a reaction with dilute hydrogen peroxide. This test is performed by adding hydrogen peroxide to the acidified samples, and then visually inspecting for evidence of reaction (effervescence generated by peroxide decomposition) while measuring peroxide and iron concentrations, pH, temperature and PID headspace readings. As the reaction occurs, if iron decreases then the catalyst may require the addition of iron for a field application; similarly, a rapid reaction indicated by high temperatures and effervescence indicates that sufficient natural iron is present and stabilizers may be required in the catalyst formulation. For each test, a 50% solids soil slurry was prepared with 50 g of soil and 50 mL of groundwater. The slurries were acidified with 0.5 mL of 10% sulfuric acid, and then 5 mL of 35% H_2O_2 was added. The extent of reaction was observed and recorded. A second test was set up identically, except that 0.35 g of ferrous sulfate was also added to assess reactivity and compare with the reactor that did not receive additional iron.

3.3.4. Slurry Oxidation Tests

Slurry oxidation tests were performed to evaluate contaminant destruction and to assess potential effects of the oxidative treatment on other chemical parameters, such as arsenic concentration. Oxidation tests were performed at oxidant: contaminant mass ratios of 10:1, 20:1, and 40:1. Developing test conditions for the reactors to ensure that the results would be comparable among the slurries was difficult due to the overall high relative contaminant concentrations and large differences in the contaminant concentrations among the samples. This required balancing the oxidant requirements, sample size requirements for the planned analytes, differing buffering capacity of the soils, and the maximum 4-L volume of the reactors. It was not possible to balance every parameter among every test while still maintaining reasonable sample volumes. Therefore the volumes of soil and groundwater were adjusted among the tests, while still maintaining the desired oxidant: contaminant mass ratios. In order to provide sufficient liquid volume for all of the tests required for the 20:1 sample, two identical reactors were required for the 20:1 sample for each oxidant. The test conditions are summarized in Table 3-3 for the Fenton's reagent slurries and Table 3-4 for the persulfate slurries.

For the Fenton's reagent slurries (Table 3-3), the total VOC and SVOC masses were taken from the baseline sample results (see Section 4). The VOC and SVOC concentrations included the tentatively-identified compounds (TICs). The VOC and SVOC concentrations, along with the volume of groundwater and the mass of soil, were utilized to determine the total contaminant mass in the reactor. The oxidant mass equivalent to the 10:1, 20:1, and 40:1 oxidant: contaminant mass ratios were calculated, and then converted to mass of diluted peroxide. The catalyst solution was utilized to adjust pH and iron concentration as well as dilute the peroxide in order to maintain reasonable sample volumes. The volume of groundwater, mass of soil, and concentration of the oxidant solution were optimized so that the total volume of groundwater, oxidant solution, and soil did not exceed the 4-L capacity of the reactors. The concentration of peroxide was adjusted among the different dosages for a sample in order to maintain a constant volume in the reactor.

For the persulfate slurries (Table 3-4), the total VOC and SVOC masses were calculated as in Table 3-3. The oxidant mass was calculated as solid sodium persulfate; solid sodium persulfate was added to the reactors and allowed to dissolve (rather than adding the persulfate as a concentrated solution) in order to maintain reasonable total volumes. Next, the mass of solid sodium hydroxide (NaOH) necessary to establish a pH greater than 11 (see Section 3.3.2) and also to balance the acidity of the sodium persulfate (stoichiometric requirement is 2 moles of NaOH per 1 mole of persulfate) was calculated for each test. The volume of groundwater and mass of soil utilized were adjusted so that the total volume of groundwater was sufficient to dissolve the oxidant and NaOH, provide sufficient sample volume for the analytical tests, and so that the total volume did not exceed the 4-L capacity of the reactors.

Reactors consisted of 4-L HDPE bottles, which were continuously mixed and lightly sealed during the oxidant additions. The reactors could not be completely sealed due to the offgases (primarily carbon dioxide and oxygen) produced by the oxidation reactions (autoclave tests were performed separately to evaluate volatilization; see Section 3.3.6). The required volumes of soil and water were added to the reactor. The liquid pH was adjusted to less than 4 (for the Fenton's reagent tests) or greater than 11 (for the persulfate tests) by addition of sulfuric acid and NaOH, respectively. The oxidant was then added periodically while continuously mixing the reactors. The oxidant was added slowly enough to avoid excessive heat generation in the reactors. Liquids in the reactors were periodically tested for pH to ensure conditions remained optimal for each oxidant. After the oxidant additions were complete, the reactors were allowed to continue mixing until the oxidant was consumed, which was determined with peroxide test strips (for Fenton's reagent) and permanganate addition (for persulfate). Samples were then collected and submitted to analytical laboratories as summarized in Tables 3-1 and 3-2.

Table 3-3. Fenton's Reagent Slurry Test Conditions

	Baseline VOCs and SVOCs			
P-1	Water (ug/L)	Soil (ug/kg)		
Total VOCs (including TICs)	19,864	117,756		
Total SVOCs (including TICs)	12,010	205,382		
Total	31,873	323,138		
Liters of groundwater =	2.5			
Kilos of soil =	1.0			
Total VOC + SVOC mass =	0.40	grams VOC + SVOC		
10:1 ratio =	4.0	grams of H_2O_2 =	115.1	grams 3.5% H_2O_2
20:1 ratio =	8.1	grams of H_2O_2 =	115.1	grams 7% H_2O_2
40:1 ratio =	16.1	grams of H_2O_2 =	115.1	grams 14% H_2O_2
	Baseline VOCs and SVOCs			
SS-1	Water (ug/L)	Soil (ug/kg)		
Total VOCs (including TICs)	34,401	3,613,700		
Total SVOCs (including TICs)	32,969	67,961,200		
Total	67,370	71,574,900		
Liters of groundwater =	0.40			
Kilos of soil =	0.40			
Total VOC + SVOC mass =	28.66	grams VOC + SVOC		
10:1 ratio =	287	grams of H_2O_2 =	3,275	grams 8.75% H_2O_2
20:1 ratio =	573	grams of H_2O_2 =	3,275	grams 17.5% H_2O_2
40:1 ratio =	1,146	grams of H_2O_2 =	3,275	grams 35% H_2O_2
	Baseline VOCs and SVOCs			
SS-2	Water (ug/L)	Soil (ug/kg)		
Total VOCs (including TICs)	22,538	5,119,600		
Total SVOCs (including TICs)	10,465	28,780,490		
Total	33,003	33,900,090		
Liters of groundwater =	0.72			
Kilos of soil =	0.72			
Total VOC + SVOC mass =	24.43	grams VOC + SVOC		
10:1 ratio =	244	grams of H_2O_2 =	2,792	grams 8.75% H_2O_2
20:1 ratio =	489	grams of H_2O_2 =	2,792	grams 17.5% H_2O_2
40:1 ratio =	977	grams of H_2O_2 =	2,792	grams 35% H_2O_2

Table 3-4. Persulfate Slurry Test Conditions

	Baseline VOCs and SVOCs	
P-1	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	31,873	323,138
Liters of groundwater =	1.50	
Kilos of soil =	1.50	
Total VOC + SVOC mass =	0.53	grams VOC + SVOC
Persulfate Demand		
10:1 ratio =	5.3	g sodium persulfate
20:1 ratio =	10.7	g sodium persulfate
40:1 ratio =	21.3	g sodium persulfate
NaOH Demand - 5.0 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	8	g NaOH
Sodium Persulfate at 10:1 ratio =	1.8	g NaOH
Sodium Persulfate at 20:1 ratio =	3.6	g NaOH
Sodium Persulfate at 40:1 ratio =	7.2	g NaOH
Total NaOH =	20.0	g

	Baseline VOCs and SVOCs	
SS-1	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	67,370	71,574,900
Liters of groundwater =	1.50	
Kilos of soil =	0.50	
Total VOC + SVOC mass =	35.89	grams VOC + SVOC
Persulfate Demand		
10:1 ratio =	358.9	g sodium persulfate
20:1 ratio =	717.8	g sodium persulfate
40:1 ratio =	1,435.5	g sodium persulfate
NaOH Demand - 1.6 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	0.8	g NaOH
Sodium Persulfate at 10:1 ratio =	120.6	g NaOH
Sodium Persulfate at 20:1 ratio =	241.2	g NaOH
Sodium Persulfate at 40:1 ratio =	482.3	g NaOH
Total NaOH =	844.9	g

	Baseline VOCs and SVOCs	
SS-2	Water (ug/L)	Soil (ug/kg)
Total VOCs + SVOCs (incl. TICs)	33,003	33,900,090
Liters of groundwater =	1.50	
Kilos of soil =	0.50	
Total VOC + SVOC mass =	17.00	grams of organics
Persulfate Demand		
10:1 ratio =	170.0	g sodium persulfate
20:1 ratio =	340.0	g sodium persulfate
40:1 ratio =	680.0	g sodium persulfate
NaOH Demand - 1.7 g NaOH per kg soil + 2 moles NaOH per 1 mol persulfate		
Soil =	0.9	g NaOH
Sodium Persulfate at 10:1 ratio =	57.1	g NaOH
Sodium Persulfate at 20:1 ratio =	114.2	g NaOH
Sodium Persulfate at 40:1 ratio =	228.5	g NaOH
Total NaOH =	400.7	g

3.3.5. Soil Column (Residual Saturation) Tests

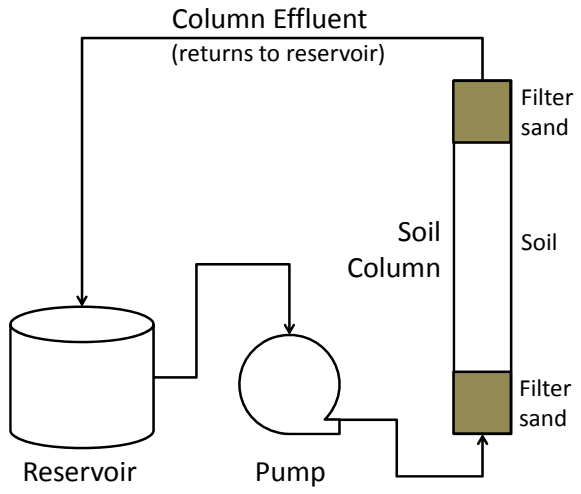
Soil column experiments were performed to evaluate NAPL destruction as an oxidant solution is passed through a soil column, and to evaluate the potential mobility of the NAPL during oxidation. One column test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. A schematic of the soil column apparatus is provided in Figure 3-1. The columns are cylindrical, constructed of polycarbonate, and have an inside diameter of 3.7 cm and length of 30 cm. Each column was filled with 180 grams of soil from SS-1, with a layer of filter sand pack at each end of the column to prevent clogging of the pump system. A chemical metering pump was utilized to flush oxidant solution through the column. Influent to the column was at the base to minimize air entrapment, and effluent from the column recycled back to an oxidant reservoir.

For the Fenton's reagent test, one liter of an acidic catalyst solution was prepared and cycled through the column until the pH of the column effluent was less than 4, to establish the acidic conditions optimal for Fenton's reagent. Concentrated (35%) hydrogen peroxide was then added to this reservoir to achieve a concentration of approximately 1% H_2O_2. The oxidative solution was cycled through the column until the hydrogen peroxide concentration decreased to less than 0.1%, at which time the reservoir was replenished with 35% H_2O_2. The columns were allowed to recirculate overnight and the H_2O_2 was completely expended each morning, at which time the solution was replaced with fresh oxidant solution. A total of 736 g of 35% H_2O_2 was used, equivalent to a 20:1 mass ratio of oxidant: contaminant. Pumping rates generally ranged from approximately 5 to 15 mL per minute. The range in flow-through rates was due to offgases from the oxidation reaction. Gas bubbles formed in the column, periodically reducing flow through the column. The flow rate increased once the gas bubbles cleared.

For the persulfate column, a 5% solution of sodium persulfate was prepared. The total volume of this stock solution (20:1 mass ratio of oxidant: contaminant) was 5.2 L, which was divided into two aliquots of 2.6 L each. The pH was adjusted to 11 with potassium hydroxide, and then one aliquot of the stock solution was recycled continuously through the column for three days. The solution was then replaced with the second aliquot, which was then recycled for three additional days. Pumping rates were approximately 15 mL per minute.

Visual observations of the presence or absence of NAPL, including photographs, were collected at approximately one-hour intervals for both columns. After operating the columns for one week (sufficient for consumption of the oxidant), soil samples were collected for VOC and SVOC analysis.

Figure 3-1. Soil Column Schematic

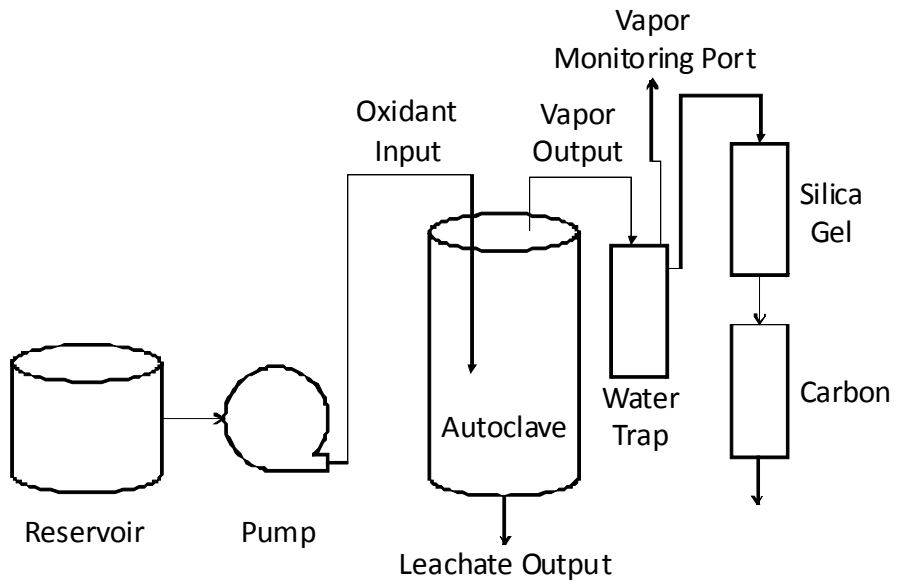


3.3.6. Autoclave Tests

Autoclave tests were conducted to provide a completely closed system and to allow quantification of volatile loss as a component of the mass balance. The autoclaves are sealed vessels in which all inputs and outputs, as well as temperature and pressure, are controlled (Figure 3-2). Offgas from the oxidation reaction is vented with a pressure-relief check valve, through a water trap (to remove liquid water in the vent line), then through silica gel (to trap water vapor) and carbon (to trap VOCs in the offgas). A vapor monitoring port on the water trap allows measurement of carbon dioxide, oxygen, and photoionization detector readings during the test to monitor progress.

The tests were performed with the SS-1 soil using a 20:1 ratio of oxidant: contaminant mass. The autoclaves were loaded with 300 g of soil. The silica gel trap contained 180 g of silica gel, and the carbon trap contained 140 g of activated carbon. For the Fenton's reagent test, an initial charge of 300 mL of acidic catalyst solution was added to the autoclave. A total of 1,227 g of 35% H_2O_2 (equivalent to 20 times the VOC and SVOC mass) was added incrementally, typically at a rate of 5-10 mL per addition in 15 to 30 minute intervals, to control the rate of offgassing and temperature. For the persulfate test, a solution of 429.4 g of sodium persulfate was dissolved in 1.5 L of water (28.6 weight percent solution), and 1 mL of 45% potassium hydroxide was added to adjust pH to greater than 11. This solution was then injected at a rate of 5-10 mL per addition in 15 to 30 minute intervals. Both autoclaves were gently mixed on an orbital shaker table to displace gas bubbles. Offgas measurements were collected at approximately one-hour intervals. At the conclusion of the experiment (seven days), samples of the treated soil, leachate, silica gel, and carbon were collected for analysis of VOCs and SVOCs.

Figure 3-2. Autoclave Schematic



4. Results and Discussion

All laboratory analytical data are summarized in Tables 4-1 through 4-3 (included in the appendix).

4.1. Baseline Soil and Groundwater Conditions

The VOCs and SVOCs detected and their relative concentrations in the baseline samples were consistent with the expected sample conditions. The most heavily impacted sample is from the SS-1 location (Table 4-1). Visible, separate-phase NAPL was present in the SS-1 sample. The total VOC and SVOC concentrations in SS-1 soil were 662,700 ug/kg and 64,769,200 ug/kg, respectively, and in groundwater the VOC and SVOC concentrations were 11,501 ug/L and 29,802 ug/L, respectively. Sample SS-2 was also heavily impacted with contaminant residuals (Table 4-2), but there was no apparent, separate-phase NAPL observed in the sample. Sample SS-2 yielded soil VOC and SVOC concentrations of 873,600 ug/kg and 34,062,890 ug/kg, respectively, and groundwater VOC and SVOC concentrations of 5,221 ug/L and 7,706 ug/L, respectively. Sample P-1 (Table 4-3) was the least impacted of the three samples. Sample P-1 yielded soil VOC and SVOC concentrations of 32,456 ug/kg and 129,182 ug/kg, respectively, and groundwater VOC and SVOC concentrations of 6,614 ug/L and 7,805 ug/L, respectively. The VOCs detected in all of the samples consisted of benzene, toluene, ethylbenzene, and xylenes (cumulatively referred to as BTEX), and isopropylbenzene. The primary SVOCs detected in the samples were PAHs consistent with coal tar, including naphthalene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene. The predominant TICs were generally non-target PAHs, primarily indene, indane, methylnaphthalenes, and methylphenols. Among the metals, the concentration of arsenic in groundwater from P-1 (13,500 ug/L) and SS-2 (342 ug/L) exceeded the Federal Maximum Contaminant Level (MCL) of 10 ug/L. Lead (92.4 ug/L) in the P-1 groundwater sample also exceeded the MCL of 15 ug/L. Sulfate concentrations exceeded Federal Secondary Water Quality Standard (WQS) of 250 mg/L in the baseline groundwater samples from SS-2 and P-1.

4.2. Soil Buffering and Reactivity Tests

4.2.1. Acid Soil Buffering Capacity

The acid buffering test results for SS-1, SS-2, and P-1 are summarized in Figures 4-1 through 4-3, respectively. Each sample was done in triplicate to assess variability, which was found to be negligible. Addition of 0.5 mL of 10% sulfuric acid initially lowered pH to approximately 1 in all three slurries, thus further additions were unnecessary and the test was modified to evaluate pH buffering and rebound over time. Over a three-hour period after the initial additions, the pH in all three samples rebounded to approximately 3. Fenton's reagent oxidation is favored at acidic pH ranges in order to maintain iron in solution and to eliminate bicarbonate scavenging. The acid buffering capacity tests indicate that the three soil samples do not have a significant amount of carbonate solids, which react with and consume the acid and thus inhibit the acidic pH conditions optimal for Fenton's reagent treatment.

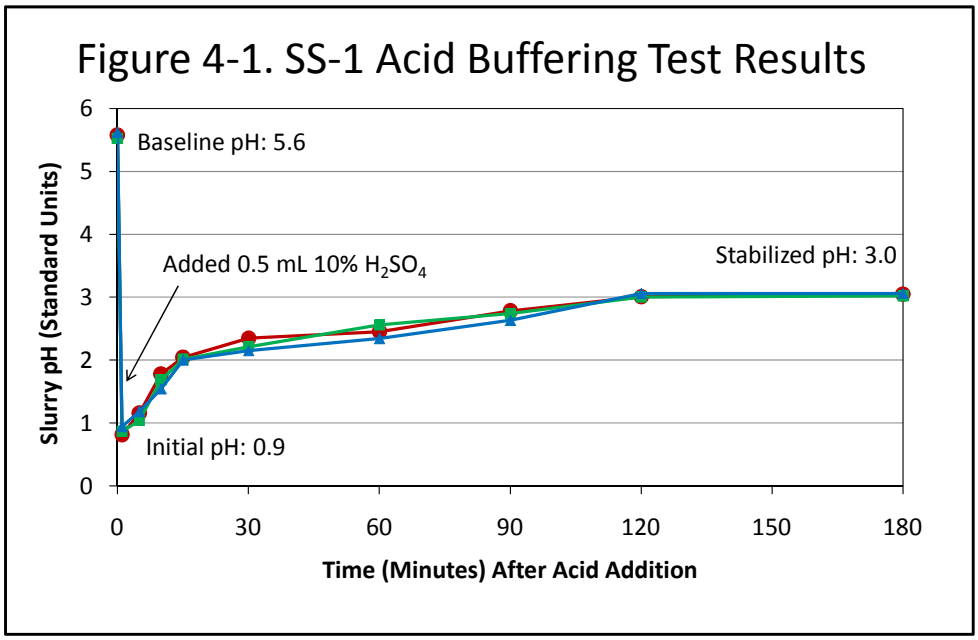


Figure 4-1. SS-1 Acid Buffering Test Results
Baseline pH: 5.6
Added 0.5 mL 10% H_2SO_4
Stabilized pH: 3.0
Initial pH: 0.9
Slurry pH (Standard Units)
Time (Minutes) After Acid Addition
0
1
2
3
4
5
6
0
30
60
90
120
150
180

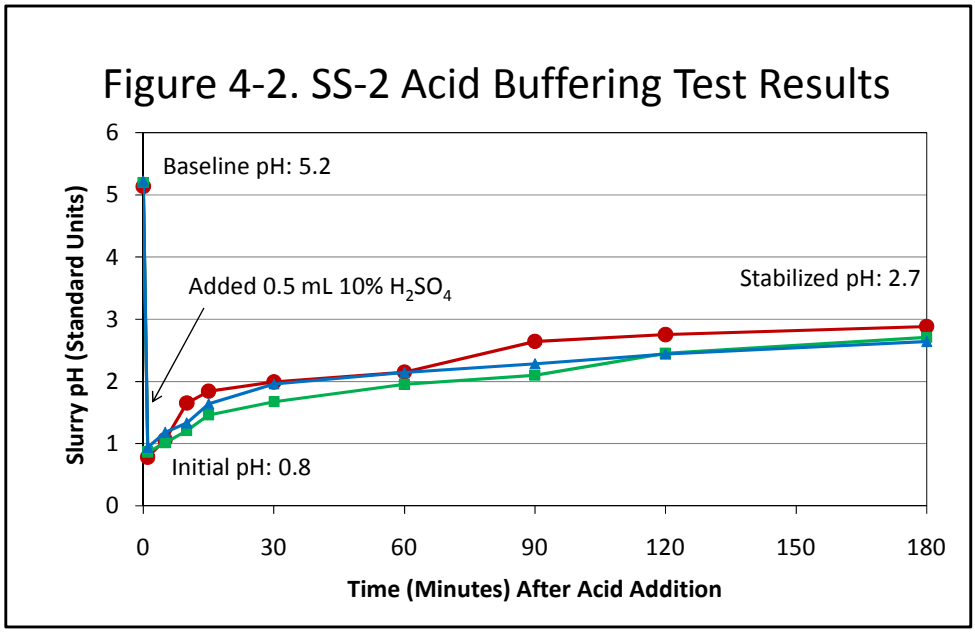
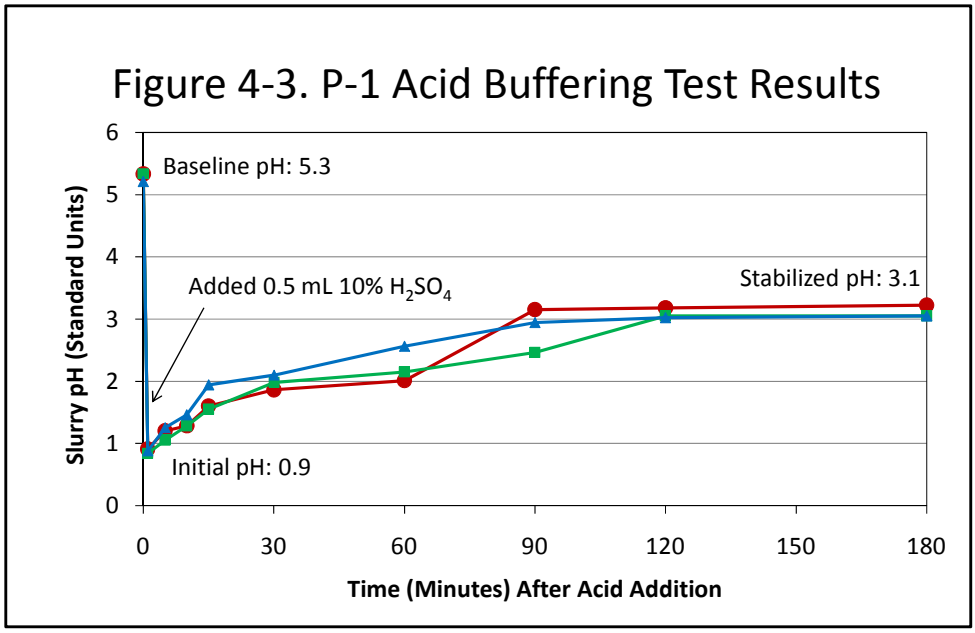
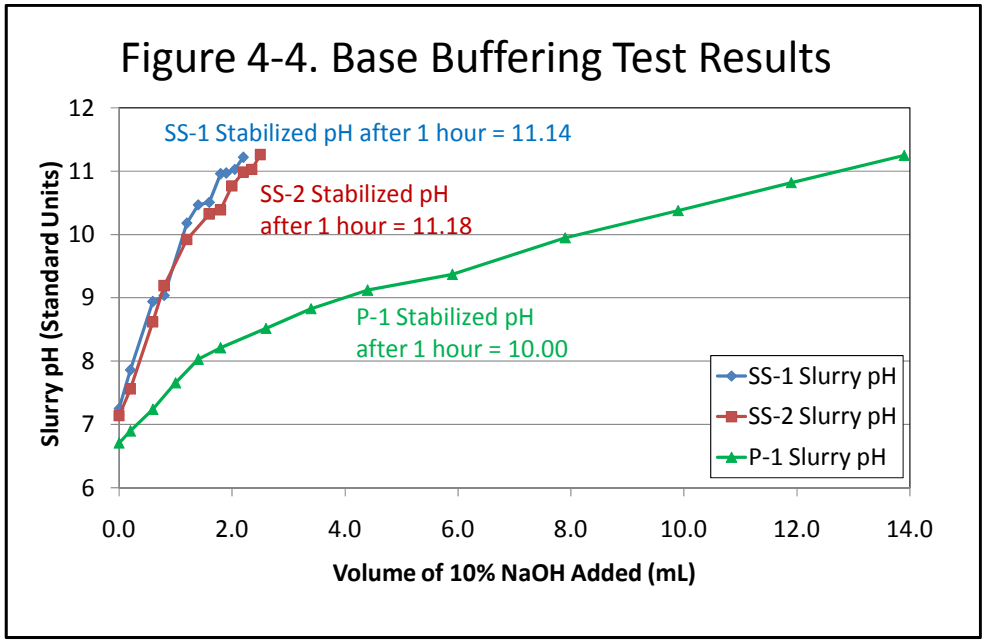


Figure 4-2. SS-2 Acid Buffering Test Results
Baseline pH: 5.2
Added 0.5 mL 10% H_2SO_4
Stabilized pH: 2.7
Initial pH: 0.8
Slurry pH (Standard Units)
Time (Minutes) After Acid Addition
0
1
2
3
4
5
6
0
30
60
90
120
150
180



4.2.2. Base Soil Buffering Capacity

The base buffering test results for SS-1, SS-2, and P-1 are summarized in Figure 4-4. The acid buffering capacity tests performed in triplicate indicated little variability within samples, so only one aliquot was done for each sample for the base tests. In contrast to the acid buffering tests, the initial additions did not increase the slurry pH to the target levels, so incremental reagent additions continued until pH was stable above 11. Addition of 2.0-2.5 mL of 10% sodium hydroxide raised pH to greater than 11 in SS-1 and SS-2, and over the course of one hour after the last addition the pH remained stable at greater than 11. In contrast, P-1 required 14 mL of sodium hydroxide solution to raise the pH to greater than 11, and over the course of one hour after the last addition the pH dropped to approximately 10. This indicates that the SS-1 and SS-2 have little buffering capacity with respect to base addition, while the P-1 sample has high buffering capacity with respect to base addition. Because sample P-1 exhibited relatively little acid buffering capacity (Figure 4-3), the high base buffering capacity (Figure 3-4) for this sample may be due to organic acids associated with the peat matrix in this sample. The amount of base needed to establish a pH greater than 11 was calculated as grams of solid NaOH per kilogram of soil from the buffering tests for each of the three samples, and was then utilized as part of the NaOH demand for the catalyzed persulfate oxidation tests (Table 3-4).



4.3. Peroxide Reactivity Tests

The peroxide reactivity test results are presented in Figures 4-5 through 4-7. All three samples yielded evidence of good reaction without any additional iron amendment, based upon temperature elevations of 13-16 ˚F and PID readings reduced by 57-82% over two hours during the experiment (compare the data series with filled markers in Figures 4-5 through 4-7). Effervescence was evident, also indicating a reaction was occurring. The reaction was enhanced, however, by addition of 0.35 g of ferrous sulfate. The iron addition resulted in a temperature increase of approximately 28-29˚F and a 91-99% decrease in the PID readings (compare the data series with unfilled markers in Figures 4-5 through 4-7). Overall, these results indicated that a mild reaction can be maintained by native iron released by the increased acidity associated with a Fenton's reagent treatment. Iron addition can be expected to result in a more rapid reaction.

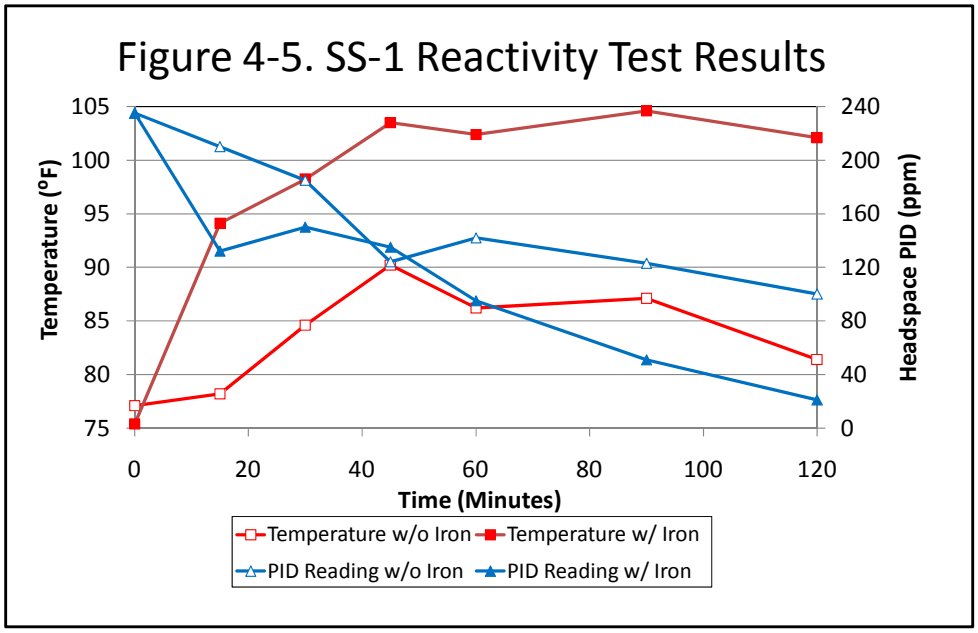


Figure 4-5. SS-1 Reactivity Test Results
Temperature (ºF)
105
100
95
90
85
80
75
Headspace PID (ppm)
240
200
160
120
80
40
0
0
20
40
60
80
100
120
Time (Minutes)
Temperature w/o Iron
Temperature w/ Iron
PID Reading w/o Iron
PID Reading w/ Iron

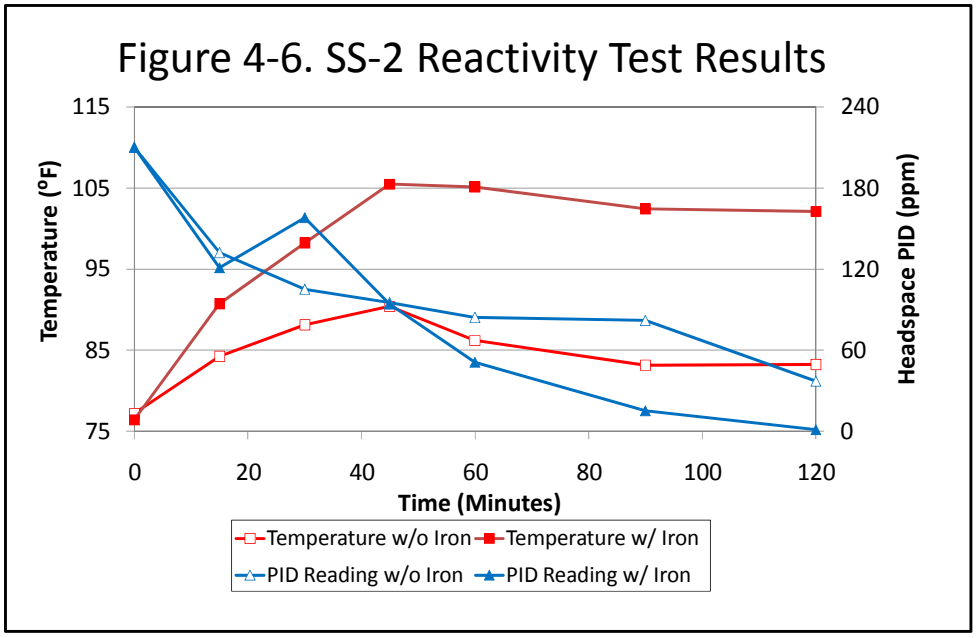
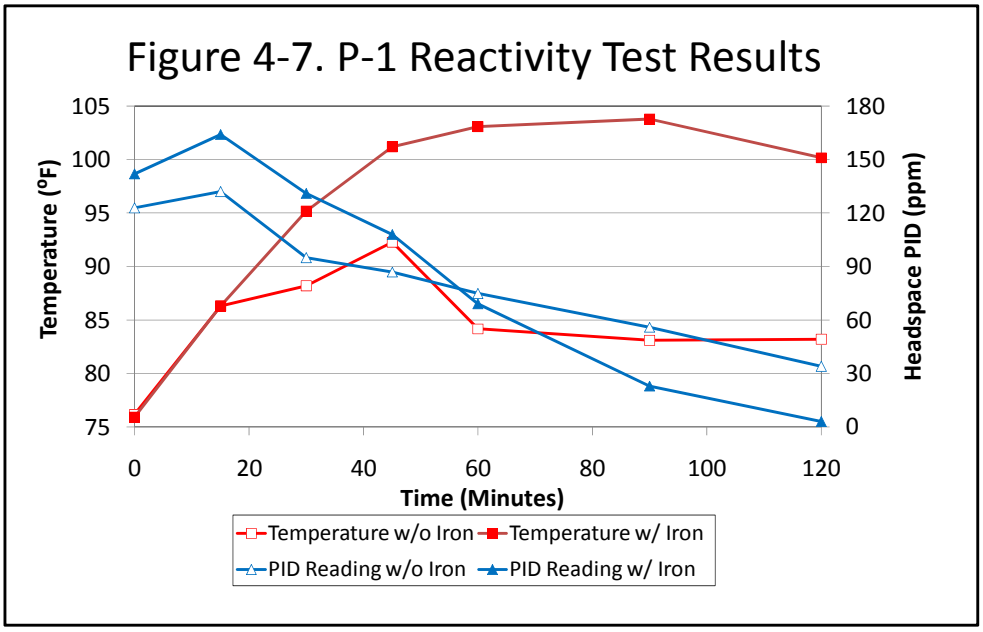


Figure 4-6. SS-2 Reactivity Test Results
Temperature (ºF)
115
105
95
85
75
Headspace PID (ppm)
240
180
120
60
0
0
20
40
60
80
100
120
Time (Minutes)
Temperature w/o Iron
Temperature w/ Iron
PID Reading w/o Iron
PID Reading w/ Iron



4.4. Slurry Oxidation Tests

The laboratory analytical data for the slurry test results are tabulated in Tables 4-1 through 4-3. In the following sections, the results for the Fenton's reagent slurries are discussed first, followed by a discussion of the persulfate slurries. The relative performance of the oxidants is discussed in Section 5. For each oxidant and sample, charts are presented to illustrate the results in terms of soil concentrations, water concentrations, and contaminant mass for each dosage, and oxidation efficiency (percent destruction) as a function of formula weight for the 40:1 experiments.

Persulfate is generally considered to be more stable and have a longer lifetime in the subsurface than Fenton's reagent. Thus an expectation is that the persulfate slurries require a longer period of time to allow the oxidant to be consumed. In the case of the slurry tests conducted for this bench test, the amount of time required for both the Fenton's reagent slurries and the persulfate slurries was very similar. This is because the persulfate oxidant could all be added in a very short period of time (within an hour) and allowed to react for several days due to the slower overall reaction rate of the persulfate. However the oxidant addition for the Fenton's tests must be conducted much more slowly due to the more rapid reaction, in order to control heat production and to allow for efficient oxidant consumption. Thus the overall duration of the slurry experiments was very similar for both the persulfate and Fenton's reagent slurries.

4.4.1. Fenton's Reagent Slurries

4.4.1.1. Sample SS-1

The results for the SS-1 sample are presented on Table 4-1 and in Figures 4-8 through 4-11. Percent reductions in contaminant mass were utilized to assess destruction. The percent reductions were calculated by determining total contaminant mass (sum of all of the sample phases) in the treated samples, relative to the baseline, as calculated in Table 3-3 for example. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 65-83% for the SVOCs, and 91-99.9% for the VOCs (Figure 4-8). In the aqueous phase of the slurries, the oxidation efficiency ranged from 95-99% for the SVOCs and from 93-99% for VOCs (Figure 4-9). In terms of overall contaminant mass, the oxidation efficiency ranged from 68-83% for the SVOCs and from 90-99.7% for the VOCs (Figure 4-10). All three charts of oxidation efficiency as a function of oxidant dosage (Figures 4-8 through 4-10) exhibit a pattern in which most of the oxidation occurs with the lowest oxidant dose (the 10:1 ratio). Additional oxidant results in greater oxidation, but there is an asymptotic pattern with lower contaminant mass destroyed per oxidant mass added.

The oxidation efficiency was also related to formula weight. The oxidation efficiency (percent mass reduction) was plotted as a function of the formula weight for the 40:1 test in Figure 4-11 (phenols are not plotted because they are formed as intermediate oxidation products). Benzene (formula weight 78.11) and pyrene (formula weight 202.26) are identified as representative low- and high-molecular weight compounds, respectively on Figure 4-11 and similar charts for other experiments (other compounds are shown on certain charts to identify outliers). At formula weights of approximately 160 or less, oxidation efficiency was nearly 100%. At formula weights above approximately 160, the oxidation efficiency generally decreased negatively in proportion to the formula weight. This is consistent with previous studies, which have also found that the higher molecular weight compounds are less susceptible to oxidation, due to a number of factors such as water solubility. A significant outlier in this general trend is acenaphthylene, which yielded anomalously low oxidation efficiency (46-63% with oxidant dosages between 10:1 and 40:1) in the SS-1 Fenton slurries.

The following potential intermediate compounds were observed: acetone, 2-butanone, phenol, 2-methylphenol, 3&4 methylphenol, and methyl acetate. None of these compounds have a Federal MCL. Acetone and 2-butanone were not detected in the baseline samples, but were detected at relatively low concentrations in the treated slurries. The maximum concentrations of acetone were 1,060 ug/kg in soil and 782 ug/L in water (for the 10:1 sample), and of 2-butanone were 30.6 ug/kg in soil (for the 40:1 sample) and non-detect in water (Table 4-1). Ketones are an oxidation product often detected in the treated slurries is not unusual. Other potential intermediate compounds include phenols. The concentration of phenol, 2-methylphenol, and 3&4-methylphenol do not exhibit an increasing concentration with greater oxidation (the concentration of 3&4-methyphenol increases in the 20:1 and

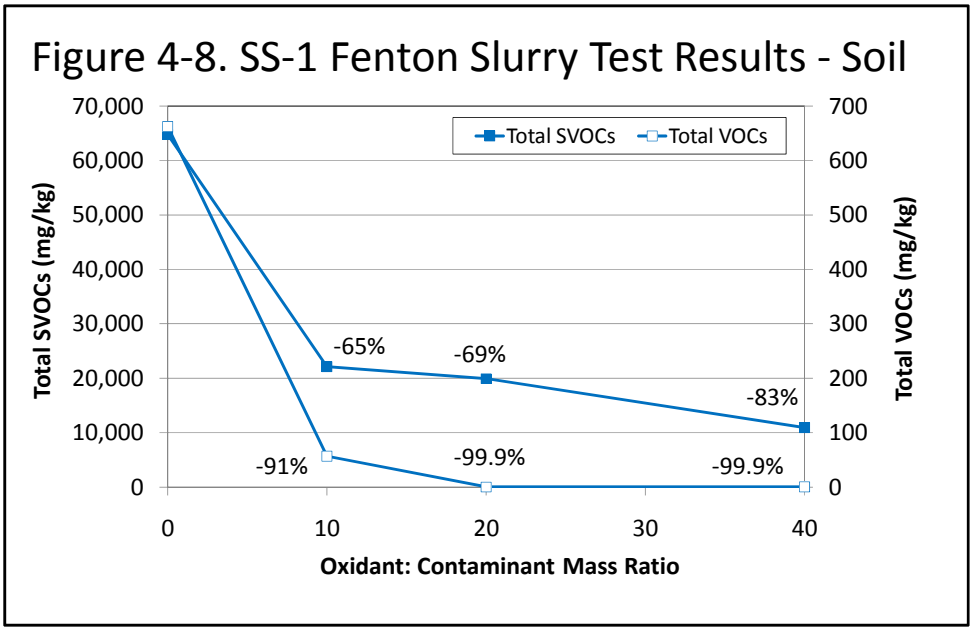


Figure 4-8. SS-1 Fenton Slurry Test Results - Soil
Total SVOCs
Total VOCs
Total SVOCs (mg/kg)
Total VOCs (mg/kg)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
700
600
500
400
300
200
100
0
-65%
-69%
-83%
-91%
-99.9%
-99.9%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

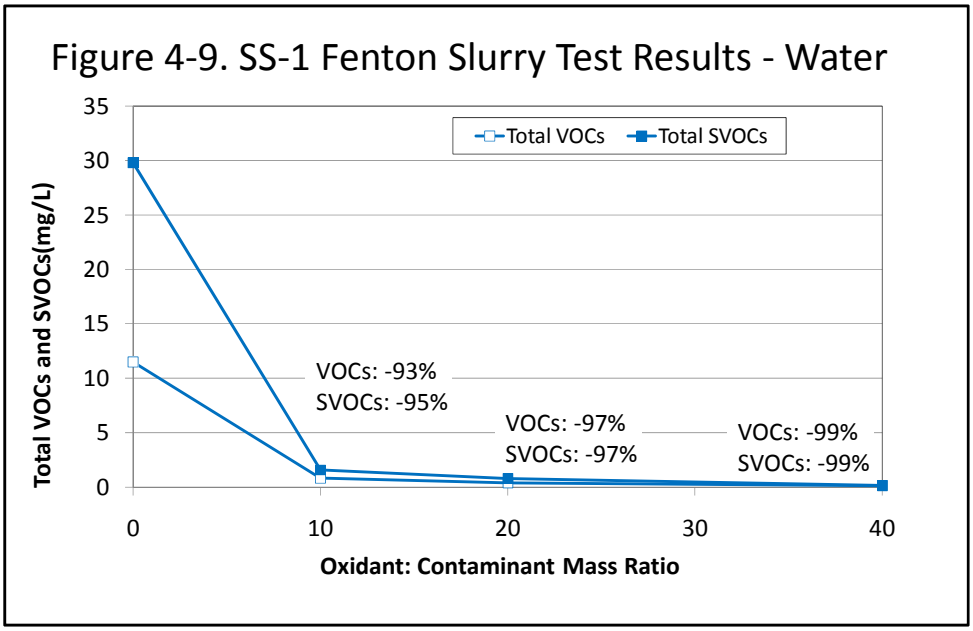


Figure 4-9. SS-1 Fenton Slurry Test Results - Water
Total VOCs
Total SVOCs
Total VOCs and SVOCs(mg/L)
35
30
25
20
15
10
5
0
VOCs: -93%
SVOCs: -95%
VOCs: -97%
SVOCs: -97%
VOCs: -99%
SVOCs: -99%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

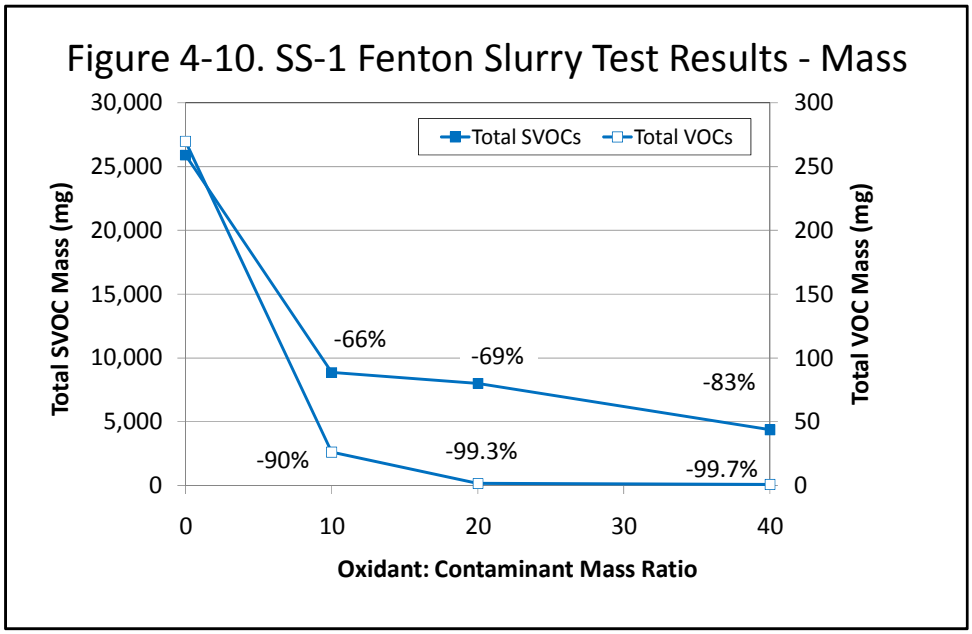


Figure 4-10. SS-1 Fenton Slurry Test Results - Mass
Total SVOCs
Total VOCs
Total SVOC Mass (mg)
Total VOC Mass (mg)
30,000
25,000
20,000
15,000
10,000
5,000
0
300
250
200
150
100
50
0
-66%
-69%
-83%
-90%
-99.3%
-99.7%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

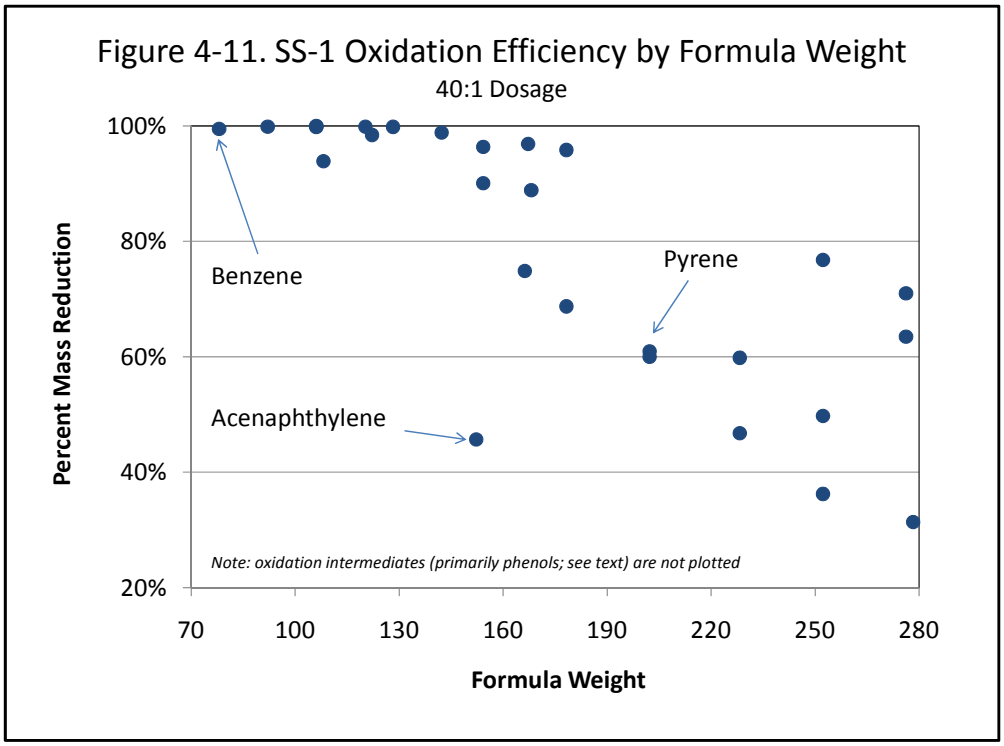


Figure 4-11. SS-1 Oxidation Efficiency by Formula Weight
40:1 Dosage
Percent Mass Reduction
100%
80%
60%
40%
20%
Benzene
Pyrene
Acenaphthylene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
70
100
130
160
190
220
250
280
Formula Weight

40:1 slurries, but the concentrations are very close to the detection limit of the baseline sample, thus it is not clear if the concentrations in the 20:1 and 40:1 slurries represent intermediate formation). Thus if these compounds are being formed, then in these tests the compounds were also being oxidized at a rate at least as fast as their formation. Methyl acetate was detected in the soil phase of the 10:1 slurry at 5,740 ug/kg, but not in the baseline (<2,300 ug/kg) or the other slurries (<38 ug/kg). This is discussed further with the results for SS-2 (Section 4.4.1.2).

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-1. Metals were analyzed in soil and groundwater in each sample and experiment. Ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water, as expected due to the use of an acidic catalyst solution containing ferrous sulfate. Chromium(VI) concentration increased from non-detectable (<0.010 mg/L) to 0.071 mg/L in the 20:1 sample (there is no Federal MCL for chromium(VI)). Arsenic concentration in the water samples increased from 20.6 ug/L in the baseline to a range between 459-590 ug/L. This most likely is due to acidification and leaching from the soil, because the soil concentrations decreased from 20.6 mg/kg in the baseline to a range from 14.9-16.1 mg/kg in the treated soil samples. Arsenic speciation analysis indicates that the arsenic in the treated sample was entirely in the oxidized As(V) valence state. All other metals also exhibited increases in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from non-detectable (<10 mg/L) to 1,710 mg/L, which exceeded the Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

4.4.1.2. Sample SS-2

The results for the SS-2 sample are provided in Table 4-2 and summarized in Figures 4-12 through 4-15. Overall oxidation efficiency in the soil samples ranged from 59-92% for the SVOCs, and 88-97% for the VOCs (Figure 4-12). In the aqueous phase of the slurries, oxidation efficiency ranged from 45-91% for the SVOCs and from 65-82% for VOCs (Figure 4-13). In terms of overall contaminant mass, the oxidation efficiency ranged from 59-92% for the SVOCs and from 87-96% for the VOCs (Figure 4-14). As observed with SS-1, oxidation efficiency as a function of oxidant dosage (Figures 4-12 through 4-14) exhibits an asymptotic pattern of less contaminant mass destroyed per oxidant mass added with increasing dosage.

The oxidation efficiency was also related to formula weight. Oxidation efficiency (percent mass reduction) was plotted as a function of formula weight for the 40:1 test in Figure 4-13. As observed with SS-1 (Figure 4-15), at formula weights of approximately 160 or less, oxidation efficiency was generally nearly 100% (benzene was slightly lower, at 88%). At formula weights above approximately 160, the oxidation efficiency generally decreased negatively in proportion to the formula weight. In contrast to the results for SS-1, acenaphthylene did not yield anomalously low oxidation efficiency in SS-2.

The following potential intermediate compounds were observed: acetone, 2-butanone, phenol, and methyl acetate. None of these compounds have a Federal MCL. As with SS-1, acetone and 2-butanone

Figure 4-12. SS-2 Fenton Slurry Test Results - Soil

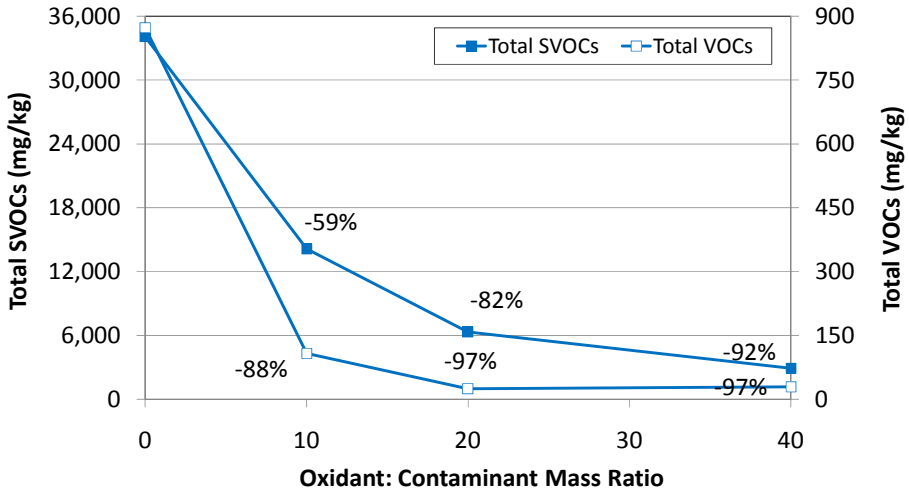
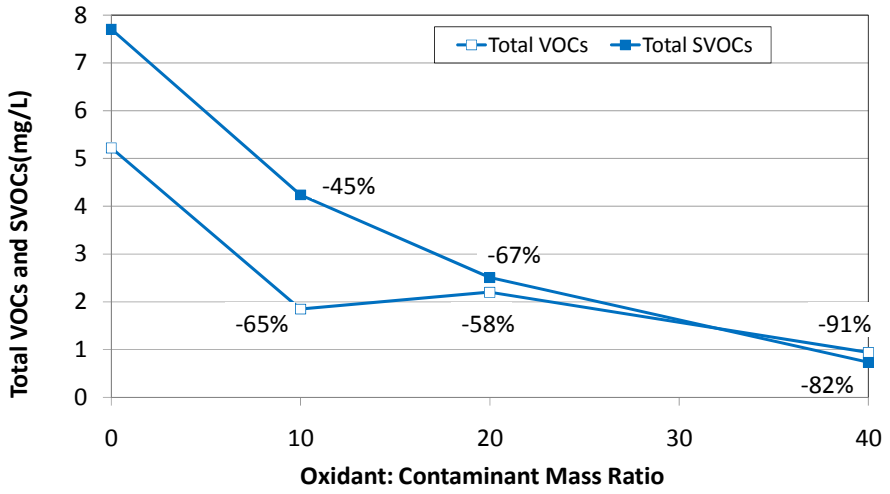


Figure 4-13. SS-2 Fenton Slurry Test Results - Water



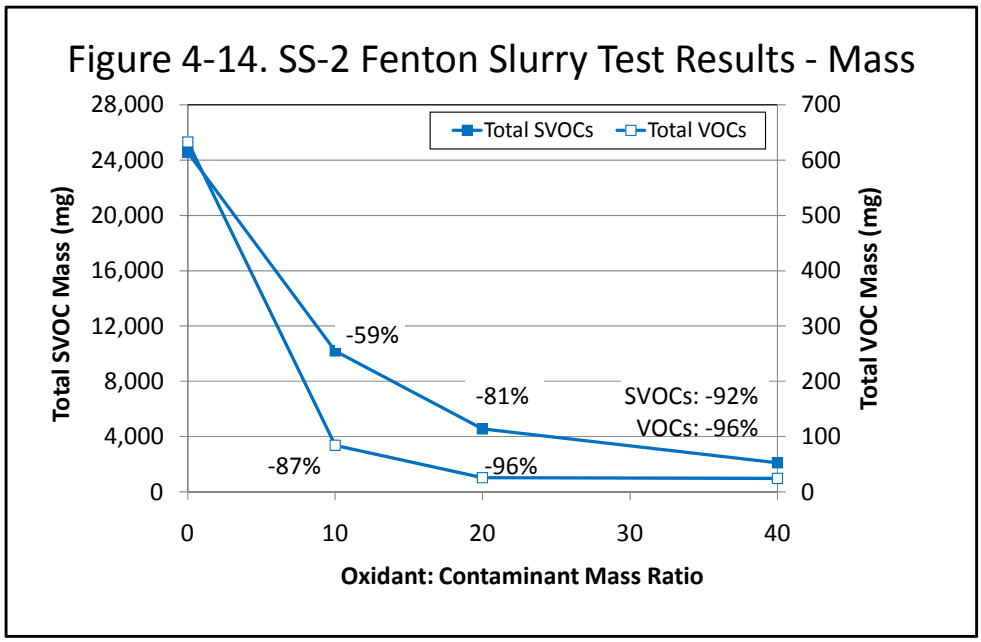


Figure 4-14. SS-2 Fenton Slurry Test Results - Mass
Total SVOCs
Total VOCs
Total SVOC Mass (mg)
Total VOC Mass (mg)
28,000
24,000
20,000
16,000
12,000
8,000
4,000
0
700
600
500
400
300
200
100
0
-59%
-81%
SVOCs: -92%
VOCs: -96%
-87%
-96%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

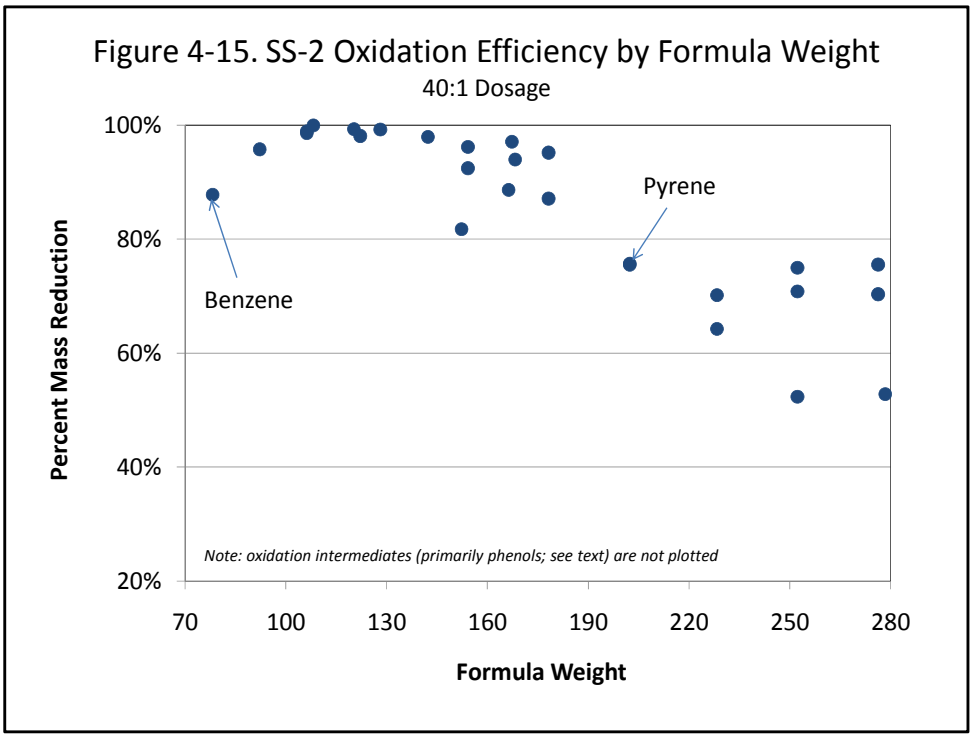


Figure 4-15. SS-2 Oxidation Efficiency by Formula Weight
40:1 Dosage
Percent Mass Reduction
100%
80%
60%
40%
20%
Pyrene
Benzene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
70
100
130
160
190
220
250
280
Formula Weight

were detected in the treated SS-2 slurries but were not detected in the baseline sample. Both compounds were detected only in the aqueous samples. The maximum concentrations detected were 2,100 ug/L for acetone and 42.8 ug/L for 2-butanone. Phenol was detected persistently in the treated samples at a concentration ranging from 18.8-52.3 ug/L in the aqueous phase, but was not detected in the baseline (<0.56 ug/L), indicating that formation as an intermediate product is possible. The concentrations of methylphenols decreased relative to their baseline, indicating that if they were formed then they were being oxidized at a rate faster than they were being formed.

The concentration of methyl acetate in the soil phase appears to have increased substantially relative to the baseline. Methyl acetate was not detected in the baseline (<2,600 ug/kg) or the 10:1 slurry (<14,000 ug/kg), but was detected at 6,420 ug/kg (estimated) in the 20:1 slurry and at 14,000 ug/kg in the 40:1 slurry. Methyl acetate was detected in the 10:1 slurry for sample SS-1. Methyl acetate is a known oxidation product of MTBE (Burbano et al., 2002; Carver and Brown, 2007), but MTBE is not detected at the site. It is possible that other methylated compounds could produce methyl acetate as an oxidation product, but this has not been reported previously in the literature. However in contrast to ketone intermediates, methyl acetate is susceptible to further oxidation.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. As expected and also observed in SS-1, the ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water. Chromium(VI) concentration increased from non-detectable (<0.010 mg/L) to 0.069 mg/L in the 20:1 sample. Arsenic concentration in the baseline water sample was 342 ug/L and increased in two of the three treated samples, to a range between 262-928 ug/L. The increased concentrations of arsenic are most likely is due to acidification and leaching from the soil. Arsenic speciation analysis indicates that the arsenic in the treated sample was primarily in the oxidized As(V) valence state (1,090 ug/L) relative to the reduced and more mobile As(III) state (6.53 ug/L). Barium, cadmium, total chromium, lead, manganese, and selenium also exhibited increases in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from 414 mg/L to 4,520 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

4.4.1.3. Sample P-1

The results for the P-1 sample are provided in Table 4-3 and Figures 4-16 through 4-19. Overall oxidation efficiency in the soil samples ranged from 75-95% for the SVOCs, and 90-95% for the VOCs (Figure 4-16). In the aqueous phase of the slurries, the oxidation efficiency was over 99% for the SVOCs and from 62-91% for VOCs (Figure 4-17). In terms of overall contaminant mass, the oxidation efficiency ranged from 78-96% for the SVOCs and from 81-94% for the VOCs (Figure 4-18). The VOC results indicate slightly higher concentrations in the 40:1 sample than in the 10:1 and 20:1 samples, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. All three charts of oxidation efficiency as a function of oxidant dosage (Figures 4-16 through 4-18) exhibit the

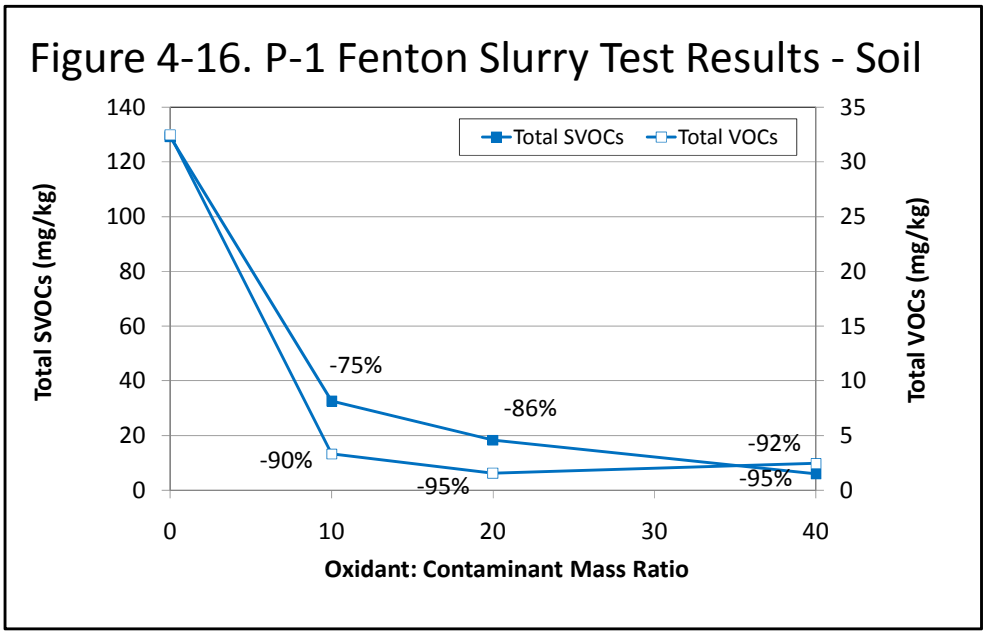


Figure 4-16. P-1 Fenton Slurry Test Results - Soil
Total SVOCs
Total VOCs
Total SVOCs (mg/kg)
Total VOCs (mg/kg)
140
120
100
80
60
40
20
0
35
30
25
20
15
10
5
0
-75%
-86%
-92%
-90%
-95%
-95%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

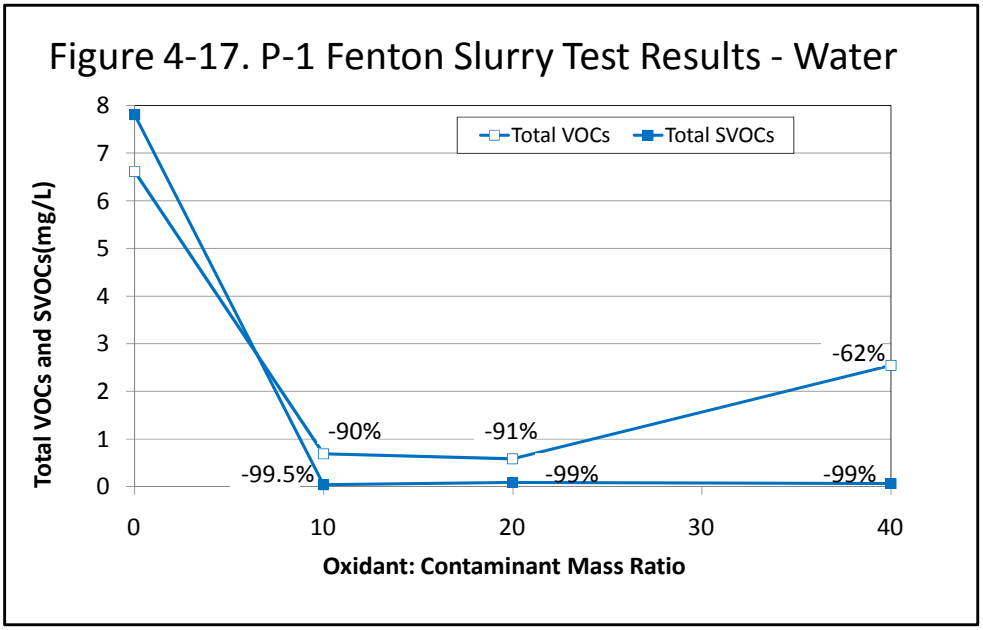


Figure 4-17. P-1 Fenton Slurry Test Results - Water
Total VOCs
Total SVOCs
Total VOCs and SVOCs(mg/L)
8
7
6
5
4
3
2
1
0
-62%
-90%
-91%
-99.5%
-99%
-99%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

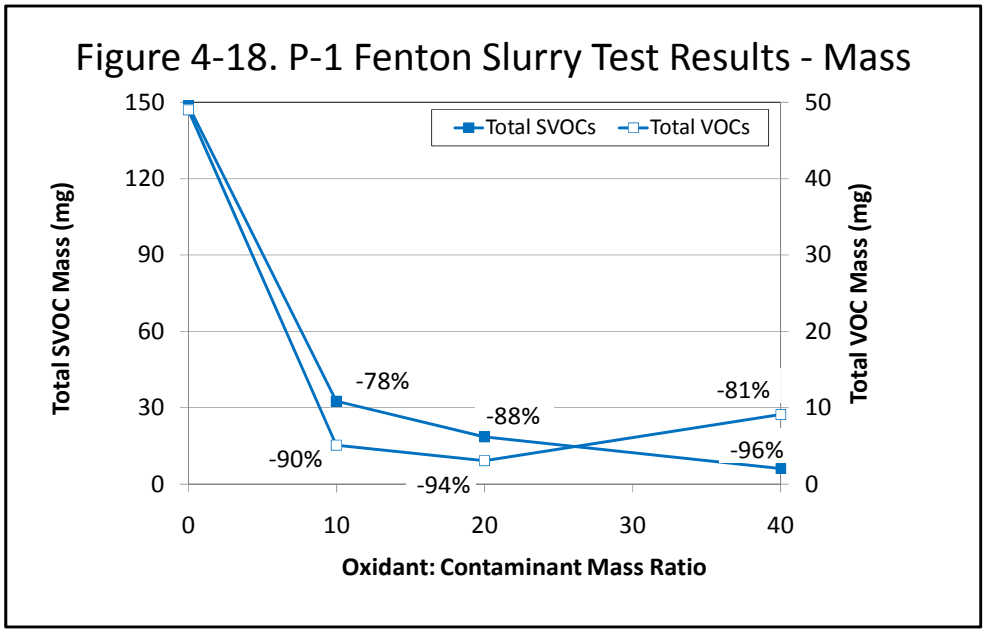


Figure 4-18. P-1 Fenton Slurry Test Results - Mass
Total SVOCs
Total VOCs
Total SVOC Mass (mg)
Total VOC Mass (mg)
150
120
90
60
30
0
50
40
30
20
10
0
-78%
-88%
-81%
-90%
-94%
-96%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

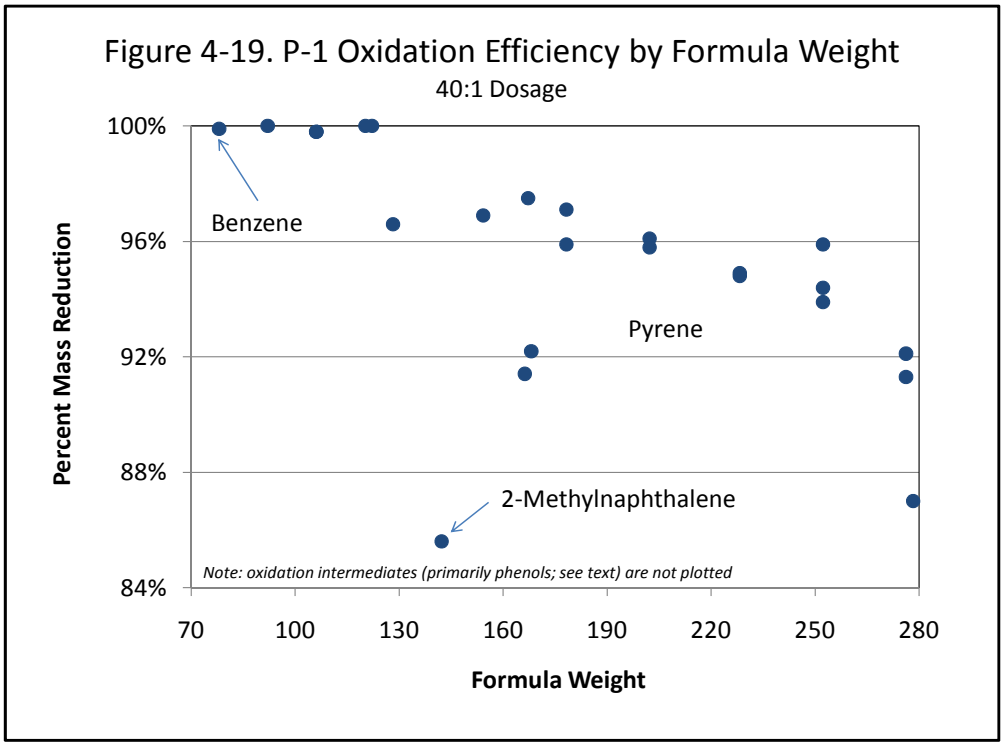


Figure 4-19. P-1 Oxidation Efficiency by Formula Weight
40:1 Dosage
Percent Mass Reduction
100%
96%
92%
88%
84%
Benzene
Pyrene
2-Methylnaphthalene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
70
100
130
160
190
220
250
280
Formula Weight

asymptotic pattern of less contaminant mass destroyed per oxidant mass added with increasing dosage, as observed with SS-1 and SS-2 (Figures 4-10 and 4-14, respectively). The oxidation efficiency was also related to formula weight. The oxidation efficiency (percent mass reduction) was plotted as a function of the formula weight for the 40:1 test in Figure 4-19. As observed with SS-1 and SS-2 (Figures 4-11 and 4-15, respectively), analytes with higher formula weights exhibit lower oxidation efficiencies; however, the inflection point at which oxidation efficiency decreases is at formula weight of approximately 130, which is slightly less than for SS-1 and SS-2. 2-Methylnaphthalene yielded anomalously low oxidation efficiency in P-1.

The following potential intermediate compounds were observed: acetone, 2-butanone, and phenol. None of these compounds have a Federal MCL. Acetone and 2-butanone were not detected in the baseline samples, but were detected in the treated slurries. The maximum concentrations of acetone were 2,100 ug/kg in soil and 2,340 ug/L in water (for the 40:1 sample), and of 2-butanone were 237 ug/kg in soil (for the 10:1 sample) and 172 ug/L in water (for the 40:1 sample). Ketones are an oxidation product often detected in laboratory and field implementations of ISCO (see discussion in Section 2.1), and thus their detection in the treated slurries is not unusual. Other potential intermediate compounds include phenols. Phenol was not detected in the baseline but was detected in the aqueous phase of the 40:1 sample at an estimated concentration of 2.0 ug/L; methylphenols were not detected. Thus if these compounds are being formed, then in these tests the compounds were also being oxidized at a rate at least as fast as their formation. Methyl acetate was detected in the aqueous phase of the 40:1 slurry at 13.2 ug/L, which is below the detection limit for the baseline (<42 ug/L), thus it is unclear if this is an oxidation intermediate or was present in the baseline sample below the detection limit.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. As expected, and also observed in SS-1, the ferrous iron, total iron, and sulfate concentrations increased while the pH decreased in the water. Chromium(VI) was not detected in the baseline or in the 20:1 sample. Arsenic concentration was elevated in the baseline (13,500 ug/L in the groundwater) and decreased in the slurries, to range between 132-2,690 ug/L. Arsenic speciation analysis indicates that the arsenic in the treated sample was primarily in the oxidized As(V) valence state (288 ug/L) relative to the reduced and more mobile As(III) state (6.86 ug/L).The decrease in arsenic concentration is likely due to coprecipitation of the oxidized As(V) with iron oxide precipitates generated by the Fenton's reagent. Total chromium and manganese concentrations increased in the treated slurries, which is also most likely attributable to the acidic pH conditions and soil leaching. Sulfate concentration increased from 2,510 mg/L to 4,770 mg/L relative to a Federal Secondary WQS of 250 mg/L, due to use of ferrous sulfate and sulfuric acid reagents.

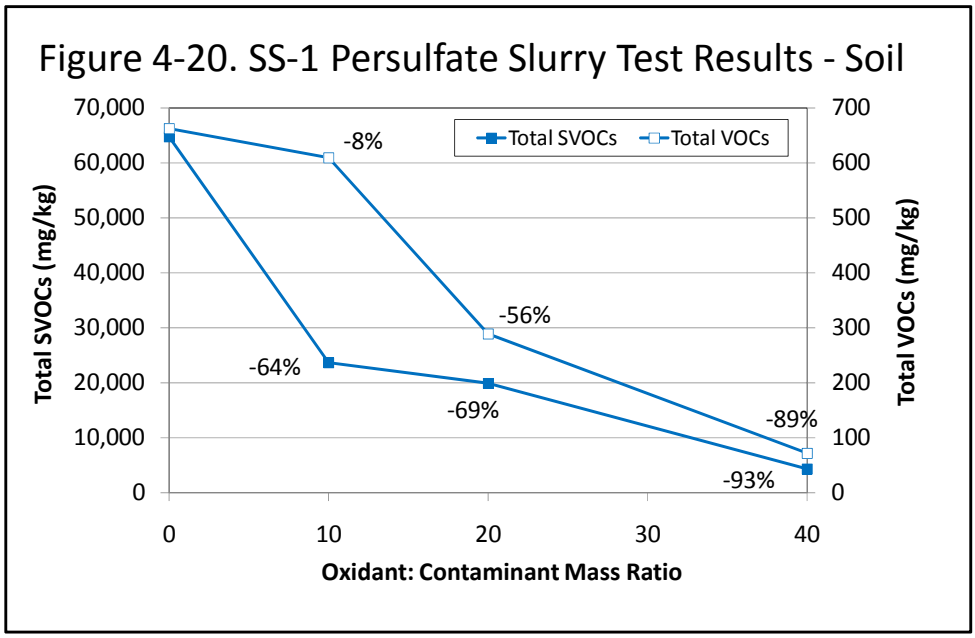


Figure 4-20. SS-1 Persulfate Slurry Test Results - Soil
Total SVOCs
Total VOCs
-8%
-56%
-89%
-64%
-69%
-93%
Total SVOCs (mg/kg)
Total VOCs (mg/kg)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
700
600
500
400
300
200
100
0
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

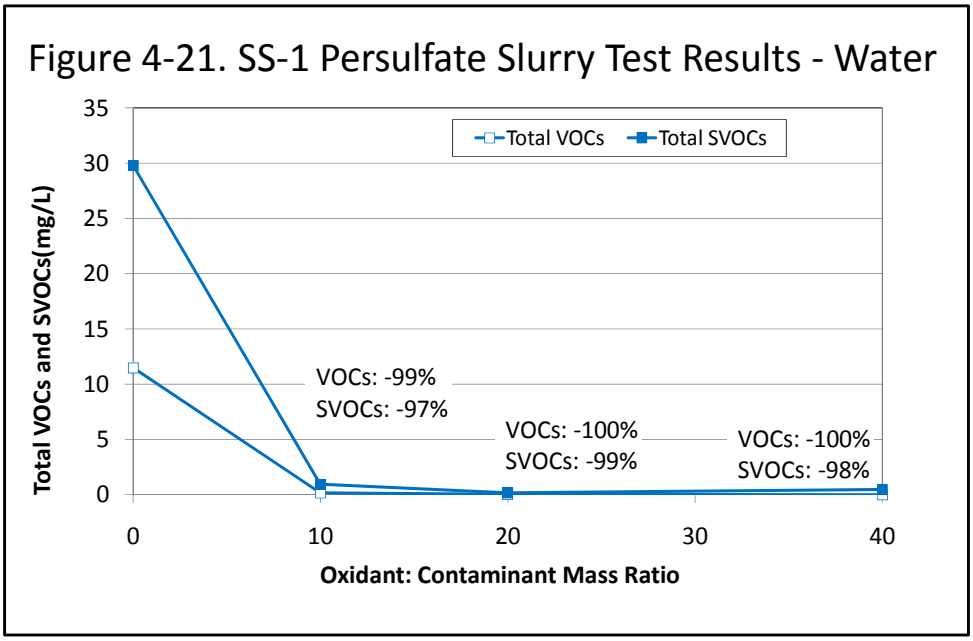


Figure 4-21. SS-1 Persulfate Slurry Test Results - Water
Total VOCs
Total SVOCs
VOCs: -99%
SVOCs: -97%
VOCs: -100%
SVOCs: -99%
VOCs: -100%
SVOCs: -98%
Total VOCs and SVOCs(mg/L)
35
30
25
20
15
10
5
0
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

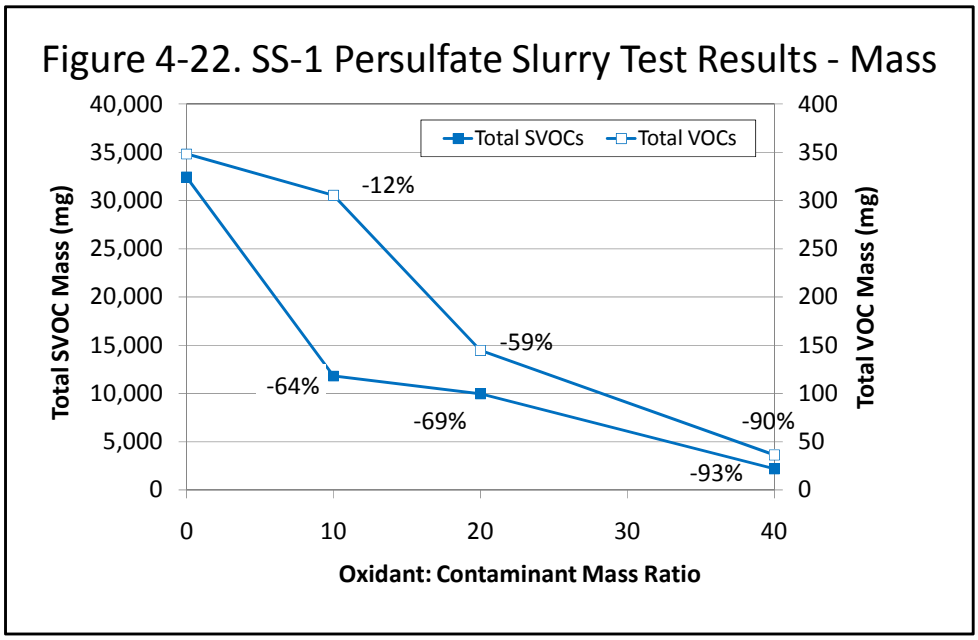


Figure 4-22. SS-1 Persulfate Slurry Test Results - Mass
Total SVOCs
Total VOCs
Total SVOC Mass (mg)
Total VOC Mass (mg)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
400
350
300
250
200
150
100
50
0
-12%
-59%
-90%
-64%
-69%
-93%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

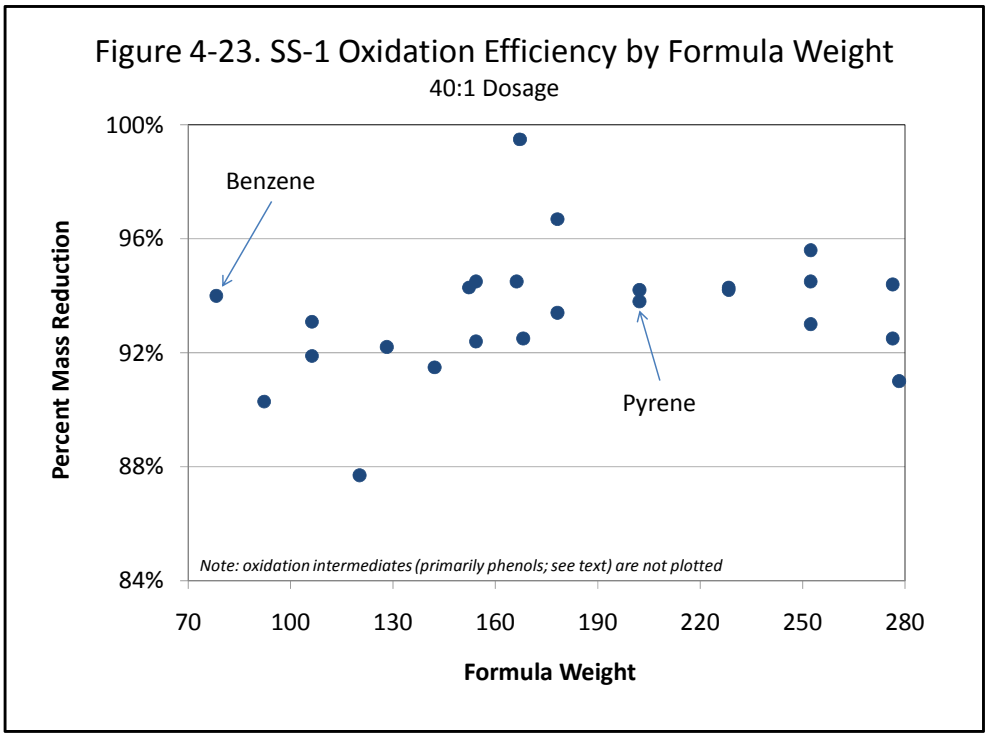


Figure 4-23. SS-1 Oxidation Efficiency by Formula Weight
40:1 Dosage
Percent Mass Reduction
100%
96%
92%
88%
84%
Benzene
Pyrene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
70
100
130
160
190
220
250
280
Formula Weight

4.4.2. Sodium Persulfate Slurries

4.4.2.1. Sample SS-1

The results for the SS-1 persulfate slurry samples are presented in Table 4-1 and on Figures 4-20 through 4-23. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 64-93% for the SVOCs, and 8-89.9% for the VOCs (Figure 4-20). In the aqueous phase of the slurries, the oxidation efficiency ranged from 97-99% for the SVOCs and from 99-100% for VOCs (Figure 4-21). In terms of overall contaminant mass, the oxidation efficiency ranged from 64-93% for the SVOCs and from 12-90% for the VOCs (Figure 4-22). No intermediate compounds (e.g., ketones) were detected; phenol (a potential intermediate) was detected but at lower concentrations than in the baseline sample.

Oxidation efficiency for the soil and total mass as a function of oxidant dose (Figures 4-20 and 4-22) appears to be a more linear relationship compared to the asymptotic pattern observed with the Fenton's slurries. The degree of oxidation in the aqueous phase results (Figure 4-21) is too rapid to tell if the relationship is linear or asymptotic. The oxidation efficiency also appears to be unrelated to formula weight (Figure 4-23).

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-1. Metals were analyzed in soil and groundwater in each sample and experiment. Sulfate concentration increased to 62,100 mg/L and pH increased to 13.42 in the water from the use of sodium persulfate and sodium hydroxide as reagents (there are no Federal MCLs for sulfate or pH). Total arsenic concentration increased from a baseline of 20.6 ug/L to a range of 385-683 ug/L in the slurries, however no As(III) was detected in the treated sample. Lead concentrations increased from non-detectable in the baseline to a range of 1,700-5,600 ug/L in the slurries. Total chromium increased from non-detectable in the baseline to a range of 90.2-193 ug/L in the slurries, but chromium(VI) remained undetectable in the 20:1 slurry. Potential causes for increased lead and chromium concentrations were not identified. Sulfate concentrations increased from non-detectable (<10 mg/L) to 62,100 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.4.2.2. Sample SS-2

The results for the SS-2 persulfate slurry samples are presented on Table 4-2 and in Figures 4-24 through 4-27. Overall oxidation efficiency in the soil samples (which represents approximately 75% of the total contaminant mass in the baseline sample) ranged from 48-64% for the SVOCs, and 15-58% for the VOCs (Figure 4-24). The SVOC concentration in the 40:1 slurry is higher than in the 10:1 and 20:1 slurries, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application rather than a treatment efficiency factor. In the aqueous phase of the slurries, the oxidation efficiency ranged from 89-99% for the SVOCs and from 71-100% for VOCs (Figure 4-25). In terms of overall contaminant mass, the oxidation efficiency ranged from 48-64% for the SVOCs and from 16-59%

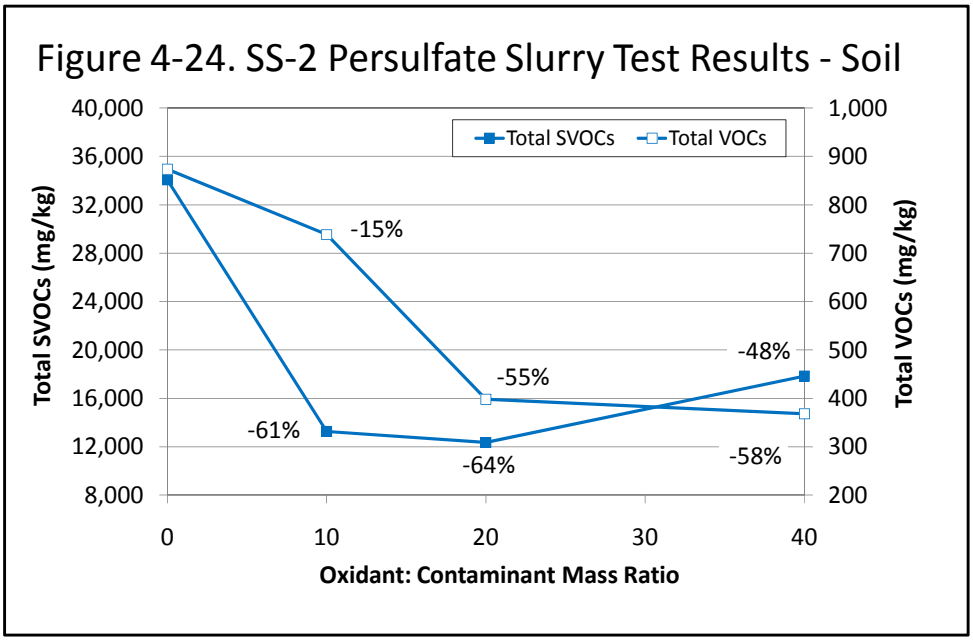


Figure 4-24. SS-2 Persulfate Slurry Test Results - Soil
Total SVOCs
Total VOCs
Total SVOCs (mg/kg)
Total VOCs (mg/kg)
40,000
36,000
32,000
28,000
24,000
20,000
16,000
12,000
8,000
1,000
900
800
700
600
500
400
300
200
-15%
-55%
-48%
-61%
-64%
-58%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

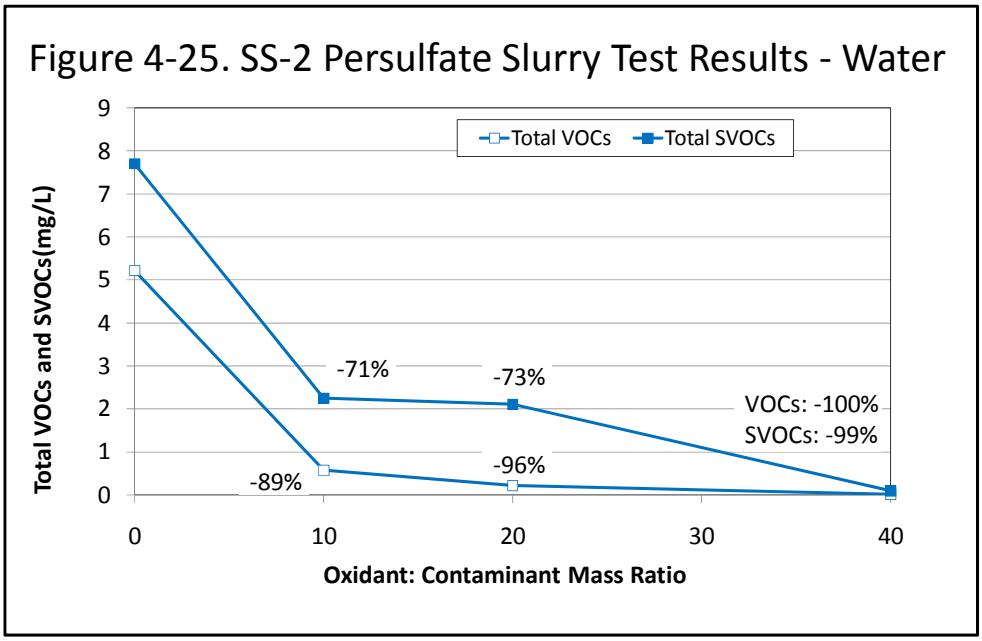


Figure 4-25. SS-2 Persulfate Slurry Test Results - Water
Total VOCs
Total SVOCs
Total VOCs and SVOCs(mg/L)
9
8
7
6
5
4
3
2
1
0
-71%
-73%
VOCs: -100%
SVOCs: -99%
-89%
-96%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

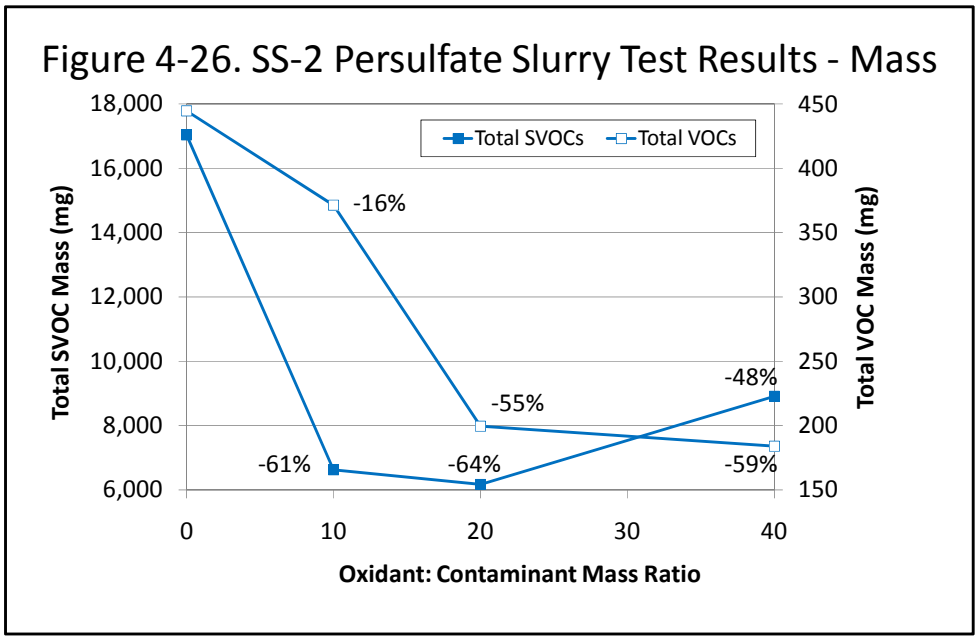


Figure 4-26. SS-2 Persulfate Slurry Test Results - Mass
Total SVOCs
Total VOCs
Total SVOC Mass (mg)
Total VOC Mass (mg)
18,000
16,000
14,000
12,000
10,000
8,000
6,000
450
400
350
300
250
200
150
-16%
-55%
-48%
-61%
-64%
-59%
0
10
20
30
40
Oxidant: Contaminant Mass Ratio

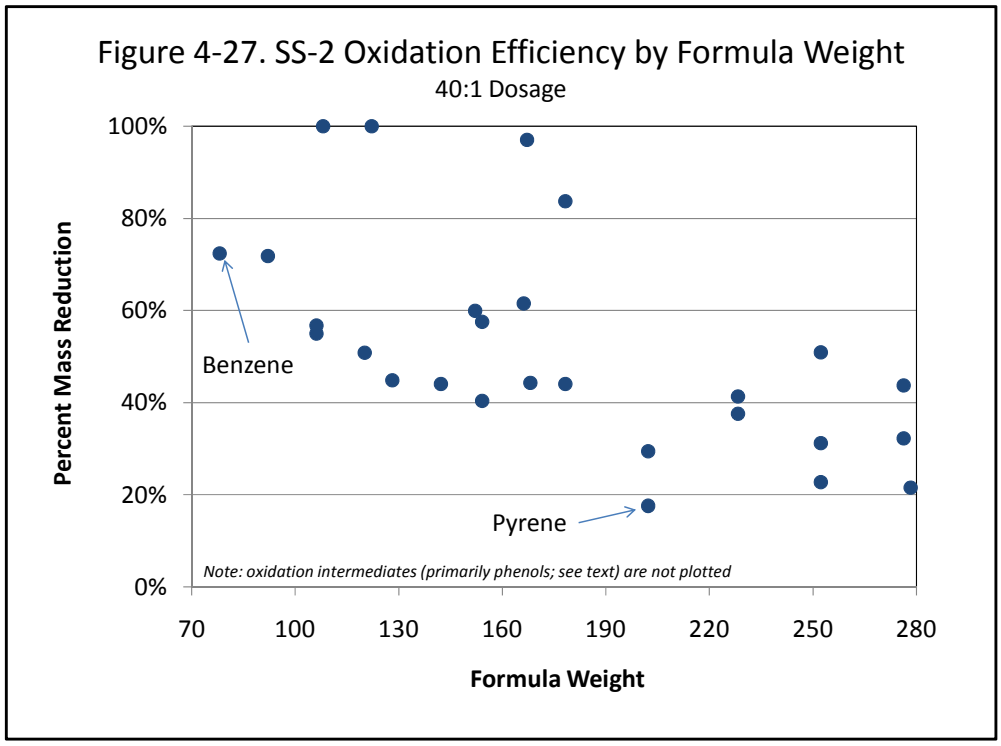


Figure 4-27. SS-2 Oxidation Efficiency by Formula Weight
40:1 Dosage
Percent Mass Reduction
100%
80%
60%
40%
20%
0%
Benzene
Pyrene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
70
100
130
160
190
220
250
280
Formula Weight

for the VOCs and the kinetics were asymptotic (Figure 4-26). However, the SVOC mass in the 40:1 sample is anomalously high, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. A plot of oxidation efficiency as a function of formula weight (Figure 4-27) indicates that there is a slightly negative relationship with higher oxidation efficiency and lower formula weights.

The following potential intermediate compounds were observed: acetone and 2-butanone. None of these compounds have a Federal MCL. Among the potential intermediate products, acetone and 2-butanone were detected in the 10:1 slurry at concentrations of 485 ug/L and 29.4 ug/L (estimated), respectively, but not detected at the higher oxidant dosages. Phenolic compounds were not detected in the treated samples.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-2. Metals were analyzed in soil and groundwater in each sample and experiment. Sulfate concentration and pH increased in the water from the use of sodium persulfate and sodium hydroxide as reagents. Total arsenic concentration increased from a baseline of 342 ug/L to a range of 480-834 ug/L in the treated slurries, but As(III) remained undetectable. Lead concentration increased from 3.9 ug/L in the baseline to a range of 6.2 to 4,280 ug/L in the treated slurries. Total chromium concentration increased from non-detectable in the baseline to a range of 137-310 ug/L in the treated slurries, with Cr(VI) increasing from non-detectable to 0.034 mg/L in the 20:1 slurry. Potential causes for increased lead and chromium concentrations were not identified. Sulfate concentrations increased from 414 mg/L to 50,600 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.4.2.3. Sample P-1

The results for the P-1 persulfate slurry samples are presented on Table 4-3 and in Figures 4-28 through 4-31. Oxidation efficiency results for the soil were variable, and the SVOC concentration exhibits an apparent increase ranging from 4-59% relative to the baseline (Figure 4-28). In contrast, the oxidation efficiency results in the groundwater were as expected, with 76-81% reduction in the VOC concentrations and 80-88% reduction in the SVOC concentrations (Figure 4-29). The soil concentration data affect the overall mass reduction (Figure 4-30). The VOCs exhibit a variable reduction of 9-39%, while the SVOCs exhibit an initial 7% decrease in the 10:1 slurry and an apparent 49-52% increase in the 20:1 and 40:1 slurries. Considering the lithology of this soil sample (peat with residual constituent concentrations), the variability in the soil results is likely the result of variable contaminant distribution between the samples prior to oxidant application coupled with an overall very low oxidation efficiency in the soil phase. The VOCs and SVOCs desorbed from the soil into the liquid phase were readily oxidized, based upon the reductions observed in the aqueous phase concentrations (Figure 4-29).

The apparent oxidation efficiency was plotted as a function of formula weight to determine if the variability was influenced by physical parameters that may correlate with formula weight (Figure 4-31).

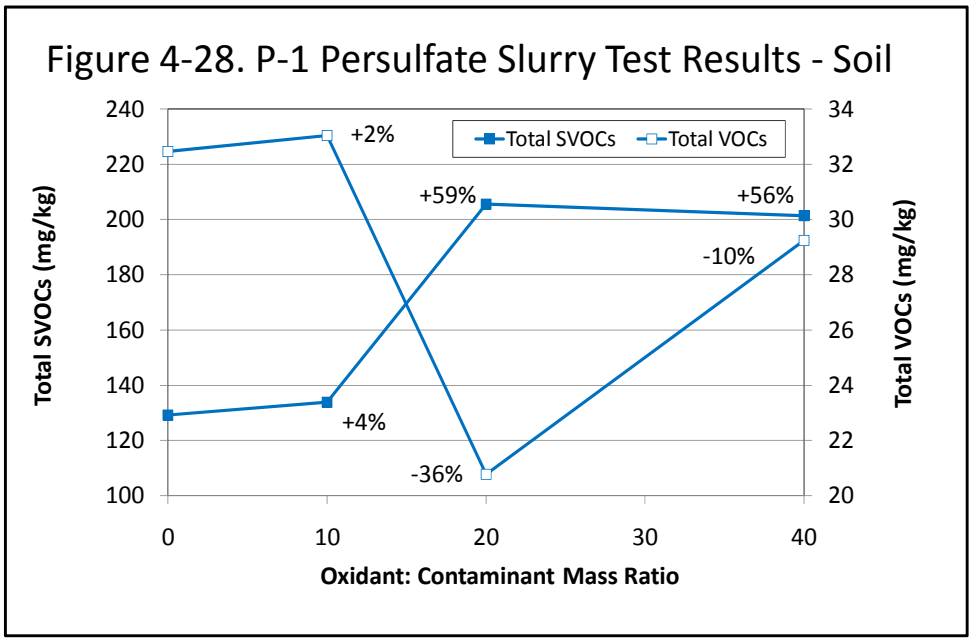


Figure 4-28. P-1 Persulfate Slurry Test Results - Soil
Total SVOCs
Total VOCs
+2%
+59%
+56%
-10%
+4%
-36%
Total SVOCs (mg/kg)
Total VOCs (mg/kg)
Oxidant: Contaminant Mass Ratio
240
220
200
180
160
140
120
100
34
32
30
28
26
24
22
20
0
10
20
30
40

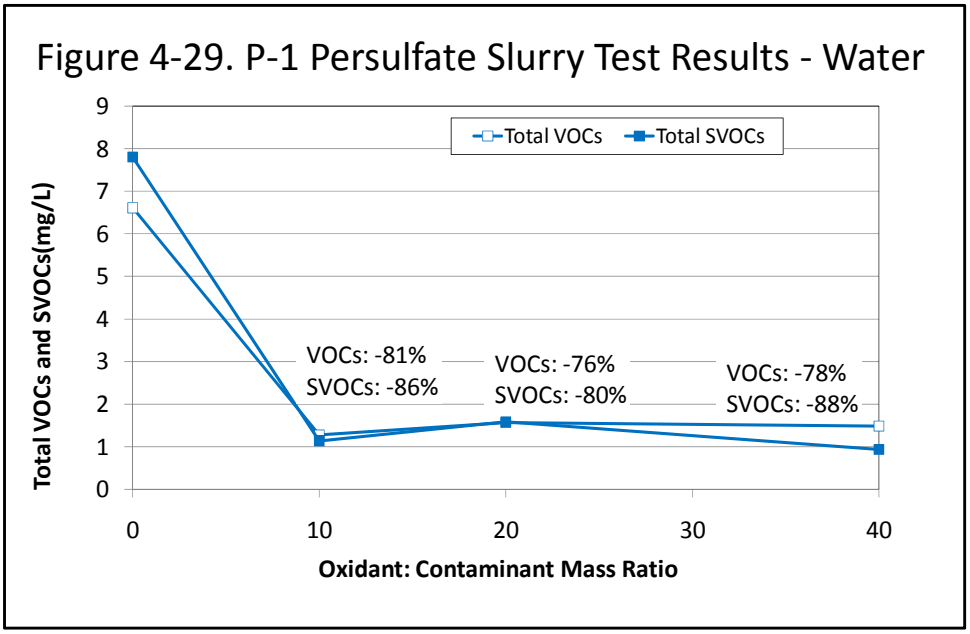


Figure 4-29. P-1 Persulfate Slurry Test Results - Water
Total VOCs
Total SVOCs
VOCs: -81%
SVOCs: -86%
VOCs: -76%
SVOCs: -80%
VOCs: -78%
SVOCs: -88%
Total VOCs and SVOCs(mg/L)
Oxidant: Contaminant Mass Ratio
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40

Figure 4-30. P-1 Persulfate Slurry Test Results - Mass

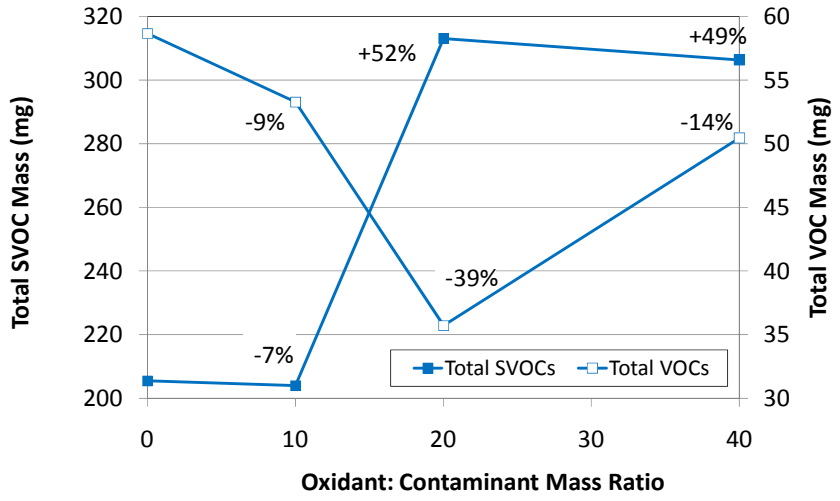
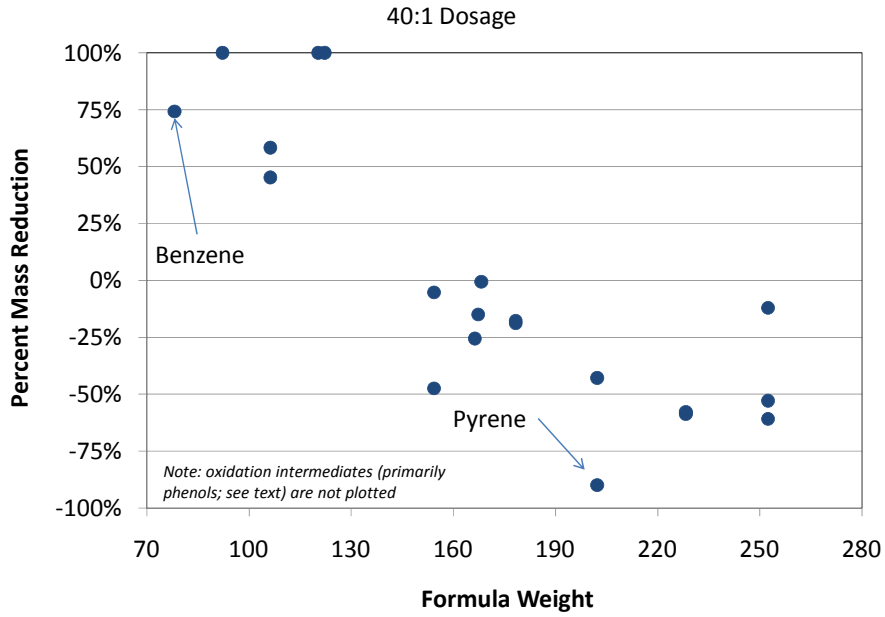


Figure 4-31. P-1 Oxidation Efficiency by Formula Weight



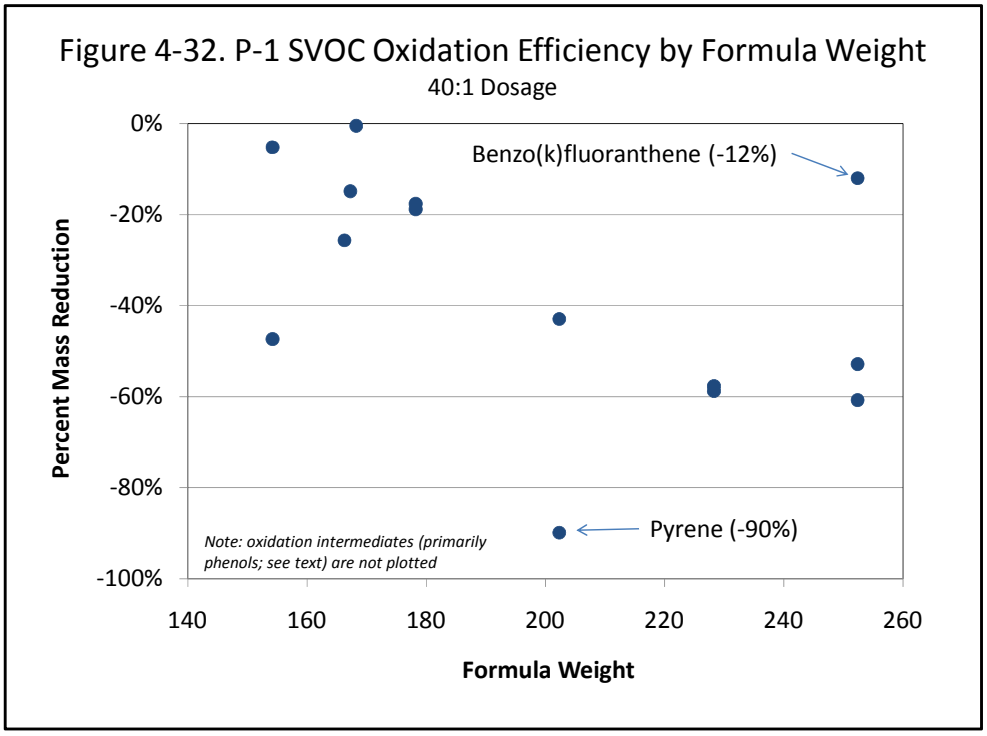


Figure 4-32. P-1 SVOC Oxidation Efficiency by Formula Weight
40:1 Dosage
0%
-20%
-40%
-60%
-80%
-100%
Percent Mass Reduction
Benzo(k)fluoranthene (-12%)
Pyrene (-90%)
Note: oxidation intermediates (primarily phenols; see text) are not plotted
140
160
180
200
220
240
260
Formula Weight

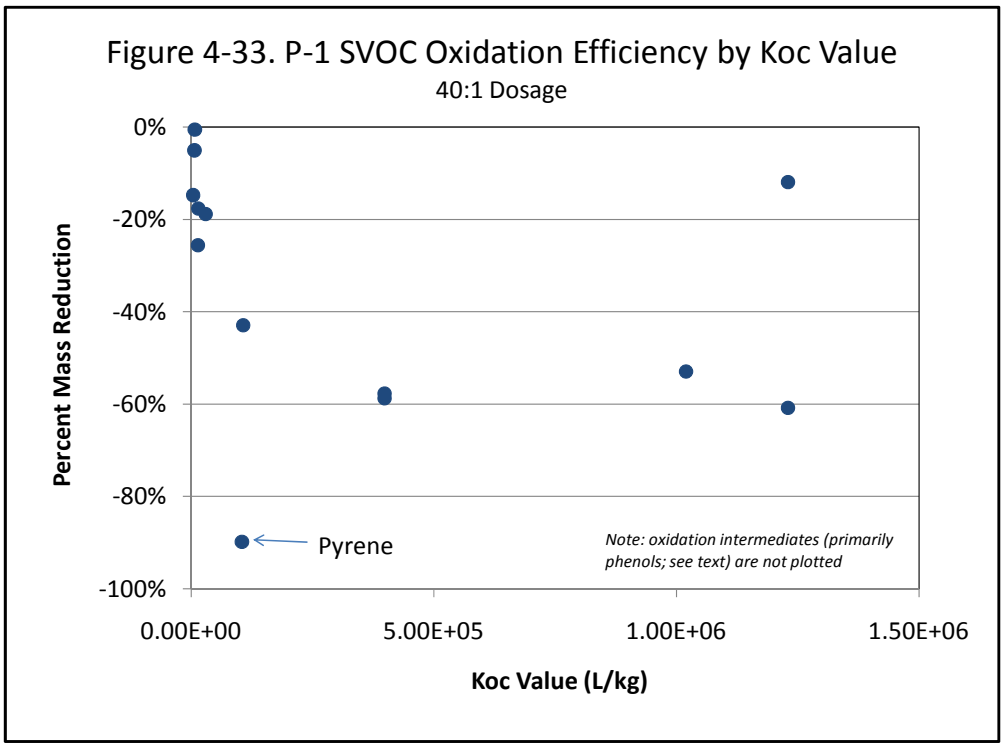


Figure 4-33. P-1 SVOC Oxidation Efficiency by Koc Value
40:1 Dosage
0%
-20%
-40%
-60%
-80%
-100%
Percent Mass Reduction
Pyrene
Note: oxidation intermediates (primarily phenols; see text) are not plotted
0.00E+00
5.00E+05
1.00E+06
1.50E+06
Koc Value (L/kg)

There is a negative relationship, with lower apparent oxidation efficiency (reflecting *higher* concentrations in the treated samples relative to the baseline concentration) at higher formula weights. The VOCs (BTEX and isopropylbenzene) and one SVOC (2,4-dimethylphenol), all with formula weights of 120.2 or less, exhibit overall reductions. Isopropylbenzene, toluene, and 2,4-dimethylphenol yielded 100% reductions; isopropylbenzene and toluene were present at relatively low concentrations (601 ug/kg or less) in the baseline, while 2,4-dimethylphenol was present at 3,400 ug/kg (consistent with the range of concentrations of other SVOCs).

Potential interpretations for the pattern exhibited in Figure 4-31 were evaluated, including VOC loss during sample handling and soil sorption. A plot of oxidation efficiency versus formula weight for the non-volatile compounds (Figure 4-32) indicates that the negative correlation remains, although is weaker than when the VOCs are included. The potential effect of soil sorption (due to the high peat content of the P-1 sample) was evaluated by plotting the organic carbon partitioning coefficient (Koc) versus formula weight (Figure 4-33). No relationship of oxidation efficiency with Koc is apparent. Thus it appears the scatter in oxidation efficiency data cannot be simply interpreted as due to either volatility or adsorption.

The following potential intermediate compounds were observed: acetone, carbon disulfide, methyl acetate, and phenol. None of these compounds have a Federal MCL. Acetone increased from non-detectable to 806 ug/L. Methyl acetate was detected only in soil and increased from non-detectable to a range of 10,300-20,500 ug/kg. Phenol was detected in the 10:1 slurry at concentrations of 388 ug/L in water and 9,000 ug/kg in soil, relative to non-detectable in the baseline and the other treated slurries. All of these compounds are potential oxidation intermediates as discussed in Sections 2.1 and 4.4.2.2. Carbon disulfide was not detected in the baseline but was detected in the treated slurries at a range of 17.2-52.6 ug/L. Carbon disulfide is not a known oxidation product, and was not detected in any of the slurries for other samples.

A wide range of general chemistry parameters were analyzed in the baseline sample and in the 20:1 tests, and are summarized in Table 4-3. The pH of the treated slurries ranged from 10.12 to 10.20. Due to the elevated pH and induced surface charges on the fine peat particles, the slurries tended to “fluff” and strongly maintain fine particles in solution. The suspension could not be clarified with centrifugation, and would not break until the pH was decreased into an acidic range for acid-preserved samples. As a result, obtaining a relatively low turbidity sample for metals analysis was not possible. Arsenic concentration decreased from 13,500 ug/L in the baseline to a range of 1,370-4,080 ug/L in the treated slurries, although As(III) remained detectable at 132 ug/L in the 20:1 slurry. Total chromium increased from non-detectable to a range of 389-778 ug/L in the treated slurries, although Cr(VI) remained non-detectable in the 20:1 slurry. Sulfate concentrations increased from 2,510 mg/L to 3,440 mg/L, relative to the Federal Secondary WQS of 250 mg/L, due to the persulfate reagent.

4.5. Soil Column Tests

Soil column experiments were performed as described in Section 3.3.5, to evaluate NAPL destruction as an oxidant solution is passed through a soil column, and to evaluate the potential mobility of the NAPL during oxidation. One column test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. Post-treatment samples of the soil in the column were collected and analyzed for VOCs and SVOCs. Results are tabulated in Table 4-1 and are discussed in the following Sections 4.5.1 and 4.5.2.

4.5.1. Fenton's Reagent Column

A series of photographs of the Fenton's reagent soil column over the course of the experiment is provided in Figure 4-34. The reservoir is the glass beaker on the left side of each photograph. No visible NAPL was mobilized through the column and discharged via the effluent into the reservoir. However, the filter sand became slightly stained from white to a browner color over the course of the experiment. The color of the oxidant solution also darkened, however the reddish tint of the oxidant solution and sand is primarily due to oxidized iron generated by the primary reaction that occurs during Fenton's reagent oxidation (Section 2.1, equation 1). The analytical results for the Fenton's column indicate an 83% reduction in the SVOCs and an 84% reduction in the VOCs (Table 4-1). The analytical results are overall very comparable to the slurry oxidation efficiency results, which achieved 99% oxidation of the VOCs and 69% oxidation of the SVOCs with the 20:1 slurry test. Based upon the observational results, the NAPL does not appear to be very mobile in a vertical column test with Fenton's reagent.

4.5.2. Sodium Persulfate Column

A series of photographs of the persulfate soil column over the course of the experiment is provided in Figure 4-35. The reservoir is the glass beaker on the left side of each photograph. As with the Fenton's reagent soil column, no visible NAPL was mobilized through the column and discharged via the effluent into the reservoir. However, the filter sand became slightly stained from white to a browner color over the course of the experiment. The color of the oxidant solution also darkened, and the reddish tint of the oxidant solution and soil is most likely due to oxidized iron although iron is not added as part of the catalyst for sodium persulfate. The analytical results for the persulfate column (Table 4-1) indicate an apparent 49% increase in the total VOC concentration. This apparent increase is primarily in xylene concentration in the treated soil compared to the baseline soil, which is most likely the result of variable contaminant distribution between the samples prior to oxidant application. All other VOC concentrations are lower in the treated soil, with an average decrease of 30% when xylenes are excluded. The SVOCs yielded a 59% reduction overall. The analytical results indicate less oxidation efficiency in the column than in the 20:1 slurry, which achieved 56% oxidation of the VOCs and 69% oxidation of the SVOCs (Figure 4-20). Based upon the observational results, the NAPL also does not appear to be very mobile in a vertical column test with persulfate.

Figure 4-34. Fenton's Reagent Soil Column Photographs

Day 1 (Start) **Day 3 (Midpoint)** **Day 7 (End)**

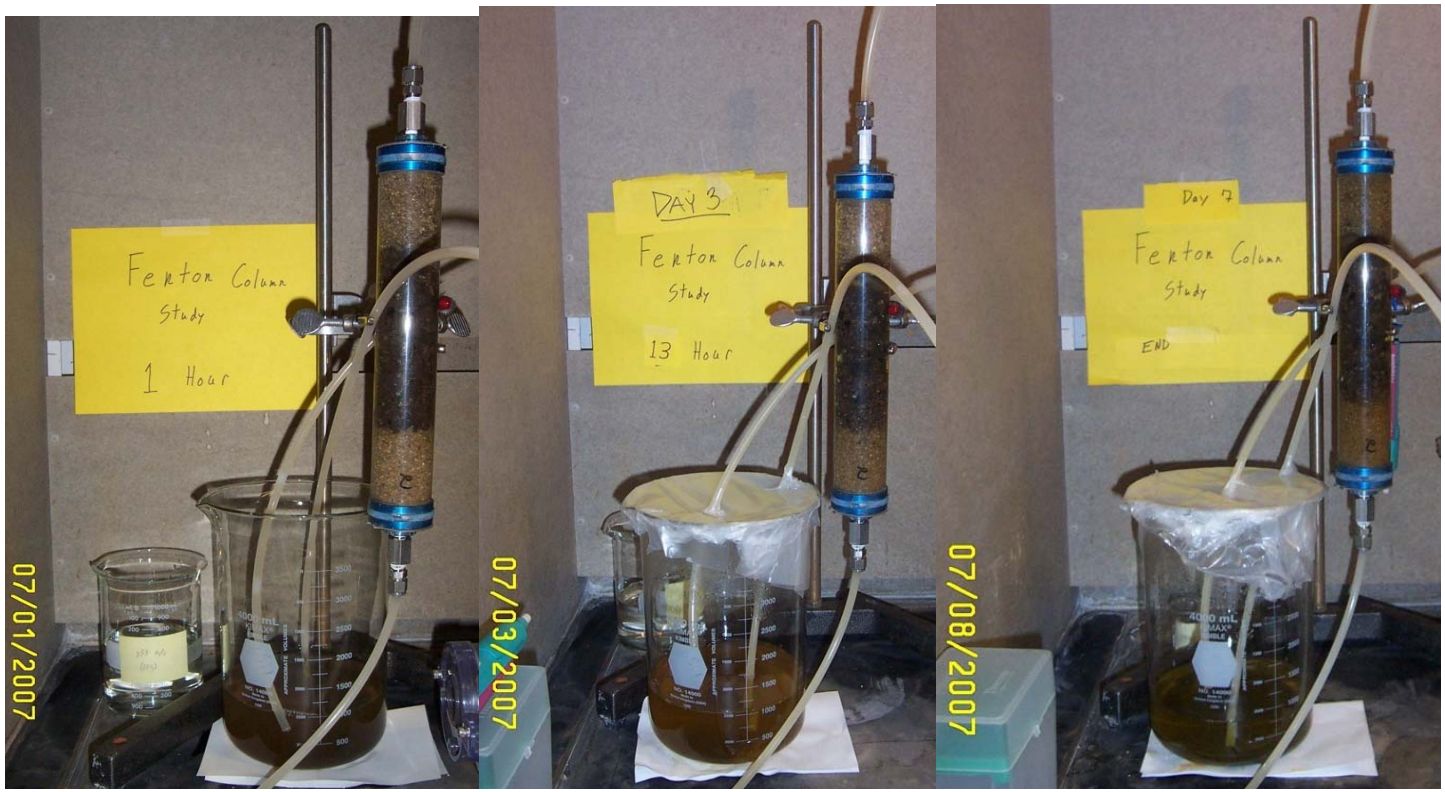
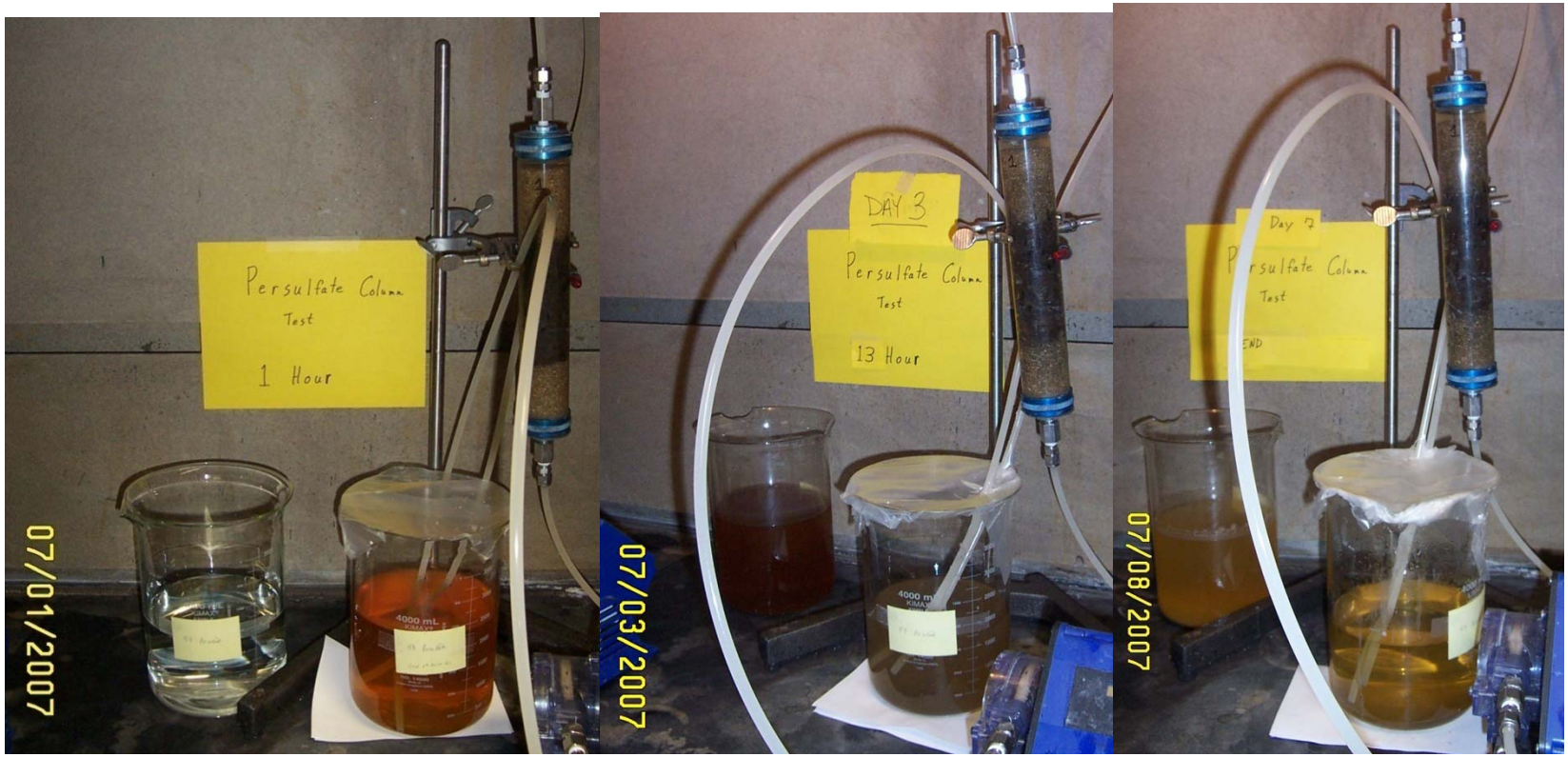


Figure 4-35. Sodium Persulfate Soil Column Photographs

Day 1 (Start) **Day 3 (Midpoint)** **Day 7 (End)**



4.6. Autoclave Tests

Autoclave experiments were performed as described in Section 3.3.6, in order to calculate a mass balance on the oxidation experiment and to evaluate contributions of volatilization and leaching to the overall observed volatile loss in the oxidation experiments. One test was performed for each oxidant, using the SS-1 soil and a 20:1 mass ratio of oxidant: contaminant. Volatile loss was monitored by passing offgas liberated by the oxidation reactions first through silica gel (to trap water vapor) and then carbon (to trap VOCs). Post-treatment samples of the treated soil, leachate, silica gel, and carbon were collected and analyzed for VOCs and SVOCs, and a mass balance was calculated. The laboratory analytical results are tabulated in Table 4-1, and the mass balance is calculated in Table 4-4. The results are discussed in the following Sections 4.6.1 and 4.6.2.

Traces of chlorinated VOCs including 1,1,1-trichloroethane, 1,1-dichloroethene, 1,2-dichloroethane, tetrachloroethene, trichloroethene, methylene chloride, trichlorofluormethane, and Freon 113, and the non-chlorinated VOCs MTBE and methylcyclohexane, were detected in the silica gel or the carbon (Table 4-1). All of the detected concentrations were low. The highest concentrations were for methylene chloride (a common laboratory contaminant) at a maximum concentration of 1,070 ug/kg; concentrations of other compounds were less than 155 ug/kg. The silica gel and carbon were virgin materials used only for these tests, and these are not known contaminants at the site. The analytes are therefore considered to most likely be spurious, trace contaminants introduced either in the bench test laboratory or the analytical laboratory, and are excluded from the mass balance calculations. Acetone and 2-butanone were also detected, but were included in the overall VOC mass balance because they are known oxidation products and were detected in other experiments.

4.6.1. Fenton's Reagent Autoclave

The Fenton's reagent autoclave test yielded approximately 99% overall oxidation. VOCs and SVOCs were transferred from the soil to the silica gel and carbon (representing volatilization) and to the leachate in measurable concentrations; however from a mass balance perspective the transferred masses were negligible relative to oxidation. Over 99.7% of the VOCs in the soil sample were oxidized, while 0.04% of the VOCs were retained on the soil, 0.10% was leached, and 0.14% was volatilized. Approximately 98.5% of the SVOCs were oxidized, while 1.5% of the SVOCs were retained on the soil. The fractions that were leached or volatilized were negligible: approximately 0.01% was leached and 0.001% was volatilized. These data indicate that overall, oxidation and destruction is the predominant mechanism accounting for loss of VOCs and SVOCs from the soil with Fenton's reagent.

4.6.2. Sodium Persulfate Autoclave

The persulfate autoclave test yielded significantly less overall oxidation than the Fenton's reagent test, however relatively little of the organic mass lost to from the soil was volatilized or leached. Over 58.9% of the VOCs in the soil sample were oxidized, while 39.7% of the VOCs were retained on the soil, 1.2%

was leached, and 0.13% was volatilized. Approximately 70.2% of the SVOCs were oxidized, while 29.8% of the SVOCs were retained on the soil. The fraction of the SVOCs that was leached or volatilized was negligible: approximately 0.02% was leached and 0.004% was volatilized. These data indicate that overall, oxidation and destruction is also the predominant mechanism accounting for loss of VOCs and SVOCs from the soil with persulfate, however overall destruction efficiency is less than for the Fenton's reagent.

Table 4-4. Autoclave Mass Balance Calculations

Fenton's Reagent Autoclave

Phase Masses		
Soil Mass (kg)	0.30	
Silica Gel Mass (kg)	0.18	
Carbon Mass (kg)	0.14	
Leachate Volume (kg)	1.53	
Phase Concentrations	**Baseline**	**Treated**
Soil [Target VOC] (ug/kg)	662,700	297
Soil [Target SVOC] (ug/kg)	64,769,200	984,820
Silica Gel [Target VOC] (ug/kg)	0	185
Silica Gel [Target SVOC] (ug/kg)	0	592
Carbon [Target VOC] (ug/kg)	0	1,813
Carbon [Target SVOC] (ug/kg)	0	0
Leachate [Target VOC] (ug/L)	0	126
Leachate [Target SVOC] (ug/L)	0	656

Analyte Mass by Phase (milligrams)

Baseline	**Soil**	**Silica Gel**	**Carbon**	**Leachate**	**Total**
VOCs	198.81	0.00	0.00	0.00	198.81
SVOCs	19,430.76	0.00	0.00	0.00	19,430.76
Autoclave					
VOCs	0.09	0.03	0.25	0.19	0.56
SVOCs	295.45	0.11	0.00	1.00	296.56

Mass Balance	**% Retained**	**% Leached**	**% Volatilized**	**% Oxidized**
Total VOCs	0.04%	0.10%	0.14%	99.72%
Total SVOCs	1.52%	0.01%	0.001%	98.47%

Persulfate Autoclave

Phase Masses		
Soil Mass (kg)	0.30	
Silica Gel Mass (kg)	0.18	
Carbon Mass (kg)	0.14	
Leachate Volume (kg)	1.93	
Phase Concentrations	**Baseline**	**Treated**
Soil [Target VOC] (ug/kg)	662,700	263,200
Soil [Target SVOC] (ug/kg)	64,769,200	19,296,130
Silica Gel [Target VOC] (ug/kg)	0	269
Silica Gel [Target SVOC] (ug/kg)	0	2,263
Carbon [Target VOC] (ug/kg)	0	1,540
Carbon [Target SVOC] (ug/L)	0	1,968
Leachate [Target VOC] (ug/L)	0	1,258
Leachate [Target SVOC] (ug/L)	0	2,111

Analyte Mass by Phase (milligrams)

Baseline	**Soil**	**Silica Gel**	**Carbon**	**Leachate**	**Total**
VOCs	198.81	0.00	0.00	0.00	198.81
SVOCs	19,430.76	0.00	0.00	0.00	19,430.76
Autoclave					
VOCs	78.96	0.05	0.21	2.43	81.65
SVOCs	5,788.84	0.42	0.27	4.07	5,793.60

Mass Balance	**% Retained**	**% Leached**	**% Volatilized**	**% Oxidized**
Total VOCs	39.72%	1.22%	0.13%	58.93%
Total SVOCs	29.79%	0.02%	0.004%	70.18%

5. Conclusions

Chemical oxidation bench tests were completed under a variety of different test methods, with different oxidants and soil types, from the Quanta Resources Superfund Site. A summary of the oxidation efficiencies for each test and soil type is presented in Table 5-1.

Table 5-1. Summary of Contaminant Mass Oxidation Efficiency

	Percent Reductions Relative to Baseline					
	Slurry Tests			Column	Autoclave	Average
Sampe / Oxidant	**10:1**	**20:1**	**40:1**	**20:1**	**20:1**	**20:1***
Sample SS-1: Silty sand with visible coal tar NAPL						
Fenton's Reagent						
VOC Mass	90.3%	99.3%	99.7%	84.2%	99.7%	94.4%
SVOC Mass	65.8%	69.2%	83.1%	82.8%	98.5%	83.5%
Total VOC + SVOC Mass	66.0%	69.5%	83.3%	82.8%	98.5%	83.6%
Sodium Persulfate						
VOC Mass	12.4%	58.5%	89.6%	-49.5%	58.9%	22.6%
SVOC Mass	63.5%	69.3%	93.3%	58.5%	70.2%	66.0%
Total VOC + SVOC Mass	63.0%	69.1%	93.2%	57.4%	70.1%	65.5%
Sample SS-2: Silty sand with residual coal tar (no visible NAPL)						
Fenton's Reagent				Column and Autoclave tests not performed for SS-2		
VOC Mass	86.7%	96.0%	96.2%			
SVOC Mass	58.5%	81.5%	91.5%			
Total VOC + SVOC Mass	59.2%	81.8%	91.6%			
Sodium Persulfate						
VOC Mass	16.5%	55.1%	58.6%			
SVOC Mass	61.1%	63.8%	47.7%			
Total VOC + SVOC Mass	60.0%	63.6%	48.0%			
Sample P-1: Peat with residual coal tar (no visible NAPL)						
Fenton's Reagent				Column and Autoclave tests not performed for P-1		
VOC Mass	89.5%	93.7%	81.4%			
SVOC Mass	78.0%	87.5%	95.9%			
Total VOC + SVOC Mass	80.9%	89.0%	92.3%			
Sodium Persulfate						
VOC Mass	9.2%	39.1%	14.0%			
SVOC Mass	0.7%	52.3%	49.0%			
Total VOC + SVOC Mass	2.6%	32.0%	35.0%			

*Average 20:1 is the average of the slurry test result, column test result, and autoclave result, at the 20:1 dosage.

Specific objectives of the bench test outlined in Section 1, and the following sections in which each objective is specifically discussed, are:

- Determine if ISCO is likely to be applicable for source zones, residual impact areas, or both (Section 5.1).
- Determine the relative ability of Fenton's reagent and sodium persulfate to oxidize VOCs and SVOCs in soil and groundwater from the site (Section 5.2).
- Quantify the reduction of VOC and SVOC concentrations in soil and groundwater after treatment with ISCO (Section 5.3).
- Determine the relative fractions of contaminants that are oxidized, volatilized, and leached during the ISCO process (Section 5.4).
- Estimate total oxidant demand of the media (Section 5.5).
- Evaluate the effects of ISCO on constituents at the site other than VOCs and SVOCs, including arsenic, to determine if a secondary hazard may be created (Section 5.6).

Overall conclusions are presented in Section 5.7.

5.1. ISCO Applicability

The remedial objective of ISCO treatment evaluated for the purpose of this report is to destroy the mobile NAPL phase and reduce the overall VOC and SVOC mass by 80%. The results of these bench tests demonstrate:

- For NAPL source zones (represented by sample SS-1, silty sand containing visible NAPL), overall contaminant mass was reduced by approximately 66% to 99% with Fenton's reagent, and from approximately 63% to 93% with sodium persulfate, generally proportional to oxidant dosage (Table 5-1). Both oxidants achieved NAPL destruction. Thus ISCO appears to be applicable in general to NAPL-impacted soils. The relative performance of Fenton's reagent and sodium persulfate is discussed in Section 5.2.
- For residual source areas characterized by silty sand lithology (represented by sample SS-2), overall contaminant mass was reduced by 59-92% by Fenton's reagent proportional to oxidant dosage (Table 5-1). Reductions ranging from 48-64% were achieved by sodium persulfate, however the efficiency was not proportional to oxidant dosage; the highest dosage resulted in the lowest apparent reduction (Table 5-1).
- For residual source areas characterized by peat lithology (represented by sample P-1), overall contaminant mass was reduced by 81-92% by Fenton's reagent and from 3-35% by sodium persulfate, depending upon oxidant dosage. Sodium persulfate achieved a significantly lower

oxidation efficiency in the P-1 sample relative to either sodium persulfate oxidation in the SS-2 sample (silty sand with residual impact), or relative to Fenton's reagent in the P-1 or SS-2 samples. Sodium persulfate applicability is therefore more limited in peat-rich soil areas at the site relative to Fenton's reagent.

5.2. Relative Performance of Fenton's Reagent and Sodium Persulfate

Both oxidants reduced overall contaminant mass in both soil and groundwater, for both VOC and SVOC constituents of the coal tar. However, Fenton's reagent achieved greater oxidation efficiency relative to sodium persulfate in nearly every test and oxidant dosage (Table 5-1). In the most comprehensive series of tests, three different types of experiments were conducted with the 20:1 oxidant dosage for the SS-1 (NAPL-impacted) sample: slurry tests, column tests, and autoclave tests. The results show that:

- Fenton's reagent achieved 70-99% reduction among the three different types of tests, with an overall average 84% contaminant mass reduction
- Sodium persulfate achieved 57-70% reduction among the three tests, with an overall average 66% contaminant mass reduction.

Fenton's reagent also outperformed sodium persulfate in slurry tests performed for SS-2 and P-1 (with residual coal tar impacts). For comparison using the 20:1 oxidant dosages for these tests:

- Fenton's reagent achieved 82-89% contaminant mass reduction.
- Sodium persulfate achieved 32-64% contaminant mass reduction.

Sodium persulfate oxidation was relatively inefficient for the P-1 (peat) sample, achieving only 32% overall contaminant mass reduction compared to 89% for Fenton's reagent at the 20:1 dosage. Thus in terms of relative performance, Fenton's reagent yielded better oxidation efficiency at equivalent oxidant dosages than sodium persulfate.

5.3. Quantified Reduction of VOCs and SVOCs in Soil and Groundwater

The percent reductions for overall VOC and SVOC mass overall are summarized in Section 5.2 and Table 5-1. The percent reductions in the soil and groundwater concentrations for specific VOCs and SVOCs are summarized in Tables 5-2 through 5-4. Analytes included in Tables 5-2 and 5-4 are all compounds detected in the baseline samples, except potential intermediate compounds (methylphenols, phenol, and ketones). Key compounds identified in Section 1.1 are the VOCs (BTEX and isopropylbenzene) and five SVOCs (naphthalene, phenanthrene, acenaphthylene, anthracene, and pyrene).

Table 5-2. Sample SS-1 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
Analyte	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**
Volatile Organic Compounds												
Benzene	95.1%	99.7%	99.5%	31.7%	73.5%	94.0%	100.0%	99.9%	100.0%	98.3%	99.7%	99.9%
Toluene	96.4%	99.9%	99.8%	16.5%	54.2%	91.9%	99.9%	99.9%	100.0%	98.4%	99.9%	100.0%
Ethylbenzene	95.0%	97.5%	99.9%	12.8%	57.0%	90.3%	99.0%	99.9%	100.0%	97.4%	100.0%	100.0%
Xylene (total)	91.2%	92.6%	99.9%	1.4%	2.2%	87.7%	98.2%	99.9%	100.0%	99.3%	100.0%	100.0%
Isopropylbenzene	88.5%	96.0%	100.0%	44.2%	60.1%	93.1%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total VOCs	93.0%	95.6%	99.9%	11.1%	31.9%	89.7%	99.7%	99.9%	100.0%	98.4%	99.8%	100.0%
Semivolatile Organic Compounds												
1,1'-Biphenyl	54.8%	91.8%	90.1%	64.0%	63.0%	92.4%	59.4%	91.9%	96.1%	81.5%	87.6%	91.0%
2,4-Dimethylphenol	100.0%	100.0%	98.4%	100.0%	100.0%	100.0%	100.0%	99.9%	100.0%	100.0%	100.0%	100.0%
2-Methylnaphthalene	69.8%	92.7%	98.9%	57.2%	61.4%	91.5%	76.5%	98.5%	99.7%	97.0%	93.5%	98.3%
Acenaphthene	61.8%	88.2%	96.4%	67.6%	65.0%	94.5%	68.5%	92.5%	98.8%	99.6%	98.9%	99.0%
Acenaphthylene	50.0%	78.1%	45.7%	80.9%	61.3%	94.3%	97.6%	99.0%	99.4%	95.3%	99.1%	99.3%
Anthracene	61.8%	88.2%	95.8%	67.5%	67.7%	96.7%	93.8%	96.3%	99.3%	97.1%	98.1%	98.9%
Benzo(a)anthracene	44.7%	65.5%	59.8%	65.3%	62.0%	94.2%	85.0%	78.9%	95.8%	90.1%	91.1%	92.9%
Benzo(a)pyrene	37.9%	68.7%	76.8%	61.1%	61.5%	95.6%	87.5%	84.0%	98.1%	96.9%	96.9%	96.2%
Benzo(b)fluoranthene	34.0%	56.4%	36.2%	53.4%	59.1%	93.0%	82.0%	78.3%	96.5%	85.9%	84.8%	89.6%
Benzo(g,h,i)perylene	53.4%	68.7%	71.0%	74.6%	63.3%	94.4%	94.0%	89.8%	98.6%	91.7%	91.8%	93.6%
Benzo(k)fluoranthene	18.3%	56.5%	49.8%	71.9%	47.9%	94.5%	80.9%	81.1%	96.2%	86.4%	85.9%	89.7%
Carbazole	77.4%	95.1%	96.9%	87.5%	84.7%	99.5%	87.7%	99.0%	99.8%	96.6%	98.8%	99.5%
Chrysene	42.3%	65.8%	46.8%	67.1%	64.7%	94.3%	80.3%	74.9%	93.9%	81.4%	82.7%	89.1%
Dibenzo(a,h)anthracene	15.1%	58.2%	31.4%	56.9%	36.8%	91.0%	90.6%	84.4%	96.3%	90.2%	92.6%	94.0%
Dibenzofuran	53.4%	83.6%	88.9%	61.6%	59.7%	92.5%	70.3%	90.2%	96.3%	82.7%	79.1%	90.4%
Fluoranthene	45.9%	67.5%	60.0%	66.4%	64.9%	94.2%	84.6%	79.9%	95.7%	87.1%	84.4%	91.5%
Fluorene	41.8%	72.7%	74.9%	66.7%	62.0%	94.5%	57.8%	76.3%	92.7%	97.7%	89.8%	96.2%
Indeno(1,2,3-cd)pyrene	44.8%	61.3%	63.5%	64.4%	52.0%	92.5%	92.3%	87.2%	97.7%	91.5%	90.5%	92.8%
Naphthalene	92.2%	97.8%	99.8%	60.6%	72.8%	92.2%	95.1%	99.8%	100.0%	96.2%	94.5%	98.0%
Phenanthrene	54.1%	74.5%	68.7%	64.9%	63.7%	93.4%	80.4%	83.1%	95.9%	79.3%	84.1%	93.1%
Pyrene	46.4%	63.3%	61.0%	64.8%	55.6%	93.8%	87.6%	81.7%	96.8%	91.9%	94.7%	94.3%
Total SVOCs	65.8%	83.5%	83.1%	63.5%	66.0%	93.2%	92.3%	96.7%	99.2%	95.6%	94.8%	97.7%

Table 5-3. Sample SS-2 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
Analyte	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**
Volatile Organic Compounds												
Benzene	100.0%	89.1%	87.9%	76.5%	80.1%	72.4%	99.2%	99.3%	99.4%	97.9%	98.0%	99.6%
Toluene	93.5%	96.2%	95.7%	62.7%	68.7%	71.8%	95.7%	98.1%	98.3%	96.8%	90.8%	99.4%
Ethylbenzene	88.4%	98.1%	98.6%	46.0%	51.2%	55.0%	96.5%	99.3%	99.5%	99.4%	95.1%	100.0%
Xylene (total)	86.5%	98.3%	99.0%	47.4%	52.9%	56.7%	93.2%	98.7%	99.4%	99.6%	95.4%	100.0%
Isopropylbenzene	83.5%	100.0%	99.4%	49.2%	48.0%	50.8%	88.6%	97.7%	100.0%	100.0%	92.4%	100.0%
Total VOCs	88.3%	97.7%	98.1%	50.3%	55.3%	58.6%	96.5%	99.0%	99.3%	98.6%	95.9%	99.8%
Semivolatile Organic Compounds												
1,1'-Biphenyl	43.8%	76.4%	92.4%	55.0%	50.2%	40.4%	-94.1%	-191.0%	45.5%	47.3%	55.9%	100.0%
2,4-Dimethylphenol	100.0%	100.0%	98.1%	100.0%	100.0%	100.0%	90.6%	93.3%	97.8%	100.0%	100.0%	100.0%
2-Methylnaphthalene	63.8%	91.3%	98.0%	57.7%	65.8%	44.0%	-30.4%	-8.2%	84.1%	64.6%	90.6%	100.0%
Acenaphthene	59.2%	86.3%	96.2%	64.5%	70.2%	57.5%	-92.9%	-149.1%	66.9%	93.0%	72.5%	100.0%
Acenaphthylene	56.7%	81.9%	81.8%	65.1%	64.8%	59.9%	0.7%	18.7%	100.0%	76.7%	100.0%	100.0%
Anthracene	74.1%	84.7%	95.2%	80.9%	82.0%	83.7%	10.0%	0.8%	35.0%	100.0%	100.0%	100.0%
Benzo(a)anthracene	7.0%	51.2%	70.2%	52.3%	46.2%	37.6%	100.0%	100.0%	-60.0%	13.3%	100.0%	100.0%
Benzo(a)pyrene	8.1%	55.3%	75.1%	51.3%	51.6%	50.9%	100.0%	100.0%	0.0%	20.0%	100.0%	100.0%
Benzo(g,h,i)perylene	21.1%	61.9%	75.5%	58.3%	54.2%	43.7%	100.0%	100.0%	10.4%	100.0%	100.0%	100.0%
Benzo(k)fluoranthene	21.8%	36.1%	70.9%	47.5%	44.6%	31.2%	100.0%	100.0%	-70.5%	19.3%	100.0%	100.0%
Carbazole	80.1%	88.9%	97.2%	93.4%	96.3%	97.0%	41.1%	59.4%	85.0%	98.0%	99.6%	100.0%
Chrysene	11.8%	49.5%	64.3%	58.1%	50.8%	41.3%	100.0%	100.0%	-86.7%	13.3%	100.0%	100.0%
Dibenzofuran	51.5%	79.0%	94.0%	60.8%	64.5%	44.3%	-87.0%	-142.5%	57.9%	29.3%	57.1%	100.0%
Fluoranthene	25.4%	58.4%	75.8%	52.5%	42.3%	29.4%	74.5%	60.0%	-41.8%	57.3%	100.0%	100.0%
Fluorene	41.4%	71.0%	88.7%	66.2%	69.7%	61.5%	-201.1%	-343.7%	-21.2%	67.2%	94.9%	100.0%
Indeno(1,2,3-cd)pyrene	13.4%	49.8%	70.3%	51.9%	44.1%	32.2%	100.0%	100.0%	100.0%	-580.9%	100.0%	100.0%
Naphthalene	85.6%	98.1%	99.3%	59.3%	69.1%	44.8%	54.6%	87.3%	96.0%	68.5%	68.0%	98.5%
Phenanthrene	44.0%	70.5%	87.1%	61.2%	59.3%	44.0%	-61.6%	-128.8%	-4.1%	40.2%	94.8%	100.0%
Pyrene	17.5%	55.8%	75.5%	46.1%	31.2%	17.5%	74.7%	57.0%	-40.5%	100.0%	100.0%	100.0%
Total SVOCs	59.2%	81.7%	91.8%	61.2%	64.0%	47.9%	44.2%	68.5%	91.5%	70.1%	71.9%	98.8%

Table 5-4. Sample P-1 Percent Reductions in Concentration by Analyte, Phase, Oxidant, and Dosage

	Soil						Water					
	Fenton's Reagent			Sodium Persulfate			Fenton's Reagent			Sodium Persulfate		
Analyte	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**	**10:1**	**20:1**	**40:1**
Volatile Organic Compounds												
Benzene	99.2%	99.7%	99.9%	74.9%	77.3%	74.4%	99.6%	99.9%	99.8%	78.3%	81.5%	84.1%
Toluene	93.1%	98.1%	100.0%	100.0%	100.0%	100.0%	99.7%	100.0%	100.0%	91.6%	91.9%	92.2%
Ethylbenzene	96.7%	99.4%	99.8%	38.1%	49.2%	45.2%	99.8%	100.0%	99.9%	93.1%	92.4%	92.7%
Xylene (total)	97.7%	99.5%	99.8%	55.9%	63.9%	58.3%	99.7%	100.0%	99.9%	92.6%	91.2%	91.1%
Isopropylbenzene	98.2%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Total VOCs	98.1%	99.6%	99.9%	63.7%	69.4%	65.3%	99.7%	100.0%	99.9%	88.1%	88.4%	89.3%
Semivolatile Organic Compounds												
1,1'-Biphenyl	67.8%	56.7%	79.9%	-58.4%	-115.4%	-47.4%	100.0%	96.6%	98.4%	100.0%	100.0%	100.0%
2,4-Dimethylphenol	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	95.4%	96.1%	96.6%	100.0%	100.0%	100.0%
2-Methylnaphthalene	57.2%	60.2%	85.6%	-172.8%	-243.9%	-142.8%	99.6%	97.8%	99.2%	100.0%	73.8%	100.0%
Acenaphthene	81.8%	87.3%	96.9%	4.8%	-34.5%	-5.1%	99.6%	97.8%	99.4%	100.0%	100.0%	100.0%
Anthracene	74.5%	88.5%	97.1%	32.5%	-16.2%	-18.8%	100.0%	99.1%	100.0%	100.0%	100.0%	100.0%
Benzo(a)anthracene	73.5%	84.8%	94.9%	30.1%	-53.1%	-58.7%	100.0%	98.6%	99.2%	100.0%	100.0%	100.0%
Benzo(a)pyrene	72.9%	83.5%	94.4%	21.6%	-58.6%	-52.9%	100.0%	98.9%	100.0%	100.0%	100.0%	100.0%
Benzo(b)fluoranthene	69.9%	82.7%	93.9%	13.6%	-92.6%	-60.8%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Benzo(g,h,i)perylene	58.1%	74.3%	91.3%	-42.0%	-170.5%	-146.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Benzo(k)fluoranthene	78.1%	87.5%	95.9%	50.0%	3.9%	-11.9%	100.0%	98.5%	100.0%	100.0%	100.0%	100.0%
Carbazole	75.6%	90.1%	97.5%	27.2%	-2.2%	-14.8%	100.0%	98.3%	99.4%	100.0%	100.0%	100.0%
Chrysene	73.7%	85.0%	94.8%	28.4%	-50.9%	-57.7%	100.0%	98.4%	99.2%	100.0%	100.0%	100.0%
Dibenzo(a,h)anthracene	23.1%	60.3%	87.0%	-108.7%	-263.0%	-200.5%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Dibenzofuran	75.5%	78.6%	92.2%	8.4%	-34.6%	-0.5%	100.0%	95.9%	98.1%	100.0%	100.0%	100.0%
Fluoranthene	75.4%	86.8%	96.1%	34.9%	-35.4%	-42.9%	99.7%	97.9%	99.0%	100.0%	100.0%	100.0%
Fluorene	73.8%	75.0%	91.4%	-3.0%	-59.1%	-25.6%	99.7%	96.3%	98.4%	100.0%	100.0%	100.0%
Indeno(1,2,3-cd)pyrene	62.1%	77.3%	92.1%	-13.1%	-129.5%	-112.6%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Naphthalene	71.5%	92.9%	96.6%	-218.1%	-218.1%	-213.3%	99.6%	99.5%	99.8%	85.6%	75.3%	86.1%
Phenanthrene	78.9%	86.2%	95.9%	36.3%	-20.2%	-17.6%	99.9%	98.1%	99.1%	100.0%	71.7%	100.0%
Pyrene	75.4%	86.3%	95.8%	12.0%	-80.8%	-89.8%	99.7%	98.0%	99.0%	100.0%	100.0%	100.0%
Total SVOCs	75.3%	85.9%	95.4%	4.4%	-58.4%	-55.9%	99.6%	99.0%	99.5%	90.2%	79.2%	90.6%

For sample SS-1:

- Fenton's reagent reduced the VOC concentration in both the soil and water phases by 93-100% overall, with greater reduction at higher dosages. All VOC concentrations were reduced by at least 88.5% (isopropylbenzene in the 10:1 dosage for soil).
- Fenton's reagent reduced the SVOC concentration in soil by 66-83% overall. The lowest overall reduction (66%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 84% and 83%, respectively. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 46-78%, anthracene 62-96%, naphthalene 92-100%, phenanthrene 54-75%, and pyrene 46-63%.
- The SVOCs were more susceptible to Fenton's reagent oxidation in the aqueous phase. Overall reductions ranged from 92-99%, with reductions of individual compounds as follows: acenaphthylene 98-99%, anthracene 94-99%, naphthalene 95-100%, phenanthrene 80-96%, and pyrene 82-97%.
- Sodium persulfate reduced the VOC concentration in soil by 11-90% overall, proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 32-94%, toluene 17-92%, ethylbenzene 13-90%, xylenes 1-88%, and isopropylbenzene 44-93%. In the aqueous phase, sodium persulfate reduced the VOC concentrations by 98-100% overall, with the minimum oxidation efficiency of 97% for ethylbenzene in the 10:1 dosage.
- Sodium persulfate reduced the SVOC concentration in soil by 64-93% overall, proportional to oxidant dosage. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 81-94%, anthracene 68-97%, naphthalene 61-92%, phenanthrene 64-93%, and pyrene 56-94%.
- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 95-98% in the dissolved phase, with reductions of individual compounds as follows: acenaphthylene 95-99%, anthracene 97-99%, naphthalene 95-98%, phenanthrene 79-93%, and pyrene 92-95%.

For sample SS-2:

- Fenton's reagent reduced the VOC concentration by 88-98% in soil and 99-100% in water overall, with generally greater reduction at higher dosages. All VOC concentrations were reduced by at least 84 % (isopropylbenzene in the 10:1 dosage for soil).

- Fenton's reagent reduced the SVOC concentration in soil by 59-92% overall. The lowest overall reduction (59%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 82% and 92%, respectively. Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 57-82%, anthracene 74-95%, naphthalene 86-99%, phenanthrene 44-87%, and pyrene 18-76%.

- The SVOC reductions from Fenton's reagent oxidation were more variable in the aqueous phase than in the soil, with some compounds showing apparent increases, most likely due to enhanced desorption. Overall reductions ranged from 44-92%, with reductions of individual compounds as follows: acenaphthylene 1-100%, anthracene 1-35%, naphthalene 55-96%, phenanthrene 4-129% increase, and pyrene 41% increase to 75% decrease.

- Sodium persulfate reduced the VOC concentration in soil by 50-59% overall, proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 72-80%, toluene 63-72%, ethylbenzene 46-55%, xylenes 47-57%, and isopropylbenzene 44-93%. In the aqueous phase, sodium persulfate reduced the VOC concentrations by 48-51% overall.

- Sodium persulfate reduced the SVOC concentration in soil by 48-64% overall, but the reductions were not proportional to oxidant dosage; the lowest reductions (48% overall) were observed at the highest dosage (40:1). Oxidation of individual compounds was variable and not always proportional to oxidant dosage. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene 60-65%, anthracene 81-84%, naphthalene 45-69%, phenanthrene 44-61%, and pyrene 18-75%.

- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 70-99% in the dissolved phase, proportional to oxidant dosage. Reductions of individual compounds were as follows: acenaphthylene 77-100%, anthracene 100%, naphthalene 68-99%, phenanthrene 40-100%, and pyrene 100%.

For sample P-1:

- Fenton's reagent reduced the VOC concentration by 98-100% in soil and in water overall. All VOC concentrations were reduced by at least 93% (toluene in the 10:1 dosage for soil).

- Fenton's reagent reduced the SVOC concentration in soil by 75-95% overall. The lowest overall reduction (75%) was for the 10:1 dosage, while the 20:1 and 40:1 samples yielded 86% and 95%, respectively. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene was not detected in the baseline, anthracene 75-97%, naphthalene 72-97%, phenanthrene 79-96%, and pyrene 75-96%.

- The SVOCs were more susceptible to Fenton's reagent oxidation in the aqueous phase. Overall reductions were 99-100% at all dosages. Reductions of individual compounds as follows: acenaphthylene not detected in the baseline, anthracene 99-100%, naphthalene 100%, phenanthrene 99-100%, and pyrene 99-100%.

- Sodium persulfate reduced the VOC concentration in soil by 64-69% overall. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 74-77%, toluene 100%, ethylbenzene 38-49%, xylenes 56-64%, and isopropylbenzene 100%.

- In the aqueous phase, sodium persulfate reduced the VOC concentrations by 88-89% overall. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: benzene 79-85%, toluene 92%, ethylbenzene 93%, xylenes 91-93%, and isopropylbenzene 100%.

- SVOC destruction with sodium persulfate was variable, ranging from a reduction of 4% to an apparent increase of 58%, and the differences were not proportional to oxidant dosage; the lowest reductions (4.4% overall) were observed at the lowest dosage (10:1). Oxidation of individual compounds was variable. Among the key compounds identified in Section 1.1, reductions in soil concentrations were as follows: acenaphthylene not detected in the baseline, anthracene 19% increase to 33% decrease, naphthalene 213-218% increase, phenanthrene 18% increase to 36% decrease, and pyrene 90% increase to 12% decrease.

- The SVOCs were more susceptible to persulfate oxidation in the aqueous phase. Overall reductions ranged from 79-91% in the dissolved phase, but variable and not proportional to oxidant dosage. Reductions of individual compounds were as follows: acenaphthylene not detected in the baseline, anthracene 100%, naphthalene 75-86%, phenanthrene 72-100%, and pyrene 100%.

5.4. Oxidation Mass Balance

Table 4-4 summarizes the oxidation mass balance for sample SS-1 with a 20:1 dosage for each oxidant. For Fenton's reagent, the autoclave test results indicate that 99.7% of the VOCs and 98.5% of the SVOCs were oxidized. For the VOCs, approximately 0.14% were volatilized, 0.10% were leached, and 0.04% were retained on the treated soil. For the SVOCs, approximately 0.001% were volatilized, 0.01% were leached, and 1.5% were retained on the treated soil.

The persulfate results show overall lower oxidation efficiency. Approximately 58.9% of the VOCs and 70.2% of the SVOCs were oxidized. For the VOCs, approximately 1.2% were leached, 0.13% were volatilized, and 39.7% were retained on the treated soil. For the SVOCs, approximately 0.02% were leached, 0.004% were volatilized, and 29.8% were retained on the treated soil.

Thus although Fenton's reagent was a more efficient oxidant that persulfate, results for both oxidants indicate that oxidation, rather than leaching or volatilization, are the predominant mechanisms for loss of VOCs and SVOCs from the treated soils. Volatilization and leaching from the soils are negligible relative to oxidation.

5.5. Oxidant Demand

Oxidant demand is commonly expressed in terms of mass of oxidant required to satisfy the demand from a soil sample (with units of grams of oxidant per kilogram of soil or equivalent), and demand from the contaminants is typically much smaller than the demand from the soil. However with samples impacted with contaminants at relatively high concentrations such as the samples tested in this study, contaminant oxidant demand becomes much more significant. In those cases, oxidant demand is more effectively evaluated as the mass of oxidant required to achieve a specified level of contaminant reduction, and the oxidant demand is scaled as a ratio of oxidant mass to contaminant mass.

The treatment objectives evaluated are: elimination of NAPL, and 80% VOC and SVOC mass reduction. Contaminant mass reductions achieved as a function of oxidant dosage are summarized in Tables 5-1 and 5-2. Based upon physical observations for both Fenton's reagent and persulfate, no visible NAPL remained in SS-1 after a 10:1 application for either oxidant. The NAPL was apparently either destroyed, transformed by partial oxidation to a non-mobile condition, or both. Therefore, achieving a treatment goal of NAPL elimination only, with more modest overall contaminant mass reduction, can likely be achieved with a 10:1 dosage or less with either oxidant.

Overall contaminant mass reductions were generally greater for Fenton's reagent than for persulfate. For sample SS-1, a Fenton's reagent oxidant dosage of 20:1 achieved 70-99% oxidation and averaged about 84% oxidation overall. The autoclave test yielded 99% oxidation with a 20:1 dosage of Fenton's reagent. A dosage of between 10:1 and 20:1 can be expected to achieve greater than 80% oxidation (potentially up to 99% oxidation) in addition to NAPL destruction. In contrast, a persulfate dosage of 20:1 achieved 57-70% oxidation, which appears sufficient to destroy NAPL but appears unlikely to achieve a high degree of oxidation (exceeding 80%). A 93% mass reduction was achieved with a persulfate dosage of 40:1.

For sample SS-2, a 20:1 dosage of Fenton's reagent achieved 82% oxidation by mass while a 40:1 dosage increased the oxidation efficiency to 92%. In contrast, the persulfate results were more ambiguous and exhibited less overall reduction. The 20:1 persulfate dosages achieved 64% oxidation by mass, and the 40:1 dosage achieved an even less efficient oxidation of 48%.

For sample P-1, a 20:1 dosage of Fenton's reagent achieved 89% oxidation by mass while a 40:1 dosage increased the oxidation efficiency to 92%. In contrast, the persulfate results exhibited substantially less mass reduction. The 20:1 persulfate dosage achieved only 32% mass reduction, and a 40:1 dosage achieved 35% destruction. This indicates that the persulfate oxidant demand for portions of the site

represented by P-1 would be very high. The persulfate oxidant demand required to achieve significant contaminant reduction (>80%) is not likely to be achieved with a reasonable oxidant volume.

5.6. Effects of ISCO on Constituents Other Than VOCs and SVOCs

A number of other constituents were analyzed to determine how they may be affected by the ISCO reagents and treatment. Generally of most concern at the site is the impact on metals, particularly chromium and arsenic because the redox status affects mobility and toxicity of these metals. Chromium can be oxidized to the more mobile and toxic Cr(VI) valence state by chemical oxidation, while arsenic can be oxidized from the mobile As(III) valence state to the less mobile As(V) valence state. Constituents may also be present in the ISCO reagents. The concentrations of other constituents were monitored in the baseline soil and groundwater and in the soil and groundwater from the 20:1 slurries for each oxidant in order to evaluate how these other constituents may be affected. The data for the aqueous phase samples in the slurries are summarized and compared with Federal MCLs in Tables 5-5 through 5-7 and discussed below.

Total chromium and Cr(VI) were non-detectable in the baseline groundwater samples. Total chromium concentrations increased in the aqueous phase of the slurries for both oxidants. In the persulfate slurries, the total chromium concentration in the aqueous phase increased to the range of 192-778 ug/L. In the Fenton's reagent slurries, the total chromium concentration in the aqueous phase increased to the range of 21.1-4,690 ug/L. Sample SS-1 exhibited the largest total chromium increase in the aqueous phase (4,690 ug/L); total chromium in the SS-1 soil sample also exhibited a very large increase (from non-detectable in the baseline to 1,420 ug/kg), suggesting that the increased total chromium may have either been contributed by an unusual soil particle or from the reagent. The fact that large increases in soil chromium concentrations are not observed in SS-2 or P-1 suggests that the large increase is not due to the reagents. The concentration of Cr(VI) increased but not as significantly as total chromium. In the persulfate slurries, Cr(VI) ranged from non-detectable to 34 ug/L, while in the Fenton's slurries the Cr(VI) ranged from non-detectable to 71 ug/L.

Total arsenic concentration in the baseline for sample P-1 (collected from a portion of the site known to have elevated arsenic concentration) was 13,500 ug/L. However total arsenic concentrations decreased significantly in the treated samples, to 4,080 ug/L in the persulfate slurry and to 183 ug/L in the Fenton's reagent slurry. The most likely reason for the decrease is that the arsenic was oxidized from the relatively soluble As(III) valence state to the relatively immobile As(V) valence state, and with the Fenton's slurry the arsenic was likely coprecipitated with iron oxides. This interpretation is supported by the soil arsenic data and the arsenic speciation data. The soil arsenic concentration was non-detectable in the baseline soil, but increased to 43.2 ug/kg in the persulfate slurry and to 59.9 ug/kg in the Fenton's reagent slurry. The sum of the As(III) and As(V) arsenic speciation concentrations do not precisely match the total arsenic concentration (likely due to different analytical methods and preservation), however the relative proportion of As(III) to As(V) decreases from 0.39 in the baseline to 0.17 in the persulfate

slurry and 0.02 in the Fenton's slurry. This indicates less overall contribution of As(III) to the total arsenic concentration.

Total arsenic concentrations in SS-1 and SS-2 increased relative to their baseline groundwater concentrations. In SS-1, total arsenic increased from 20.6 ug/L in the baseline to 683 ug/L in the persulfate slurry and to 558 ug/L in the Fenton's slurry. In SS-2, total arsenic increased from 342 ug/L in the baseline to 767 ug/L in the persulfate slurry and to 928 ug/L in the Fenton's slurry. However as with P-1, the relative proportion of arsenic in the As(III) valence state decreased in the treated samples. In the baseline of sample SS-1, the ratio of As(III) to As(V) was 2.5 in the baseline but As(III) was non-detectable in the treated samples. In SS-2, the ratio of As(III) to As(V) was 6.9 in the baseline but As(III) was non-detectable in the persulfate slurry and the ratio was reduced to 0.006 in the Fenton's slurry.

The impact of the reagents was apparent in the total and ferrous iron concentration, sulfate concentration, and pH of the slurries. The Fenton's reagent slurries exhibited large increases in total iron concentration from the use of iron catalyst. In SS-1, total iron increased from a baseline of 1,280 ug/L to 833,000 ug/L in the slurry. In SS-2, total iron increased from 41,800 ug/L to 1,550,000 ug/L in the slurry. In P-1, total iron increased from 535,000 ug/L to 241,000 ug/L in the treated slurry. The increased iron in the Fenton's slurries will precipitate once the pH shift associated with the acidic catalyst is ameliorated. The pH of the slurries reflects the acidic catalyst for the Fenton's slurries and the base catalyst for the persulfate slurries. In SS-1, the baseline pH was 7.2, which decreased to 2.2 for the Fenton slurry and increased to 13.4 for the persulfate slurry. In SS-2 the baseline pH was 6.34, which decreased to 2.2 for the Fenton's slurry and increased to 13.1 for the persulfate slurry. In P-1 the baseline pH was 6.2, which decreased to 2.9 for the Fenton's slurry and increased to 10.2 for the persulfate slurry. Sulfate concentrations also increased, because of sulfate liberated from the persulfate as well as from the ferrous sulfate and sulfuric acid utilized in the Fenton's reagent catalyst. In SS-1, the baseline sulfate was non-detectable, and increased to 1,750 mg/L for the Fenton slurry and to 62,100 mg/L for the persulfate slurry. In SS-2 the baseline sulfate was 414 mg/L, which decreased to 4,520 mg/L for the Fenton's slurry and to 50,600 mg/L for the persulfate slurry. In P-1 the baseline sulfate concentration was 2,510 mg/L, which increased to 4,770 mg/L for the Fenton's slurry and to 3,440 mg/L for the persulfate slurry. Elemental sulfur was identified as a TIC in the SVOC analyses of the soil samples from the persulfate slurries, thus a portion of the sulfate in the persulfate slurries may have been precipitated.

Other metals with MCLs that were exceeded in the treated slurries are cadmium, selenium, and lead. Cadmium concentrations were non-detect in the SS-1 and SS-2 baseline and was 11.9 ug/L in the P-1 baseline. Cadmium remained non-detectable in the persulfate slurries, but in the Fenton slurries increased to 31.8 ug/L in SS-1, 36.0 ug/L in SS-2, and 4.4 ug/L in P-1. Selenium was non-detectable in the SS-1 and SS-2 baselines and was 48.8 ug/L in the P-1 baseline. In the persulfate slurries, selenium increased to 160 ug/L in SS-1, 164 ug/L in SS-2, and decreased to non-detectable (but with an elevated detection limit) in P-1. In the Fenton slurries, selenium increased to 93.0 ug/L in SS-1, 93.1 ug/L in SS-2, and decreased to non-detectable in P-1. Lead concentrations were non-detect in the SS-1 baseline, 3.9

Table 5-5. Impact of ISCO on Other Constituents in Sample SS-1

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		51.6		1.4	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		51.7		1.4	
Nitrogen, Nitrite	1	ND (<0.010)		0.11		ND (<0.010)	
Petroleum Hydrocarbons	None	5.3	1,970	ND (<0.53)	2,210	0.51	2,360
Phosphorus, Total	None	0.32		ND (<0.050)		50.8	
Sulfate	None	ND (<10)		62,100		1,750	
Total Organic Carbon	None	92.9	537,000	808	192,000	1,070	554,000
pH, standard units	None	7.20		13.42		2.19	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	20.6	20.6	683	4.9	558	14.9
Arsenic (III)	None	7.5		ND (<0.56)		ND (<1.23)	
Arsenic (V)	None	3.0		658		752	
Barium	2,000	ND (<200)	89.8	ND (<2,000)	25.8	456	95.5
Cadmium	5	ND (<4.0)	1.4	ND (<40)	ND (<0.62)	31.8	ND (<0.22)
Chromium (total)	100	ND (<10)	11.7	193	2.3	4,690	1,420
Chromium (VI)	None	ND (<10)		ND (<100)		71	
Iron (total)	None	1,280	19,600	1,260	5,470	833,000	16,300
Iron (II)	None	360		110		101,000	
Lead	15	ND (<3.0)	91.1	5,600	25.5	3,070	139
Manganese	None	79.8		ND (<150)	38.9	6,270	209
Mercury	2	ND (<0.40)	0.17	0.95	0.045	ND (<0.20)	0.92
Selenium	50	ND (<10)	3.3	160	ND (<2.5)	93.0	1.6
Silver	None	ND (<10)	ND (<1.2)	ND (<100)	ND (<1.2)	12.9	ND (<0.23)
Thallium	0.5	ND (<10)	ND (<1.2)	ND (<100)	ND (<1.2)	ND (<10)	ND (<1.2)

Table 5-6. Impact of ISCO on Other Constituents in Sample SS-2

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		4.5		2.0	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		4.6		2.0	
Nitrogen, Nitrite	1	ND (<0.010)		0.12		ND (<0.010)	
Petroleum Hydrocarbons	None	2.5	7,270	ND (<0.62)	1,550	ND (<0.51)	1,990
Phosphorus, Total	None	0.11		4.8		ND (<0.050)	
Sulfate	None	414		50,600		4,520	
Total Organic Carbon	None	20.7	297,000	546	321,000	1,790	228,000
pH, standard units	None	6.34		13.06		2.21	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	342	9.9	767	4.2	928	9.2
Arsenic (III)	None	110		ND (<0.56)		6.53	
Arsenic (V)	None	15.9		729		1,090	
Barium	2,000	236	92.2	ND (<400)	43.1	317	54.6
Cadmium	5	ND (<4.0)	ND (<0.63)	ND (<8.0)	ND (<0.72)	36.0	ND (<0.72)
Chromium (total)	100	ND (<10)	9.0	192	5.2	463	87.9
Chromium (VI)	None	ND (<10)		34		69	
Iron (total)	None	41,800	10,700	ND (<200)	9,010	1,550,000	5,910
Iron (II)	None	36,100		980		249,000	
Lead	15	3.9	116	395	64.6	2,900	80.4
Manganese	None	3,650		ND (<30)	88.5	9,070	46.5
Mercury	2	ND (<0.20)	2.1	ND (<0.40)	0.83	ND (<0.20)	1.8
Selenium	50	ND (<10)	ND (<2.5)	164	ND (<2.9)	93.1	ND (<2.9)
Silver	None	ND (<10)	ND (<1.3)	ND (<20)	ND (<1.4)	ND (<10)	ND (<1.4)
Thallium	0.5	ND (<10)	ND (<1.3)	ND (<20)	ND (<1.4)	ND (<50)	ND (<1.4)

Table 5-7. Impact of ISCO on Other Constituents in Sample P-1

Analyte	Federal MCL	Baseline		Persulfate 20:1		Fenton 20:1	
		Groundwater	Soil	Groundwater	Soil	Groundwater	Soil
General Chemistry (mg/L or mg/Kg unless noted)							
Nitrogen, Nitrate	10	ND (<0.11)		ND (<2.1)		0.14	
Nitrogen, Nitrate + Nitrite	None	ND (<0.10)		ND (<0.10)		0.14	
Nitrogen, Nitrite	1	ND (<0.010)		ND (<2.0)		ND (<0.010)	
Petroleum Hydrocarbons	None	27.8	309	ND (<0.53)	ND (<110)	ND (<0.53)	266
Phosphorus, Total	None	0.86		15.4		0.14	
Sulfate	None	2,510		3,440		4,770	
Total Organic Carbon	None	42.9	162,000	8,700	116,000	473	187,000
pH, standard units	None	6.23		10.17		2.89	
Metals (ug/L or mg/kg)							
Arsenic (total)	10	13,500	ND (<6.4)	4,080	43.2	183	59.9
Arsenic (III)	None	5,880		132		6.86	
Arsenic (V)	None	14,900		767		288	
Barium	2,000	ND (<200)	ND (<64)	ND (<1,000)	ND (<45)	ND (<200)	25.5
Cadmium	5	11.9	ND (<1.6)	ND (<20)	ND (<1.1)	4.4	ND (<0.56)
Chromium (total)	100	ND (<10)	24.1	778	17.9	21.1	19.8
Chromium (VI)	None	ND (<10)		ND (<1,000)		ND (<10)	
Iron (total)	None	535,000	18,500	159,000	19,100	241,000	14,900
Iron (II)	None	766,000		146,000		308,000	
Lead	15	92.4	10.3	106	9.8	28.1	8.3
Manganese	None	397		956	79.9	1,880	49.1
Mercury	2	0.93	ND (<0.054)	ND (<8.0)	ND (<0.15)	ND (<0.40)	ND (<0.075)
Selenium	50	48.8	ND (<6.4)	ND (<50)	ND (<4.5)	ND (<10)	ND (<2.2)
Silver	None	ND (<10)	ND (<3.2)	ND (<50)	ND (<2.3)	ND (<10)	ND (<1.1)
Thallium	0.5	ND (<10)	ND (<3.2)	ND (<50)	ND (<2.3)	ND (<10)	ND (<1.1)

ug/L in the SS-2 baseline and was 92.4 ug/L in the P-1 baseline. In the persulfate slurries, lead increased to 5,600 ug/L in SS-1, 395 ug/L in SS-2, and 106 ug/L in P-1. In the Fenton slurries, lead increased to 3,070 ug/L in SS-1, 2,900 ug/L in SS-2, and 28.1 ug/L in P-1.

Sulfate is a component of the catalyst in the Fenton's reagent system, and is a component of the oxidant in the persulfate system, thus increases in sulfate concentration are expected with both oxidants. The Federal Secondary WQS for sulfate is 250 mg/L. Baseline sulfate concentrations ranged from non-detectable (<10 mg/L) to 2,510 mg/L in the baseline samples. Sulfate concentrations increased in all of the slurries. With Fenton's reagent, the sulfate concentration in the 20:1 treated samples ranged from to 1,070 mg/L to 4,770 mg/L. With persulfate, the sulfate concentration in the 20:1 treated samples ranged from to 3,440 mg/L to 62,100 mg/L.

5.7. Overall Conclusions

(1) Bench tests were conducted with Fenton's reagent and base-catalyzed sodium persulfate to determine if in-situ chemical oxidation may be a viable technology for the Quanta Resources Superfund Site. Three samples were tested. Two samples represent silty sand soil impacted with residual coal tar constituents, one of which also contained visible NAPL. The third sample represented a peat soil impacted with residual coal tar constituents.

(2) Soil pH buffering tests indicate that both acidic pH conditions (favorable for Fenton's reagent) and alkaline pH conditions (favorable for persulfate) can be readily achieved with all three soil types tested.

(3) Known intermediate oxidation products were observed. Those products included ketones (acetone, 2-butanone), phenols (phenol and methylphenol), and methyl acetate. None of these compounds has a Federal MCL.

(4) ISCO affected the aqueous concentrations of several constituents other than VOCs and SVOCs. Sulfate and iron included as components of the reagents utilized increased, while pH decreased for the Fenton's slurries and increased for the persulfate slurries. Several metals were either mobilized from the soil or may have been present in the catalyst components, including arsenic, chromium, cadmium, selenium, and lead. There was relatively little oxidation of chromium to the more mobile and toxic Cr(VI) valence state. Total arsenic concentrations increased in the silty sand tests (which do not have elevated baseline arsenic concentrations), but in contrast to chromium, almost all of the arsenic was oxidized from the relatively mobile As(III) valence state to the less mobile As(V) valence state. In the peat sample (with elevated baseline arsenic), arsenic concentrations decreased in the treated slurries.

(5) Based upon visual observations during the slurry tests, NAPL was either destroyed or was transformed to a non-mobile condition by both oxidants at dosages with ratios of oxidant to contaminant mass of 10:1 or less.

(6) Oxidation efficiency generally was negatively correlated with formula weight for both oxidants. Compounds with lower formula weights were oxidized more efficiently than compounds with higher formula weight.

(7) Slurry tests, soil column tests, and autoclave tests all indicate that Fenton's reagent is a more efficient oxidant than persulfate for the Quanta soils. Fenton's reagent yielded 59-99% oxidation of total contaminant mass depending upon oxidant dosage, whereas persulfate yielded 3-93% oxidation.

(8) Persulfate was relatively ineffective with the peat-rich soil sample, achieving a maximum of 35% contaminant mass oxidation. Fenton's reagent achieved a maximum of 93% oxidation with the same oxidant dosage.

(9) Autoclave tests were performed with the silty sand sample containing visible NAPL to assess the contribution of volatilization and leaching to overall contaminant loss from the soil. Tests with both oxidants indicate that oxidation is the predominant mechanism. Fenton's reagent was most effective, and achieved 99.7% oxidation of the VOCs and 98.5% oxidation of the SVOCs, and only about 0.3% of the total contaminant mass was transferred to the leachate or volatilized. Persulfate achieved 58.9% VOC oxidation and 70.2% SVOC oxidation. Approximately 1.3% of the VOCs were leached or volatilized, and approximately 0.02% of the SVOCs were leached or volatilized. The balance of the VOCs and SVOCs were retained on the treated soils.

(10) For Fenton's reagent, ratios of oxidant : contaminant mass between 10:1 and 20:1 resulted in loss of visible NAPL and 60-99% contaminant mass destruction, with an average 84% destruction for three different types of tests utilizing 20:1 dosages. For persulfate, oxidant : contaminant mass ratios between 10:1 and 20:1 also resulted in loss of visible NAPL and 57-93% oxidation, excluding the peat-rich sample. The peat-rich sample yielded a maximum of 35% oxidation with a 40:1 mass ratio of persulfate to contaminant mass.

(11) Fenton's reagent achieved better oxidation efficiencies in all three soils types tested.

(12) Fenton's reagent and persulfate are likely to be relatively equal in terms of ease of implementation in the silty-sand portions of the site. This is because both oxidants require modification of the groundwater chemistry that can be readily achieved, and because both oxidants require mixing and injection of liquid reagents. In the peat-rich portions of the site, persulfate will most likely be more difficult to implement due to dispersion of fine-grained soil materials under high-pH conditions, which resulted in significant "fluffing" of the peat matrix. This may significantly affect the ability to inject the liquid reagents.

(13) Fenton's reagent is likely to be less costly than persulfate to achieve the same magnitude of treatment. Lower dosages were required for Fenton's reagent relative to persulfate, and hydrogen peroxide is a significantly less costly oxidant than persulfate.

6. References

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Appendix C

Construction Implementation Plan

APPENDIX C

Quanta Resources Superfund Site: Draft Construction Implementation Plan

The object of this Construction Implementation Plan is to describe the general processes and procedures for implementing future construction activities associated with remediating the Quanta Resources Superfund Site, especially in and around 115 River Road. The procedure and process described will allow safe and efficient implementation while mitigating impacts to the community and environment.

Respondents have worked closely with the owner of the Quanta property and the 115 River Road property in developing remedies and the Construction Implementation Plan. Building operations have been reviewed and implementation logistics discussed with the owner in order to minimize potential impacts to tenants during construction activities.

Implementation of construction activities in and around the 115 River Road building can be performed while tenants occupy the building. Protection can be provided through the use of construction techniques that minimize disruption to the building (e.g., flexible scheduling, directional drilling), engineering controls (e.g., vapor and dust suppression), and air monitoring. Prior to remedy implementation, the current tenants list and location will be reevaluated and discussed with regulatory agencies and the owner to determine if it is necessary to relocate any tenants.

The final Construction Implementation Plan will provide more detail than can be reasonably included in this document at this time (that is, before the final remedy is selected and designed). In addition, it should be noted that the final construction and implementation plan may vary from the general approach described herein.

The site is located in Edgewater, New Jersey, adjacent to the Hudson River. It consists of the former Quanta Resources property and locations to which contamination from the property and former operations have migrated. Constituents associated with former operations have been observed in parts of the following areas, which together make up OU1:

- Block 95, Lot 1 (the Quanta property)
- Block 91, Lot 1 (the former Celotex property)
- Block 96, Lot 3.01 (the 115 River Road property)
- Block 99, Lot 1 (the former Lever Brothers property)
- River and Gorge Roads
- Block 93 (north, central, and south)
- Block 94, Lot 1
- Block 92.01 (north of Gorge Road)

The text below describes procedures and approaches that can be used to facilitate and direct construction work at the site. During detailed design of the selected remedy, new information,

including input from vendors and subcontractors, may result in the use of alternative means and methods to implement the remedial action.

Health and Safety and Community Impacts

Odor and Vapor Control

Remediation activities that disturb the subsurface, particularly in areas within the shallow NAPL zones, may release strong odors and cause migration of vapors to the surrounding area. Coal tar odors, while similar to those from routine street paving, tend to raise public concern when resulting from remediation activities. Odors and vapors can also affect the construction workers implementing the remedy. Therefore odor and vapor control will be an important construction consideration for the site. The following common mitigation measures are likely to be considered for OU1:

- Monitoring Program—Monitoring stations for odor/vapor, noise, and fugitive dust will be established at the perimeter of the construction area based on prevailing wind direction, to protect the safety and welfare of the public during construction. Odor and vapor monitoring will be performed during intrusive activities or when significant impacted materials are exposed. The owner's representative will have the authority to implement various controls to limit odors and vapors from affecting the public. Air will be monitored with both handheld, direct measurement devices, and air samples will be collected throughout construction. The air inside the 115 River Road building also will be monitored.
- Procedure—Only small areas will be excavated or stabilized at a time to limit the amount of odor, vapors, and dust.
- Foam Suppressants—Odor foams can be applied to form a consistent encapsulating layer between contaminated materials and the environment, to suppress VOCs, dust, and odors. Construction will be sequenced and performed in a manner so as to expose only small areas of contaminated soils at a time and then backfilled quickly.
- Scheduling—Construction work will be staged according to the seasons, weekends, and off hours, as possible to reduce potential for exposure to odors.
- Building Ventilation—The ventilation system of building at 115 River Road may be modified temporarily to address inhalation concerns.
- Construction Equipment—A hood or cover will be used to draw vapors from soil-mixing augers if used during construction.

The mitigation measures may be used in combinations with each other, such as foam suppressants and scheduling work during cooler months as an example.

Noise Control

Remediation equipment and equipment transport vehicles can be disruptive to both workers and residents. Noise must be taken into consideration for its health and safety effects. The following measures typically are used to mitigate noise impacts:

- Equipment Selection—Where possible, heavy construction equipment that makes less noise during operation will be selected. For example, use of hydraulic methods such as silent

pilers to drive pilings and sheet pile, rather than a vibratory hammer, near the 115 River Road building.

- Mufflers—Construction equipment will be equipped with the latest muffler systems. Wherever possible, stationary equipment (e.g., a batch plant) would be located as far from neighbors as possible. If necessary, a temporary sound barrier could be constructed around such equipment.

- Scheduling—Construction will be performed during normal business hours in accordance with local noise ordinances. Construction during off hours will also be scheduled in accordance with local noise ordinances. Arrangement will be coordinated with the nearby tenants to keep windows closed during intrusive construction activities.

Dust Control

Dust and emission control procedures are critical to the success of the remediation of the Quanta site. Based upon the site's proximity to the Hudson River and adjacent public areas, there will be two primary sources of dust: (1) dust generated by moving equipment around the site, and (2) dust generated by active construction. The following dust mitigation measures are likely to be considered:

- Spraying the surface of exposed soils with water and/or dust suppression materials
- Good housekeeping
- Sweeping to remove dust from concrete and asphalt in the work areas and/or high traffic areas
- Installing a privacy/wind screen on perimeter fencing

Emergency Entrance and Exit

Construction in the area around the building at 115 River Road must acknowledge the following issues before work begins:

- Access to the property from River Road in accordance with fire codes
- Parking for occupants of and visitors to the building
- Access from the parking area to the building
- Access into and egress from the building in accordance with fire codes
- Traffic flow
- Handicap access
- Proper signage communicating these messages (possibly in several languages)

Emergency entrances and exits at the 115 River Road property and building will be maintained during the remedial action. The following measures can be taken to allow continued access to the 115 River Road building while completing remedial construction:

- During design, building fire codes will be reviewed to determine emergency and handicap access required. Based on that evaluation and proposed remediation work, modifications to doorways and stairs, and the need for handicap accessibility, will be determined.

- A temporary parking lot will be constructed on the Quanta site or the former Lever Brothers properties to replace the existing parking spaces that will be rendered unavailable to tenants during remedy construction because they will be located within work areas. Two temporary

walkways will be created from the 115 River Road building to the temporary parking lot to control pedestrian traffic. Temporary walkways also will be placed along the building to maintain safe access to and egress from the building.

- Traffic through work areas will be limited to construction vehicles. The sequence of construction activities will attempt to limit disturbances to tenants and nearby property owners. This could include an option that construction occur outside normal business hours that will allow continued access to the 115 River Road building while limiting disturbance to its tenants and occupants. Impacts and measures to mitigate them must be balanced to create a cost-effective solution that minimizes overall impact to tenants and nearby property owners.

Protection of Structures and Hudson River

Utilities

Identifying and protecting utilities before construction and subsurface work is important because of health and safety implications and potential damage to local business and residents if it is not performed properly. Therefore, the following items will be implemented:

- Before field work begins, the locations of utilities will be identified and protective measures implemented to avoid adverse impacts. The work will include potholing of all critical utilities using vacuum excavation procedures to positively identify them.
- An emergency utility repair plan will be prepared before the intrusive work begins so that if an unidentified or miss located utility is affected, the proper utility company can be notified so that repairs can be performed promptly by properly trained utilities contractors.
- Excavation, stabilization, or remediation work near utilities will be limited or restricted. Selection of final method and distance from the utilities is significantly dependent on the final utility survey. Once utilities are identified, remediation can be performed at a safe distance from the utility corridor, and then gradually moved farther away from the corridor.

115 River Road Building

Sheet piling will be pretrenched or hydraulically pushed adjacent to the building at 115 River Road, rather than using a vibratory hammer, since the latter could compromise the structural integrity of the building. Vibratory pile driving can also cause backfill to compact and settle which could result in differential settlement.

Hudson River and Bulkhead

Boom inspections will continue at OU2 throughout construction. It is expected that booms will remain in place throughout the duration of construction activities that take place along the shoreline work and may need to be replaced frequently. To protect the Hudson River, a temporary sheet pile wall will be installed during work along the river to manage turbidity during construction. Based on final design, a higher cement ratio may be used in the columns immediately adjacent to the shoreline or bulkhead to increase stability during the in situ treatment process.

Construction Sequencing Options

Access during construction may require sequencing of the construction areas and scheduling to limit disturbance to tenants and occupants of adjacent properties. The preliminary sequencing of construction associated with the preferred alternatives is discussed below and represented in Figures C-1 through C-4. Figure C-5 shows the summary of remedial action components to be implemented at the site. It is expected that major construction work will occur in four stages. The construction sequence was developed to protect both the public and the Hudson River, while allowing tenants to use the 115 River Road building during construction without major impacts. The work and duration of construction activities associated with each stage are described briefly below and represented on the preliminary schedule (Figure C-6).

Stage 1 (Estimated duration - 250 work days): Mobilization and solidification/stabilization of NZ-1 on Quanta property and Block 93 (Figure C-1)

1. Submit permits to state and federal agencies (as applicable).
2. Mobilize and setup laydown area on Quanta Property (set up truck access to Quanta).
3. Clear and grub the Quanta property.
4. Locate utilities within the footprint of construction area (Quanta and Block 93properties).
5. Install sub slab depressurization system in basements of buildings 7 and 8 of 115 River Road.
6. Remove debris and foundations on NZ-1 (Quanta and Block 93 Central properties).
7. Perform in situ solidification and stabilization of NZ-1 (including tar boils) on Quanta property.
8. Complete NZ-1 activities on Blocks 93 (excavate and transfer to Quanta property for stabilization or in situ stabilization and solidification). Excavation and backfill adjacent to buildings on Block 93 Central may need to be done in a series of perpendicular trenches to maintain lateral support of the structures.
9. Install temporary sheet pile along the Hudson River to about 10 feet below the sediment. The sheet pile along the Hudson River is a temporary structure to manage turbidity during construction. It is not intended for structural strength. This task can be completed concurrently with others after mobilization and setup of the laydown area.

Stage 2 (Estimated duration—150 work days): Solidification/stabilization of NZ-2 and NZ-5 immediately adjacent to the Hudson River (Figure C-2):

1. Create parking lot on stabilized part of NZ-1 on Quanta or former Lever Brothers Properties to provide parking for 115 River Road tenants.
   - Parking lot will be of sufficient size to compensate for parking spaces temporarily closed on the north side of 115 River Road property. Parking on 115 River Road pier will continue to be open through construction, although short-term impacts may occur.

- Access from River Road to the parking lot on a stabilized part of NZ-1 on the Quanta site will be through the southwestern part of the property, where the existing gate and ramp are located. The ramp is steep and must be regraded before use.

2. Create walkways and perimeter fence (with plastic sheeting on work area side of fence and reduced visibility on walkway side) from parking lot on NZ-1.
3. Install jersey barriers in the 115 River Road parking lot to allow access to 115 River Road parking on pier.
4. Locate utilities within the footprint of NZ-2 and NZ-5 (Quanta, former Celotex, and former Lever Brothers properties).
5. Remove debris and foundations on NZ-2 and NZ-5.
6. Complete in situ stabilization and solidification or jet grouting along shoreline, including jet grouting under the 115 River Road Building pier.
   - The first row of columns of in situ stabilization and solidification or jet grouting will be completed to the bottom of the NAPL or confining layer to act as a vertical NAPL barrier between the site and the river.
   - A utility corridor runs adjacent to the building at 115 River Road, about 25 feet from the building foundation. With the exception of a vertical NAPL barrier near the river, remedial construction will not occur between the utility corridor and the foundation. No remedial construction will occur within 5 feet of utilities.
   - The occupants of Building 1 (i.e., property owner's office) will need to be temporarily displaced for 6 to 8 weeks during the jet grouting under 115 River Road and restoration of the office space. Jet grouting will be performed during off hours to reduce the noise impacts to the adjacent tenants. Utilities located under the building can be visually identified and will be protected or avoided.

Stage 3 (Estimated duration—55 work days): Solidification and stabilization of NZ-1 (115 River Road Property) and NZ-2 (115 River Road and former Lever Brothers properties) (Figure C-3):

1. Locate utilities within the footprint of NZ-1 and NZ-2.
2. Solidify and stabilize both sides of the 115 River Road building and a small part of NZ-1 and NZ-2 on Lever Brothers Property:
   - Utility corridors run adjacent to the building at 115 River Road, about 25 feet north and about 15 feet south of the building foundation. Remedial construction will not occur between the utility corridor and the foundation. No remedial construction will occur within 5 feet of utilities. A utility plan and clearance will be performed before implementation.
   - Solidification and stabilization will begin on the southeastern part of the 115 River Road building and proceed west.

  - Solidification and stabilization will continue on the northeastern part of the building and proceed west. The work will be scheduled during off hours to provide continued access to the Pier Building parking; however, short term limitations may be necessary.

3. Sheet piles along bulkhead on the Quanta property can be removed once adjacent columns in Stage 2 have cured.
4. Restore asphalt areas of 115 River Road parking lot, and remove jersey barriers and restore walkways.

Stage 4 (Estimated duration—145 work days): Solidification and stabilization of NZ-2 (Quanta property) and NZ-5, capping, installation of horizontal wells, permeable reactive barrier, and submersible reactive barrier, and demobilization (Figure C-4):

1. Move laydown area to allow for installation of permeable reactive barrier.
2. Locate utilities within the footprint of NZ-2 (Quanta property) and NZ-5.
3. Remove debris and foundations on NZ-2 and NZ-5.
4. Solidify and stabilize NZ-2 (including tar boils) on the Quanta property and NZ-5.
5. Install horizontal wells under building at 115 River Road.
6. Install permeable reactive barrier. Short-term access limitations to the parking lot located on the former Celotex property may be necessary.
7. Install engineered caps on Blocks 93, 94, and 92.01 and on the former Celotex and Quanta properties.
8. Demobilize.
9. Install subaqueous reactive barrier in the river when implementing the OU2 remedial action.

To avoid subcontractor downtime, the following tasks could be completed at different stages.

- Remove sheet pile once columns of in situ solidification and stabilization or jet grouting adjacent to the shoreline are completed.
- Install horizontal wells once in situ stabilization and solidification or jet grouting is completed. Horizontal wells need not be installed at the end of construction immediately before installation of engineered caps.
- Install final grading and engineered caps when there is a sufficient quantity for efficient installation.

Community Outreach and Coordination

A comprehensive community involvement and communication program will be developed in conjunction with the various community relation groups before initiating construction work and will be carried out through the duration of the construction activities. The program could include the following elements:

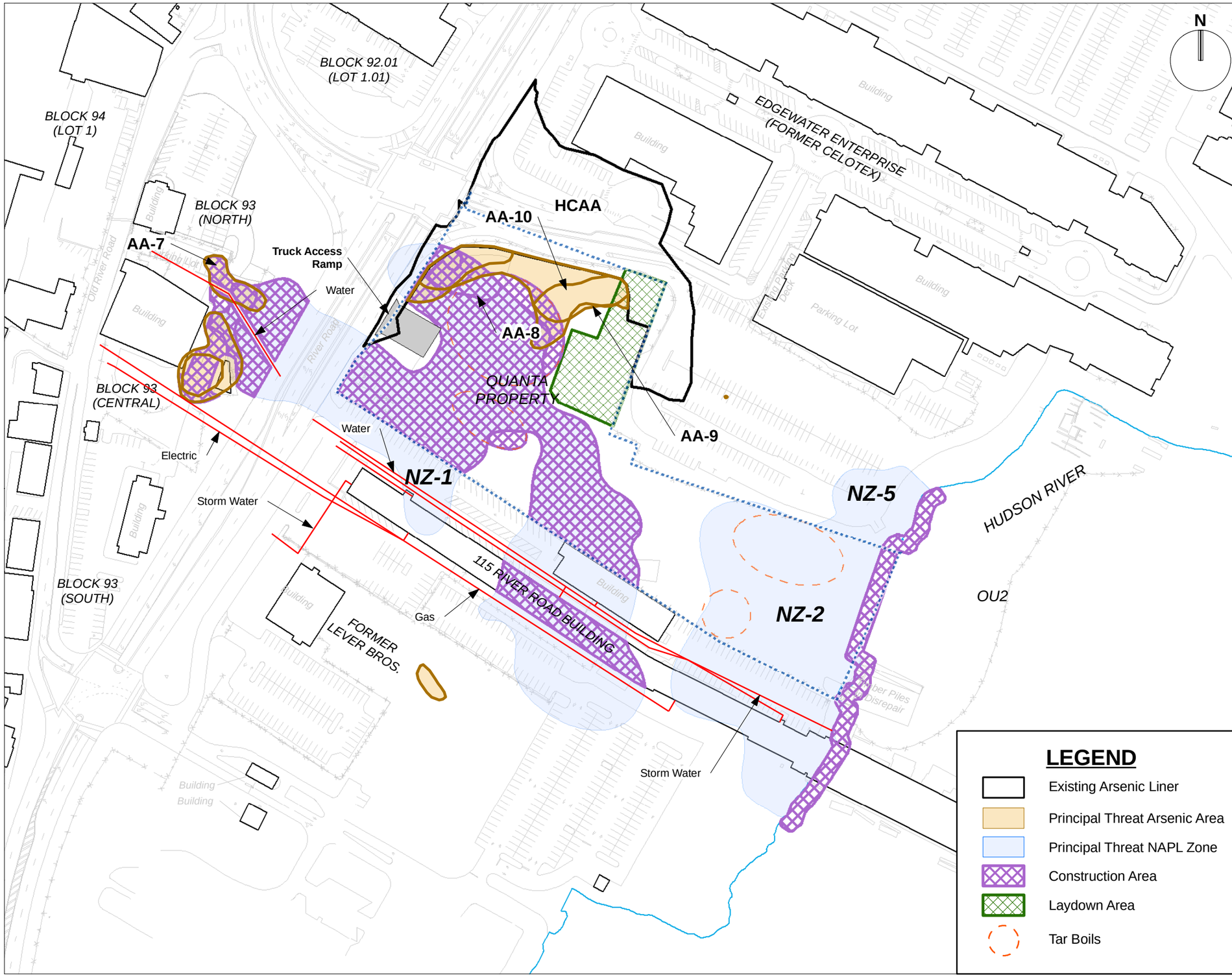
- Initial kickoff meeting with property owners, notifying them of construction schedule, fence line monitoring program, traffic management plan, and disturbances that could affect their properties and mitigate measures.
- Initial kickoff meeting with Edgewater Mayor's office and Building Department, and the fire and police departments notifying them of plans.
- Public meetings held during the construction period to notify the public of proposed and completed schedules and tasks.
- Flyers (weekly, biweekly, or monthly), a Web site, or 24-hour call number may be created to notify the public of work completed and potential inconveniences (increased truck traffic, noise, etc.).

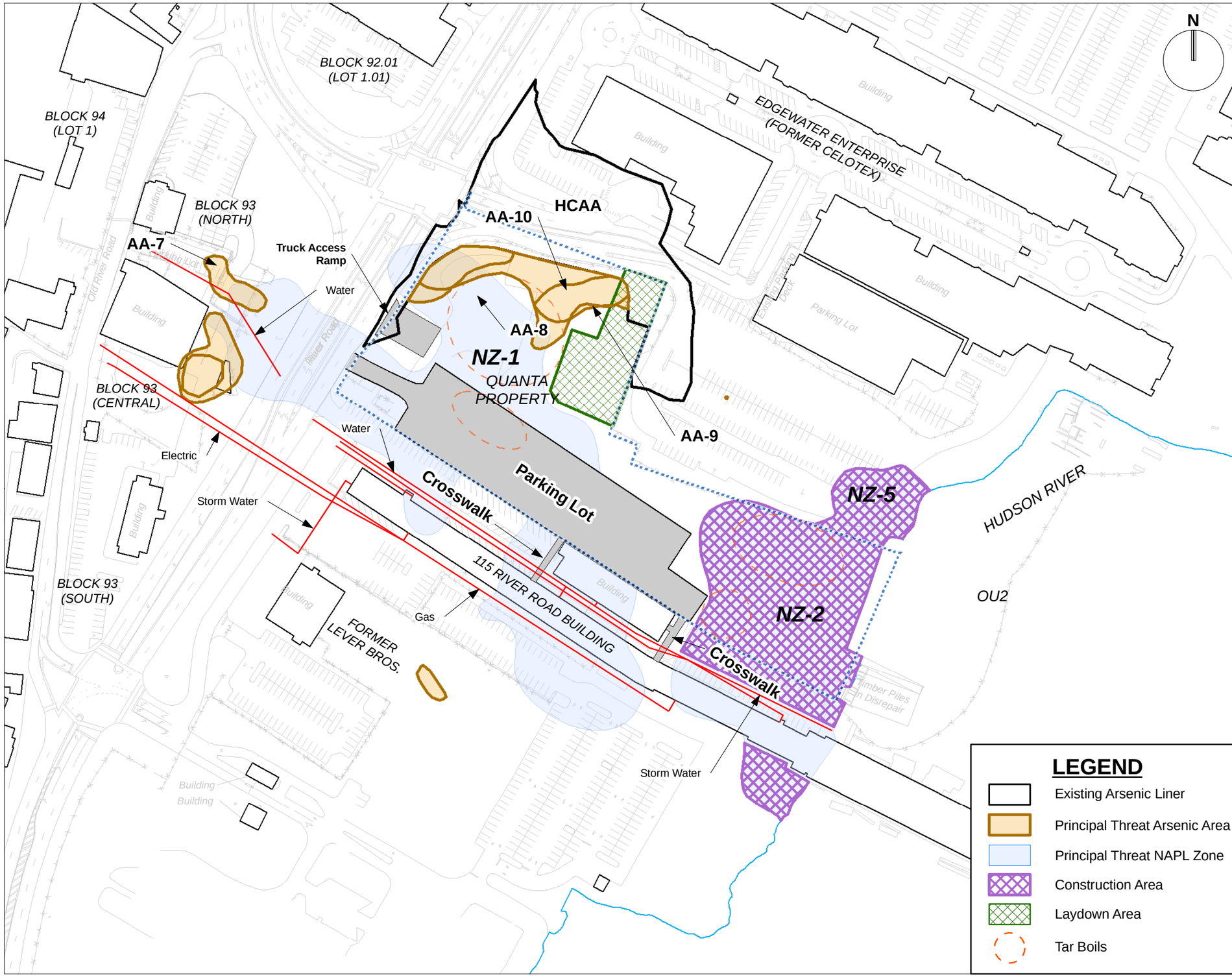
Traffic Flow

Because of the scale of remedial work at the site, there will be increased traffic related to construction. Throughout the construction period, a fire lane will remain open in accordance with state, county, and municipal regulations. Truck access from River Road to the site will be through the southwestern part of the Quanta property, north of the existing gate and ramp. The following equipment and materials will be transported throughout the project duration:

- Initial mobilization of field equipment
- Mobilization of crane and augers
- Stabilization reagent
- PRB reagent
- Backfill operations
- Debris for offsite removal

The building at 115 River Road does not have a loading dock for tenants, so neither modifications to the building nor temporary parking are required. Handicap parking will be provided in accordance with county, state, and federal regulations. Temporary handicap parking could be created in the parking garage of Building 12 (115 River Road).


N
BLOCK 92.01
(LOT 1.01)
BLOCK 94
(LOT 1)
BLOCK 93
(NORTH)
BLOCK 93
(CENTRAL)
BLOCK 93
(SOUTH)
Old River Road
River Road
EDGEWATER ENTERPRISE
(FORMER CELOTEX)
HCAA
AA-7
AA-8
AA-9
AA-10
Truck Access
Ramp
Water
Water
Electric
Storm Water
Gas
Storm Water
QUANTA
PROPERTY
NZ-1
NZ-2
NZ-5
115 RIVER ROAD BUILDING
FORMER
LEVER BROS.
HUDSON RIVER
OU2
Building
Parking Lot
Building
Building
Building



Notes:
Activities Associated with Stage 2 Construction.

1. Create parking lot on stabilized part of NZ-1 on Quanta or former Lever Brothers Properties to provide parking for 115 River Road tenants.
   a. Parking lot will be of sufficient size to compensate for parking spaces temporarily closed on the north side of 115 River Road property. Parking on 115 River Road pier will continue to be open through construction.
   b. Access from River Road to the parking lot on a stabilized part of NZ-1 on the Quanta site will be through the southwestern part of the property, where the existing gate and ramp are located. The ramp is steep and must be regraded before use.
2. Create walkways and perimeter fence (with plastic sheeting on work area side of fence and reduced visibility on walkway side) from parking lot on NZ-1.
3. Install jersey barriers in the 115 River Road parking lot to allow access to 115 River Road parking on pier.
4. Locate utilities within the footprint of NZ-2 and NZ-5 (Quanta, former Celotex, and former Lever Brothers properties).
5. Remove debris and foundations on NZ-2 and NZ-5.
6. Complete in situ stabilization and solidification or jet grouting along shoreline, including jet grouting under the 115 River Road Building pier.
   a. The first row of columns of in situ stabilization and solidification or jet grouting will be completed to the bottom of the NAPL or confining layer to act as a vertical NAPL barrier between the site and the river.
   b. A utility corridor runs adjacent to the building at 115 River Road, about 25 feet from the building foundation.
   c. The occupants of Building 2 will need to be temporarily displaced for approximately 7 weeks during the jet grouting under 115 River Road and restoration of the office space. Jet grouting will be performed during off hours to reduce the noise impacts to the adjacent tenants. Utilities located under the building can be visually identified and will be protect or avoided.
7. Location of utilities shown is approximate and will need to be confirmed.

0 70 140 ft.

LEGEND

- Existing Arsenic Liner
- Principal Threat Arsenic Area
- Principal Threat NAPL Zone
- Construction Area
- Laydown Area
- Tar Boils

CH2MHILL

STAGE 2 - CONSTRUCTION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010

FIGURE C-2

400392

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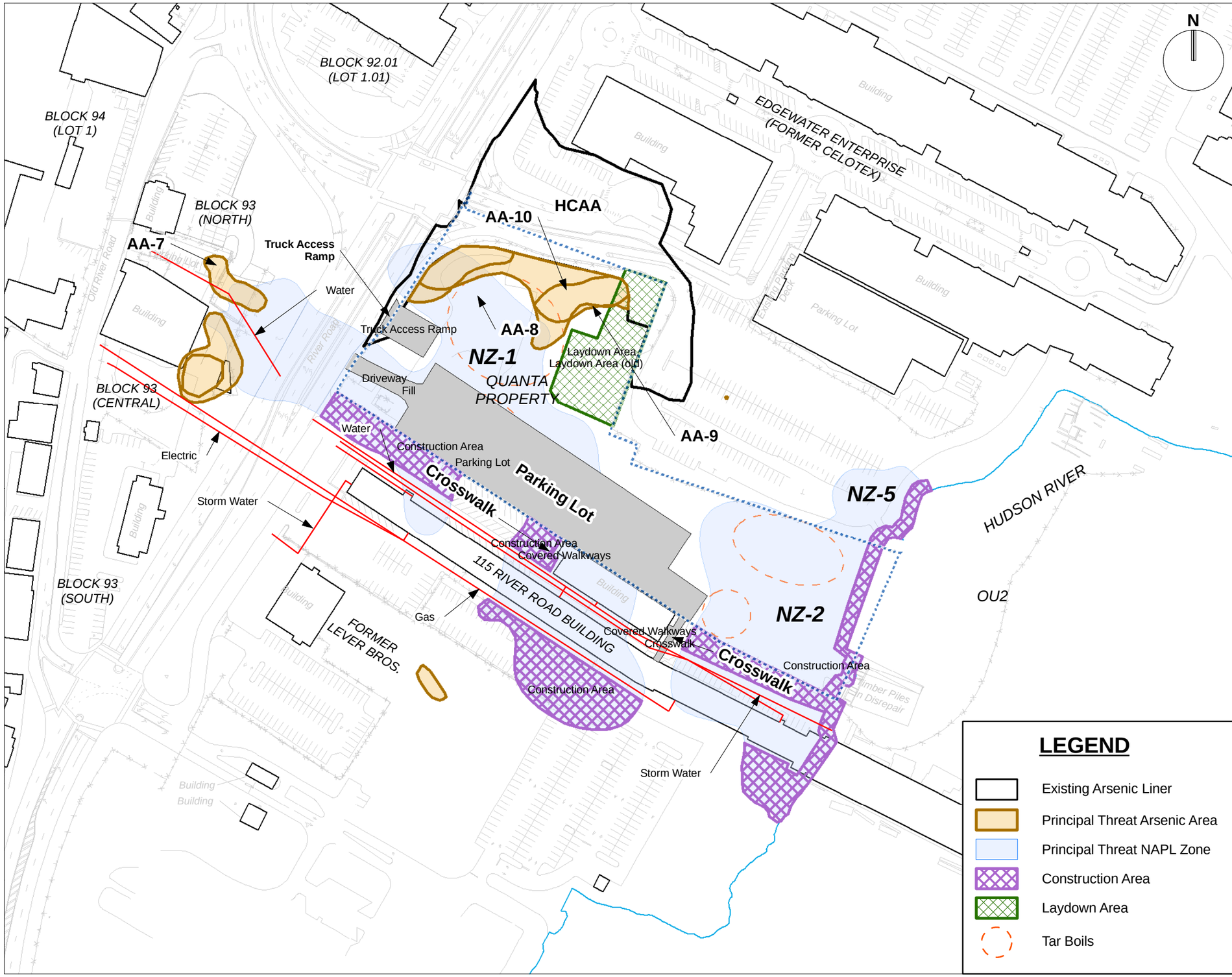

Notes:
Activities associated with stage 3 construction.

1. Locate utilities within the footprint of NZ-1 and NZ-2.
2. Solidify and stabilize both sides of the 115 River Road building and a small part of NZ-1 and NZ-2 on Lever Brothers Property:
   a. Utility corridors run adjacent to the building at 115 River Road, about 25 feet north and about 15 feet south of the building foundation. A utility plan and clearance will be performed before implementation.
   b. Solidification and stabilization will begin on the southeastern part of the 115 River Road building and proceed west.
   c. Solidification and stabilization will continue on the northeastern part of the building and proceed west. Work will be scheduled during off hours to provide continued access to the Pier Building parking; however short term limitation may be necessary.
3. Sheet piles along bulkhead on the Quanta property can be removed once adjacent columns in Stage 2 have cured.
4. Restore asphalt areas of 115 River Road parking lot, and remove jersey barriers and restore walkways.
5. Location of utilities shown is approximate and will need to be confirmed.

0 70 140 ft.

LEGEND

- Existing Arsenic Liner
- Principal Threat Arsenic Area
- Principal Threat NAPL Zone
- Construction Area
- Laydown Area
- Tar Boils

CH2MHILL

STAGE 3 - CONSTRUCTION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE C-3**

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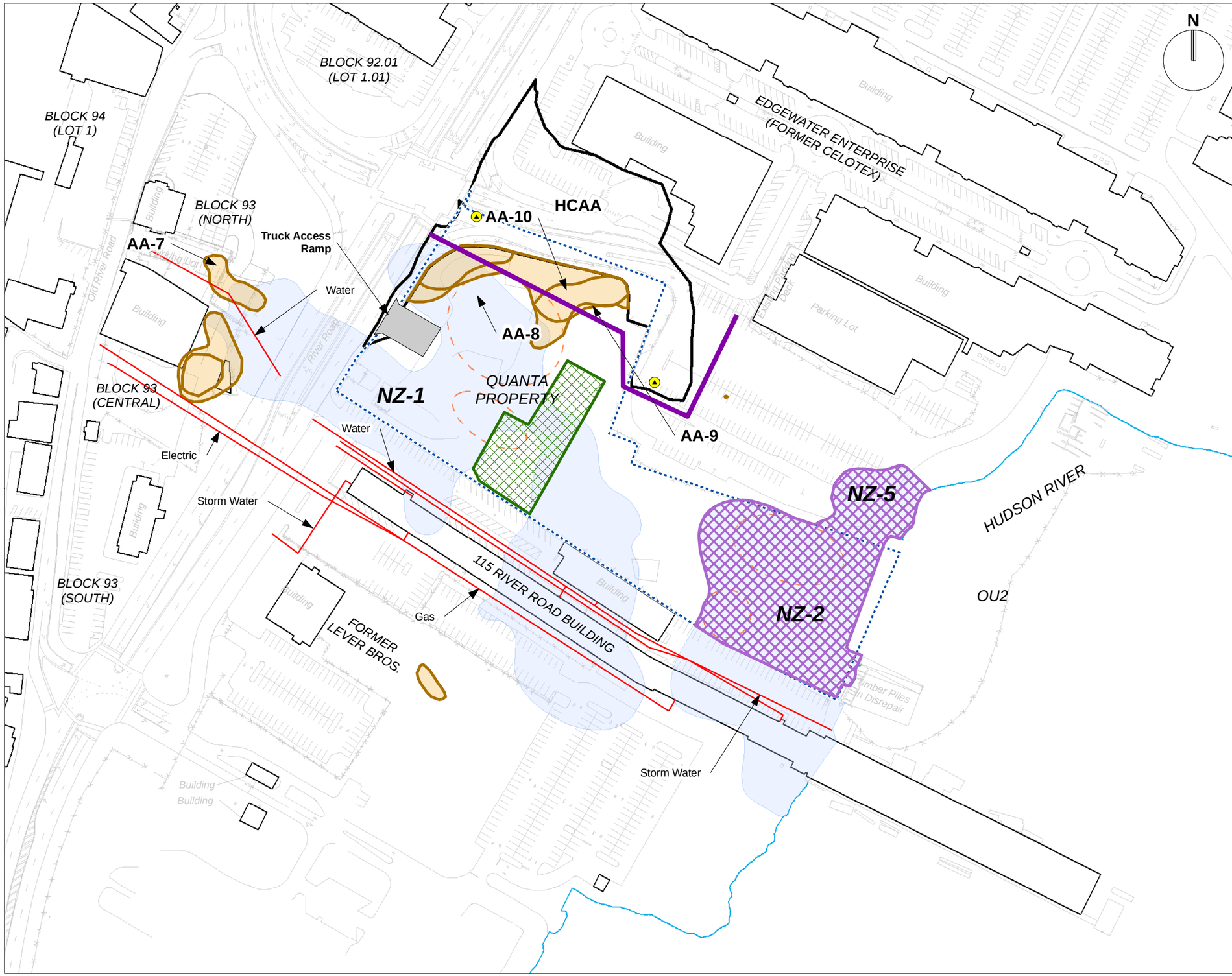

LEGEND

- Existing Arsenic Liner
- Principal Threat Arsenic Area
- Principal Threat NAPL Zone
- Construction Area
- Subaqueous Reactive Barrier (SRB)
- Tar Boils
- Barrier Wall
- Groundwater Extraction Well

Notes:
Activities Associated with Stage 4 Construction.

1. Move laydown area to allow for installation of permeable reactive barrier.
2. Locate utilities within the footprint of NZ-2 (Quanta property) and NZ-5.
3. Remove debris and foundations on NZ-2 and NZ-5.
4. Solidify and stabilize NZ-2 (including tar boils) on the Quanta property and NZ-5.
5. Install barrier wall and extraction wells.
6. Install engineered caps on Blocks 93, 94, and 92.01 and on the former Celotex and Quanta properties.
7. Demobilize.
8. Install subaqueous reactive barrier in the river when implementing the OU2 remedial action.
9. Location of utilities shown is approximate and will need to be confirmed.

0 70 140 ft.

CH2MHILL

STAGE 4 - CONSTRUCTION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE C-4**

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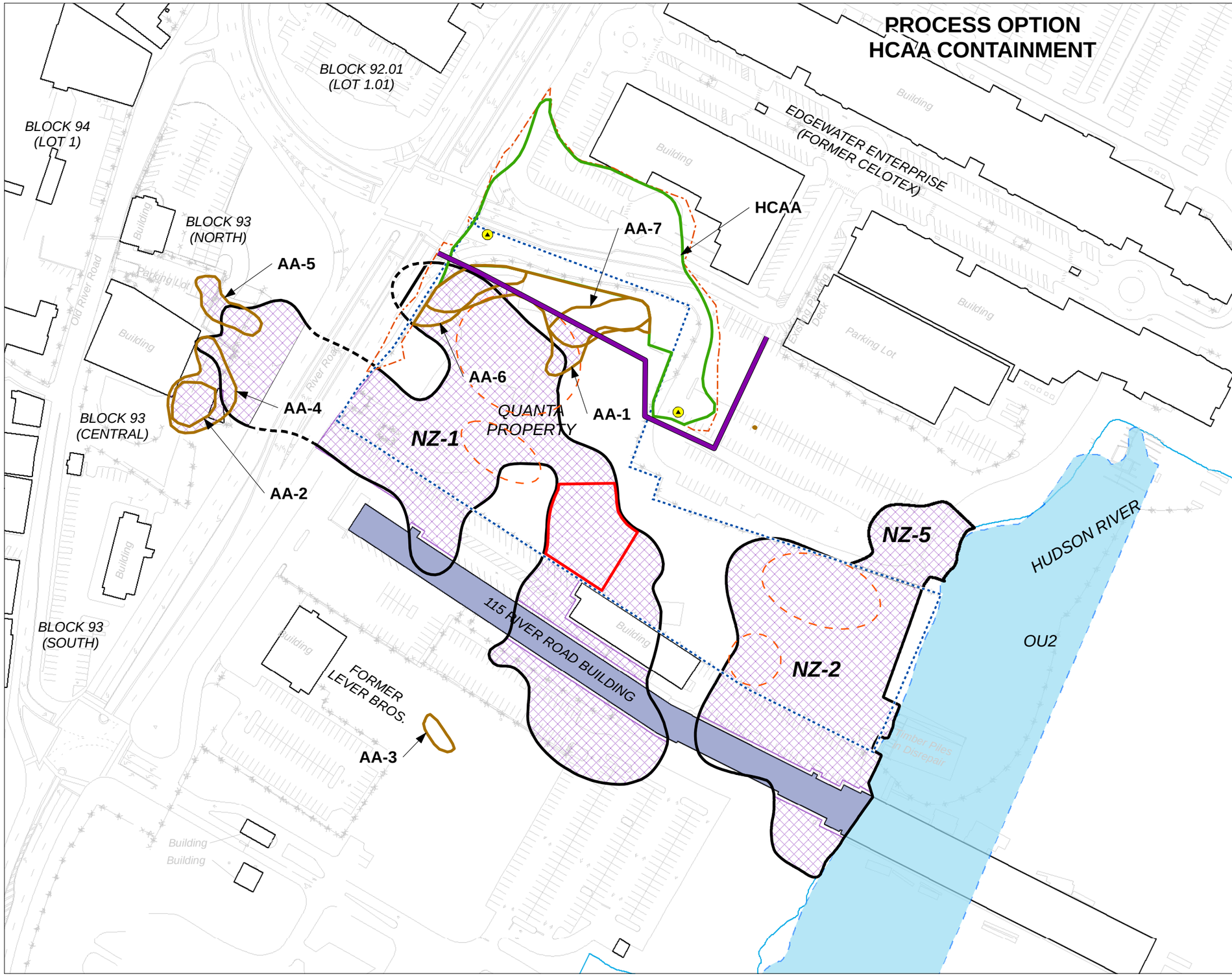

LEGEND

- Quanta Property Boundary
- Existing Arsenic Liner
- NZ-2 Principal Threat NAPL Zone
- HCAA High Concentration Arsenic Area
- AA-7 Principal Threat Arsenic Area
- Area of NZ-3 Treatment
- Approximate area of tar "boils" (Not necessarily present throughout depicted area)

Remedial Action Component

- Vapor Intrusion Engineering Controls
- Stabilization/Solidification
- Subaqueous Reactive Barrier (SRB)
- Barrier Wall
- Groundwater Extraction Well
- Passive NAPL Recovery

Note:

1. Alternative also includes capping of residual soils.
2. Methods and reagents for solidification and stabilization may vary for the various NAPL and arsenic areas.
3. Response action for NZ-1 under River Road to be coordinated with Bergen County when future roadway work occurs.
4. It is assumed that AA-3 will be addressed as part of the remediation efforts performed by iPark

0 70 140 ft.

CH2MHILL

ALTERNATIVE 4A - NAPL AND ARSENIC IN SITU SOLIDIFICATION/STABILIZATION

Quanta Resources Superfund Site
Operable Unit 1
Edgewater, New Jersey

July 6, 2010 | **FIGURE C-5**

\\LAKEFRONT\PROJ\GIS\HONEYWELL\QUANTA\REPORTS\363725_QUANTA_2008FS_REPORT\MAPFILES\FINAL_FS_DELIVERABLE_2010\DRAFT_FINAL_FS_REPORT_060910\APPENDIX C\C-5_QUANTAOU1_ALT4_INSITUSOLIDIFICATIONSTABILIZATION.MXD JHANSEN1 7/8/2010 17:16:27

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ID		Task Name	Duration
1		**Construction Implementation Plan**	**560 days**
2		**Stage 1: Mobilization and ISS of NZ-1 on Quanta Property and Block 93C and Block 94**	**250 days**
3		Planning, Submittals	90 days
4		Construction Permits	90 days
5		Mobilization	45 days
6		Site Prep/Access/Lay down Area	20 days
7		Clear and Grub - Quanta	30 days
8		Utility Demarcation (Quanta, Block 93 and Block 94)	25 days
9		Install Sub slab Depressurization System (115 RR - basements of building 7 and 8)	30 days
10		Remove Debris and Foundation in NZ-1 (Quanta and Block 93)	20 days
11		Excavate and Backfill NZ-1 and AA-7 (Block 93)	20 days
12		Install Engineered Caps (Block 93, 94 and 92.01 Properties)	30 days
13		ISS NZ-1(Quanta Property Only)	65 days
14		Install Temporary Sheet Pile Along Hudson	25 days
15		**Stage 2: ISS (NZ-2 and NZ-5) Immediately Adjacent to Hudson**	**150 days**
16		Create Temporary Parking Lot (on Quanta Property)	20 days
17		Create Walkway and Install Jersey Barrier	10 days
18		Utility Demarcation (115 River Road and former Lever Brothers)	15 days
19		Remove Debris and Foundation on NZ-2 (Quanta and former Lever Brothers) and NZ-5 (former Celotex)	35 days
20		ISS or Jet Grouting (NZ-2 and NZ-5) Immediately Adjacent to Hudson	60 days
21		ISS or Jet Grouting under 115 RR Building Immediately Adjacent to Hudson	35 days
22		**Stage 3: ISS (NZ-2 and NZ-1) on 115 RR and former Lever Brothers**	**55 days**
23		ISS NZ-2 (South Side of 115 RR Building)	10 days
24		ISS NZ-1 (South Side of 115 RR Building)	20 days
25		ISS NZ-2 (North Side of 115 RR Building)	15 days
26		ISS NZ-1 (North Side of 115 RR Building)	10 days
27		**Stage 4: ISS (NZ-2 and NZ-5) Portions Away from the Hudson River**	**145 days**
28		Restore Asphalt Areas of 115 RR Parking Lot, Remove Jersey Barriers and Walkways	45 days
29		Relocate Lay down Area to Allow for Installation of PRB	10 days
30		ISS or Jet Grouting (NZ-2) Away from Hudson River	30 days
31		ISS or Jet Grouting (NZ-5) Away from Hudson River	15 days
32		Install Horizontal Wells Under 115 RR Building	15 days
33		Install PRB (Down gradient of HCAA Area)	15 days
34		Remove Temporary Sheet Pile along NZ-2 on Quanta	15 days
35		Install Engineered Caps (former Celotex and Quanta Properties)	60 days
36		Demobilize	20 days

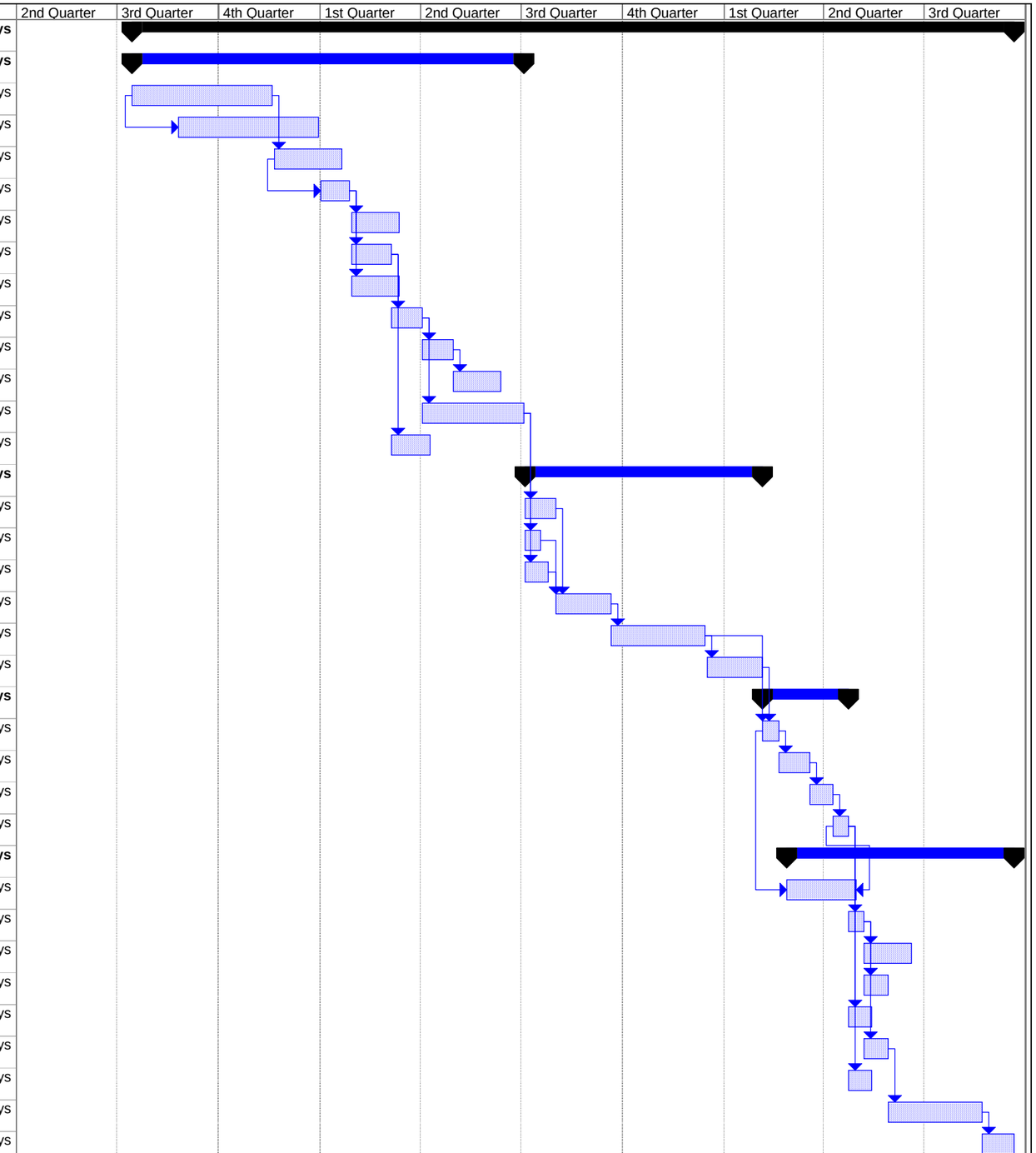

Figure C-6
Project: Quanta - CIP
Date: Wed 11/11/09

Task | Progress | Summary | External Tasks | Split
Split | Milestone | Project Summary | External MileTask

400396

Appendix D
Groundwater Modeling Results

APPENDIX D
GROUNDWATER MODELING REPORT
QUANTA RESOURCES SUPERFUND SITE
EDGEWATER, NEW JERSEY

Prepared for
CH2M HILL
Boston, MA
June 2, 2010

Prepared by

CORNERSTONE
Environmental Group, LLC

90 Crystal Run Road, Suite 201
Middletown, New York 10941

Project 100260.01

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1 INTRODUCTION

1.1 OBJECTIVES AND SCOPE

This Ground Water Modeling Report (GWMR) was prepared to document the development, calibration, and predictive simulations of a three-dimensional, finite-difference groundwater flow model used in support of the Feasibility Study for the Quanta Resources Superfund Site in Edgewater, New Jersey. The primary objective of the modeling effort was to assess the impact of selected soil and groundwater remedies and post remedy development on groundwater elevations, flow directions, and gradients. The model was also used to directly address concerns by USEPA that groundwater elevations may rise or that groundwater velocities my increase due to creation of the proposed in-situ soil stabilization (ISS) zones. The scope of the modeling effort consisted of the following tasks:

- Development of a conceptual model of site hydrogeology and groundwater flow
- Selection of the model code
- Construction of the site-specific model grid and boundary conditions
- Assignment of model input values
- Model calibration
- Simulation of selected remedial scenarios
- Sensitivity analysis

1.2 CONCEPTUAL MODEL

The numerical groundwater flow model was developed based on a conceptual model formulated from the site characterization presented in the draft RI Report (CH2M HILL, 2007) and in the Supplemental Remedial Investigation (SRI) Report for Operable Unit 1 (reference). The key aspects of this conceptual model may be summarized as follows:

1. The stratigraphy consists of conformable layers of unconsolidated sediments overlying bedrock. These units thicken from west to east as shown on Figure 1-1 these layers are:
    - Fill
    - Peat layer (where present)
    - Native sand

- Silty Clay
- Deep Sand
- Weathered Bedrock/Till

2. The top of the bedrock surface slopes from west to east as shown on Figure 1-2. A localized mound in the bedrock surface is present within the study area and causes groundwater flow in the shallow zones to be diverted around this area.
3. The competent bedrock is considered to be impermeable and is thus not included as a model layer.
4. The Peat layer is only present in the western portion of the study area as shown on Figure 1-3. East of this area, the Fill is in direct contact with the underlying Native sand.
5. The Deep Sand is separated from the Native sand by the Silty Clay deposit.
6. Groundwater flow is generally from west to east with discharge into the Hudson River. The bedrock outcrop/escarpment west of the site serves as a recharge boundary to groundwater flow in all zones.
7. A "groundwater convergence zone" is present south of the site as shown on Figure 1-4. This zone has been shown to serve as a localize discharge area to groundwater in the Shallow Zone.
8. The bulkhead along the River restricts groundwater flow in the Shallow zone to a degree and causes a slight head buildup of west of the bulkhead. There is the potential for several breaches in the wall that locally allow an enhanced connection to the river.
9. Deposits within the former gypsum landfill extend below the saturated zone and have a hydraulic conductivity of 0.028 ft/d (1 x 10-5 cm/s).

2 MODEL DEVELOPMENT

Code Selection

The program used for this project is Visual MODFLOW-Pro developed by Schlumberger Water Services. This program incorporates the MODFLOW-2000 groundwater flow code with proprietary pre- and post-processors. MODFLOW-2000 was originally developed by the US Geological Survey (Harbaugh, et al, 2000) and is well accepted in the industry. MODFLOW was selected due to its ability to simulate fully three-dimensional groundwater flow and incorporate each of the boundary conditions and remedial options that are under consideration such as barrier walls and soil stabilization areas.

Model Grid

The model domain was selected to extend well beyond the Quanta project area as shown on Figure 2-1. The horizontal finite-difference grid consists of 241 rows and 200 columns for a total of 48,200 cells per layer. A variable grid spacing was used with the finer cells over the Quanta site to allow a more accurate prediction of groundwater flow around simulated barrier walls and pumping wells. As shown on Figure 2-2, grid spacing is on the order of 10 feet by 10 feet in this area compared to 100 feet by 100 feet in the outlying areas.

Vertically, the model consists of 6 layers as shown on Figure 1-1. Since the Peat layer is not present throughout the model domain, Model Layer 2 represents both the Peat layer and the native sand, depending on the location.

Boundary Conditions

There are three primary boundary conditions used in the model. The first is a constant head boundary located at the bedrock outcrop along the western portion of the study area as shown on Figure 2-3. This outcrop was assigned variable head values in Layer 1 ranging from 6 feet to 3 feet (msl) based on various groundwater elevation contour maps. The constant head cells were also assigned to lower layers by reducing the specified head by approximately one foot through the vertical section to simulate downward gradients.

The second boundary condition as the simulation of the Hudson River with model "river" cells. A specified elevation of 0.0 feet was used for the mean tide elevation in these cells. The conductance term representing the riverbed sediments was initially set to 0.0028 ft/d (1.0×10^{-6} cm/s), and was varied during model calibration.

The final hydraulic boundary condition simulated in the model was the groundwater convergence zone located in the southern portion of the area. This zone was simulated

using model “drain” cells with the specified elevation selected based on various groundwater elevation contour maps. These elevations ranged from 3.0 feet (msl) on the west side to 1.0 feet (msl) near the River.

Recharge

Recharge to the groundwater system was assigned as an annual average of the expected rate of infiltration of precipitation. This is standard procedure for models that are to be run to steady state conditions. The input values used for the calibration runs were derived from current land use conditions and were provided to Cornerstone by CH2M Hill as shown on Figure 2-4. The values range from 1 inch/year over paved and covered surfaces to 18 inches/year over open/vegetated areas. The cap placed over the high concentration arsenic area (HCAA) was simulated by eliminating recharge from precipitation in this area as shown on the figure.

3 MODEL CALIBRATION

The model was calibrated to pre-development conditions using an initial set of model input parameters. These values were selected to represent average subsurface conditions based on a review of data from prior investigations. The model was then calibrated to steady state conditions by comparing the predicted heads with those measured in September 2009. The final calibrated input values are shown below and are within reasonable ranges relative to the initial values.

Hydro-stratigraphic Interval	Model Layer	Horizontal Hydraulic Conductivity	Vertical Hydraulic Conductivity
Overburden	1	5.0 ft/d	0.5 ft/d
Peat layer	2	0.028 ft/d	0.0028 ft/d
Native Sand	3	8.0 ft/d	0.8 ft/d
Silty Clay	4	0.002 ft/d	0.0002 ft/d
Lower Sand	5	10 ft/d	1.0 ft/d
Till/Weathered Rx	6	0.1 ft/d	0.01 ft/d

Predicted groundwater elevations within the Fill and Native sand are presented on Figures 3-1 and 3-2, respectively and indicate that the general orientation of the elevation contours are in close agreement with those developed from the field data. The influence of the bedrock mound in the Native sand is evident on Figure 3-2, with groundwater flow being diverted around this area. The influence of the groundwater convergence area is also evident on the southern side of the site, especially in the Shallow zone.

The calibration of the model was also evaluated statistically by cross-plotting predicted heads versus measured heads for each of the available monitoring well locations on Figure 3-3. Each symbol on the plot represents a monitoring well with a measured groundwater elevation value. A perfect fit is illustrated by the 45-degree line shown for reference. The results indicate that the 95% confidence interval is centered around this line and that the normalized root mean square of the data (NRMS) is calculated at

11.8 percent. This is within the generally accepted guideline for model calibration which ranges from 10 to 15% for complex systems. The groundwater flow system at the Quanta site is relatively complex due to the varied land use, tidal influences from the Hudson River, proximity to the upgradient bedrock escarpment, subsurface bedrock mound, variable bulkhead conditions, and subsurface utilities.

4 PREDICTIVE SIMULATIONS

Two remedial scenarios were simulated using the calibrated groundwater flow model described in Section 3. Each scenario includes the in-situ stabilization of soil which has been assumed to render the treated material relatively impermeable to groundwater flow. Remedial Alternative 4 consists of in-situ soil stabilization zones only, whereas Remedial Alternative 4a consists of a reduced area of soil stabilization in the HCAA and the addition of a subsurface barrier wall and groundwater pumping wells. The remedial simulations are further described below.

4.1 Remedial Alternative 4: In-situ Soil Stabilization Only

The calibrated model was modified to simulate the ISS zones by changing the hydraulic conductivity distribution in Layer 1. As shown in Figure 4-1, the ISS zones were assigned a hydraulic conductivity of 1×10^{-6} ft/d. Also shown is the reduced permeability associated with the former gypsum landfill and the bedrock mound. The recharge array was changed to represent post-remedy conditions as shown on Figure 4-2. The ISS areas were assigned a recharge of zero, and the asphalt and engineered cap/cover areas were assigned an annual average recharge rate of 1 in/year.

The predicted groundwater elevations in the Fill and in the Native sand are shown on Figures 4-3 and 4-4, respectively. Groundwater elevations indicate that most site groundwater will preferentially move beneath the ISS zones where they are underlain by Native Sand. This scenario occurs in the central and eastern portions of the site. By comparison, groundwater flow generally moves around the ISS zones in the western portion of the site (west of River Road where they are underlain by peat deposits. The figures also illustrate that post remedy horizontal gradients are relatively low and thus groundwater velocities will be relatively slow. It is also noted that post-remedy groundwater flow direction is predicted to change from northeast to southeast along the northern OU-1 boundary and flow will be onto the site from the northern properties.

4.2 Remedial Alternative 4a: In-Situ Soil Stabilization and HCAA Barrier Wall with Groundwater Pumping

In this remedial scenario, the extent of ISS in the HCAA has been reduced and a downgradient subsurface barrier wall has been included to prevent arsenic contaminated groundwater from migrating to the south as shown on Figure 4-5. The “wall” feature in MODFLOW was used to simulate the subsurface barrier that is part of this remedial

scenario. For the purpose of modeling, it was assumed that the wall is 1 foot thick and had a permeability of 1 x 10^{-6} cm/s. The wall would extend vertically through the Peat layer and tie into the bedrock mound on the east side of the area. Since groundwater elevations would build up behind the wall, two groundwater pumping wells were simulated by the model to reduce heads and capture contaminated groundwater. The wells were assumed to be screened in the Fill above the peat. Their location is shown on Figure 4-5.

The predicted groundwater elevations in the Fill and in the Native sand are shown in Figures 4-6 and 4-7, respectively. Groundwater elevations indicate that pumping of the wells lowers heads within the HCAA such that flow is fully captured within the barrier wall. The effectiveness of the wall is aided by the presence of the bedrock mound to the northeast. The predicted pumping rate for this scenario is approximately 1.5 gpm for each well for a total of 3 gpm.

5 SENSITIVITY ANALYSIS

In order to assess the robustness of the model results, a sensitivity analysis was conducted on selected input parameters. The objective of the sensitivity analysis was to quantitatively determine the sensitivity of the various parameters as they relate to USEPA's concern that groundwater levels may rise due to ISS zones placed near the downgradient end of the site, and/or land use changes that increase the infiltration of precipitation. Calibrated input values were used as the starting point of the analysis and were increased and decreased within ranges that were appropriate for the parameter. Parameters were tested one at a time with calibrated values used for all remaining inputs. The model was run to steady state conditions for each value being tested and the predicted impact on groundwater elevations recorded.

A total of seven parameters were tested in the sensitivity analysis as shown on Figure 5-1. The ranges were selected based on the nature of the parameter and the quality of the field data. For each run, the elevation of the groundwater table in the central and eastern portion of the site was reviewed for changes. It should be remembered however, that when the calibrated values are changed, the model no longer calibrates to field measured water level data and thus a prediction of high elevations may not be related to the remedy itself.

The placement of the ISS zones did not have a impact on groundwater elevations due to the ability of groundwater to flow around the blocks on the western portion of the site and beneath them in the central and eastern portions of the site. Similarly, changing the vertical permeability of the Peat had little effect since the Peat is not a continuous layer across the site.

Groundwater elevations were relatively sensitive to the horizontal permeability of the riverbed sediments and the Native sand. Predicted heads rose with a reduction in the permeability value since a steeper gradient is required to move groundwater to its point of discharge in the River. However, since these parameters are not influenced by remedies or land use changes, and since the model only calibrated to the base case values, these results are not significant.

Recharge from precipitation was observed to cause an appreciable rise in groundwater levels especially at the high end of the tested range. This is not unexpected since the relationship between recharge and hydraulic gradient is inversely proportional in most flow systems. However, since the proposed remedy includes some form of cap/cover material over the majority of the site, the risk of having unexpectedly high local recharge areas is relatively low. Routine water level monitoring would also help to reduce these risks.

6 CONCLUSIONS

The following conclusions have been developed based on the modeling simulations described above and to address EPA's questions regarding the potential for groundwater to rise and/or increase in velocity as it interacts with the ISS zones

- Groundwater within the Fill will preferentially move beneath the stabilization zones where they are underlain by Native Sand (east of River Road).
- Groundwater within the Fill will generally move around the stabilization zones where they are underlain by Peat deposits (west of River Road).
- Formation of the ISS zones is not predicted to cause groundwater elevations to rise. Model predictions shows that groundwater will easily move around and beneath the ISS zones.
- Horizontal hydraulic gradients are low in post-remedial predictions and thus groundwater velocities will continue to be relatively slow.
- Post-remedy groundwater flow is predicted to change from northeast to southeast along the northern OU-1 boundary.
- Post remedy convergence zone will continue to provide a flow boundary to the south.
- The results of a sensitivity analysis on model input parameters indicate that formation of the ISS blocks will have little adverse impact on groundwater flow direction or elevations.
- Local increases in recharge from precipitation have the potential to raise groundwater levels in the Fill and should be managed in accordance with the proposed capping remedy.
- With respect to Remedy 4a, installation of a cut off wall and pumping wells downgradient of the HCAA will effectively capture groundwater from this area with flow rates in the 2 to 3 gpm range.
- Predicted groundwater elevations downgradient of the cut off wall are similar in both Remedy 4 and 4a simulations since pumping from the extraction wells mitigates any head buildup that may occur upgradient of the wall.

Appendix E
Detailed Cost Summary

TABLE E-1
Comparison of Total Cost of Remedial Alternatives
Draft Final Feasibility Study, Quanta Resources Site, Edgewater, New Jersey

	Alternative 2 NAPL and Arsenic Containment	**Alternative 3** NAPL and Arsenic Containment with NAPL Recovery	**Alternative 4a Process Option** NAPL and Arsenic In Situ Solidification/Stabilization	**Alternative 4b Process Option** NAPL and Arsenic In Situ Solidification/Stabilization with Demolition of the 115 River Road Buildings	**Alternative 5a Process Option** NAPL In Situ Chemical Oxidation with Arsenic Stabilization	**Alternative 5b Process Option** NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demolition of the 115 River Road Building	**Alternative 6a** NAPL and Arsenic Excavation	**Alternative 6b** NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings
Total Capital Cost	**$32,270,000**	**$42,300,000**	**$54,410,000**	**$152,880,000**	**$226,450,000**	**$335,090,000**	**$184,550,000**	**$288,280,000**
Soil	$18,260,000	$18,260,000	$19,140,000	$116,570,000	$7,300,000	$104,900,000	$32,850,000	$130,450,000
NAPL and Arsenic	$0	$2,800,000	$31,020,000	$32,060,000	$198,380,000	$209,420,000	$131,850,000	$137,980,000
Groundwater	$14,010,000	$21,240,000	$4,250,000	$4,250,000	$20,770,000	$20,770,000	$19,850,000	$19,850,000
Vapor	$650,000	$650,000	$650,000	$0	$650,000	$0	$650,000	$0
Total O&M Cost	**$19,230,000**	**$47,200,000**	**$40,000,000**	**$37,000,000**	**$176,280,000**	**$181,890,000**	**$48,560,000**	**$47,240,000**
Total Periodic Cost	**$520,000**	**$520,000**	**$520,000**	**$520,000**	**$520,000**	**$520,000**	**$520,000**	**$520,000**
Total Present Value	**$41,490,000**	**$63,640,000**	**$72,240,000**	**$168,820,000**	**$365,640,000**	**$480,260,000**	**$205,920,000**	**$308,210,000**

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the remedial alternatives. This is an order-of-magnitude cost estimate that is expected to be within +50 to -30 percent of the actual project costs. Rev. June 18, 2010.

Alternative 2: NAPL and Arsenic Containment — COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	Tar boils at the ground surface throughout the site, NAPL present in NZ-1, NZ-2 and NZ-5 would be capped. Institutional controls would be established to document and limit use of areas with COCs remaining in place. A funnel-and-gate system (barrier wall with a permeable reactive barrier) would be installed to prevent potential NAPL migration to the Hudson River.
Arsenic	Arsenic-contaminated soils >390 ppm from 0-2 ft bgs and soils >1,000 ppm from 2-10 ft bgs would be capped. Liner over the HCAA would remain. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	A vapor mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Road. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	Site groundwater would be contained with a funnel-and-gate system (barrier wall with permeable reactive barrier) before discharging to the River. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	25	DY	$ 1,500	$ 37,500	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	24	MO	$ 4,300	$ 103,200	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 396,700*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	24	MO	$ 12,000	$ 288,000	CH2M Est.	
SUBTOTAL				*$ 513,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility mark out	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	TN	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility mark out	1	DY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 16,352		
Mobilization/Demobilization	5%			$ 818	Source 3	
Subcontractor general conditions	20%			$ 3,270	Source 3	
SUBTOTAL				*$ 20,440*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil sub grade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		
Upgrade Asphalt Cap (115 River Road)						
Fine grading	7,059	SY	$ 1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$ 54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$ 6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 316,416		
Mobilization/Demobilization	5%			$ 15,821	Source 3	
Subcontractor general conditions	20%			$ 63,283	Source 3	
SUBTOTAL				*$ 395,519*		
Asphalt Cap (Edgewater - NZ-5)						
Fine grading	1,508	SY	$ 1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$ 54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$ 11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$ 6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 64,238		
Mobilization/Demobilization	5%			$ 3,212	Source 3	
Subcontractor general conditions	20%			$ 12,848	Source 3	
SUBTOTAL				*$ 80,297*		

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Alternative 2: NAPL and Arsenic Containment — COST ESTIMATE SUMMARY - DRAFT

Upgrade Asphalt Cap (Block 93 North and Central)							
Fine grading	11,532	SY	$	1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$	54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$	6	$ 11,927	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 462,836		
Mobilization/Demobilization	5%				$ 23,142	Source 3	
Subcontractor general conditions	20%				$ 92,567	Source 3	
SUBTOTAL					*$ 578,544*		
Upgrade Asphalt Cap (Block 94)							
Fine grading	2,322	SY	$	1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 161,073		
Mobilization/Demobilization	5%				$ 8,054	Source 3	
Subcontractor general conditions	20%				$ 32,215	Source 3	
SUBTOTAL					*$ 201,341*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	90	DY	$	718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$	106	$ 279,760	Source 4 + CH2M H&S	
SUBTOTAL					*$ 368,400*		
CAPITAL SUBTOTAL - SOIL					$ 11,810,365		
Contingency	25%				$ 2,952,591	10% Scope + 15% Bid	
SUBTOTAL					$ 14,762,957		
Project Management	5%				$ 738,148	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 885,777	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 885,777	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 2,509,703		
Contractor Fees							
ODC & Subs	5%		$	14,762,957	$ 738,148		
Labor	10%	max	$	2,509,703	$ 250,970		
SUBTOTAL					$ 989,118		
TOTAL CAPITAL COST - SOIL					**$ 18,260,000**		

GROUNDWATER

General							
Preconstruction Investigations							
Pump test	1	LS	$	230,000	$ 230,000		
Updates to the groundwater model	1	LS	$	20,000	$ 20,000		
Bench-scale testing (Arsenic and NAPL)	2	EA	$	75,000	$ 150,000		
Pilot-scale testing	1	LS	$	150,000	$ 150,000		
SUBTOTAL					*$ 550,000*		
Replacement Monitoring Wells							
Soil borings	480	FT	$	47	$ 22,320		Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$	31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen
2-inch PVC well screen	160	FT	$	34	$ 5,398	MEANS 33-23-0256	
Well development	16	EA	$	1,600	$ 25,600	Source 3	
Off-site disposal of soil cuttings from well installation	50	TN	$	128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$	1.00	$ 10,000	Source 3	Assumes water is non-hazardous
SUBTOTAL					$ 79,712		
Mobilization/Demobilization	5%				$ 3,986	Source 3	
Subcontractor general conditions	20%				$ 15,942	Source 3	
SUBTOTAL					*$ 99,640*		
Funnel and Gate							
Cutoff Wall at Shoreline							
Remove concrete decking	2,500	SF	$	15	$ 37,500	Envirocon ROM estimate	
Rip-rap removal	1,040	CY	$	25	$ 26,000	Envirocon ROM estimate	
Barrier wall at 115 River Road (under building)	1	LS	$	600,000	$ 600,000	Envirocon ROM estimate	
Sealed sheet piling - shoreline	42,000	SF	$	127	$ 5,334,000	Source 3	Assumes an average depth of 35-ft
SUBTOTAL					$ 5,997,500		
Mobilization/Demobilization	5%				$ 299,875	Source 3	
Subcontractor general conditions	20%				$ 1,199,500		
SUBTOTAL					*$ 7,496,875*		
Air Sparge System							
One-pass trench w/air sparge piping	7,650	SF	$	25	$ 191,250	Source 3	
Well vaults	2	EA	$	8,000	$ 16,000		
Manifolds and valves	1	LS	$	25,000	$ 25,000		
Disposal of soil cuttings	1,044	CY	$	128	$ 133,653	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Trenching for conveyance piping	67	CY	$	13	$ 870	MEANS 17-03-0202	
Conveyance piping	300	LF	$	54	$ 16,200	MEANS 33-26-0406	Assume blower skids near wells
Backfill trench	1,100	CY	$	54	$ 59,690	MEANS 17-03-0423	
Electrical to skids	1	LS	$	40,000	$ 40,000	CH2M HILL Est.	
Concrete pad	2	LS	$	10,000	$ 20,000	CH2M HILL Est.	
Shelter and fence	2	LS	$	12,000	$ 24,000	CH2M HILL Est.	
Blower skids	2	EA	$	15,000	$ 30,000	CH2M HILL Est.	
Startup	1	LS	$	5,000	$ 5,000		
SUBTOTAL					$ 561,662		
Mobilization/Demobilization	15%				$ 84,249	Source 3	
Subcontractor general conditions	20%				$ 112,332	Source 3	
SUBTOTAL					*$ 758,244*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	30	DY	$	718	$ 21,525	Source 4 + CH2M H&S	
PPE provisions for workers (initial)	8	EA	$	252	$ 2,015	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,056	EA	$	106	$ 111,904	Source 4 + CH2M H&S	
SUBTOTAL					$ 154,471		
CAPITAL SUBTOTAL - GROUNDWATER					$ 9,059,230		
Contingency	25%				$ 2,264,808	10% Scope + 15% Bid	
SUBTOTAL					$ 11,324,038		
Project Management	5%				$ 566,202	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 679,442	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 679,442	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 1,925,086		
Contractor Fees							
ODC & Subs	5%		$	11,324,038	$ 566,202		
Labor	10%	max	$	1,925,086	$ 192,509		
SUBTOTAL					$ 758,711		
TOTAL CAPITAL COST - GROUNDWATER					**$ 14,010,000**		

VAPOR

Vapor Mitigation							
Preconstruction Investigations							
Evaluate building systems	1	LS	$	10,000	$ 10,000	Radiation Data Quote Phase 1	
SUBTOTAL					*$ 10,000*		
Install Sub Slab Depressurization System							
Install new french drain system	1	LS	$	50,000	$ 50,000	Source 3	
Upgrade dewatering equipment	1	LS	$	50,000	$ 50,000	Source 3	
Add carbon and bag filter system	1	LS	$	120,000	$ 120,000	Source 3	
Install sub slab depressurization system	1	LS	$	65,000	$ 65,000	Radiation Data Quote Phase 2	
SUBTOTAL					$ 285,000		
Mobilization/Demobilization	5%				$ 14,250		
Subcontractor general conditions	20%				$ 57,000		
SUBTOTAL					*$ 356,250*		
CAPITAL SUBTOTAL - VAPOR					$ 366,250		
Contingency	25%				$ 91,563	10% Scope + 15% Bid	
SUBTOTAL					$ 457,813		

Project Management	8%			$ 36,625		USEPA 2000, p. 5-13, $100K - $500K
Remedial Design	15%			$ 68,672		USEPA 2000, p. 5-13, $100K - $500K
Construction Management	10%			$ 45,781		USEPA 2000, p. 5-13, $100K - $500K
SUBTOTAL				$ 151,078		
Contractor Fees						
ODC & Subs	5%		$ 457,813	$ 22,891		
Labor	10%	max	$ 151,078	$ 15,108		
SUBTOTAL				$ 37,998		
TOTAL CAPITAL COST - VAPOR				**$ 650,000**		
TOTAL CAPITAL COST				**$ 32,920,000**		

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 24,130	$ 24,130		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 34,130		
Contingency	25%			$ 8,533	10% Scope + 15% Bid	
SUBTOTAL				$ 42,663		
Project Management	10%			$ 4,266	USEPA 2000, p. 5-13, <$100K	
Remedial Design	20%			$ 8,533	USEPA 2000, p. 5-13, <$100K	
Construction Management	15%			$ 6,399	USEPA 2000, p. 5-13, <$100K	
SUBTOTAL				$ 19,198		
Contractor Fees						
ODC & Subs	5%		$ 42,663	$ 2,133		
Labor	10%	max	$ 19,198	$ 1,920		
SUBTOTAL				$ 4,053		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		
GROUNDWATER						
Air Sparge System O&M						
Operator	208	HR	$ 80	$ 16,640		Assumes 4 hrs/week for one operator
Sampling for Discharge Compliance	1	EA	$ 10,057	$ 10,057	Source 4	Assumes annual compliance samples at 8 wells
Parts Replacement / Consumables	1	LS	$ 12,500	$ 12,500		
Electricity - SVE Skids	131,400	KWH	$ 0.1	$ 13,140		Assume 2- 10 HP blowers
Misc. Electrical Site Usage	12	MO	$ 215	$ 2,584	MEANS 33-42-0106	
Reporting	100	HR	$ 100	$ 10,000		
Allowance for Misc. Items	1	LS	$ 12,984	$ 12,984		Assumes 20% of capital cost
SUBTOTAL				$ 77,906		
Subcontractor general conditions	25%			$ 19,476		
SUBTOTAL				*$ 97,382*		
Contingency	25%			$ 24,346	10% Scope + 15% Bid	
SUBTOTAL				$ 121,728		
Project Management	8%			$ 9,738	USEPA 2000, p. 5-13, $100K - $500K	
Remedial Design	15%			$ 18,259	USEPA 2000, p. 5-13, $100K - $500K	
Construction Management	10%			$ 12,173	USEPA 2000, p. 5-13, $100K - $500K	
SUBTOTAL				$ 40,170		
Contractor Fees						
ODC & Subs	5%		$ 121,728	$ 6,086		
Labor	10%	max	$ 40,170	$ 4,017		
SUBTOTAL				$ 10,103		
TOTAL ANNUAL O&M COST - Air Sparge System O&M				**$ 172,001**		
Groundwater Monitoring						
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals
QC Samples	5	EA	$ 1,000	$ 4,998		
Groundwater Sampling, Level D						
Labor	300	HR	$ 80	$ 24,000		Assumes 3 persons for 5 days
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3	
Consumables	1	LS	$ 3,000	$ 3,000	Source 3	
Data Validation	96	HR	$ 100	$ 9,600		
Reporting	240	HR	$ 100	$ 24,000		
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758		Assumes 10% of the capital costs
SUBTOTAL				$ 118,340		
Mobilization/Demobilization	5%			$ 5,917		
Subcontractor general conditions	25%			$ 29,585		
SUBTOTAL				*$ 153,842*		
Contingency	25%			$ 38,461	10% Scope + 15% Bid	
SUBTOTAL				$ 192,303		
Project Management	8%			$ 15,384	USEPA 2000, p. 5-13, $100K - $500K	
Remedial Design	15%			$ 28,845	USEPA 2000, p. 5-13, $100K - $500K	
Construction Management	10%			$ 19,230	USEPA 2000, p. 5-13, $100K - $500K	
SUBTOTAL				$ 63,460		
Contractor Fees						
ODC & Subs	5%		$ 192,303	$ 9,615		
Labor	10%	max	$ 63,460	$ 6,346		
SUBTOTAL				$ 15,961		
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 1,258,896**	Quarterly for first year (Four GW sampling events)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 443,725**	Annual for Years 2 to 30 (one GW sampling event per year)	
VAPOR						
Vapor Intrusion Operation Bldg 115						
Routine Operations, Maintenance, Monitoring	240	HR	$ 80	$ 19,200		Assumes part time operator performs duties 5 days/month
Parts Replacement / Consumables	1	LS	$ 2,000	$ 2,000	Source 3	
Electricity	13,140	KWH	$ 0.10	$ 1,314	Source 3	
Replace bag filters and carbon media	4	EA	$ 2,500	$ 10,000		Assume carbon replacement every 3 months -
Reporting	80	HR	$ 80	$ 6,400	CH2M Est.	
SUBTOTAL				$ 38,914		
Mobilization/Demobilization	5%			$ 1,946		
Subcontractor general conditions	25%			$ 9,729		
SUBTOTAL				*$ 50,588*		
Contingency	25%			$ 12,647	10% Scope + 15% Bid	
SUBTOTAL				$ 63,235		
Project Management	10%			$ 6,324	USEPA 2000, p. 5-13, <$100K	
Remedial Design	20%			$ 12,647	USEPA 2000, p. 5-13, <$100K	
Construction Management	15%			$ 9,485	USEPA 2000, p. 5-13, <$100K	
SUBTOTAL				$ 28,456		
Contractor Fees						
ODC & Subs	5%		$ 63,235	$ 3,162		
Labor	10%	max	$ 28,456	$ 2,846		
SUBTOTAL				$ 6,007		
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)				**$ 100,000**		

Alternative 2: NAPL and Arsenic Containment — COST ESTIMATE SUMMARY - DRAFT

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 18,260,000	$ 18,260,000	1.000	$ 18,260,000	
CAPITAL COST - GROUNDWATER	0	$ 14,010,000	$ 14,010,000	1.000	$ 14,010,000	
CAPITAL COST - VAPOR	0	$ 650,000	$ 650,000	1.000	$ 650,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 1,258,896	$ 1,258,896	0.935	$ 1,176,538	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 12,868,016	$ 443,725	11.474	$ 5,091,502	
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)	1 to 30	$ 3,000,000	$ 100,000	12.409	$ 1,240,904	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 52,667,911			$ 41,493,638	

TOTAL PRESENT VALUE OF ALTERNATIVE 2 — $ 41,490,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5 and via horizontal recovery wells under the 115 River Road Building. Capping and institutional controls would be established to document and limit use of areas with COCs remaining in place.
Arsenic	Arsenic-contaminated soils >390 ppm from 0-2 ft bgs and soils >1,000 ppm from 2-10 ft bgs would be capped. A barrier wall with groundwater extraction and treatment installed downgradient of the HCAA. Liner over the HCAA would remain. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	A vapor mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Road. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	Site groundwater would be contained with a barrier and groundwater extraction at the shoreline and downgradient of the HCAA. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	25	DY	$ 1,500	$ 37,500	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	24	MO	$ 4,300	$ 103,200	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 396,700*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	24	MO	$ 12,000	$ 288,000	CH2M Est.	
SUBTOTAL				*$ 513,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 16,352		
Mobilization/Demobilization	5%			$ 818	Source 3	
Subcontractor general conditions	20%			$ 3,270	Source 3	
SUBTOTAL				*$ 20,440*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		
Upgrade Asphalt Cap (115 River Road)						
Fine grading	7,059	SY	$ 1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$ 54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$ 6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 316,416		
Mobilization/Demobilization	5%			$ 15,821	Source 3	
Subcontractor general conditions	20%			$ 63,283	Source 3	
SUBTOTAL				*$ 395,519*		
Asphalt Cap (Edgewater - NZ-5)						
Fine grading	1,508	SY	$ 1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$ 54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$ 11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$ 6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 64,238		
Mobilization/Demobilization	5%			$ 3,212	Source 3	
Subcontractor general conditions	20%			$ 12,848	Source 3	
SUBTOTAL				*$ 80,297*		
Upgrade Asphalt Cap (Block 93 North and Central)						
Fine grading	11,532	SY	$ 1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$ 54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$ 6	$ 11,927	MEANS 32.16.19.10.0150	

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Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

SUBTOTAL					$ 462,836		
Mobilization/Demobilization	5%				$ 23,142	Source 3	
Subcontractor general conditions	20%				$ 92,567	Source 3	
SUBTOTAL					*$ 578,544*		
Upgrade Asphalt Cap (Block 94)							
Fine grading	2,322	SY	$	1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 161,073		
Mobilization/Demobilization	5%				$ 8,054	Source 3	
Subcontractor general conditions	20%				$ 32,215	Source 3	
SUBTOTAL					*$ 201,341*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	90	DY	$	718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$	106	$ 279,760	Source 4 + CH2M H&S	
SUBTOTAL					*$ 368,400*		
CAPITAL SUBTOTAL - SOIL					$ 11,810,365		
Contingency	25%				$ 2,952,591	10% Scope + 15% Bid	
SUBTOTAL					$ 14,762,957		
Project Management	5%				$ 738,148	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 885,777	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 885,777	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 2,509,703		
Contractor Fees							
ODC & Subs	5%		$	14,762,957	$ 738,148		
Labor	10%	max	$	2,509,703	$ 250,970		
SUBTOTAL					$ 989,118		
TOTAL CAPITAL COST - SOIL					**$ 18,260,000**		
NAPL and ARSENIC							
NAPL Recovery							
Preconstruction Investigations							
Slurry compatibility test	1	LS	$	25,000	$ 25,000		
Pump test	1	LS	$	75,000	$ 75,000	CH2M Est.	
Pilot field test	1	LS	$	100,000	$ 100,000	CH2M Est., assumed design of test is included in design line item (@ 8%)	
Utility markout / locating service	3	DAY	$	5,000	$ 15,000		
SUBTOTAL					*$ 215,000*		
Passive Horizontal Recovery Well Installation							
Horizontal drilling (115 River Road Building)	940	LF	$	209	$ 196,460	Source 3	4-inch borehole, includes well development
Well screen and misc. materials	450	LF	$	75	$ 33,750	Source 3	
Well casing material	490	LF	$	15	$ 7,350	Source 3	
Well completion	6	EA	$	250	$ 1,500	Source 3	Two per recovery well
Well cuttings disposal	20	TN	$	128	$ 2,567	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Sump/manholes	3	EA	$	8,000	$ 24,000	Source 3	
Product recovery pumps	3	EA	$	4,000	$ 12,000	Source 3	
SUBTOTAL					$ 277,627		
Mobilization/Demobilization	5%				$ 13,881		
Subcontractor general conditions	20%				$ 55,525		
SUBTOTAL					*$ 347,033*		
NAPL Recovery in existing monitoring wells							
Product recovery pumps	3	EA	$	4,000	$ 12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$ 12,000		
Mobilization/Demobilization	5%				$ 600		
Subcontractor general conditions	20%				$ 2,400		
SUBTOTAL					*$ 15,000*		
Vertical NAPL Recovery Wells							
Soil borings	125	LF	$	47	$ 5,813	Source 3	Assumes 10 recovery wells
4-inch PVC well casing	75	LF	$	51	$ 3,823	MEANS	
4-inch PVC well screen	50	LF	$	54	$ 2,679	MEANS	
Well vaults	10	EA	$	8,000	$ 80,000	Source 3	
Well cuttings disposal	20	TN	$	128	$ 2,560	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Storage tanks	1	EA	$	4,572	$ 4,572	MEANS 33-10-9658	2000-gallon HDPE tank with secondary containment
Product recovery pumps	8	EA	$	4,000	$ 4,000		Positive displacement piston pump, 1HP motor, 0-7 GPM - includes 3 extra for existing monitoring wells
SUBTOTAL					$ 103,446		
Mobilization/Demobilization	5%				$ 5,172		
Subcontractor general conditions	20%				$ 20,689		
SUBTOTAL					*$ 129,307*		
Install Equipment & Utilities for NAPL Collection/Handling							
Utility trenching	62	CY	$	13	$ 812	MEANS 17-03-0202	
Electrical conduit	560	LF	$	8.00	$ 4,480	Source 3	
Backfill to grade	62	CY	$	54.26	$ 3,376	MEANS 17-03-0401	
Control wiring	1,120	LF	$	11	$ 12,320	Source 3	
Power supply to the site	1	LS	$	16,000	$ 16,000	Source 3	
Power wiring, #10 insulated strand wire	1,120	LF	$	0.59	$ 661	ECHOS 20.02.0505	
Electrical disconnect, weatherhead, and installation of wiring	1	LS	$	5,000	$ 5,000	Source 3	
SUBTOTAL					$ 42,649		
Mobilization/Demobilization	5%				$ 2,132		
Subcontractor general conditions	20%				$ 8,530		
SUBTOTAL					*$ 53,311*		
Offsite Treatment / Disposal							
Off-site disposal of decontamination and development water	10,000	GAL	$	1.00	$ 10,000	Source 3	Assumes water is non-hazardous
Off-site disposal of municipal waste	20	CY	$	200	$ 4,000	Source 3	
SUBTOTAL					$ 14,000		
Mobilization/Demobilization	5%				$ 700		
Subcontractor general conditions	20%				$ 2,800		
SUBTOTAL					*$ 17,500*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	8	MO	$	1,043	$ 8,340	Source 4	
Air monitoring based on air monitoring plan	30	MO	$	20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations
PPE provisions for workers (initial)	20	EA	$	252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	3,520	EA	$	106	$ 373,013	Source 4 + CH2M H&S	
SUBTOTAL					$ 999,163		
CAPITAL SUBTOTAL - NAPL and ARSENIC					$ 1,776,314		
Contingency	25%				$ 444,079	10% Scope + 15% Bid	
SUBTOTAL					$ 2,220,393		
Project Management	5%				$ 111,020	**USEPA 2000, p. 5-13, $2M - $10M**	
Remedial Design	8%				$ 177,631	**USEPA 2000, p. 5-13, $2M - $10M**	
Construction Management	6%				$ 133,224	**USEPA 2000, p. 5-13, $2M - $10M**	
SUBTOTAL					$ 421,875		
Contractor Fees							
ODC & Subs	5%		$	2,220,393	$ 111,020		
Labor	10%	max	$	421,875	$ 42,187		
SUBTOTAL					$ 153,207		
TOTAL CAPITAL COST - NAPL and ARSENIC					**$ 2,800,000**		

Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$ 230,000	$ 230,000			
Updates to the groundwater model	1	LS	$ 20,000	$ 20,000			
Bench-scale testing (Arsenic and NAPL)	2	EA	$ 75,000	$ 150,000			
Pilot-scale testing	1	LS	$ 150,000	$ 150,000			
SUBTOTAL				*$ 550,000*			
Replacement Monitoring Wells							
Soil borings	480	FT	$ 47	$ 22,320			Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$ 31	$ 9,994	MEANS 33-23-0101		Assumes 10-ft screen
2-inch PVC well screen	160	FT	$ 34	$ 5,398	MEANS 33-23-0256		
Well development	16	EA	$ 1,600	$ 25,600	Source 3		
Off-site disposal of soil cuttings from well installation	50	TN	$ 128	$ 6,400	MEANS 33-19-7270		Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$ 1.00	$ 10,000	Source 3		Assumes water is non-hazardous
SUBTOTAL				$ 79,712			
Mobilization/Demobilization	5%			$ 3,986	Source 3		
Subcontractor general conditions	20%			$ 15,942	Source 3		
SUBTOTAL				*$ 99,640*			
Cutoff Wall with Hydraulic Containment							
Cutoff Wall at Shoreline							
Remove concrete decking	2,500	SF	$ 15	$ 37,500	Envirocon ROM estimate		
Rip-rap removal	1,040	CY	$ 25	$ 26,000	Envirocon ROM estimate		
Barrier wall at 115 River Road (under building)	1	LS	$ 600,000	$ 600,000	Envirocon ROM estimate		
Sealed sheet piling - shoreline	42,000	SF	$ 127	$ 5,334,000	Envirocon ROM estimate		
SUBTOTAL				$ 5,997,500			
Mobilization/Demobilization	5%			$ 299,875	Source 3		
Subcontractor general conditions	20%			$ 1,199,500			
SUBTOTAL				*$ 7,496,875*			
Cutoff Wall at HCAA							
Slurry wall	18,000	VSF	$ 65	$ 1,170,000	Envirocon ROM estimate		Assumes 25-ft deep wall
Restoration of ground surface	6,000	SY	$ 25	$ 150,000	CH2M HILL Estimate		
Disposal of soil cuttings	3,300	TN	$ 128	$ 422,400	MEANS 33-19-7270		Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
SUBTOTAL				$ 1,742,400			
Mobilization/Demobilization	5%			$ 87,120	Source 3		
Subcontractor general conditions	20%			$ 348,480			
SUBTOTAL				*$ 2,178,000*			
Groundwater Extraction							
Soil borings	315	LF	$ 47	$ 14,648	Source 3		Assumes 9 extraction wells to an average depth of 35-ft bgs
4-inch PVC well casing	180	LF	$ 51	$ 9,175	MEANS		
4-inch PVC well screen	135	LF	$ 54	$ 7,232	MEANS		Assumes 15-ft screen
Well vaults/pumps	9	EA	$ 8,000	$ 72,000	Source 3		
Manifolds and valves	1	LS	$ 25,000	$ 25,000	Source 3		
Disposal of soil cuttings	15	TN	$ 128	$ 1,935	MEANS 33-19-7270		
Trenching for conveyance piping	2,778	CY	$ 13	$ 36,229	MEANS 17-03-0202		
Conveyance piping	2,500	LF	$ 54	$ 135,000	MEANS 33-26-0406		
Backfill trench	3,333	CY	$ 54	$ 180,878	MEANS 17-03-0423		
Electrical to wells	1	LS	$ 120,000	$ 120,000			
SUBTOTAL				$ 602,096			
Mobilization/Demobilization	5%			$ 30,105	Source 3		
Subcontractor general conditions	20%			$ 120,419			
SUBTOTAL				*$ 752,621*			
Wastewater Treatment Plant to Treat Extracted Water							System to treat 50 gpm
Pumping and Equalization of Influent Water							
8,000 gallon polypropylene equalization tanks	2	EA	$ 6,340	$ 12,679	MEANS 33-10-9661		Provides 8-hrs of storage at 100 gpm
Sludge pump	1	EA	$ 3,820	$ 3,820	Source 3		
Off-gas pump	1	EA	$ 1,322	$ 1,322	Source 3		
Effluent pump	4	EA	$ 4,221	$ 16,883	Source 3		50 GPM effluent pump (MAX @ 65'TDH)
NAPL pump	1	EA	$ 3,864	$ 3,864	Source 3		
Chemical feed systems (caustic and acid)	2	EA	$ 3,130	$ 6,260	Source 3		
SUBTOTAL				$ 44,829			
Mobilization/Demobilization	5%			$ 2,241	Source 3		
Subcontractor general conditions	20%			$ 8,966	Source 3		
SUBTOTAL				*$ 56,036*			
Removal of NAPLs and Solids							
Oil-water separator, 50 gpm	1	EA	$ 16,910	$ 16,910	ECHOS 19.04.0412		
Packaged 1,500 Gallon Steel Product Tank	1	EA	$ 4,950	$ 4,950	ECHOS 19.04.0604		
Packaged 20 gpm Oil Pump out unit w/controls	1	EA	$ 7,670	$ 7,670	ECHOS 33.13.1211		
Effluent pump	2	EA	$ 5,231	$ 10,462	MEANS 33-23-0555		50 GPM(one in operation and one in stand-by) (MAX@ 65'TDH)
Chemical feed systems	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		Caustic, acid, polymer, hydrogen peroxide, and ferric chloride
SUBTOTAL				$ 55,642			
Mobilization/Demobilization	5%			$ 2,782	Source 3		
Subcontractor general conditions	20%			$ 11,128	Source 3		
SUBTOTAL				*$ 69,553*			
Advanced oxidation							
Flocculation tanks connected in series	4	EA	$ 4,572	$ 18,287	MEANS 33-10-9658		
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	$ 4,009	$ 8,018	MEANS 33-29-0120		
SUBTOTAL				$ 41,955			
Mobilization/Demobilization	5%			$ 2,098	Source 3		
Subcontractor General Conditions	20%			$ 8,391	Source 3		
SUBTOTAL				*$ 52,444*			
Solid-liquid Separation							
Inclined plate clarifier (0.25 GPM/SF of area)	3	EA	$ 26,520	$ 79,560	ECHOS 33.13.0414		
100 GPM effluent pump for use with plate clarifier	1	EA	$ 6,211	$ 6,211	Source 3		
Sludge pump for use with plate clarifier	1	EA	$ 3,130	$ 3,130	Source 3		
Bag filters	2	EA	$ 1,500	$ 3,000	Source 3		
Offgas pumps for use with bag filters	2	EA	$ 1,500	$ 3,000	Source 3		
Effluent pumps for use with bag filters	2	EA	$ 4,200	$ 8,400	Source 3		
Liquid waste pump for use with sludge settling tank	1	EA	$ 4,200	$ 4,200	Source 3		
Filter press, 95% removal efficiency	2	EA	$ 90,100	$ 180,200	ECHOS 33.33.3013		10 CF w/sludge tanks, pumps, mixers, sludge cart
SUBTOTAL				$ 287,701			
Mobilization/Demobilization	5%			$ 14,385	Source 3		
Subcontractor general conditions	20%			$ 57,540	Source 3		
SUBTOTAL				*$ 359,627*			
Effluent Polishing							
Packaged 36,000 GPD water treatment plant	2	EA	$ 32,400	$ 64,800	ECHOS 19.01.0807		Includes GAC, pumps, tanks
Concrete Wet Well, 12'x36"	4	EA	$ 9,200	$ 36,800	ECHOS 19.02.0304		
Packaged Lift Station (70 gpm)	4	EA	$ 9,950	$ 39,800	ECHOS 19.02.0304		
Ion exchange units	2	EA	$ 25,000	$ 50,000	Source 3		One in operation and one standby/regeneration phase
SUBTOTAL				$ 191,400			
Mobilization/Demobilization	5%			$ 9,570	Source 3		
Subcontractor general conditions	20%			$ 38,280	Source 3		
SUBTOTAL				*$ 239,250*			
Building & Controls							
Building / HVAC / Electrical	1	EA	$ 300,000	$ 300,000	Source 3		
SCADA computer control system/Instrumentation	1	LS	$ 400,000	$ 400,000	Source 3		
SUBTOTAL				$ 700,000			
Mobilization/Demobilization	5%			$ 35,000	Source 3		
Subcontractor general conditions	20%			$ 140,000	Source 3		
SUBTOTAL				*$ 875,000*			
Piping, Instrumentation, & Equipment Installation							
2-inch schedule 80 PVC piping and fittings	3,000	LF	$ 24	$ 72,000	Source 3		
2-inch carbon steel piping	1,000	LF	$ 67	$ 67,000	Source 3		
Pipe supports and misc metals	1	LS	$ 30,000	$ 30,000	Source 3		
Install equipment	30	CD	$ 3,000	$ 90,000	Source 3		
Plumbing and fire suppression	1	LS	$ 40,000	$ 40,000	Source 3		
Lighting and misc electrical	1	LS	$ 25,000	$ 25,000	Source 3		
Chemical reagents	1	LS	$ 20,000	$ 20,000	Source 3		
Chemical storage tanks	5	EA	$ 8,000	$ 40,000	Source 3		550 Gallon double walled tanks
Chemical feed system I&C	1	LS	$ 100,000	$ 100,000	Source 3		Metering pumps, gauges, valves, and flow-meters
Installation of discharge point to surface water	1	LS	$ 80,000	$ 80,000			
SUBTOTAL				$ 564,000			
Mobilization/Demobilization	5%			$ 28,200	Source 3		
Subcontractor general conditions	20%			$ 112,800	Source 3		
SUBTOTAL				*$ 705,000*			
System Startup	1	LS	$ 150,000	*$ 150,000*	Source 3		

Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

Compliance Monitoring and Health & Safety						
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4	
Decon shed	6	MO	$ 1,043	$ 6,255	Source 4	
Air monitoring	30	DY	$ 718	$ 21,525	Source 4 + CH2M H&S	
PPE provisions for workers (initial)	8	EA	$ 252	$ 2,015	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,056	EA	$ 106	$ 111,904	Source 4 + CH2M H&S	
SUBTOTAL				$ 154,471		
CAPITAL SUBTOTAL - GROUNDWATER				$ 13,738,516		
Contingency	25%			$ 3,434,629	10% Scope + 15% Bid	
SUBTOTAL				$ 17,173,145		
Project Management	5%			$ 858,657	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%			$ 1,030,389	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%			$ 1,030,389	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL				$ 2,919,435		
Contractor Fees						
ODC & Subs	5%		$ 17,173,145	$ 858,657		
Labor	10%	max	$ 2,919,435	$ 291,943		
SUBTOTAL				$ 1,150,601		
TOTAL CAPITAL COST - GROUNDWATER				**$ 21,240,000**		
VAPOR						
Vapor Mitigation						
Preconstruction Investigations						
Evaluate building systems	1	LS	$ 10,000	$ 10,000	Radiation Data Quote Phase 1	
SUBTOTAL				*$ 10,000*		
Install Sub Slab Depressurization System						
Install new french drain system	1	LS	$ 50,000	$ 50,000	Source 3	
Upgrade dewatering equipment	1	LS	$ 50,000	$ 50,000	Source 3	
Add carbon and bag filter system	1	LS	$ 120,000	$ 120,000	Source 3	
Install sub slab depressurization system	1	LS	$ 65,000	$ 65,000	Radiation Data Quote Phase 2	
SUBTOTAL				$ 285,000		
Mobilization/Demobilization	5%			$ 14,250		
Subcontractor general conditions	20%			$ 57,000		
SUBTOTAL				*$ 356,250*		
CAPITAL SUBTOTAL - VAPOR				$ 366,250		
Contingency	25%			$ 91,563	10% Scope + 15% Bid	
SUBTOTAL				$ 457,813		
Project Management	8%			$ 36,625	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 68,672	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 45,781	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 151,078		
Contractor Fees						
ODC & Subs	5%		$ 457,813	$ 22,891		
Labor	10%	max	$ 151,078	$ 15,108		
SUBTOTAL				$ 37,998		
TOTAL CAPITAL COST - VAPOR				**$ 650,000**		
TOTAL CAPITAL COST				**$ 42,950,000**		

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 24,130	$ 24,130		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 34,130		
Contingency	25%			$ 8,533	10% Scope + 15% Bid	
SUBTOTAL				$ 42,663		
Project Management	10%			$ 4,266	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 8,533	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,399	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 19,198		
Contractor Fees						
ODC & Subs	5%		$ 42,663	$ 2,133		
Labor	10%	max	$ 19,198	$ 1,920		
SUBTOTAL				$ 4,053		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		
NAPL						
NAPL Recovery Wells						
Routine Operations, Maintenance, Monitoring	240	HR	$ 100	$ 24,000	Assumes part time operator performs duties for NAPL system (5 days/month)	
Parts Replacement / Consumables	1	LS	$ 1,000	$ 1,000		
Electricity	13,140	KWH	$ 0.10	$ 1,314	Assume 2 hp total	
Reporting	100	HR	$ 100	$ 10,000		
Pumping & Transport of NAPL (Vac Truck)	3,000	GAL	$ 3.00	$ 9,000		Assume each truck 1000 gallons
Off-site Disposal of NAPL	3,000	GAL	$ 9.00	$ 27,000		
SUBTOTAL				$ 72,314		
Mobilization/Demobilization	5%			$ 3,616		
Subcontractor general conditions	25%			$ 18,079		
SUBTOTAL				*$ 94,008*		
Contingency	25%			$ 23,502	10% Scope + 15% Bid	
SUBTOTAL				$ 117,510		
Project Management	8%			$ 9,401	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 17,627	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 11,751	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 38,778		
Contractor Fees						
ODC & Subs	5%		$ 117,510	$ 5,876		
Labor	10%	max	$ 38,778	$ 3,878		
SUBTOTAL				$ 9,753		
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 166,042**		
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 166,042**		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 166,042**		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 166,042**	Assumes NAPL recovery will cease after 10 years	
GROUNDWATER						
Groundwater Treatment System O&M						
Misc. Electrical Site Usage	12	MO	$ 215	$ 2,584	MEANS 33-42-0106	
Routine Operations, Maintenance, Monitoring	2,080	HR	$ 80	$ 166,400		40 hrs/week for one operator
Chemicals / Consumables	12	MO	$ 10,000	$ 120,000		
Electricity	394,200	KWH	$ 0.10	$ 39,420		
Replace Filters/ Carbon	12	MO	$ 5,000	$ 60,000		
Sampling and Analysis	12	MO	$ 1,055	$ 12,665	Source 4	Assumes one compliance sample per month
Reporting	200	HR	$ 100	$ 20,000	CH2M Est.	
Allowance for Misc. Items	1	LS	$ 84,214	$ 84,214		Assumes 20% of the capital costs
SUBTOTAL				$ 505,283		
Subcontractor general conditions	25%			$ 126,321		
SUBTOTAL				*$ 631,603*		
Contingency	25%			$ 157,901	10% Scope + 15% Bid	
SUBTOTAL				$ 789,504		
Project Management	6%			$ 47,370	**USEPA 2000, p. 5-13, $500K - $2M**	
Remedial Design	12%			$ 94,741	**USEPA 2000, p. 5-13, $500K - $2M**	
Construction Management	8%			$ 63,160	**USEPA 2000, p. 5-13, $500K - $2M**	
SUBTOTAL				$ 205,271		

Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

Contractor Fees							
ODC & Subs	5%		$ 789,504	$ 39,475			
Labor	10%	max	$ 205,271	$ 20,527			
SUBTOTAL				$ 60,002			
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M				**$ 1,054,778**			
Groundwater Monitoring							
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4		MNA, VOCs, PCBs, SVOCs, metals
QC Samples	5	EA	$ 1,000	$ 4,998			
Groundwater Sampling, Level D							
Labor	300	HR	$ 80	$ 24,000			Assumes 3 persons for 5 days
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3		
Consumables	1	LS	$ 3,000	$ 3,000	Source 3		
Data Validation	96	HR	$ 100	$ 9,600			
Reporting	240	HR	$ 100	$ 24,000			
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758			Assumes 10% of the capital costs
SUBTOTAL				$ 118,340			
Mobilization/Demobilization	5%			$ 5,917			
Subcontractor general conditions	25%			$ 29,585			
SUBTOTAL				*$ 153,842*			
Contingency	25%			$ 38,461	10% Scope + 15% Bid		
SUBTOTAL				$ 192,303			
Project Management	8%			$ 15,384	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 28,845	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 19,230	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 63,460			
Contractor Fees							
ODC & Subs	5%		$ 192,303	$ 9,615			
Labor	10%	max	$ 63,460	$ 6,346			
SUBTOTAL				$ 15,961			
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**			
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 2,141,672**	Quarterly for first year (Four GW sampling events)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 1,326,501**	Annual for Years 2 to 30 (one GW sampling event per year)		
VAPOR							
Vapor Intrusion Operation Bldg 115							
Routine Operations, Maintenance, Monitoring	240	HR	$ 80	$ 19,200			Assumes part time operator performs duties 5 days/month
Parts Replacement / Consumables	1	LS	$ 2,000	$ 2,000	Source 3		
Electricity	13,140	KWH	$ 0.10	$ 1,314	Source 3		
Replace bag filters and carbon media	4	EA	$ 2,500	$ 10,000			Assume carbon replacement every 3 months -
Reporting	80	HR	$ 80	$ 6,400	CH2M Est.		
SUBTOTAL				$ 38,914			
Mobilization/Demobilization	5%			$ 1,946			
Subcontractor general conditions	25%			$ 9,729			
SUBTOTAL				*$ 50,588*			
Contingency	25%			$ 12,647	10% Scope + 15% Bid		
SUBTOTAL				$ 63,235			
Project Management	10%			$ 6,324	**USEPA 2000, p. 5-13, <$100K**		
Remedial Design	20%			$ 12,647	**USEPA 2000, p. 5-13, <$100K**		
Construction Management	15%			$ 9,485	**USEPA 2000, p. 5-13, <$100K**		
SUBTOTAL				$ 28,456			
Contractor Fees							
ODC & Subs	5%		$ 63,235	$ 3,162			
Labor	10%	max	$ 28,456	$ 2,846			
SUBTOTAL				$ 6,007			
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)				**$ 100,000**			

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

Alternative 3: NAPL and Arsenic Containment with NAPL Recovery — COST ESTIMATE SUMMARY - DRAFT

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 18,260,000	$ 18,260,000	1.000	$ 18,260,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 2,800,000	$ 2,800,000	1.000	$ 2,800,000	
CAPITAL COST - GROUNDWATER	0	$ 21,240,000	$ 21,240,000	1.000	$ 21,240,000	
CAPITAL COST - VAPOR	0	$ 650,000	$ 650,000	1.000	$ 650,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 166,042	$ 166,042	0.935	$ 155,179	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 166,042	$ 166,042	0.873	$ 145,027	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$ 1,162,294	$ 166,042	5.216	$ 866,002	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 2,141,672	$ 2,141,672	0.935	$ 2,001,563	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 38,468,536	$ 1,326,501	11.474	$ 15,220,888	
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)	1 to 30	$ 3,000,000	$ 100,000	12.409	$ 1,240,904	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 90,675,586			$ 63,644,259	

TOTAL PRESENT VALUE OF ALTERNATIVE 3 — $ 63,640,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	In situ solidification/stabilization of tar boils, NAPL present in NZ-1, NZ-2, NZ-5, and small portion of NZ-3. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place.
Arsenic	Arsenic on Block 93 will be solidified/stabilized and a barrier wall with extraction and treatment installed downgradient of the HCAA. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction a
Vapor	A vapor mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Road. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would b

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	30	MO	$ 4,300	$ 129,000	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 460,000*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	30	MO	$ 12,000	$ 360,000	CH2M Est.	
SUBTOTAL				*$ 585,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
Excavation and stockpile of 10-ft of backfill	5,025	CY	$ 30	$ 149,254	MEANS 17-03-0276	Assumes material can be replaced following the completion of remedial activities
SUBTOTAL				$ 165,605		
Mobilization/Demobilization	5%			$ 8,280	Source 3	
Subcontractor general conditions	20%			$ 33,121	Source 3	
SUBTOTAL				*$ 207,007*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

Upgrade Asphalt Cap (115 River Road)							
Fine grading	7,059	SY	$	1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$	54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$	11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$	11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$	6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 316,416		
Mobilization/Demobilization	5%				$ 15,821	Source 3	
Subcontractor general conditions	20%				$ 63,283	Source 3	
SUBTOTAL					*$ 395,519*		
Asphalt Cap (Edgewater - NZ-5)							
Backfilling and compaction of excavated clean fill material	5,025	CY	$	19	$ 94,435	MEANS 17-03-0423	
Rough grading	1,508	SY	$	1.75	$ 2,636	MEANS 17-03-0101	Replacement of removed material
Fine grading	1,508	SY	$	1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$	54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$	11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$	11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$	11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$	6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 161,308		
Mobilization/Demobilization	5%				$ 8,065	Source 3	
Subcontractor general conditions	20%				$ 32,262	Source 3	
SUBTOTAL					*$ 201,635*		
Cover (Lever Bros. Property - NZ-1 and NZ-2)							
Rough grading	3,499	SY	$	1.75	$ 6,117	MEANS 17-03-0101	
Fine grading	3,499	SY	$	1.22	$ 4,272	MEANS 17-03-0101	
Protective layer, 6" compacted soil subgrade	580	CY	$	19	$ 10,899	MEANS 17-03-0423	
Drainage layer, 6" granular soil (assume gravel)	580	CY	$	54	$ 31,473	MEANS 32.11.23.23.1511	
Hydroseed	31,500	SF	$	0.07	$ 2,205	Source 3	
SUBTOTAL					$ 54,966		
Mobilization/Demobilization	5%				$ 2,748	Source 3	
Subcontractor general conditions	20%				$ 10,993	Source 3	
SUBTOTAL					*$ 68,707*		
Upgrade Asphalt Cap (Block 93 North and Central)							
Fine grading	11,532	SY	$	1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$	54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$	6	$ 11,927	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 462,836		
Mobilization/Demobilization	5%				$ 23,142	Source 3	
Subcontractor general conditions	20%				$ 92,567	Source 3	
SUBTOTAL					*$ 578,544*		
Upgrade Asphalt Cap (Block 94)							
Fine grading	2,322	SY	$	1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 161,073		
Mobilization/Demobilization	5%				$ 8,054	Source 3	
Subcontractor general conditions	20%				$ 32,215	Source 3	
SUBTOTAL					*$ 201,341*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	90	DY	$	718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$	106	$ 279,760	Source 4 + CH2M H&S	
SUBTOTAL					*$ 368,400*		
CAPITAL SUBTOTAL - SOIL					$ 12,380,710		
Contingency	25%				$ 3,095,178	10% Scope + 15% Bid	
SUBTOTAL					$ 15,475,888		
Project Management	5%				$ 773,794	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 928,553	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 928,553	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 2,630,901		
Contractor Fees							
ODC & Subs	5%		$	15,475,888	$ 773,794		
Labor	10%	max	$	2,630,901	$ 263,090		
SUBTOTAL					$ 1,036,884		
TOTAL CAPITAL COST - SOIL					**$ 19,140,000**		
NAPL and ARSENIC							
NAPL Recovery							
NAPL Recovery in existing monitoring wells							
Product recovery pumps	3	EA	$	4,000	$ 12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$ 12,000		
Mobilization/Demobilization	5%				$ 600		
Subcontractor general conditions	20%				$ 2,400		
SUBTOTAL					*$ 15,000*		
In Situ Solidification/Stabilization							
Preconstruction Investigations							
Bench scale test	1	LS	$	75,000	$ 75,000	CH2M Est., assumed design of test is included in design line item	
Pilot field test	1	LS	$	150,000	$ 150,000	CH2M Est., assumed design of test is included in design line item	
Utility markout /locating service	3	DAY	$	5,000	$ 15,000		
SUBTOTAL					*$ 240,000*		
In Situ Solidification/Stabilization - NAPL NZ-1 (Quanta, 115 River Road, and Former Lever Bros.)							
NAPL area - cement	52,323	CY	$	30	$ 1,569,685	Source 3	Assumes an average depth of 11-ft
NAPL area - stabilization	52,323	CY	$	35	$ 1,831,300	Source 3	
Odor suppression equipment rental	12	MO	$	10,000	$ 120,000		Assumes two rental units
Odor suppression material	353	DRUM	$	350	$ 123,613		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 3,644,598		
Mobilization/Demobilization	5%				$ 182,230		
Subcontractor general conditions	20%				$ 728,920		
SUBTOTAL					*$ 4,555,747*		
In Situ Solidification/Stabilization - Portion of NAPL NZ-3 over NZ-1 only							
NAPL area - cement	5,547	CY	$	30	$ 166,400	Source 3	Assumes an average depth of 14-ft additional for NZ-3
NAPL area - stabilization	5,547	CY	$	35	$ 194,133	Source 3	
Odor suppression equipment rental	10	MO	$	10,000	$ 100,000		Assumes two rental units
Odor suppression material	37	DRUM	$	350	$ 13,104		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 473,637		
Mobilization/Demobilization	5%				$ 23,682		
Subcontractor general conditions	20%				$ 94,727		
SUBTOTAL					*$ 592,047*		
In Situ Solidification/Stabilization - NAPL NZ-1 (Block 93 - not including material comingled with arsenic)							
NAPL area - excavate and stockpile	6,008	CY	$	30	$ 178,439	Source 3	Assumes an average depth of 11-ft
NAPL area - cement	6,008	CY	$	30	$ 180,241	Source 3	
NAPL area - stabilization	6,008	CY	$	35	$ 210,281	Source 3	
NAPL area - haul and place on Quanta	7,210	CY	$	10	$ 72,096	Source 3	Assumes a 20% increase in volume due to expansion
Certified clean fill for backfilling excavation	6,008	CY	$	19	$ 112,900	MEANS 17-03-0423	
Odor suppression equipment rental	2	MO	$	10,000	$ 20,000		Assumes two rental units
Odor suppression material	41	DRUM	$	350	$ 14,194		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 788,152		
Mobilization/Demobilization	5%				$ 39,408		
Subcontractor general conditions	20%				$ 157,630		
SUBTOTAL					*$ 985,189*		

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

In Situ Solidification/Stabilization - NAPL NZ-2 and NZ-5							
NAPL area - cement	54,761	CY	$	30	$ 1,642,832		Assumes average depth of 25-ft in half the area and 11-ft for remaining
NAPL area - stabilization	54,761	CY	$	35	$ 1,916,637		
NAPL area - stabilization NZ-5 jet grouting	7,036	CY	$	300	$ 2,110,656		Assumes ISS will occur at depth of 10-24
Odor suppression equipment rental	12	MO	$	10,000	$ 120,000		Assumes two rental units
Odor suppression material	370	DRUM	$	350	$ 129,373		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 5,919,498		
Mobilization/Demobilization	5%				$ 295,975		
Subcontractor general conditions	20%				$ 1,183,900		
SUBTOTAL					*$ 7,399,372*		
In Situ Solidification/Stabilization - Arsenic Area (Block 93 & S. of HCAA - including material commingled with NAPL)							
Arsenic area - excavate and stockpile	2,372	CY	$	30	$ 70,451	Source 3	Assumes average depth of 2-ft bgs for half the area and 11-ft for the remaining
Arsenic area - reagents	2,372	CY	$	22	$ 52,186	Source 3	
Arsenic area - cement	2,372	CY	$	30	$ 71,162	Source 3	
Arsenic area - stabilization	2,372	CY	$	35	$ 83,023	Source 3	
Arsenic area - haul and place on Quanta	2,846	CY	$	10	$ 28,465	Source 3	
Certified clean fill for backfilling excavation	2,372	CY	$	19	$ 44,575	MEANS 17-03-0423	
SUBTOTAL					$ 349,861		
Mobilization/Demobilization	5%				$ 17,493		
Subcontractor general conditions	20%				$ 69,972		
SUBTOTAL					*$ 437,326*		
Temporary Sheetpile at Shoreline							
Remove concrete decking	2,500	SF	$	15	$ 37,500	Envirocon ROM estimate	
Rip-rap removal	1,040	CY	$	25	$ 26,000	Envirocon ROM estimate	
Barrier wall at 115 River Road (under building)	1	LS	$	600,000	$ 600,000	Envirocon ROM estimate	
Temporary sheet piling - shoreline	10,100	SF	$	80	$ 808,000	Envirocon ROM estimate	Turbidity Barrier only, includes removal
SUBTOTAL					$ 1,471,500		
Mobilization/Demobilization	5%				$ 73,575	Source 3	
Subcontractor general conditions	20%				$ 294,300		
SUBTOTAL					*$ 1,839,375*		
Arsenic (HCAA) Barrier Wall							
Slurry wall installation	18,000	VSF	$	65	$ 1,170,000	Envirocon ROM estimate	Assume 3' wide trench, 25 feet deep
Restoration of ground surface	6,000	SY	$	25	$ 150,000	CH2M HILL Estimate	
Transport and Disposal of Trench Spoils	3,300	TN	$	128	$ 422,400	MEANS 33-19-7270	
Vertical Wells for Gradient Control							
Soil Borings	90	LF	$	47	$ 4,185		Assumes 3 locations to 30-ft
4-inch PVC Well Casing	75	LF	$	51	$ 3,823	MEANS	
4-inch PVC Well Screen	15	LF	$	54	$ 804	Source 3	Assumes 5-ft screens
Well Vaults	3	EA	$	8,000	$ 24,000	Source 3	
Disposal of soil cuttings	4	TN	$	128	$ 553	MEANS 33-19-7270	
Extraction well pumps	3	EA	$	4,200	$ 12,600		
Treatment System							Assumes treatment includes removal of VOCs, TSS, and arsenic at 5 gpm and discharge to POTW
Conveyance piping	420	FT	$	54	$ 22,680	MEANS 33-26-0406	Assumes 2-inch HDPE
Carbon vessels system	1	EA	$	25,000	$ 25,000	Source 3	System consist of two vessels in series
Solids removal	1	EA	$	286,301	$ 286,301		Incline plate clarifier, baf filters, filter press
Ion exchange resin	1	EA	$	25,000	$ 25,000	Source 3	
Electrical and Mechanical Installation	1	LS	$	134,394	$ 134,394	Source 3	
Building Structure	1	LS	$	85,000	$ 85,000	Source 3	
Discharge application fee	1	LS	$	4,000	$ 4,000		Based on Bergen County industrial discharge permit fees
SUBTOTAL					$ 2,370,740		
Mobilization/Demobilization	5%				$ 118,537		
Subcontractor General Conditions	20%				$ 474,148		
SUBTOTAL					*$ 2,963,425*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	8	MO	$	1,043	$ 8,340	Source 4	
Air monitoring based on air monitoring plan	30	MO	$	20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations
PPE provisions for workers (initial)	22	EA	$	252	$ 5,541	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	3,872	EA	$	106	$ 410,314	Source 4 + CH2M H&S	
SUBTOTAL					$ 1,036,968		
CAPITAL SUBTOTAL - NAPL and ARSENIC					$ 20,064,450		
Contingency	25%				$ 5,016,112	10% Scope + 15% Bid	
SUBTOTAL					$ 25,080,562		
Project Management	5%				$ 1,254,028	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 1,504,834	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 1,504,834	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 4,263,696		
Contractor Fees							
ODC & Subs	5%		$	25,080,562	$ 1,254,028		
Labor	10%	max	$	4,263,696	$ 426,370		
SUBTOTAL					$ 1,680,398		
TOTAL CAPITAL COST - NAPL and ARSENIC					**$ 31,020,000**		
GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$	230,000	$ 230,000		
Updates to the groundwater model	1	LS	$	20,000	$ 20,000		
Bench-scale testing (Arsenic and NAPL)	2	EA	$	75,000	$ 150,000		
Pilot-scale testing	1	LS	$	150,000	$ 150,000		
SUBTOTAL					*$ 550,000*		
Replacement Monitoring Wells							
Soil borings	480	FT	$	47	$ 22,320		Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$	31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen
2-inch PVC well screen	160	FT	$	34	$ 5,398	MEANS 33-23-0256	
Well development	16	EA	$	1,600	$ 25,600	Source 3	
Off-site disposal of soil cuttings from well installation	50	TN	$	128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$	1.00	$ 10,000	Source 3	Assumes water is non-hazardous
SUBTOTAL					$ 79,712		
Mobilization/Demobilization	5%				$ 3,986	Source 3	
Subcontractor general conditions	20%				$ 15,942	Source 3	
SUBTOTAL					*$ 99,640*		
Subaqueous Reactive Barrier							
Site Preparation							
Erosion control	1	LS	$	20,000	$ 20,000	Source 3	
Permitting	1	LS	$	150,000	$ 150,000	Source 3	
Survey (pre and post installation)	2	EA	$	2,500	$ 5,000	Source 3	
Staging pad	1	LS	$	10,000	$ 10,000	Source 3	
Rental and operation of generator	1	MO	$	17,050	$ 17,050	Source 3	$150/dy rent + $400/dy fuel = $550/dy
Rental of frac tank	1	MO	$	500	$ 500	Source 3	
Portadam® Barriers - setup, teardown, and one month rental	1,200	LF	$	100	$ 120,000	Source 3	
Portadam® Barriers - additional rental	2	WK	$	15,600	$ 31,200	Source 3	
Cut-off timber piles allowance	1	LS	$	150,000	$ 150,000	Source 3	
SUBTOTAL					$ 503,750		
Mobilization/Demobilization	5%				$ 25,188	Source 3	
Subcontractor general conditions	20%				$ 100,750	Source 3	
SUBTOTAL					*$ 629,688*		
Excavate 2' of Impacted Sediment							
Pump out area within Portadams®	30	DY	$	1,275	$ 38,250	Source 3	750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL	$	4	$ 6,000	Source 3	3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY	$	25	$ 275,000	Source 3	Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY	$	4	$ 44,000	Source 3	
SUBTOTAL					$ 363,250		
Mobilization/Demobilization	5%				$ 18,163	Source 3	
Subcontractor general conditions	20%				$ 72,650	Source 3	
SUBTOTAL					*$ 454,063*		
Install RCM Mat & Armor Layer							
Organoclay RCM material	120	ROLL	$	3,000	$ 360,000	Source 3	20% extra for overlap - 1,500 ft2/roll x $2.00/ft2
Install organoclay RCM	170,000	SF	$	0.50	$ 85,000	Source 3	
12" sand armor layer (material only)	6,000	CY	$	20	$ 120,000	Source 3	
Install 12" sand armor layer	6,000	CY	$	7	$ 42,000	Source 3	
SUBTOTAL					$ 607,000		
Mobilization/Demobilization	5%				$ 30,350	Source 3	
Subcontractor general conditions	20%				$ 121,400	Source 3	
SUBTOTAL					*$ 758,750*		

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	30	DY	$	718	$ 21,525	Source 4 + CH2M H&S	
PPE provisions for workers (initial)	12	EA	$	252	$ 3,023	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,584	EA	$	106	$ 167,856	Source 4 + CH2M H&S	
SUBTOTAL					$ 211,431		
CAPITAL SUBTOTAL - GROUNDWATER					$ 2,703,571		
Contingency	25%				$ 675,893	10% Scope + 15% Bid	
SUBTOTAL					$ 3,379,463		
Project Management	5%				$ 168,973	**USEPA 2000, p. 5-13, $2-$10M**	
Remedial Design	8%				$ 270,357	**USEPA 2000, p. 5-13, $2-$10M**	
Construction Management	6%				$ 202,768	**USEPA 2000, p. 5-13, $2-$10M**	
SUBTOTAL					$ 642,098		
Contractor Fees							
ODC & Subs	5%		$	3,379,463	$ 168,973		
Labor	10%	max	$	642,098	$ 64,210		
SUBTOTAL					$ 233,183		
TOTAL CAPITAL COST - GROUNDWATER					**$ 4,250,000**		
VAPOR							
Vapor Mitigation							
Preconstruction Investigations							
Evaluate building systems	1	LS	$	10,000	$ 10,000	Radiation Data Quote Phase 1	
SUBTOTAL					*$ 10,000*		
Install Sub Slab Depressurization System							
Install new french drain system	1	LS	$	50,000	$ 50,000	Source 3	
Upgrade dewatering equipment	1	LS	$	50,000	$ 50,000	Source 3	
Add carbon and bag filter system	1	LS	$	120,000	$ 120,000	Source 3	
Install sub slab depressurization system	1	LS	$	65,000	$ 65,000	Radiation Data Quote Phase 2	
SUBTOTAL					$ 285,000		
Mobilization/Demobilization	5%				$ 14,250		
Subcontractor general conditions	20%				$ 57,000		
SUBTOTAL					*$ 356,250*		
CAPITAL SUBTOTAL - VAPOR					$ 366,250		
Contingency	25%				$ 91,563	10% Scope + 15% Bid	
SUBTOTAL					$ 457,813		
Project Management	8%				$ 36,625	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%				$ 68,672	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%				$ 45,781	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL					$ 151,078		
Contractor Fees							
ODC & Subs	5%		$	457,813	$ 22,891		
Labor	10%	max	$	151,078	$ 15,108		
SUBTOTAL					$ 37,998		
TOTAL CAPITAL COST - VAPOR					**$ 650,000**		
TOTAL CAPITAL COST					**$ 55,060,000**		

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 26,031	$ 26,031		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 36,031		
Contingency	25%			$ 9,008	10% Scope + 15% Bid	
SUBTOTAL				$ 45,038		
Project Management	10%			$ 4,504	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 9,008	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,756	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 20,267		
Contractor Fees						
ODC & Subs	5%		$ 45,038	$ 2,252		
Labor	10%	max	$ 20,267	$ 2,027		
SUBTOTAL				$ 4,279		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		
NAPL						
NAPL Recovery Wells						
Routine Operations, Maintenance, Monitoring	240	HR	$ 100	$ 24,000	Assumes part time operator performs duties for NAPL system (5 days/month)	
Parts Replacement / Consumables	1	LS	$ 1,000	$ 1,000		
Reporting	100	HR	$ 100	$ 10,000		
Off-site Disposal of NAPL	180	GAL	$ 9.00	$ 1,620		Assumes 5-gallons from each well each month
SUBTOTAL				$ 36,620		
Mobilization/Demobilization	5%			$ 1,831		
Subcontractor general conditions	25%			$ 9,155		
SUBTOTAL				*$ 47,606*		
Contingency	25%			$ 11,902	10% Scope + 15% Bid	
SUBTOTAL				$ 59,508		
Project Management	8%			$ 4,761	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 8,926	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 5,951	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 19,637		
Contractor Fees						
ODC & Subs	5%		$ 59,508	$ 2,975		
Labor	10%	max	$ 19,637	$ 1,964		
SUBTOTAL				$ 4,939		
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 84,084**	Assumes NAPL recovery will cease after 10 years	
GROUNDWATER						
Inspection of Subaqueous Reactive Barrier (SRB)						
Sampling of barrier during low tide	1	LS	$ 15,000	$ 15,000		Excavator onsite for 5 days--expose 5% of barrier every 10 years
Barrier replacement	1	LS	$ 227,625	$ 227,625		30% of barrier every 10 years
Allowance for Misc. Items	1	LS	$ 48,525	$ 48,525		Assumes 20% of capital cost
SUBTOTAL				$ 291,150		
Mobilization/Demobilization	5%			$ 14,558		
Subcontractor general conditions	25%			$ 72,788		
SUBTOTAL				*$ 378,495*		
Contingency	25%			$ 94,624	10% Scope + 15% Bid	
SUBTOTAL				$ 473,119		
Project Management	8%			$ 37,850	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 70,968	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 47,312	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 156,129		
Contractor Fees						
ODC & Subs	5%		$ 473,119	$ 23,656		
Labor	10%	max	$ 156,129	$ 15,613		
SUBTOTAL				$ 39,269		
TOTAL ANNUAL O&M COST - SRB				**$ 668,517**		

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

Arsenic Slurry Cutoff Wall Gradient Control

Routine Operations, Maintenance, Monitoring	720	HR	$	80	$	57,600		60 hrs/month for one operator
Electricity	131,400	KWH	$	0.10	$	13,140		
Replace Filters/ Carbon/Resin	12	MO	$	5,000	$	60,000		
Annual POTW discharge fee	1	LS	$	4,500	$	4,500	Based on Bergen County industrial discharge permit fees	
Sampling and Analysis	12	MO	$	1,055	$	12,665		
Disposal of process residual waste	61	TON	$	2,500	$	152,083		
Reporting	200	HR	$	100	$	20,000	CH2M Est.	
Allowance for Misc. Items	1	LS	$	63,998	$	63,998		Assumes 20% of the capital costs
SUBTOTAL					$	383,986		
Subcontractor general conditions	20%				$	76,797		
SUBTOTAL					*$*	*460,783*		
Contingency	25%				$	115,196	10% Scope + 15% Bid	
SUBTOTAL					$	575,979		
Project Management	6%				$	34,559	**USEPA 2000, p. 5-13, $500K - $2M**	
Remedial Design	12%				$	69,117	**USEPA 2000, p. 5-13, $500K - $2M**	
Construction Management	8%				$	46,078	**USEPA 2000, p. 5-13, $500K - $2M**	
SUBTOTAL					$	149,754		
Contractor Fees								
ODC & Subs	5%		$	575,979	$	28,799		
Labor	10%	max	$	149,754	$	14,975		
SUBTOTAL					$	43,774		
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M					**$**	**769,508**		

Groundwater Monitoring

Groundwater Samples	40	EA	$	1,000	$	39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals
QC Samples	5	EA	$	1,000	$	4,998		
Groundwater Sampling, Level D								
Labor	300	HR	$	80	$	24,000		Assumes 3 persons for 5 days
Equipment - meters	1	LS	$	2,000	$	2,000	Source 3	
Consumables	1	LS	$	3,000	$	3,000	Source 3	
Data Validation	96	HR	$	100	$	9,600		
Reporting	240	HR	$	100	$	24,000		
Allowance for Misc. Items	1	LS	$	10,758	$	10,758		Assumes 10% of the capital costs
SUBTOTAL					$	118,340		
Mobilization/Demobilization	5%				$	5,917		
Subcontractor general conditions	25%				$	29,585		
SUBTOTAL					*$*	*153,842*		
Contingency	25%				$	38,461	10% Scope + 15% Bid	
SUBTOTAL					$	192,303		
Project Management	8%				$	15,384	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%				$	28,845	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%				$	19,230	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL					$	63,460		
Contractor Fees								
ODC & Subs	5%		$	192,303	$	9,615		
Labor	10%	max	$	63,460	$	6,346		
SUBTOTAL					$	15,961		
TOTAL ANNUAL O&M COST - Groundwater Monitoring					**$**	**271,724**		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)					**$**	**1,856,402**	Quarterly for first year (Four GW sampling events)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)					**$**	**1,041,231**	Annual for Years 2 to 30 (one GW sampling event per year)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)					**$**	**668,517**	Additional cost for years 10, 20, 30	

VAPOR

Vapor Intrusion Operation Bldg 115

Routine Operations, Maintenance, Monitoring	240	HR	$	80	$	19,200		Assumes part time operator performs duties 5 days/month
Parts Replacement / Consumables	1	LS	$	2,000	$	2,000	Source 3	
Electricity	13,140	KWH	$	0.10	$	1,314	Source 3	
Replace bag filters and carbon media	4	EA	$	2,500	$	10,000		Assume carbon replacement every 3 months -
Reporting	80	HR	$	80	$	6,400	CH2M Est.	
SUBTOTAL					$	38,914		
Mobilization/Demobilization	5%				$	1,946		
Subcontractor general conditions	25%				$	9,729		
SUBTOTAL					*$*	*50,588*		
Contingency	25%				$	12,647	10% Scope + 15% Bid	
SUBTOTAL					$	63,235		
Project Management	10%				$	6,324	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%				$	12,647	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%				$	9,485	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL					$	28,456		
Contractor Fees								
ODC & Subs	5%		$	63,235	$	3,162		
Labor	10%	max	$	28,456	$	2,846		
SUBTOTAL					$	6,007		
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)					**$**	**100,000**		

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT		UNIT COST		TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$	20,000	$	20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$	8,000	$	8,000	
Reapplication for the CEA (Deed)	16	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$	20,000	$	20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$	8,000	$	8,000	
					Total	$	521,000	
TOTAL PERIODIC COST						**$**	**520,000**	

Alternative 4a - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with HCAA Barrier Wall COST ESTIMATE SUMMARY - DRAFT

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 19,140,000	$ 19,140,000	1.000	$ 19,140,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 31,020,000	$ 31,020,000	1.000	$ 31,020,000	
CAPITAL COST - GROUNDWATER	0	$ 4,250,000	$ 4,250,000	1.000	$ 4,250,000	
CAPITAL COST - VAPOR	0	$ 650,000	$ 650,000	1.000	$ 650,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 84,084	$ 84,084	0.935	$ 78,583	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 84,084	$ 84,084	0.873	$ 73,442	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$ 672,673	$ 84,084	5.216	$ 438,546	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 1,856,402	$ 1,856,402	0.935	$ 1,734,955	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 30,195,704	$ 1,041,231	11.474	$ 11,947,567	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	10	$ 668,517	$ 668,517	0.508	$ 339,840	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	20	$ 668,517	$ 668,517	0.258	$ 172,757	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	30	$ 668,517	$ 668,517	0.131	$ 87,821	
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)	1 to 30	$ 3,000,000	$ 100,000	12.409	$ 1,240,904	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 95,579,497			$ 72,239,111	

TOTAL PRESENT VALUE OF ALTERNATIVE 4a - Process Option $ 72,240,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 4b - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with Demoliton of 115 River Road Buildi COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	In situ solidification/stabilization of tar boils, NAPL present in NZ-1, NZ-2, NZ-5 and small portion of NZ-3, including the demoliton of the buildings on the 115 River Road property. Institutional controls would be established and maintained to document and limit use of areas with COCs remaining in place.
Arsenic	Arsenic on Block 93 will be solidified/stabilized and a barrier wall with extraction and treatment installed downgradient of the HCAA. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	30	MO	$ 4,300	$ 129,000	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 460,000*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	30	MO	$ 12,000	$ 360,000	CH2M Est.	
SUBTOTAL				*$ 585,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
Excavation and stockpile of 10-ft of backfill	5,025	CY	$ 30	$ 149,254	MEANS 17-03-0276	Assumes material can be replaced following the completion of remedial activities
SUBTOTAL				$ 165,605		
Mobilization/Demobilization	5%			$ 8,280	Source 3	
Subcontractor general conditions	20%			$ 33,121	Source 3	
SUBTOTAL				*$ 207,007*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Demolition of 115 River Road Buildings						
Temporary relocation of tenants	1	LS	$ 2,000,000	$ 2,000,000	Assumes 60 businesses moved twice - cost provided by Honeywell real estate group	
Loss of rent	1	LS	$ 7,000,000	$ 7,000,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Differential in rent for tenants	1	LS	$ 500,000	$ 500,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Building demolition	1	LS	$ 2,000,000	$ 2,000,000	Assumes bldg 86,000 ft^2 - cost provided by Honeywell real estate group	
Building reconstruction	1	LS	$ 39,000,000	$ 39,000,000	Cost provided by Honeywell real estate group	
SUBTOTAL				$ 50,500,000		
Mobilization/Demobilization	5%			$ 2,525,000	Source 3	
Subcontractor general conditions	20%			$ 10,100,000	Source 3	
SUBTOTAL				*$ 63,125,000*		

Alternative 4b - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with Demoliton of 115 River Road Buildi COST ESTIMATE SUMMARY - DRAFT

Capping							
New Vegetative Cap (Quanta)							
Rough grading	26,463	SY	$	1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$	1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$	19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$	19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$	15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$	54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$	2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$	0.07	$ 16,674	Source 3	
SUBTOTAL					$ 925,855		
Mobilization/Demobilization	5%				$ 46,293	Source 3	
Subcontractor general conditions	20%				$ 185,171	Source 3	
SUBTOTAL					*$ 1,157,318*		
Upgrade Asphalt Cap (115 River Road)							
Fine grading	7,059	SY	$	1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$	54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$	11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$	11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$	6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 316,416		
Mobilization/Demobilization	5%				$ 15,821	Source 3	
Subcontractor general conditions	20%				$ 63,283	Source 3	
SUBTOTAL					*$ 395,519*		
Asphalt Cap (Edgewater - NZ-5)							
Rough grading	1,508	SY	$	1.75	$ 2,636	MEANS 17-03-0101	Replacement of removed material
Fine grading	1,508	SY	$	1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$	54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$	11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$	11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$	11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$	6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 66,873		
Mobilization/Demobilization	5%				$ 3,344	Source 3	
Subcontractor general conditions	20%				$ 13,375	Source 3	
SUBTOTAL					*$ 83,592*		
Cover (Lever Bros. Property - NZ-1 and NZ-2)							
Rough grading	3,499	SY	$	1.75	$ 6,117	MEANS 17-03-0101	
Fine grading	3,499	SY	$	1.22	$ 4,272	MEANS 17-03-0101	
Protective layer, 6" compacted soil subgrade	580	CY	$	19	$ 10,899	MEANS 17-03-0423	
Drainage layer, 6" granular soil (assume gravel)	580	CY	$	54	$ 31,473	MEANS 32.11.23.23.1511	
Hydroseed	31,500	SF	$	0.07	$ 2,205	Source 3	
SUBTOTAL					$ 54,966		
Mobilization/Demobilization	5%				$ 2,748	Source 3	
Subcontractor general conditions	20%				$ 10,993	Source 3	
SUBTOTAL					*$ 68,707*		
Upgrade Asphalt Cap (Block 93 North and Central)							
Fine grading	11,532	SY	$	1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$	54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$	11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$	6	$ 11,927	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 462,836		
Mobilization/Demobilization	5%				$ 23,142	Source 3	
Subcontractor general conditions	20%				$ 92,567	Source 3	
SUBTOTAL					*$ 578,544*		
Upgrade Asphalt Cap (Block 94)							
Fine grading	2,322	SY	$	1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$ 161,073		
Mobilization/Demobilization	5%				$ 8,054	Source 3	
Subcontractor general conditions	20%				$ 32,215	Source 3	
SUBTOTAL					*$ 201,341*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	6	MO	$	1,043	$ 6,255	Source 4	
Air monitoring	90	DY	$	718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$	106	$ 279,760	Source 4 + CH2M H&S	
SUBTOTAL					*$ 368,400*		
CAPITAL SUBTOTAL - SOIL					$ 75,387,667		
Contingency	25%				$ 18,846,917	10% Scope + 15% Bid	
SUBTOTAL					$ 94,234,583		
Project Management	5%				$ 4,711,729	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 5,654,075	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 5,654,075	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 16,019,879		
Contractor Fees							
ODC & Subs	5%		$	94,234,583	$ 4,711,729		
Labor	10%	max	$	16,019,879	$ 1,601,988		
SUBTOTAL					$ 6,313,717		
TOTAL CAPITAL COST - SOIL					**$ 116,570,000**		
NAPL and ARSENIC							
NAPL Recovery							
NAPL Recovery in existing monitoring wells							
Product recovery pumps	3	EA	$	4,000	$ 12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$ 12,000		
Mobilization/Demobilization	5%				$ 600		
Subcontractor general conditions	20%				$ 2,400		
SUBTOTAL					*$ 15,000*		
In Situ Solidification/Stabilization							
Preconstruction Investigations							
Bench scale test	1	LS	$	75,000	$ 75,000	CH2M Est., assumed design of test is included in design line item	
Pilot field test	1	LS	$	150,000	$ 150,000	CH2M Est., assumed design of test is included in design line item	
Utility markout /locating service	3	DAY	$	5,000	$ 15,000		
SUBTOTAL					*$ 240,000*		
In Situ Solidification/Stabilization - NAPL NZ-1 (Quanta, 115 River Road, and Former Lever Bros.)							
NAPL area - cement	52,323	CY	$	30	$ 1,569,685	Source 3	Assumes an average depth of 11-ft
NAPL area - stabilization	52,323	CY	$	35	$ 1,831,300	Source 3	
Odor suppression equipment rental	12	MO	$	10,000	$ 120,000		Assumes two rental units
Odor suppression material	353	DRUM	$	350	$ 123,613		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 3,644,598		
Mobilization/Demobilization	5%				$ 182,230		
Subcontractor general conditions	20%				$ 728,920		
SUBTOTAL					*$ 4,555,747*		
In Situ Solidification/Stabilization - NAPL NZ-3 (Quanta, 115 River Road, and Former Lever Bros.)							
NAPL area - cement	5,547	CY	$	30	$ 166,400	Source 3	Assumes an average depth of 11-ft
NAPL area - stabilization	5,547	CY	$	35	$ 194,133	Source 3	
Odor suppression equipment rental	10	MO	$	10,000	$ 100,000		Assumes two rental units
Odor suppression material	37	DRUM	$	350	$ 13,104		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 473,637		
Mobilization/Demobilization	5%				$ 23,682		
Subcontractor general conditions	20%				$ 94,727		
SUBTOTAL					*$ 592,047*		

Alternative 4b - Process Option: NAPL and Arsenic In Situ Solidification/Stabilization with Demoliton of 115 River Road Buildi COST ESTIMATE SUMMARY - DRAFT

In Situ Solidification/Stabilization - NAPL NZ-1 (Block 93 - not including material comingled with arsenic)							
NAPL area - excavate and stockpile	6,008	CY	$	30	$ 178,439	Source 3	Assumes an average depth of 11-ft
NAPL area - cement	6,008	CY	$	30	$ 180,241	Source 3	
NAPL area - stabilization	6,008	CY	$	35	$ 210,281	Source 3	
NAPL area - haul and place on Quanta	7,210	CY	$	10	$ 72,096	Source 3	Assumes a 20% increase in volume due to expansion
Certified clean fill for backfilling excavation	6,008	CY	$	19	$ 112,900	MEANS 17-03-0423	
Odor suppression equipment rental	2	MO	$	10,000	$ 20,000		Assumes two rental units
Odor suppression material	41	DRUM	$	350	$ 14,194		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 788,152		
Mobilization/Demobilization	5%				$ 39,408		
Subcontractor general conditions	20%				$ 157,630		
SUBTOTAL					*$ 985,189*		
In Situ Solidification/Stabilization - NAPL NZ-2 and NZ-5							
NAPL area - cement	62,691	CY	$	30	$ 1,880,742		Assumes average depth of 25-ft in half the area and 11-ft for remaining
NAPL area - stabilization	62,691	CY	$	35	$ 2,194,199		
NAPL area - stabilization NZ-5 jet grouting	7,036	CY	$	300	$ 2,110,656		Assumes ISS will occur at depth of 10-24
Odor suppression equipment rental	12	MO	$	10,000	$ 120,000		Assumes two rental units
Odor suppression material	423	DRUM	$	350	$ 148,108		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
SUBTOTAL					$ 6,453,705		
Mobilization/Demobilization	5%				$ 322,685		
Subcontractor general conditions	20%				$ 1,290,741		
SUBTOTAL					*$ 8,067,131*		
In Situ Solidification/Stabilization - Arsenic Area (Block 93 & S. of HCAA - including material commingled with NAPL)							
Arsenic area - excavate and stockpile	2,372	CY	$	30	$ 70,451	Source 3	Assumes average depth of 2-ft bgs for half the area and 11-ft for the remaining
Arsenic area - reagents	2,372	CY	$	22	$ 52,186	Source 3	
Arsenic area - cement	2,372	CY	$	30	$ 71,162	Source 3	
Arsenic area - stabilization	2,372	CY	$	35	$ 83,023	Source 3	
Arsenic area - haul and place on Quanta	2,846	CY	$	10	$ 28,465	Source 3	
Certified clean fill for backfilling excavation	2,372	CY	$	19	$ 44,575	MEANS 17-03-0423	
SUBTOTAL					$ 349,861		
Mobilization/Demobilization	5%				$ 17,493		
Subcontractor general conditions	20%				$ 69,972		
SUBTOTAL					*$ 437,326*		
Temporary Sheetpile at Shoreline							
Remove concrete decking	2,500	SF	$	15	$ 37,500	Envirocon ROM estimate	
Rip-rap removal	1,040	CY	$	25	$ 26,000	Envirocon ROM estimate	
Barrier wall at 115 River Road (under building)	1	LS	$	600,000	$ 600,000	Envirocon ROM estimate	
Temporary sheet piling - shoreline	10,100	SF	$	80	$ 808,000	Envirocon ROM estimate	Turbidity Barrier only, includes removal
SUBTOTAL					$ 1,471,500		
Mobilization/Demobilization	5%				$ 73,575	Source 3	
Subcontractor general conditions	20%				$ 294,300		
SUBTOTAL					*$ 1,839,375*		
Arsenic (HCAA) Barrier Wall							
Slurry wall installation	18,000	VSF	$	65	$ 1,170,000	Envirocon ROM estimate	Assume 3' wide trench, 25 feet deep
Restoration of ground surface	6,000	SY	$	25	$ 150,000	CH2M HILL Estimate	
Transport and Disposal of Trench Spoils	3,300	TN	$	128	$ 422,400	CH2M HILL Estimate	
Vertical Wells for Gradient Control							
Soil Borings	90	LF	$	47	$ 4,185		Assumes 3 locations to 30-ft
4-inch PVC Well Casing	75	LF	$	51	$ 3,823	MEANS	
4-inch PVC Well Screen	15	LF	$	54	$ 804	Source 3	Assumes 5-ft screens
Well Vaults	3	EA	$	8,000	$ 24,000	Source 3	
Well cuttings disposal	4	TN	$	128	$ 553		
Extraction well pumps	3	EA	$	4,200	$ 12,600		
Treatment System							Assumes treatment includes removal of VOCs, TSS, and arsenic at 5 gpm and discharge to POTW
Piping from wells	420	FT	$	54	$ 22,680		Assumes 2-inch HDPE
Carbon vessels system	1	EA	$	25,000	$ 25,000	Source 3	System consist of two vessels in series
Solids removal	1	EA	$	286,301	$ 286,301		Incline plate clarifier, baf filters, filter press
Ion exchange resin	1	EA	$	25,000	$ 25,000	Source 3	
Electrical and Mechanical Installation	1	LS	$	134,394	$ 134,394	Source 3	
Building Structure	1	LS	$	85,000	$ 85,000	Source 3	
Discharge application fee	1	LS	$	4,000	$ 4,000		Based on Bergen County industrial discharge permit fees
SUBTOTAL					$ 2,370,740		
Mobilization/Demobilization	5%				$ 118,537		
Subcontractor General Conditions	20%				$ 474,148		
SUBTOTAL					*$ 2,963,425*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$ 12,772	Source 4	
Decon shed	8	MO	$	1,043	$ 8,340	Source 4	
Air monitoring based on air monitoring plan	30	MO	$	20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations
PPE provisions for workers (initial)	22	EA	$	252	$ 5,541	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	3,872	EA	$	106	$ 410,314	Source 4 + CH2M H&S	
SUBTOTAL					$ 1,036,968		
CAPITAL SUBTOTAL - NAPL and ARSENIC					$ 20,732,209		
Contingency	25%				$ 5,183,052	10% Scope + 15% Bid	
SUBTOTAL					$ 25,915,261		
Project Management	5%				$ 1,295,763	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$ 1,554,916	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$ 1,554,916	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$ 4,405,594		
Contractor Fees							
ODC & Subs	5%		$	25,915,261	$ 1,295,763		
Labor	10%	max	$	4,405,594	$ 440,559		
SUBTOTAL					$ 1,736,322		
TOTAL CAPITAL COST - NAPL and ARSENIC					**$ 32,060,000**		
GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$	230,000	$ 230,000		
Updates to the groundwater model	1	LS	$	20,000	$ 20,000		
Bench-scale testing (Arsenic and NAPL)	2	EA	$	75,000	$ 150,000		
Pilot-scale testing	1	LS	$	150,000	$ 150,000		
SUBTOTAL					*$ 550,000*		
Replacement Monitoring Wells							
Soil borings	480	FT	$	47	$ 22,320		Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$	31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen
2-inch PVC well screen	160	FT	$	34	$ 5,398	MEANS 33-23-0256	
Well development	16	EA	$	1,600	$ 25,600	Source 3	
Off-site disposal of soil cuttings from well installation	50	TN	$	128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$	1.00	$ 10,000	Source 3	Assumes water is non-hazardous
SUBTOTAL					$ 79,712		
Mobilization/Demobilization	5%				$ 3,986	Source 3	
Subcontractor general conditions	20%				$ 15,942	Source 3	
SUBTOTAL					*$ 99,640*		
Subaqueous Reactive Barrier							
Site Preparation							
Erosion control	1	LS	$	20,000	$ 20,000	Source 3	
Permitting	1	LS	$	150,000	$ 150,000	Source 3	
Survey (pre and post installation)	2	EA	$	2,500	$ 5,000	Source 3	
Staging pad	1	LS	$	10,000	$ 10,000	Source 3	
Rental and operation of generator	1	MO	$	17,050	$ 17,050	Source 3	$150/dy rent + $400/dy fuel = $550/dy
Rental of frac tank	1	MO	$	500	$ 500	Source 3	
Portadam® Barriers - setup, teardown, and one month rental	1,200	LF	$	100	$ 120,000	Source 3	
Portadam® Barriers - additional rental	2	WK	$	15,600	$ 31,200	Source 3	
Cut-off timber piles allowance	1	LS	$	150,000	$ 150,000	Source 3	
SUBTOTAL					$ 503,750		
Mobilization/Demobilization	5%				$ 25,188	Source 3	
Subcontractor general conditions	20%				$ 100,750	Source 3	
SUBTOTAL					*$ 629,688*		
Excavate 2' of Impacted Sediment							
Pump out area within Portadams®	30	DY	$	1,275	$ 38,250	Source 3	750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL	$	4	$ 6,000	Source 3	3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY	$	25	$ 275,000	Source 3	Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY	$	4	$ 44,000	Source 3	
SUBTOTAL					$ 363,250		
Mobilization/Demobilization	5%				$ 18,163	Source 3	
Subcontractor general conditions	20%				$ 72,650	Source 3	
SUBTOTAL					*$ 454,063*		
Install RCM Mat & Armor Layer							
Organoclay RCM material	120	ROLL	$	3,000	$ 360,000	Source 3	20% extra for overlap - 1,500 ft2/roll x $2.00/ft2
Install organoclay RCM	170,000	SF	$	0.50	$ 85,000	Source 3	
12" sand armor layer (material only)	6,000	CY	$	20	$ 120,000	Source 3	
Install 12" sand armor layer	6,000	CY	$	7	$ 42,000	Source 3	
SUBTOTAL					$ 607,000		
Mobilization/Demobilization	5%				$ 30,350	Source 3	

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Subcontractor general conditions	20%				$ 121,400	Source 3	
SUBTOTAL					*$ 758,750*		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772		$ 12,772	Source 4	
Decon shed	6	MO	$ 1,043		$ 6,255	Source 4	
Air monitoring	30	DY	$ 718		$ 21,525	Source 4 + CH2M H&S	
PPE provisions for workers (initial)	12	EA	$ 252		$ 3,023	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,584	EA	$ 106		$ 167,856	Source 4 + CH2M H&S	
SUBTOTAL					$ 211,431		
CAPITAL SUBTOTAL - GROUNDWATER					$ 2,703,571		
Contingency	25%				$ 675,893	10% Scope + 15% Bid	
SUBTOTAL					$ 3,379,463		
Project Management	5%				$ 168,973	**USEPA 2000, p. 5-13, $2-$10M**	
Remedial Design	8%				$ 270,357	**USEPA 2000, p. 5-13, $2-$10M**	
Construction Management	6%				$ 202,768	**USEPA 2000, p. 5-13, $2-$10M**	
SUBTOTAL					$ 642,098		
Contractor Fees							
ODC & Subs	5%		$ 3,379,463		$ 168,973		
Labor	10%	max	$ 642,098		$ 64,210		
SUBTOTAL					$ 233,183		
TOTAL CAPITAL COST - GROUNDWATER					**$ 4,250,000**		
TOTAL CAPITAL COST					**$ 152,880,000**		

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 24,850	$ 24,850		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 34,850		
Contingency	25%			$ 8,713	10% Scope + 15% Bid	
SUBTOTAL				$ 43,563		
Project Management	10%			$ 4,356	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 8,713	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,534	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 19,603		
Contractor Fees						
ODC & Subs	5%		$ 43,563	$ 2,178		
Labor	10%	max	$ 19,603	$ 1,960		
SUBTOTAL				$ 4,138		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		
NAPL						
NAPL Recovery Wells						
Routine Operations, Maintenance, Monitoring	240	HR	$ 100	$ 24,000	Assumes part time operator performs duties for NAPL system (5 days/month)	
Parts Replacement / Consumables	1	LS	$ 1,000	$ 1,000		
Reporting	100	HR	$ 100	$ 10,000		
Off-site Disposal of NAPL	180	GAL	$ 9.00	$ 1,620		
SUBTOTAL				$ 36,620		
Mobilization/Demobilization	5%			$ 1,831		
Subcontractor general conditions	25%			$ 9,155		
SUBTOTAL				*$ 47,606*		
Contingency	25%			$ 11,902	10% Scope + 15% Bid	
SUBTOTAL				$ 59,508		
Project Management	8%			$ 4,761	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 8,926	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 5,951	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 19,637		
Contractor Fees						
ODC & Subs	5%		$ 59,508	$ 2,975		
Labor	10%	max	$ 19,637	$ 1,964		
SUBTOTAL				$ 4,939		
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 84,084**	Assumes NAPL recovery will cease after 10 years	
GROUNDWATER						
Inspection of Subaqueous Reactive Barrier (SRB)						
Sampling of barrier during low tide	1	LS	$ 15,000	$ 15,000		Excavator onsite for 5 days--expose 5% of barrier every 10 years
Barrier replacement	1	LS	$ 227,625	$ 227,625		30% of barrier every 10 years
Allowance for Misc. Items	1	LS	$ 48,525	$ 48,525		Assumes 20% of capital cost
SUBTOTAL				$ 291,150		
Mobilization/Demobilization	5%			$ 14,558		
Subcontractor general conditions	25%			$ 72,788		
SUBTOTAL				*$ 378,495*		
Contingency	25%			$ 94,624	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL				$ 473,119		
Project Management	8%			$ 37,850	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 70,968	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 47,312	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 156,129		
Contractor Fees						
ODC & Subs	5%		$ 473,119	$ 23,656		
Labor	10%	max	$ 156,129	$ 15,613		
SUBTOTAL				$ 39,269		
TOTAL ANNUAL O&M COST - SRB				**$ 668,517**		
Arsenic Slurry Cutoff Wall Gradient Control						
Routine Operations, Maintenance, Monitoring	720	HR	$ 80	$ 57,600		60 hrs/month for one operator
Electricity	131,400	KWH	$ 0.10	$ 13,140		
Replace Filters/ Carbon/Resin	12	MO	$ 5,000	$ 60,000		
Annual POTW discharge fee	1	LS	$ 4,500	$ 4,500	Based on Bergen County industrial discharge permit fees	
Sampling and Analysis	12	MO	$ 1,055	$ 12,665		
Disposal of process residual waste	61	TON	$ 2,500	$ 152,083		
Reporting	200	HR	$ 100	$ 20,000	CH2M Est.	
Allowance for Misc. Items	1	LS	$ 63,998	$ 63,998		Assumes 20% of the capital costs
SUBTOTAL				$ 383,986		
Subcontractor general conditions	20%			$ 76,797		
SUBTOTAL				*$ 460,783*		
Contingency	25%			$ 115,196	10% Scope + 15% Bid	
SUBTOTAL				$ 575,979		
Project Management	6%			$ 34,559	**USEPA 2000, p. 5-13, $500K - $2M**	
Remedial Design	12%			$ 69,117	**USEPA 2000, p. 5-13, $500K - $2M**	
Construction Management	8%			$ 46,078	**USEPA 2000, p. 5-13, $500K - $2M**	
SUBTOTAL				$ 149,754		

Contractor Fees							
ODC & Subs	5%		$ 575,979	$ 28,799			
Labor	10%	max	$ 149,754	$ 14,975			
SUBTOTAL				$ 43,774			
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M				**$ 769,508**			
Groundwater Monitoring							
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals	
QC Samples	5	EA	$ 1,000	$ 4,998			
Groundwater Sampling, Level D							
Labor	300	HR	$ 80	$ 24,000		Assumes 3 persons for 5 days	
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3		
Consumables	1	LS	$ 3,000	$ 3,000	Source 3		
Data Validation	96	HR	$ 100	$ 9,600			
Reporting	240	HR	$ 100	$ 24,000			
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758		Assumes 10% of the capital costs	
SUBTOTAL				$ 118,340			
Mobilization/Demobilization	5%			$ 5,917			
Subcontractor general conditions	25%			$ 29,585			
SUBTOTAL				*$ 153,842*			
Contingency	25%			$ 38,461	10% Scope + 15% Bid		
SUBTOTAL				$ 192,303			
Project Management	8%			$ 15,384	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 28,845	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 19,230	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 63,460			
Contractor Fees							
ODC & Subs	5%		$ 192,303	$ 9,615			
Labor	10%	max	$ 63,460	$ 6,346			
SUBTOTAL				$ 15,961			
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**			
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 1,856,402**	Quarterly for first year (Four GW sampling events)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 1,041,231**	Annual for Years 2 to 30 (one GW sampling event per year)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)				**$ 668,517**	Additional cost for years 10, 20, 30		

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 116,570,000	$ 116,570,000	1.000	$ 116,570,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 32,060,000	$ 32,060,000	1.000	$ 32,060,000	
CAPITAL COST - GROUNDWATER	0	$ 4,250,000	$ 4,250,000	1.000	$ 4,250,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 84,084	$ 84,084	0.935	$ 78,583	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 84,084	$ 84,084	0.873	$ 73,442	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$ 672,673	$ 84,084	5.216	$ 438,546	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 1,856,402	$ 1,856,402	0.935	$ 1,734,955	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 30,195,704	$ 1,041,231	11.474	$ 11,947,567	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	10	$ 668,517	$ 668,517	0.508	$ 339,840	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	20	$ 668,517	$ 668,517	0.258	$ 172,757	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	30	$ 668,517	$ 668,517	0.131	$ 87,821	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 190,399,497			$ 168,818,207	

TOTAL PRESENT VALUE OF ALTERNATIVE 4b $ 168,820,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5. NAPL collection would be followed by in situ chemical oxidation in NAPL zones NZ-1, NZ 2, NZ-5, and small portion of NZ-3.
Arsenic	Arsenic on Block 93 will be solidified/stabilized and a barrier wall with extraction and treatment installed downgradient of the HCAA. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	A vapor mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Road. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	Site groundwater would be contained with a barrier wall and groundwater extraction at the shoreline and downgradient of the HCAA. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	36	MO	$ 4,300	$ 154,800	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 485,800*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	36	MO	$ 12,000	$ 432,000	CH2M Est.	
SUBTOTAL				*$ 657,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 291,756		
Mobilization/Demobilization	5%			$ 14,588	Source 3	
Subcontractor general conditions	20%			$ 58,351	Source 3	
SUBTOTAL				*$ 364,695*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 16,352		
Mobilization/Demobilization	5%			$ 818	Source 3	
Subcontractor general conditions	20%			$ 3,270	Source 3	
SUBTOTAL				*$ 20,440*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		
Upgrade Asphalt Cap (115 River Road)						
Fine grading	7,059	SY	$ 1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$ 54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$ 6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 316,416		
Mobilization/Demobilization	5%			$ 15,821	Source 3	
Subcontractor general conditions	20%			$ 63,283	Source 3	
SUBTOTAL				*$ 395,519*		

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

Asphalt Cap (Edgewater - NZ-5)							
Fine grading	1,508	SY	$ 1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$ 54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$ 11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$ 6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 64,238		
Mobilization/Demobilization	5%			$ 3,212	Source 3	
Subcontractor general conditions	20%			$ 12,848	Source 3	
SUBTOTAL				*$ 80,297*		
Upgrade Asphalt Cap (Block 93 North and Central)						
Fine grading	11,532	SY	$ 1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$ 54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$ 6	$ 11,927	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 462,836		
Mobilization/Demobilization	5%			$ 23,142	Source 3	
Subcontractor general conditions	20%			$ 92,567	Source 3	
SUBTOTAL				*$ 578,544*		
Upgrade Asphalt Cap (Block 94)						
Fine grading	2,322	SY	$ 1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$ 54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$ 11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$ 11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$ 6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 161,073		
Mobilization/Demobilization	5%			$ 8,054	Source 3	
Subcontractor general conditions	20%			$ 32,215	Source 3	
SUBTOTAL				*$ 201,341*		
Compliance Monitoring and Health & Safety						
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4	
Decon shed	6	MO	$ 1,043	$ 6,255	Source 4	
Air monitoring	90	DY	$ 718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$ 252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$ 106	$ 279,760	Source 4 + CH2M H&S	
SUBTOTAL				*$ 368,400*		
CAPITAL SUBTOTAL - SOIL				$ 4,718,813		
Contingency	25%			$ 1,179,703	10% Scope + 15% Bid	
SUBTOTAL				$ 5,898,516		
Project Management	5%			$ 294,926	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%			$ 353,911	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%			$ 353,911	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL				$ 1,002,748		
Contractor Fees						
ODC & Subs	5%		$ 5,898,516	$ 294,926		
Labor	10%	max	$ 1,002,748	$ 100,275		
SUBTOTAL				$ 395,201		
TOTAL CAPITAL COST - SOIL				**$ 7,300,000**		
NAPL and ARSENIC						
NAPL Recovery						
Preconstruction Investigations						
Slurry compatibility test	1	LS	$ 25,000	$ 25,000		
Pump test	1	LS	$ 75,000	$ 75,000	CH2M Est.	
Pilot field test	1	LS	$ 100,000	$ 100,000	CH2M Est., assumed design of test is included in design line item (@ 8%)	
Utility markout / locating service	3	DAY	$ 5,000	$ 15,000		
SUBTOTAL				*$ 215,000*		
NAPL Recovery in existing monitoring wells						
Product recovery pumps	3	EA	$ 4,000	$ 12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL				$ 12,000		
Mobilization/Demobilization	5%			$ 600		
Subcontractor general conditions	20%			$ 2,400		
SUBTOTAL				*$ 15,000*		
Vertical NAPL Recovery Wells						
Soil borings	250	LF	$ 47	$ 11,625	Source 3	Assumes 10 recovery wells
4-inch PVC well casing	150	LF	$ 51	$ 7,646	MEANS	
4-inch PVC well screen	100	LF	$ 54	$ 5,357	MEANS	
Well vaults	10	EA	$ 8,000	$ 80,000	Source 3	
Well cuttings disposal	30	TN	$ 128	$ 3,840	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Storage tanks	1	EA	$ 4,572	$ 4,572	MEANS 33-10-9658	2000-gallon HDPE tank with secondary containment
Product recovery pumps	5	EA	$ 4,000	$ 4,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL				$ 117,039		
Mobilization/Demobilization	5%			$ 5,852		
Subcontractor general conditions	20%			$ 23,408		
SUBTOTAL				*$ 146,299*		
Install Equipment & Utilities for NAPL Collection/Handling						
Utility trenching	62	CY	$ 13	$ 812	MEANS 17-03-0202	
Electrical conduit	560	LF	$ 8.00	$ 4,480	Source 3	
Backfill to grade	62	CY	$ 54.26	$ 3,376	MEANS 17-03-0401	
Control wiring	1,120	LF	$ 11	$ 12,320	Source 3	
Power supply to the site	1	LS	$ 16,000	$ 16,000	Source 3	
Power wiring, #10 insulated strand wire	1,120	LF	$ 0.59	$ 661	ECHOS 20.02.0505	
Electrical disconnect, weatherhead, and installation of wiring	1	LS	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 42,649		
Mobilization/Demobilization	5%			$ 2,132		
Subcontractor general conditions	20%			$ 8,530		
SUBTOTAL				*$ 53,311*		
Offsite Treatment / Disposal						
Off-site disposal of decontamination and development water	10,000	GAL	$ 1.00	$ 10,000	Source 3	Assumes water is non-hazardous
Off-site disposal of municipal waste	20	CY	$ 200	$ 4,000	Source 3	
SUBTOTAL				$ 14,000		
Mobilization/Demobilization	5%			$ 700		
Subcontractor general conditions	20%			$ 2,800		
SUBTOTAL				*$ 17,500*		
In Situ Solidification/Stabilization						
Preconstruction Investigations						
Bench scale test	1	LS	$ 75,000	$ 75,000	CH2M Est., assumed design of test is included in design line item	
Pilot field test	1	LS	$ 150,000	$ 150,000	CH2M Est., assumed design of test is included in design line item	
Utility markout /locating service	3	DAY	$ 5,000	$ 15,000		
SUBTOTAL				*$ 240,000*		
In Situ Solidification/Stabilization - Arsenic Area (Block 93 - including material commingled with NAPL)						
Arsenic area - excavate and stockpile	2,372	CY	$ 30	$ 70,451	Source 3	Assumes average depth of 2-ft bgs for half the area and 11-ft for the remaining
Arsenic area - reagents	2,372	CY	$ 22	$ 52,186	Source 3	
Arsenic area - cement	2,372	CY	$ 30	$ 71,162	Source 3	
Arsenic area - stabilization	2,372	CY	$ 35	$ 83,023	Source 3	
Arsenic area - haul and place on Quanta	2,846	CY	$ 10	$ 28,465	Source 3	
Certified clean fill for backfilling excavation	2,372	CY	$ 19	$ 44,575	MEANS 17-03-0423	
SUBTOTAL				$ 349,861		
Mobilization/Demobilization	5%			$ 17,493		
Subcontractor general conditions	20%			$ 69,972		
SUBTOTAL				*$ 437,326*		
In Situ Chemical Oxidation						
Preconstruction Investigations						
Pilot field test	1	LS	$ 250,000	$ 250,000	CH2M Est., assumed design of test is included in design line item (@ 8%)	
Utility markout / locating service	2	DAY	$ 5,000	$ 10,000		
SUBTOTAL				*$ 260,000*		

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

Excavation of Tar Boils & NAPL Zones NZ-1 to minus 4-ft bgs							
Excavation to 4-ft bgs	21,990	CY	$ 30	$ 653,113	Source 3	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	26,388	CY	$ 54	$ 1,431,922	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression equipment rental	2	MO	$ 10,000	$ 20,000	Vendor	Assumes two rental units
Odor suppression material	37	DRUM	$ 350	$ 12,988	Vendor	Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	36,284	TN	$ 70	$ 2,539,883	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	36,284	TN	$ 128	$ 4,644,357	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	44	EA	$ 3,735	$ 164,254	Source 4	Full TCLP analysis, 1 sample per 500 cy of excavated material
SUBTOTAL				$ 9,480,693		
Mobilization/Demobilization	5%			$ 474,035		
Subcontractor general conditions	20%			$ 1,896,139		
SUBTOTAL				*$ 11,850,866*		
Excavation of NAPL Zones NZ-2 to minus 4-ft bgs						
Excavation to 4-ft bgs	12,169	CY	$ 30	$ 361,423	Source 3	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	14,603	CY	$ 19	$ 274,412	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression equipment rental	1	MO	$ 10,000	$ 10,000		Assumes two rental units
Odor suppression material	21	DRUM	$ 350	$ 7,187		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	20,079	TN	$ 70	$ 1,405,534	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	20,079	TN	$ 128	$ 2,570,119	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	24	EA	$ 3,735	$ 90,896	Source 4	1 sample per 500 cy of excavated material
SUBTOTAL				$ 4,728,078		
Mobilization/Demobilization	5%			$ 236,404		
Subcontractor general conditions	20%			$ 945,616		
SUBTOTAL				*$ 5,910,098*		
In-Situ Chemical Oxidation						
ISCO application - NZ-1 and portion of NZ-3	63,878	CY	$ 720	$ 45,991,832		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL.
ISCO application - NZ-2 and NZ-5	54,761	CY	$ 720	$ 39,427,968		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL.
Post-application performance monitoring (assume 1 set of samples per property)	5	LS	$ 8,727	$ 43,633	Source 4	Same monitoring as for MNA: VOCs, SVOCs, PCBs, TAL metals
SUBTOTAL				$ 85,463,433		
Mobilization/Demobilization	5%			$ 4,273,172		
Subcontractor general conditions	20%			$ 17,092,687		
SUBTOTAL				*$ 106,829,291*		
Compliance Monitoring and Health & Safety						
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4	
Decon shed	24	MO	$ 1,043	$ 25,021	Source 4	
Air monitoring based on air monitoring plan	30	MO	$ 20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations
PPE provisions for workers (initial)	30	EA	$ 252	$ 7,557	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	15,840	EA	$ 106	$ 1,678,558	Source 4 + CH2M H&S	
SUBTOTAL				$ 2,323,908		
CAPITAL SUBTOTAL - NAPL and ARSENIC				$ 128,298,599		
Contingency	25%			$ 32,074,650	10% Scope + 15% Bid	
SUBTOTAL				$ 160,373,248		
Project Management	5%			$ 8,018,662	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%			$ 9,622,395	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%			$ 9,622,395	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL				$ 27,263,452		
Contractor Fees						
ODC & Subs	5%		$ 160,373,248	$ 8,018,662		
Labor	10%	max	$ 27,263,452	$ 2,726,345		
SUBTOTAL				$ 10,745,008		
TOTAL CAPITAL COST - NAPL and ARSENIC				**$ 198,380,000**		
GROUNDWATER						
General						
Preconstruction Investigations						
Pump test	1	LS	$ 230,000	$ 230,000		
Updates to the groundwater model	1	LS	$ 20,000	$ 20,000		
Bench-scale testing (Arsenic and NAPL)	2	EA	$ 75,000	$ 150,000		
Pilot-scale testing	1	LS	$ 150,000	$ 150,000		
SUBTOTAL				*$ 550,000*		
Replacement Monitoring Wells						
Soil borings	480	FT	$ 47	$ 22,320		Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$ 31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen
2-inch PVC well screen	160	FT	$ 34	$ 5,398	MEANS 33-23-0256	
Well development	16	EA	$ 1,600	$ 25,600	Source 3	
Off-site disposal of soil cuttings from well installation	50	TN	$ 128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$ 1.00	$ 10,000	Source 3	Assumes water is non-hazardous
SUBTOTAL				$ 79,712		
Mobilization/Demobilization	5%			$ 3,986	Source 3	
Subcontractor general conditions	20%			$ 15,942	Source 3	
SUBTOTAL				*$ 99,640*		
Cutoff Wall with Hydraulic Containment						
Cutoff Wall at Shoreline						
Remove concrete decking	2,500	SF	$ 15	$ 37,500	Envirocon ROM estimate	
Rip-rap removal	1,040	CY	$ 25	$ 26,000	Envirocon ROM estimate	
Barrier wall at 115 River Road (under building)	1	LS	$ 600,000	$ 600,000	Envirocon ROM estimate	
Sealed sheet piling - shoreline	42,000	SF	$ 127	$ 5,334,000	Envirocon ROM estimate	
SUBTOTAL				$ 5,997,500		
Mobilization/Demobilization	5%			$ 299,875	Source 3	
Subcontractor general conditions	20%			$ 1,199,500		
SUBTOTAL				*$ 7,496,875*		
Cutoff Wall at HCAA						
Slurry wall	18,000	VSF	$ 65	$ 1,170,000	Envirocon ROM estimate	Assumes 25-ft deep wall
Restoration of ground surface	6,000	SY	$ 25	$ 150,000	CH2M HILL Estimate	
Disposal of soil cuttings	3,300	TN	$ 128	$ 422,400	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
SUBTOTAL				$ 1,742,400		
Mobilization/Demobilization	5%			$ 87,120	Source 3	
Subcontractor general conditions	20%			$ 348,480		
SUBTOTAL				*$ 2,178,000*		
Groundwater Extraction						
Soil borings	315	LF	$ 47	$ 14,648	Source 3	Assumes 9 extraction wells to an average depth of 35-ft bgs
4-inch PVC well casing	180	LF	$ 51	$ 9,175	MEANS	
4-inch PVC well screen	135	LF	$ 54	$ 7,232	MEANS	Assumes 15-ft screen
Well vaults/pumps	9	EA	$ 8,000	$ 72,000	Source 3	
Manifolds and valves	1	LS	$ 25,000	$ 25,000	Source 3	
Disposal of soil cuttings	20	EA	$ 128	$ 2,560	MEANS 33-19-7270	
Trenching for conveyance piping	9	TN	$ 13	$ 113	MEANS 17-03-0202	
Conveyance piping	2,500	LF	$ 54	$ 135,000	MEANS 33-26-0406	
Backfill trench	10	CY	$ 54	$ 563	MEANS 17-03-0423	
Electrical to wells	1	LS	$ 120,000	$ 120,000		
SUBTOTAL				$ 386,290		
Mobilization/Demobilization	5%			$ 19,314	Source 3	
Subcontractor general conditions	20%			$ 77,258		
SUBTOTAL				*$ 482,862*		
Wastewater Treatment Plant to Treat Extracted Water						System to treat 50 gpm
Pumping and Equalization of Influent Water						
8,000 gallon polypropylene equalization tanks	2	EA	$ 6,340	$ 12,679	MEANS 33-10-9661	Provides 8-hrs of storage at 100 gpm
Sludge pump	1	EA	$ 3,820	$ 3,820	Source 3	
Off-gas pump	1	EA	$ 1,322	$ 1,322	Source 3	
Effluent pump	4	EA	$ 4,221	$ 16,883	Source 3	50 GPM effluent pump (MAX @ 65'TDH)
NAPL pump	1	EA	$ 3,864	$ 3,864	Source 3	
Chemical feed systems (caustic and acid)	2	EA	$ 3,130	$ 6,260	Source 3	
SUBTOTAL				$ 44,829		
Mobilization/Demobilization	5%			$ 2,241	Source 3	
Subcontractor general conditions	20%			$ 8,966	Source 3	
SUBTOTAL				*$ 56,036*		

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

Removal of NAPLs and Solids							
Oil-water separator, 50 gpm	1	EA	$ 16,910	$ 16,910	ECHOS 19.04.0412		
Packaged 1,500 Gallon Steel Product Tank	1	EA	$ 4,950	$ 4,950	ECHOS 19.04.0604		
Packaged 20 gpm Oil Pump out unit w/controls	1	EA	$ 7,670	$ 7,670	ECHOS 33.13.1211		
Effluent pump	2	EA	$ 5,231	$ 10,462	MEANS 33-23-0555	50 GPM(one in operation and one in stand-by) (MAX@ 65'TDH)	
Chemical feed systems	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104	Caustic, acid, polymer, hydrogen peroxide, and ferric chloride	
SUBTOTAL				$ 55,642			
Mobilization/Demobilization	5%			$ 2,782	Source 3		
Subcontractor general conditions	20%			$ 11,128	Source 3		
SUBTOTAL				*$ 69,553*			
Advanced oxidation							
Flocculation tanks connected in series	4	EA	$ 4,572	$ 18,287	MEANS 33-10-9658		
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	$ 4,009	$ 8,018	MEANS 33-29-0120		
SUBTOTAL				$ 41,955			
Mobilization/Demobilization	5%			$ 2,098	Source 3		
Subcontractor General Conditions	20%			$ 8,391	Source 3		
SUBTOTAL				*$ 52,444*			
Solid-liquid Separation							
Inclined plate clarifier (0.25 GPM/SF of area)	3	EA	$ 26,520	$ 79,560	ECHOS 33.13.0414		
100 GPM effluent pump for use with plate clarifier	1	EA	$ 6,211	$ 6,211	Source 3		
Sludge pump for use with plate clarifier	1	EA	$ 3,130	$ 3,130	Source 3		
Bag filters	2	EA	$ 800	$ 1,600	Source 3		
Offgas pumps for use with bag filters	2	EA	$ 1,500	$ 3,000	Source 3		
Effluent pumps for use with bag filters	2	EA	$ 4,200	$ 8,400	Source 3		
Liquid waste pump for use with sludge settling tank	1	EA	$ 4,200	$ 4,200	Source 3		
Filter press, 95% removal efficiency	2	EA	$ 90,100	$ 180,200	ECHOS 33.33.3013	10 CF w/sludge tanks, pumps, mixers, sludge cart	
SUBTOTAL				$ 286,301			
Mobilization/Demobilization	5%			$ 14,315	Source 3		
Subcontractor general conditions	20%			$ 57,260	Source 3		
SUBTOTAL				*$ 357,877*			
Effluent Polishing							
Packaged 36,000 GPD water treatment plant	2	EA	$ 32,400	$ 64,800	ECHOS 19.01.0807	Includes GAC, pumps, tanks	
Concrete Wet Well, 12'x36"	4	EA	$ 9,200	$ 36,800	ECHOS 19.02.0304		
Packaged Lift Station (70 gpm)	4	EA	$ 9,950	$ 39,800	ECHOS 19.02.0304		
Ion exchange units	2	EA	$ 10,000	$ 20,000	Source 3	One in operation and one standby/regeneration phase	
SUBTOTAL			$ 25,000	$ 161,400			
Mobilization/Demobilization	5%			$ 8,070	Source 3		
Subcontractor general conditions	20%			$ 32,280	Source 3		
SUBTOTAL				*$ 201,750*			
Building & Controls							
Building / HVAC / Electrical	1	EA	$ 300,000	$ 300,000	Source 3		
SCADA computer control system/Instrumentation	1	LS	$ 400,000	$ 400,000	Source 3		
SUBTOTAL				$ 700,000			
Mobilization/Demobilization	5%			$ 35,000	Source 3		
Subcontractor general conditions	20%			$ 140,000	Source 3		
SUBTOTAL				*$ 875,000*			
Piping, Instrumentation, & Equipment Installation							
2-inch schedule 80 PVC piping and fittings	3,000	LF	$ 24	$ 72,000	Source 3		
2-inch carbon steel piping	1,000	LF	$ 67	$ 67,000	Source 3		
Pipe supports and misc metals	1	LS	$ 30,000	$ 30,000	Source 3		
Install equipment	30	CD	$ 3,000	$ 90,000	Source 3		
Plumbing and fire suppression	1	LS	$ 40,000	$ 40,000	Source 3		
Lighting and misc electrical	1	LS	$ 25,000	$ 25,000	Source 3		
Chemical reagents	1	LS	$ 20,000	$ 20,000	Source 3		
Chemical storage tanks	5	EA	$ 8,000	$ 40,000	Source 3	550 Gallon double walled tanks	
Chemical feed system I&C	1	LS	$ 100,000	$ 100,000	Source 3	Metering pumps, gauges, valves, and flow-meters	
Installation of discharge point to surface water	1	LS	$ 80,000	$ 80,000			
SUBTOTAL				$ 564,000			
Mobilization/Demobilization	5%			$ 28,200	Source 3		
Subcontractor general conditions	20%			$ 112,800	Source 3		
SUBTOTAL				*$ 705,000*			
System Startup	1	LS	$ 150,000	*$ 150,000*	Source 3		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	6	MO	$ 1,043	$ 6,255	Source 4		
Air monitoring	30	DY	$ 718	$ 21,525	Source 4 + CH2M H&S		
PPE provisions for workers (initial)	8	EA	$ 252	$ 2,015	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor	
PPE provisions for workers (worker·days)	1,056	EA	$ 106	$ 111,904	Source 4 + CH2M H&S		
SUBTOTAL				$ 154,471			
CAPITAL SUBTOTAL - GROUNDWATER				$ 13,429,507			
Contingency	25%			$ 3,357,377	10% Scope + 15% Bid		
SUBTOTAL				$ 16,786,884			
Project Management	5%			$ 839,344	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 1,007,213	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 1,007,213	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 2,853,770			
Contractor Fees							
ODC & Subs	5%		$ 16,786,884	$ 839,344			
Labor	10%	max	$ 2,853,770	$ 285,377			
SUBTOTAL				$ 1,124,721			
TOTAL CAPITAL COST - GROUNDWATER				**$ 20,770,000**			
VAPOR							
Vapor Mitigation							
Preconstruction Investigations							
Evaluate building systems	1	LS	$ 10,000	$ 10,000	Radiation Data Quote Phase 1		
SUBTOTAL				*$ 10,000*			
Install Sub Slab Depressurization System							
Install new french drain system	1	LS	$ 50,000	$ 50,000	Source 3		
Upgrade dewatering equipment	1	LS	$ 50,000	$ 50,000	Source 3		
Add carbon and bag filter system	1	LS	$ 120,000	$ 120,000	Source 3		
Install sub slab depressurization system	1	LS	$ 65,000	$ 65,000	Radiation Data Quote Phase 2		
SUBTOTAL				$ 285,000			
Mobilization/Demobilization	5%			$ 14,250			
Subcontractor general conditions	20%			$ 57,000			
SUBTOTAL				*$ 356,250*			
CAPITAL SUBTOTAL - VAPOR				$ 366,250			
Contingency	25%			$ 91,563	10% Scope + 15% Bid		
SUBTOTAL				$ 457,813			
Project Management	8%			$ 36,625	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 68,672	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 45,781	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 151,078			
Contractor Fees							
ODC & Subs	5%		$ 457,813	$ 22,891			
Labor	10%	max	$ 151,078	$ 15,108			
SUBTOTAL				$ 37,998			
TOTAL CAPITAL COST - VAPOR				**$ 650,000**			
TOTAL CAPITAL COST				**$ 227,100,000**			

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 24,130	$ 24,130		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 34,130		
Contingency	25%			$ 8,533	10% Scope + 15% Bid	
SUBTOTAL				$ 42,663		
Project Management	10%			$ 4,266	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 8,533	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,399	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 19,198		
Contractor Fees						
ODC & Subs	5%		$ 42,663	$ 2,133		

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

Labor	10%	max	$ 19,198	$ 1,920			
SUBTOTAL				$ 4,053			
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**			
NAPL							
NAPL Recovery Wells							
Routine Operations, Maintenance, Monitoring	240	HR	$ 100	$ 24,000	Assumes part time operator performs duties for NAPL system (5 days/month)		
Parts Replacement / Consumables	1	LS	$ 1,000	$ 1,000			
Electricity	13,140	KWH	$ 0.10	$ 1,314	Assume 2 hp total		
Reporting	100	HR	$ 100	$ 10,000			
Pumping & Transport of NAPL (Vac Truck)	3,000	GAL	$ 3.00	$ 9,000		Assume each truck 1000 gallons	
Off-site Disposal of NAPL	3,000	GAL	$ 9.00	$ 27,000			
SUBTOTAL				$ 72,314			
Mobilization/Demobilization	5%			$ 3,616			
Subcontractor general conditions	25%			$ 18,079			
SUBTOTAL				*$ 94,008*			
Contingency	25%			$ 23,502	10% Scope + 15% Bid		
SUBTOTAL				$ 117,510			
Project Management	8%			$ 9,401	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 17,627	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 11,751	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 38,778			
Contractor Fees							
ODC & Subs	5%		$ 117,510	$ 5,876			
Labor	10%	max	$ 38,778	$ 3,878			
SUBTOTAL				$ 9,753			
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 166,042**			
In-Situ Chemical Oxidation - Re-treatment areas							
ISCO application - NZ-1	1	LS	$ 22,995,916	$ 22,995,916		Assumes re-application in 1/2 of the treatment area after 1 year.	
ISCO application - NZ-2 and NZ-5	1	LS	$ 19,713,984	$ 19,713,984		Assumes re-application in 1/2 of the treatment area after 1 year.	
Post-application performance monitoring (assume 1 set of samples per property)	5	LS	$ 8,727	$ 43,633	Source 4	Same monitoring as for MNA: VOCs, SVOCs, PCBs, TAL metals	
SUBTOTAL				$ 42,753,533			
Mobilization/Demobilization	5%			$ 2,137,677			
Subcontractor general conditions	25%			$ 10,688,383			
SUBTOTAL				*$ 55,579,593*			
Contingency	25%			$ 13,894,898	10% Scope + 15% Bid		
SUBTOTAL				$ 69,474,491			
Project Management	5%			$ 3,473,725	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 4,168,469	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 4,168,469	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 11,810,663			
Contractor Fees							
ODC & Subs	5%		$ 69,474,491	$ 3,473,725			
Labor	10%	max	$ 11,810,663	$ 1,181,066			
SUBTOTAL				$ 4,654,791			
TOTAL ANNUAL O&M COST - ISCO				**$ 85,939,945**			
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 86,105,987**	Assume reinjection in 1/2 the original treatment areas		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 43,136,014**	Assume reinjection in 1/4 the original treatment areas		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 166,042**	Assumes NAPL recovery will cease after 10 years		
GROUNDWATER							
Groundwater Treatment System O&M							
Misc. Electrical Site Usage	12	MO	$ 215	$ 2,584	MEANS 33-42-0106		
Routine Operations, Maintenance, Monitoring	2,080	HR	$ 80	$ 166,400		40 hrs/week for one operator	
Chemicals / Consumables	12	MO	$ 10,000	$ 120,000			
Electricity	394,200	KWH	$ 0.10	$ 39,420			
Replace Filters/ Carbon	12	MO	$ 5,000	$ 60,000			
Sampling and Analysis	12	MO	$ 1,055	$ 12,665	Source 4	Assumes one compliance sample per month	
Reporting	200	HR	$ 100	$ 20,000	CH2M Est.		
Allowance for Misc. Items	1	LS	$ 84,214	$ 84,214		Assumes 20% of the capital costs	
SUBTOTAL				$ 505,283			
Subcontractor general conditions	25%			$ 126,321			
SUBTOTAL				*$ 631,603*			
Contingency	25%			$ 157,901	10% Scope + 15% Bid		
SUBTOTAL				$ 789,504			
Project Management	6%			$ 47,370	**USEPA 2000, p. 5-13, $500K - $2M**		
Remedial Design	12%			$ 94,741	**USEPA 2000, p. 5-13, $500K - $2M**		
Construction Management	8%			$ 63,160	**USEPA 2000, p. 5-13, $500K - $2M**		
SUBTOTAL				$ 205,271			
Contractor Fees							
ODC & Subs	5%		$ 789,504	$ 39,475			
Labor	10%	max	$ 205,271	$ 20,527			
SUBTOTAL				$ 60,002			
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M				**$ 1,054,778**			
Groundwater Monitoring							
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals	
QC Samples	5	EA	$ 1,000	$ 4,998			
Groundwater Sampling, Level D							
Labor	300	HR	$ 80	$ 24,000		Assumes 3 persons for 5 days	
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3		
Consumables	1	LS	$ 3,000	$ 3,000	Source 3		
Data Validation	96	HR	$ 100	$ 9,600			
Reporting	240	HR	$ 100	$ 24,000			
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758		Assumes 10% of the capital costs	
SUBTOTAL				$ 118,340			
Mobilization/Demobilization	5%			$ 5,917			
Subcontractor general conditions	25%			$ 29,585			
SUBTOTAL				*$ 153,842*			
Contingency	25%			$ 38,461	10% Scope + 15% Bid		
SUBTOTAL				$ 192,303			
Project Management	8%			$ 15,384	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 28,845	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 19,230	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 63,460			
Contractor Fees							
ODC & Subs	5%		$ 192,303	$ 9,615			
Labor	10%	max	$ 63,460	$ 6,346			
SUBTOTAL				$ 15,961			
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**			
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 2,141,672**	Quarterly for first year (Four GW sampling events)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 1,326,501**	Annual for Years 2 to 30 (one GW sampling event per year)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)				**$ -**	Additional cost for years 10, 20, 30		

Alternative 5a - Process Option: NAPL In Situ Chemical Oxidation with Arsenic Stabilization and HCAA Barrie COST ESTIMATE SUMMARY - DRAFT

VAPOR

Vapor Intrusion Operation Bldg 115

Routine Operations, Maintenance, Monitoring	240	HR	$	80	$	19,200		Assumes part time operator performs duties 5 days/month
Parts Replacement / Consumables	1	LS	$	2,000	$	2,000	Source 3	
Electricity	13,140	KWH	$	0.10	$	1,314	Source 3	
Replace bag filters and carbon media	4	EA	$	2,500	$	10,000		Assume carbon replacement every 3 months -
Reporting	80	HR	$	80	$	6,400	CH2M Est.	
SUBTOTAL					$	38,914		
Mobilization/Demobilization	5%				$	1,946		
Subcontractor general conditions	25%				$	9,729		
SUBTOTAL					*$*	*50,588*		
Contingency	25%				$	12,647	10% Scope + 15% Bid	
SUBTOTAL					$	63,235		
Project Management	10%				$	6,324	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%				$	12,647	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%				$	9,485	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL					$	28,456		
Contractor Fees								
ODC & Subs	5%		$	63,235	$	3,162		
Labor	10%	max	$	28,456	$	2,846		
SUBTOTAL					$	6,007		
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)					**$**	**100,000**		

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT		UNIT COST		TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$	20,000	$	20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$	8,000	$	8,000	
Reapplication for the CEA (Deed)	16	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$	15,000	$	15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$	25,000	$	25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$	20,000	$	20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$	8,000	$	8,000	
					Total	$	521,000	
TOTAL PERIODIC COST						**$**	**520,000**	

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR		TOTAL COST		TOTAL COST PER YEAR	DISCOUNT FACTOR		PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$	7,300,000	$	7,300,000	1.000	$	7,300,000	
CAPITAL COST - NAPL and ARSENIC	0	$	198,380,000	$	198,380,000	1.000	$	198,380,000	
CAPITAL COST - GROUNDWATER	0	$	20,770,000	$	20,770,000	1.000	$	20,770,000	
CAPITAL COST - VAPOR	0	$	650,000	$	650,000	1.000	$	650,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$	2,100,000	$	70,000	12.409	$	868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$	86,105,987	$	86,105,987	0.935	$	80,472,885	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$	43,136,014	$	43,136,014	0.873	$	37,676,666	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$	1,328,336	$	166,042	5.216	$	866,002	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$	2,141,672	$	2,141,672	0.935	$	2,001,563	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$	38,468,536	$	1,326,501	11.474	$	15,220,888	
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)	1 to 30	$	3,000,000	$	100,000	12.409	$	1,240,904	
PERIODIC COST	2	$	25,000	$	25,000	0.873	$	21,836	
PERIODIC COST	4	$	25,000	$	25,000	0.763	$	19,072	
PERIODIC COST	5	$	15,000	$	15,000	0.713	$	10,695	
PERIODIC COST	6	$	25,000	$	25,000	0.666	$	16,659	
PERIODIC COST	8	$	25,000	$	25,000	0.582	$	14,550	
PERIODIC COST	10	$	40,000	$	40,000	0.508	$	20,334	
PERIODIC COST	12	$	25,000	$	25,000	0.444	$	11,100	
PERIODIC COST	14	$	25,000	$	25,000	0.388	$	9,695	
PERIODIC COST	15	$	43,000	$	43,000	0.362	$	15,585	
PERIODIC COST	16	$	25,000	$	25,000	0.339	$	8,468	
PERIODIC COST	18	$	25,000	$	25,000	0.296	$	7,397	
PERIODIC COST	20	$	40,000	$	40,000	0.258	$	10,337	
PERIODIC COST	22	$	25,000	$	25,000	0.226	$	5,643	
PERIODIC COST	24	$	25,000	$	25,000	0.197	$	4,929	
PERIODIC COST	25	$	15,000	$	15,000	0.184	$	2,764	
PERIODIC COST	26	$	25,000	$	25,000	0.172	$	4,305	
PERIODIC COST	28	$	25,000	$	25,000	0.150	$	3,760	
PERIODIC COST	30	$	68,000	$	68,000	0.131	$	8,933	
		$	403,901,546				$	365,643,602	

TOTAL PRESENT VALUE OF ALTERNATIVE 5a - Process Option $ 365,640,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	Tar boils at the ground surface throughout the site, NZ-1, and NZ-2 soils would be excavated to a depth of 4 ft bgs for off-site disposal. NAPL would be collected via standard recovery wells located in NZ-1, NZ-2 and NZ-5. NAPL collection would be followed by in situ chemical oxidation in NAPL zones NZ-1, NZ 2, NZ-5, and small portion of NZ-3. Includes the demoliton of the buildings on the 115 River Road property
Arsenic	Arsenic on Block 93 will be solidified/stabilized and a barrier wall with extraction and treatment installed downgradient of the HCAA. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	Site groundwater would be contained with a cutoff wall and groundwater extraction at the shoreline and downgradient of the HCAA. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	36	MO	$ 4,300	$ 154,800	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 485,800*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	36	MO	$ 12,000	$ 432,000	CH2M Est.	
SUBTOTAL				*$ 657,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 291,756		
Mobilization/Demobilization	5%			$ 14,588	Source 3	
Subcontractor general conditions	20%			$ 58,351	Source 3	
SUBTOTAL				*$ 364,695*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 133,524		
Mobilization/Demobilization	5%			$ 6,676	Source 3	
Subcontractor general conditions	20%			$ 26,705	Source 3	
SUBTOTAL				*$ 166,905*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 16,352		
Mobilization/Demobilization	5%			$ 818	Source 3	
Subcontractor general conditions	20%			$ 3,270	Source 3	
SUBTOTAL				*$ 20,440*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Demolition of 115 River Road Buildings						
Temporary relocation of tenants	1	LS	$ 2,000,000	$ 2,000,000	Assumes 60 businesses moved twice - cost provided by Honeywell real estate group	
Loss of rent	1	LS	$ 7,000,000	$ 7,000,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Differential in rent for tenants	1	LS	$ 500,000	$ 500,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Building demolition	1	LS	$ 2,000,000	$ 2,000,000	Assumes bldg 86,000 ft^2 - cost provided by Honeywell real estate group	
Building reconstruction	1	LS	$ 39,000,000	$ 39,000,000	Cost provided by Honeywell real estate group	
SUBTOTAL				$ 50,500,000		
Mobilization/Demobilization	5%			$ 2,525,000	Source 3	
Subcontractor general conditions	20%			$ 10,100,000	Source 3	
SUBTOTAL				*$ 63,125,000*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		

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Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

Upgrade Asphalt Cap (115 River Road)								
Fine grading	7,059	SY	$	1.22	$	8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$	54	$	64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$	11	$	80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$	11	$	80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$	6	$	13,058	MEANS 32.16.19.10.0150	
SUBTOTAL					$	316,416		
Mobilization/Demobilization	5%				$	15,821	Source 3	
Subcontractor general conditions	20%				$	63,283	Source 3	
SUBTOTAL					*$*	*395,519*		
Asphalt Cap (Edgewater - NZ-5)								
Fine grading	1,508	SY	$	1.22	$	1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$	54	$	13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$	11,638	$	11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$	11	$	17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$	11	$	17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$	6	$	2,835	MEANS 32.16.19.10.0150	
SUBTOTAL					$	64,238		
Mobilization/Demobilization	5%				$	3,212	Source 3	
Subcontractor general conditions	20%				$	12,848	Source 3	
SUBTOTAL					*$*	*80,297*		
Upgrade Asphalt Cap (Block 93 North and Central)								
Fine grading	11,532	SY	$	1.22	$	14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$	54	$	104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$	11	$	131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$	11	$	131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$	6	$	11,927	MEANS 32.16.19.10.0150	
SUBTOTAL					$	462,836		
Mobilization/Demobilization	5%				$	23,142	Source 3	
Subcontractor general conditions	20%				$	92,567	Source 3	
SUBTOTAL					*$*	*578,544*		
Upgrade Asphalt Cap (Block 94)								
Fine grading	2,322	SY	$	1.22	$	2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$	21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$	26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$	26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$	14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$	161,073		
Mobilization/Demobilization	5%				$	8,054	Source 3	
Subcontractor general conditions	20%				$	32,215	Source 3	
SUBTOTAL					*$*	*201,341*		
Compliance Monitoring and Health & Safety								
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$	12,772	Source 4	
Decon shed	6	MO	$	1,043	$	6,255	Source 4	
Air monitoring	90	DY	$	718	$	64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$	5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	2,640	EA	$	106	$	279,760	Source 4 + CH2M H&S	
SUBTOTAL					*$*	*368,400*		
CAPITAL SUBTOTAL - SOIL					$	67,843,813		
Contingency	25%				$	16,960,953	10% Scope + 15% Bid	
SUBTOTAL					$	84,804,766		
Project Management	5%				$	4,240,238	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$	5,088,286	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$	5,088,286	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$	14,416,810		
Contractor Fees								
ODC & Subs	5%		$	84,804,766	$	4,240,238		
Labor	10%	max	$	14,416,810	$	1,441,681		
SUBTOTAL					$	5,681,919		
TOTAL CAPITAL COST - SOIL					**$**	**104,900,000**		
NAPL and ARSENIC								
NAPL Recovery								
Preconstruction Investigations								
Slurry compatibility test	1	LS	$	25,000	$	25,000		
Pump test	1	LS	$	75,000	$	75,000	CH2M Est.	
Pilot field test	1	LS	$	100,000	$	100,000	CH2M Est., assumed design of test is included in design line item (@ 8%)	
Utility markout / locating service	3	DAY	$	5,000	$	15,000		
SUBTOTAL					*$*	*215,000*		
NAPL Recovery in existing monitoring wells								
Product recovery pumps	3	EA	$	4,000	$	12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$	12,000		
Mobilization/Demobilization	5%				$	600		
Subcontractor general conditions	20%				$	2,400		
SUBTOTAL					*$*	*15,000*		
Vertical NAPL Recovery Wells								
Soil borings	250	LF	$	47	$	11,625	Source 3	Assumes 10 recovery wells
4-inch PVC well casing	150	LF	$	51	$	7,646	MEANS	
4-inch PVC well screen	100	LF	$	54	$	5,357	MEANS	
Well vaults	10	EA	$	8,000	$	80,000	Source 3	
Well cuttings disposal	30	TN	$	128	$	3,840	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Storage tanks	1	EA	$	4,572	$	4,572	MEANS 33-10-9658	2000-gallon HDPE tank with secondary containment
Product recovery pumps	5	EA	$	4,000	$	4,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$	117,039		
Mobilization/Demobilization	5%				$	5,852		
Subcontractor general conditions	20%				$	23,408		
SUBTOTAL					*$*	*146,299*		
Install Equipment & Utilities for NAPL Collection/Handling								
Utility trenching	62	CY	$	13	$	812	MEANS 17-03-0202	
Electrical conduit	560	LF	$	8.00	$	4,480	Source 3	
Backfill to grade	62	CY	$	54.26	$	3,376	MEANS 17-03-0401	
Control wiring	1,120	LF	$	11	$	12,320	Source 3	
Power supply to the site	1	LS	$	16,000	$	16,000	Source 3	
Power wiring, #10 insulated strand wire	1,120	LF	$	0.59	$	661	ECHOS 20.02.0505	
Electrical disconnect, weatherhead, and installation of wiring	1	LS	$	5,000	$	5,000	Source 3	
SUBTOTAL					$	42,649		
Mobilization/Demobilization	5%				$	2,132		
Subcontractor general conditions	20%				$	8,530		
SUBTOTAL					*$*	*53,311*		
Offsite Treatment / Disposal								
Off-site disposal of decontamination and development water	10,000	GAL	$	1.00	$	10,000	Source 3	Assumes water is non-hazardous
Off-site disposal of municipal waste	20	CY	$	200	$	4,000	Source 3	
SUBTOTAL					$	14,000		
Mobilization/Demobilization	5%				$	700		
Subcontractor general conditions	20%				$	2,800		
SUBTOTAL					*$*	*17,500*		
In Situ Solidification/Stabilization								
Preconstruction Investigations								
Bench scale test	1	LS	$	75,000	$	75,000	CH2M Est., assumed design of test is included in design line item	
Pilot field test	1	LS	$	150,000	$	150,000	CH2M Est., assumed design of test is included in design line item	
Utility markout /locating service	3	DAY	$	5,000	$	15,000		
SUBTOTAL					*$*	*240,000*		
In Situ Solidification/Stabilization - Arsenic Area (Block 93 - including material commingled with NAPL)								
Arsenic area - excavate and stockpile	2,372	CY	$	30	$	70,451	Source 3	Assumes average depth of 2-ft bgs for half the area and 11-ft for the remaining
Arsenic area - reagents	2,372	CY	$	22	$	52,186	Source 3	
Arsenic area - cement	2,372	CY	$	30	$	71,162	Source 3	
Arsenic area - stabilization	2,372	CY	$	35	$	83,023	Source 3	
Arsenic area - haul and place on Quanta	2,846	CY	$	10	$	28,465	Source 3	
Certified clean fill for backfilling excavation	2,372	CY	$	19	$	44,575	MEANS 17-03-0423	
SUBTOTAL					$	349,861		
Mobilization/Demobilization	5%				$	17,493		
Subcontractor general conditions	20%				$	69,972		
SUBTOTAL					*$*	*437,326*		

Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

In Situ Chemical Oxidation							
Preconstruction Investigations							
Pilot field test	1	LS	$ 250,000	$ 250,000	CH2M Est., assumed design of test is included in design line item (@ 8%)		
Utility markout / locating service	2	DAY	$ 5,000	$ 10,000			
SUBTOTAL				*$ 260,000*			
Excavation of Tar Boils & NAPL Zones NZ-1 to minus 4-ft bgs							
Excavation to 4-ft bgs	21,990	CY	$ 30	$ 653,113	Source 3	Assumes direct loading of materials	
Certified clean fill for backfilling excavated areas	26,388	CY	$ 54	$ 1,431,922	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
Odor suppression equipment rental	2	MO	$ 10,000	$ 20,000	Vendor	Assumes two rental units	
Odor suppression material	37	DRUM	$ 350	$ 12,988	Vendor	Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)	
On-site stabilization of excavated soils with Portland Cement	36,284	TN	$ 70	$ 2,539,883	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy	
Disposal of stabilized soil	36,284	TN	$ 128	$ 4,644,357	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)	
Confirmation sampling	44	EA	$ 3,735	$ 164,254	Source 4	Full TCLP analysis, 1 sample per 500 cy of excavated material	
SUBTOTAL				$ 9,480,693			
Mobilization/Demobilization	5%			$ 474,035			
Subcontractor general conditions	20%			$ 1,896,139			
SUBTOTAL				*$ 11,850,866*			
Excavation of NAPL Zones NZ-2 to minus 4-ft bgs							
Excavation to 4-ft bgs	12,169	CY	$ 30	$ 361,423	Source 3	Assumes direct loading of materials	
Certified clean fill for backfilling excavated areas	14,603	CY	$ 19	$ 274,412	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
Odor suppression equipment rental	1	MO	$ 10,000	$ 10,000		Assumes two rental units	
Odor suppression material	21	DRUM	$ 350	$ 7,187		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)	
On-site stabilization of excavated soils with Portland Cement	20,079	TN	$ 70	$ 1,405,534	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy	
Disposal of stabilized soil	20,079	TN	$ 128	$ 2,570,119	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)	
Confirmation sampling	24	EA	$ 3,735	$ 90,896	Source 4	1 sample per 500 cy of excavated material	
SUBTOTAL				$ 4,728,078			
Mobilization/Demobilization	5%			$ 236,404			
Subcontractor general conditions	20%			$ 945,616			
SUBTOTAL				*$ 5,910,098*			
In-Situ Chemical Oxidation							
ISCO application - NZ-1 and portion of NZ-3	63,878	CY	$ 720	$ 45,991,832		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL.	
ISCO application - NZ-2 and NZ-5	62,691	CY	$ 720	$ 45,137,808		Vendor quote: contractor labor, equipment, setup, chemicals, injection, offsite disposal of NAPL.	
Post-application performance monitoring (assume 1 set of samples per property)	5	LS	$ 8,727	$ 43,633	Source 4	Same monitoring as for MNA: VOCs, SVOCs, PCBs, TAL metals	
SUBTOTAL				$ 91,173,273			
Mobilization/Demobilization	5%			$ 4,558,664			
Subcontractor general conditions	20%			$ 18,234,655			
SUBTOTAL				*$ 113,966,591*			
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	24	MO	$ 1,043	$ 25,021	Source 4		
Air monitoring based on air monitoring plan	30	MO	$ 20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations	
PPE provisions for workers (initial)	30	EA	$ 252	$ 7,557	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor	
PPE provisions for workers (worker·days)	15,840	EA	$ 106	$ 1,678,558	Source 4 + CH2M H&S		
SUBTOTAL				$ 2,323,908			
CAPITAL SUBTOTAL - NAPL and ARSENIC				$ 135,435,899			
Contingency	25%			$ 33,858,975	10% Scope + 15% Bid		
SUBTOTAL				$ 169,294,873			
Project Management	5%			$ 8,464,744	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 10,157,692	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 10,157,692	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 28,780,128			
Contractor Fees							
ODC & Subs	5%		$ 169,294,873	$ 8,464,744			
Labor	10%	max	$ 28,780,128	$ 2,878,013			
SUBTOTAL				$ 11,342,757			
TOTAL CAPITAL COST - NAPL and ARSENIC				**$ 209,420,000**			
GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$ 230,000	$ 230,000			
Updates to the groundwater model	1	LS	$ 20,000	$ 20,000			
Bench-scale testing (Arsenic and NAPL)	2	EA	$ 75,000	$ 150,000			
Pilot-scale testing	1	LS	$ 150,000	$ 150,000			
SUBTOTAL				*$ 550,000*			
Replacement Monitoring Wells							
Soil borings	480	FT	$ 47	$ 22,320		Assumes 16 wells at 30-ft deep	
2-inch PVC well casing	320	FT	$ 31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen	
2-inch PVC well screen	160	FT	$ 34	$ 5,398	MEANS 33-23-0256		
Well development	16	EA	$ 1,600	$ 25,600	Source 3		
Off-site disposal of soil cuttings from well installation	50	TN	$ 128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz	
Off-site disposal of development and decontamination water	10,000	GAL	$ 1.00	$ 10,000	Source 3	Assumes water is non-hazardous	
SUBTOTAL				$ 79,712			
Mobilization/Demobilization	5%			$ 3,986	Source 3		
Subcontractor general conditions	20%			$ 15,942	Source 3		
SUBTOTAL				*$ 99,640*			
Cutoff Wall with Hydraulic Containment							
Cutoff Wall at Shoreline							
Remove concrete decking	2,500	SF	$ 15	$ 37,500	Envirocon ROM estimate		
Rip-rap removal	1,040	CY	$ 25	$ 26,000	Envirocon ROM estimate		
Barrier wall at 115 River Road (under building)	1	LS	$ 600,000	$ 600,000	Envirocon ROM estimate		
Sealed sheet piling - shoreline	42,000	SF	$ 127	$ 5,334,000	Envirocon ROM estimate		
SUBTOTAL				$ 5,997,500			
Mobilization/Demobilization	5%			$ 299,875	Source 3		
Subcontractor general conditions	20%			$ 1,199,500			
SUBTOTAL				*$ 7,496,875*			
Cutoff Wall at HCAA							
Slurry wall	18,000	VSF	$ 65	$ 1,170,000	Envirocon ROM estimate	Assumes 25-ft deep wall	
Restoration of ground surface	6,000	SY	$ 25	$ 150,000	CH2M HILL Estimate		
Disposal of soil cuttings	3,300	TN	$ 128	$ 422,400	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)	
SUBTOTAL				$ 1,742,400			
Mobilization/Demobilization	5%			$ 87,120	Source 3		
Subcontractor general conditions	20%			$ 348,480			
SUBTOTAL				*$ 2,178,000*			
Groundwater Extraction							
Soil borings	315	LF	$ 47	$ 14,648	Source 3	Assumes 9 extraction wells to an average depth of 35-ft bgs	
4-inch PVC well casing	180	LF	$ 51	$ 9,175	MEANS		
4-inch PVC well screen	135	LF	$ 54	$ 7,232	MEANS	Assumes 15-ft screen	
Well vaults/pumps	9	EA	$ 8,000	$ 72,000	Source 3		
Manifolds and valves	1	LS	$ 25,000	$ 25,000	Source 3		
Disposal of soil cuttings	20	EA	$ 128	$ 2,560	MEANS 33-19-7270		
Trenching for conveyance piping	9	TN	$ 13	$ 113	MEANS 17-03-0202		
Conveyance piping	2,500	LF	$ 54	$ 135,000	MEANS 33-26-0406		
Backfill trench	10	CY	$ 54	$ 563	MEANS 17-03-0423		
Electrical to wells	1	LS	$ 120,000	$ 120,000			
SUBTOTAL				$ 386,290			
Mobilization/Demobilization	5%			$ 19,314	Source 3		
Subcontractor general conditions	20%			$ 77,258			
SUBTOTAL				*$ 482,862*			

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Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

Wastewater Treatment Plant to Treat Extracted Water							System to treat 50 gpm
Pumping and Equalization of Influent Water							
8,000 gallon polypropylene equalization tanks	2	EA	$ 6,340	$ 12,679	MEANS 33-10-9661		Provides 8-hrs of storage at 100 gpm
Sludge pump	1	EA	$ 3,820	$ 3,820	Source 3		
Off-gas pump	1	EA	$ 1,322	$ 1,322	Source 3		
Effluent pump	4	EA	$ 4,221	$ 16,883	Source 3		50 GPM effluent pump (MAX @ 65'TDH)
NAPL pump	1	EA	$ 3,864	$ 3,864	Source 3		
Chemical feed systems (caustic and acid)	2	EA	$ 3,130	$ 6,260	Source 3		
SUBTOTAL				$ 44,829			
Mobilization/Demobilization	5%			$ 2,241	Source 3		
Subcontractor general conditions	20%			$ 8,966	Source 3		
SUBTOTAL				*$ 56,036*			
Removal of NAPLs and Solids							
Oil-water separator, 50 gpm	1	EA	$ 16,910	$ 16,910	ECHOS 19.04.0412		
Packaged 1,500 Gallon Steel Product Tank	1	EA	$ 4,950	$ 4,950	ECHOS 19.04.0604		
Packaged 20 gpm Oil Pump out unit w/controls	1	EA	$ 7,670	$ 7,670	ECHOS 33.13.1211		
Effluent pump	2	EA	$ 5,231	$ 10,462	MEANS 33-23-0555		50 GPM(one in operation and one in stand-by) (MAX@ 65'TDH)
Chemical feed systems	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		Caustic, acid, polymer, hydrogen peroxide, and ferric chloride
SUBTOTAL				$ 55,642			
Mobilization/Demobilization	5%			$ 2,782	Source 3		
Subcontractor general conditions	20%			$ 11,128	Source 3		
SUBTOTAL				*$ 69,553*			
Advanced oxidation							
Flocculation tanks connected in series	4	EA	$ 4,572	$ 18,287	MEANS 33-10-9658		
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	$ 4,009	$ 8,018	MEANS 33-29-0120		
SUBTOTAL				$ 41,955			
Mobilization/Demobilization	5%			$ 2,098	Source 3		
Subcontractor General Conditions	20%			$ 8,391	Source 3		
SUBTOTAL				*$ 52,444*			
Solid-liquid Separation							
Inclined plate clarifier (0.25 GPM/SF of area)	3	EA	$ 26,520	$ 79,560	ECHOS 33.13.0414		
100 GPM effluent pump for use with plate clarifier	1	EA	$ 6,211	$ 6,211	Source 3		
Sludge pump for use with plate clarifier	1	EA	$ 3,130	$ 3,130	Source 3		
Bag filters	2	EA	$ 800	$ 1,600	Source 3		
Offgas pumps for use with bag filters	2	EA	$ 1,500	$ 3,000	Source 3		
Effluent pumps for use with bag filters	2	EA	$ 4,200	$ 8,400	Source 3		
Liquid waste pump for use with sludge settling tank	1	EA	$ 4,200	$ 4,200	Source 3		
Filter press, 95% removal efficiency	2	EA	$ 90,100	$ 180,200	ECHOS 33.33.3013		10 CF w/sludge tanks, pumps, mixers, sludge cart
SUBTOTAL				$ 286,301			
Mobilization/Demobilization	5%			$ 14,315	Source 3		
Subcontractor general conditions	20%			$ 57,260	Source 3		
SUBTOTAL				*$ 357,877*			
Effluent Polishing							
Packaged 36,000 GPD water treatment plant	2	EA	$ 32,400	$ 64,800	ECHOS 19.01.0807		Includes GAC, pumps, tanks
Concrete Wet Well, 12'x36"	4	EA	$ 9,200	$ 36,800	ECHOS 19.02.0304		
Packaged Lift Station (70 gpm)	4	EA	$ 9,950	$ 39,800	ECHOS 19.02.0304		
Ion exchange units	2	EA	$ 10,000	$ 20,000	Source 3		One in operation and one standby/regeneration phase
SUBTOTAL			$ 25,000	$ 161,400			
Mobilization/Demobilization	5%			$ 8,070	Source 3		
Subcontractor general conditions	20%			$ 32,280	Source 3		
SUBTOTAL				*$ 201,750*			
Building & Controls							
Building / HVAC / Electrical	1	EA	$ 300,000	$ 300,000	Source 3		
SCADA computer control system/Instrumentation	1	LS	$ 400,000	$ 400,000	Source 3		
SUBTOTAL				$ 700,000			
Mobilization/Demobilization	5%			$ 35,000	Source 3		
Subcontractor general conditions	20%			$ 140,000	Source 3		
SUBTOTAL				*$ 875,000*			
Piping, Instrumentation, & Equipment Installation							
2-inch schedule 80 PVC piping and fittings	3,000	LF	$ 24	$ 72,000	Source 3		
2-inch carbon steel piping	1,000	LF	$ 67	$ 67,000	Source 3		
Pipe supports and misc metals	1	LS	$ 30,000	$ 30,000	Source 3		
Install equipment	30	CD	$ 3,000	$ 90,000	Source 3		
Plumbing and fire suppression	1	LS	$ 40,000	$ 40,000	Source 3		
Lighting and misc electrical	1	LS	$ 25,000	$ 25,000	Source 3		
Chemical reagents	1	LS	$ 20,000	$ 20,000	Source 3		
Chemical storage tanks	5	EA	$ 8,000	$ 40,000	Source 3		550 Gallon double walled tanks
Chemical feed system I&C	1	LS	$ 100,000	$ 100,000	Source 3		Metering pumps, gauges, valves, and flow-meters
Installation of discharge point to surface water	1	LS	$ 80,000	$ 80,000			
SUBTOTAL				$ 564,000			
Mobilization/Demobilization	5%			$ 28,200	Source 3		
Subcontractor general conditions	20%			$ 112,800	Source 3		
SUBTOTAL				*$ 705,000*			
System Startup	1	LS	$ 150,000	*$ 150,000*	Source 3		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	6	MO	$ 1,043	$ 6,255	Source 4		
Air monitoring	30	DY	$ 718	$ 21,525	Source 4 + CH2M H&S		
PPE provisions for workers (initial)	8	EA	$ 252	$ 2,015	Source 4		10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,056	EA	$ 106	$ 111,904	Source 4 + CH2M H&S		
SUBTOTAL				$ 154,471			
CAPITAL SUBTOTAL - GROUNDWATER				$ 13,429,507			
Contingency	25%			$ 3,357,377	10% Scope + 15% Bid		
SUBTOTAL				$ 16,786,884			
Project Management	5%			$ 839,344	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 1,007,213	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 1,007,213	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 2,853,770			
Contractor Fees							
ODC & Subs	5%		$ 16,786,884	$ 839,344			
Labor	10%	max	$ 2,853,770	$ 285,377			
SUBTOTAL				$ 1,124,721			
TOTAL CAPITAL COST - GROUNDWATER				**$ 20,770,000**			
TOTAL CAPITAL COST				**$ 335,090,000**			

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 24,130	$ 24,130		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 34,130		
Contingency	25%			$ 8,533	10% Scope + 15% Bid	
SUBTOTAL				$ 42,663		
Project Management	10%			$ 4,266	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 8,533	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,399	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 19,198		
Contractor Fees						
ODC & Subs	5%		$ 42,663	$ 2,133		
Labor	10%	max	$ 19,198	$ 1,920		
SUBTOTAL				$ 4,053		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		

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Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

NAPL

NAPL Recovery Wells							
Routine Operations, Maintenance, Monitoring	240	HR	$ 100	$ 24,000	Assumes part time operator performs duties for NAPL system (5 days/month)		
Parts Replacement / Consumables	1	LS	$ 1,000	$ 1,000			
Electricity	13,140	KWH	$ 0.10	$ 1,314	Assume 2 hp total		
Reporting	100	HR	$ 100	$ 10,000			
Pumping & Transport of NAPL (Vac Truck)	3,000	GAL	$ 3.00	$ 9,000		Assume each truck 1000 gallons	
Off-site Disposal of NAPL	3,000	GAL	$ 9.00	$ 27,000			
SUBTOTAL				$ 72,314			
Mobilization/Demobilization	5%			$ 3,616			
Subcontractor general conditions	25%			$ 18,079			
SUBTOTAL				*$ 94,008*			
Contingency	25%			$ 23,502	10% Scope + 15% Bid		
SUBTOTAL				$ 117,510			
Project Management	8%			$ 9,401	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 17,627	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 11,751	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 38,778			
Contractor Fees							
ODC & Subs	5%		$ 117,510	$ 5,876			
Labor	10%	max	$ 38,778	$ 3,878			
SUBTOTAL				$ 9,753			
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 166,042**			
In-Situ Chemical Oxidation - Re-treatment areas							
ISCO application - NZ-1	1	LS	$ 22,995,916	$ 22,995,916		Assumes re-application in 1/2 of the treatment area after 1 year.	
ISCO application - NZ-2 and NZ-5	1	LS	$ 22,568,904	$ 22,568,904		Assumes re-application in 1/2 of the treatment area after 1 year.	
Post-application performance monitoring (assume 1 set of samples per property)	5	LS	$ 8,727	$ 43,633	Source 4	Same monitoring as for MNA: VOCs, SVOCs, PCBs, TAL metals	
SUBTOTAL				$ 45,608,453			
Mobilization/Demobilization	5%			$ 2,280,423			
Subcontractor general conditions	25%			$ 11,402,113			
SUBTOTAL				*$ 59,290,989*			
Contingency	25%			$ 14,822,747	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11		
SUBTOTAL				$ 74,113,736			
Project Management	5%			$ 3,705,687	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 4,446,824	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 4,446,824	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 12,599,335			
Contractor Fees							
ODC & Subs	5%		$ 74,113,736	$ 3,705,687			
Labor	10%	max	$ 12,599,335	$ 1,259,934			
SUBTOTAL				$ 4,965,620			
TOTAL ANNUAL O&M COST - ISCO				**$ 91,678,691**			
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 91,844,733**	Assume reinjection in 1/2 the original treatment areas		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 46,005,388**	Assume reinjection in 1/4 the original treatment areas		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 166,042**	Assumes NAPL recovery will cease after 10 years		

GROUNDWATER

Groundwater Treatment System O&M							
Misc. Electrical Site Usage	12	MO	$ 215	$ 2,584	MEANS 33-42-0106		
Routine Operations, Maintenance, Monitoring	2,080	HR	$ 80	$ 166,400		40 hrs/week for one operator	
Chemicals / Consumables	12	MO	$ 10,000	$ 120,000			
Electricity	394,200	KWH	$ 0.10	$ 39,420			
Replace Filters/ Carbon	12	MO	$ 5,000	$ 60,000			
Sampling and Analysis	12	MO	$ 1,055	$ 12,665	Source 4	Assumes one compliance sample per month	
Reporting	200	HR	$ 100	$ 20,000	CH2M Est.		
Allowance for Misc. Items	1	LS	$ 84,214	$ 84,214		Assumes 20% of the capital costs	
SUBTOTAL				$ 505,283			
Subcontractor general conditions	25%			$ 126,321			
SUBTOTAL				*$ 631,603*			
Contingency	25%			$ 157,901	10% Scope + 15% Bid		
SUBTOTAL				$ 789,504			
Project Management	6%			$ 47,370	**USEPA 2000, p. 5-13, $500K - $2M**		
Remedial Design	12%			$ 94,741	**USEPA 2000, p. 5-13, $500K - $2M**		
Construction Management	8%			$ 63,160	**USEPA 2000, p. 5-13, $500K - $2M**		
SUBTOTAL				$ 205,271			
Contractor Fees							
ODC & Subs	5%		$ 789,504	$ 39,475			
Labor	10%	max	$ 205,271	$ 20,527			
SUBTOTAL				$ 60,002			
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M				**$ 1,054,778**			
Groundwater Monitoring							
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals	
QC Samples	5	EA	$ 1,000	$ 4,998			
Groundwater Sampling, Level D							
Labor	300	HR	$ 80	$ 24,000		Assumes 3 persons for 5 days	
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3		
Consumables	1	LS	$ 3,000	$ 3,000	Source 3		
Data Validation	96	HR	$ 100	$ 9,600			
Reporting	240	HR	$ 100	$ 24,000			
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758		Assumes 10% of the capital costs	
SUBTOTAL				$ 118,340			
Mobilization/Demobilization	5%			$ 5,917			
Subcontractor general conditions	25%			$ 29,585			
SUBTOTAL				*$ 153,842*			
Contingency	25%			$ 38,461	10% Scope + 15% Bid		
SUBTOTAL				$ 192,303			
Project Management	8%			$ 15,384	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 28,845	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 19,230	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 63,460			
Contractor Fees							
ODC & Subs	5%		$ 192,303	$ 9,615			
Labor	10%	max	$ 63,460	$ 6,346			
SUBTOTAL				$ 15,961			
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**			
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 2,141,672**	Quarterly for first year (Four GW sampling events)		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 1,326,501**	Annual for Years 2 to 30 (one GW sampling event per year)		

Alternative 5b - Process Option : NAPL In Situ Chemical Oxidation with Arsenic Stabilization and Demoliton of the 115 River R COST ESTIMATE SUMMARY - DRAFT

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 104,900,000	$ 104,900,000	1.000	$ 104,900,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 209,420,000	$ 209,420,000	1.000	$ 209,420,000	
CAPITAL COST - GROUNDWATER	0	$ 20,770,000	$ 20,770,000	1.000	$ 20,770,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 91,844,733	$ 91,844,733	0.935	$ 85,836,199	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 46,005,388	$ 46,005,388	0.873	$ 40,182,887	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$ 1,328,336	$ 166,042	5.216	$ 866,002	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 2,141,672	$ 2,141,672	0.935	$ 2,001,563	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 38,468,536	$ 1,326,501	11.474	$ 15,220,888	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 517,499,665			$ 480,262,234	

TOTAL PRESENT VALUE OF ALTERNATIVE 5b - Process Option $ 480,260,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 6a: NAPL and Arsenic Excavation — COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	NAPL present in NZ-1, NZ-2, NZ-5, small portion of NZ-3, and tar boils would be excavated from accessible areas and disposed of off-site. Excavation would require dewatering to achieve depths greater than 4 feet, and may require shoring near existing structures. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade. A sheet pile cut off wall will be installed along NZ-2 and NZ-5 shoreline.
Arsenic	Prinicipal threat arsenic and HCAA will be excavated. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	A vapor mitigation system would be installed in the basements of Buildings 7 and 8 of 115 River Road. Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	30	MO	$ 4,300	$ 129,000	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 460,000*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	30	MO	$ 12,000	$ 360,000	CH2M Est.	
SUBTOTAL				*$ 585,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Concrete removal & sizing to less than 2'	6,061	TN	$ 173	$ 1,046,577	MEANS 02.41.13.17.5500	Concrete demolition of access ramp (curbs)
Transportation and offsite disposal of concrete	10,909	CY	$ 128	$ 1,396,378	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Excavation and stockpile of 10-ft of soils above the existing arsenic liner	21,204	CY	$ 30	$ 629,754	Source 3	Assumes material can be replaced following the completion of remedial activities, assumes 1.65 ton/cy
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 3,206,232		
Mobilization/Demobilization	5%			$ 160,312	Source 3	
Subcontractor general conditions	20%			$ 641,246	Source 3	
SUBTOTAL				*$ 4,007,790*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
Excavation and stockpile of 10-ft of backfill	5,025	CY	$ 30	$ 149,254	MEANS 17-03-0276	Assumes material can be replaced following the completion of remedial activities
SUBTOTAL				$ 165,605		
Mobilization/Demobilization	5%			$ 8,280	Source 3	
Subcontractor general conditions	20%			$ 33,121	Source 3	
SUBTOTAL				*$ 207,007*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Capping						
New Vegetative Cap (Quanta)						
Rough grading	26,463	SY	$ 1.75	$ 46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$ 1.22	$ 32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$ 19	$ 47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$ 19	$ 82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$ 15	$ 408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$ 54	$ 239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$ 2.00	$ 52,926	Source 3	
Hydroseed	238,200	SF	$ 0.07	$ 16,674	Source 3	
SUBTOTAL				$ 925,855		
Mobilization/Demobilization	5%			$ 46,293	Source 3	
Subcontractor general conditions	20%			$ 185,171	Source 3	
SUBTOTAL				*$ 1,157,318*		

Alternative 6a: NAPL and Arsenic Excavation — COST ESTIMATE SUMMARY - DRAFT

Upgrade Asphalt Cap (115 River Road)							
Fine grading	7,059	SY	$ 1.22	$ 8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$ 54	$ 64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$ 11	$ 80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$ 6	$ 13,058	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 316,416		
Mobilization/Demobilization	5%			$ 15,821	Source 3	
Subcontractor general conditions	20%			$ 63,283	Source 3	
SUBTOTAL				*$ 395,519*		
Replacement of Access Ramp and Parking Lots (Edgewater)						
Surveying	10	DY	$ 1,500	$ 15,000		
Backfilling and compaction of excavated clean fill material	21,204	CY	$ 19	$ 398,453	MEANS 17-03-0423	
Rough site grading	6,361	SY	$ 1.75	$ 11,121	MEANS 17-03-0101	Assume no fill needed for grading
Fine grading	6,361	SY	$ 1.22	$ 7,767	MEANS 17-03-0101	Assume no fill needed for grading
Surface course (2-inch)	6,361	SY	$ 11	$ 72,484	MEANS 32.12.16.13.0120	Asphalt pricing includes haul
Stabilized base course (2.5-inch)	6,361	SY	$ 13	$ 80,979	MEANS 32.12.16.13.0380	Concurrent site activities/dust control
Dense graded aggregate base course (4-inch)	6,361	SY	$ 30	$ 191,407	Source 3	
Replace access ramp	2,099	CY	$ 1,200	$ 2,519,015	CH2M Hill Estimate	
Dust suppression	20	DY	$ 567	$ 11,341	MEANS 32.12.16.13.0120	
Storm water control (3' x 3' culverts, rip-rap)	2	EA	$ 11,638	$ 23,275	MEANS 32.12.16.13.0380	
Concrete curb on perimeter	2,500	LF	$ 22	$ 55,000	MEANS 32.xx	Concrete curb and island
SUBTOTAL				$ 3,385,844		
Mobilization/Demobilization	5%			$ 169,292		
Subcontractor general conditions	20%			$ 677,169		
SUBTOTAL				*$ 4,232,305*		
Asphalt Cap (Edgewater - NZ-5)						
Backfilling and compaction of excavated clean fill material	5,025	CY	$ 19	$ 94,435	MEANS 17-03-0423	
Rough grading	1,508	SY	$ 1.75	$ 2,636	MEANS 17-03-0101	Replacement of removed material
Fine grading	1,508	SY	$ 1.22	$ 1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$ 54	$ 13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$ 11,638	$ 11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$ 11	$ 17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$ 6	$ 2,835	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 161,308		
Mobilization/Demobilization	5%			$ 8,065	Source 3	
Subcontractor general conditions	20%			$ 32,262	Source 3	
SUBTOTAL				*$ 201,635*		
Upgrade Asphalt Cap (Block 93 North and Central)						
Fine grading	11,532	SY	$ 1.22	$ 14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$ 54	$ 104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$ 11	$ 131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$ 6	$ 11,927	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 462,836		
Mobilization/Demobilization	5%			$ 23,142	Source 3	
Subcontractor general conditions	20%			$ 92,567	Source 3	
SUBTOTAL				*$ 578,544*		
Upgrade Asphalt Cap (Block 94)						
Fine grading	2,322	SY	$ 1.22	$ 2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$ 54	$ 21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$ 11,638	$ 69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$ 11	$ 26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$ 11	$ 26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$ 6	$ 14,326	MEANS 32.16.19.10.0150	
SUBTOTAL				$ 161,073		
Mobilization/Demobilization	5%			$ 8,054	Source 3	
Subcontractor general conditions	20%			$ 32,215	Source 3	
SUBTOTAL				*$ 201,341*		
Compliance Monitoring and Health & Safety						
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4	
Decon shed	24	MO	$ 1,043	$ 25,021	Source 4	
Air monitoring	90	DY	$ 718	$ 64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$ 252	$ 5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	10,560	EA	$ 106	$ 1,119,039	Source 4 + CH2M H&S	
SUBTOTAL				*$ 1,226,445*		
CAPITAL SUBTOTAL - SOIL				$ 21,243,237		
Contingency	25%			$ 5,310,809	10% Scope + 15% Bid	
SUBTOTAL				$ 26,554,046		
Project Management	5%			$ 1,327,702	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%			$ 1,593,243	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%			$ 1,593,243	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL				$ 4,514,188		
Contractor Fees						
ODC & Subs	5%		$ 26,554,046	$ 1,327,702		
Labor	10%	max	$ 4,514,188	$ 451,419		
SUBTOTAL				$ 1,779,121		
TOTAL CAPITAL COST - SOIL				**$ 32,850,000**		
NAPL and ARSENIC						
NAPL Recovery						
NAPL Recovery in existing monitoring wells						
Product recovery pumps	3	EA	$ 4,000	$ 12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL				$ 12,000		
Mobilization/Demobilization	5%			$ 600		
Subcontractor general conditions	20%			$ 2,400		
SUBTOTAL				*$ 15,000*		
Excavation, Backfilling, & Soil Disposal						
Excavation of Tar Boils & NAPL Zones NZ-1 and portion of NZ-3						
Dig permits & utility markout	5	DAY	$ 5,000	$ 25,000	Source 3	
Excavation of soils (includes NAPL comingled with arsenic)	66,020	CY	$ 30	$ 1,960,796	Source 3	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	79,224	CY	$ 19	$ 1,488,745	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	70	DY	$ 567	$ 39,695	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression equipment rental	3	MO	$ 10,000	$ 30,000	Vendor	Assumes two rental units
Odor suppression material	37	DRUM	$ 350	$ 12,988	Vendor	Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	108,933	TN	$ 70	$ 7,625,317	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	108,933	TN	$ 128	$ 13,943,437	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	132	EA	$ 3,735	$ 493,129	Source 4	1 sample per 500 cy of excavated material
Shoring around building	1,200	LF	$ 62	$ 74,400	Source 3	4'-5' depth
SUBTOTAL				$ 25,693,508		
Mobilization/Demobilization	5%			$ 1,284,675		
Subcontractor general conditions	20%			$ 5,138,702		
SUBTOTAL				*$ 32,116,884*		
Excavation of NAPL Zones NZ-2 and NZ-5						Removal of top 10-ft fill material covered above
Dig permits & utility markout	3	DAY	$ 5,000	$ 15,000	Source 3	
Excavation of soils	62,299	CY	$ 30	$ 1,850,284	Source 3	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	74,759	CY	$ 19	$ 1,404,838	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	70	DY	$ 567	$ 39,695	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression equipment rental	2	MO	$ 10,000	$ 23,333	Vendor	Assumes two rental units
Odor suppression material	24	DRUM	$ 350	$ 8,375	Vendor	Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	102,794	TN	$ 70	$ 7,195,549	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	102,794	TN	$ 128	$ 13,157,575	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	125	EA	$ 3,735	$ 465,336	CH2M HILL Est.	1 sample per 500 cy of excavated material
Shoring around building	600	LF	$ 62	$ 37,200	CH2M HILL Est.	4'-5' depth
SUBTOTAL				$ 24,197,184		
Mobilization/Demobilization	5%			$ 1,209,859		
Subcontractor general conditions	20%			$ 4,839,437		
SUBTOTAL				*$ 30,246,480*		

Alternative 6a: NAPL and Arsenic Excavation — COST ESTIMATE SUMMARY - DRAFT

Excavation of Arsenic Areas and HCAA							
Dig Permits & Utility Markout	5	DAY	$ 5,000	$ 25,000	Source 3		
Excavation of soil	33,253	CY	$ 30	$ 987,612	MEANS 17-03-0276	Assumes direct loading of materials, depths at 10ft - HCAA, 10ft for AA-1, 2ft for AA-7	
Certified clean fill for backfilling excavated areas	39,904	CY	$ 19	$ 749,850	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction	
Dust suppression	45	DY	$ 567	$ 25,518	MEANS 31.23.23.18.4500	Concurrent site activities/dust control	
On-site stabilization of excavated soils with Portland Cement	54,867	TN	$ 70	$ 3,840,713	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy	
Disposal of stabilized soil - Non-Haz Waste	54,867	TN	$ 128	$ 7,023,018	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)	
Confirmation sampling	67	EA	$ 3,735	$ 248,379	CH2M HILL Est.	1 sample per 500 cy of excavated material	
Sheet piling	12,600	SF	$ 62	$ 781,200	Source 3	Assumed sheet piling required along roadside for excavation	
Shoring around building	10,080	LF	$ 62	$ 624,960	Source 3	4'-5' depth	
SUBTOTAL				$ 14,306,250			
Mobilization/Demobilization	5%			$ 715,312			
Subcontractor general conditions	20%			$ 2,861,250			
SUBTOTAL				*$ 17,882,812*			
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	24	MO	$ 1,043	$ 25,021	Source 4		
Air monitoring based on air monitoring plan	30	MO	$ 20,000	$ 600,000	Source 4 + CH2M H&S	Assumes 8 stations	
PPE provisions for workers (initial)	30	EA	$ 252	$ 7,557	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor	
PPE provisions for workers (worker·days)	15,840	EA	$ 106	$ 1,678,558	Source 4 + CH2M H&S		
SUBTOTAL				$ 774,636			
CAPITAL SUBTOTAL - NAPL and ARSENIC				$ 85,268,117			
Contingency	25%			$ 21,317,029	10% Scope + 15% Bid		
SUBTOTAL				$ 106,585,146			
Project Management	5%			$ 5,329,257	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 6,395,109	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 6,395,109	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 18,119,475			
Contractor Fees							
ODC & Subs	5%		$ 106,585,146	$ 5,329,257			
Labor	10%	max	$ 18,119,475	$ 1,811,947			
SUBTOTAL				$ 7,141,205			
TOTAL CAPITAL COST - NAPL and ARSENIC				**$ 131,850,000**			
GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$ 230,000	$ 230,000			
Updates to the groundwater model	1	LS	$ 20,000	$ 20,000			
Bench-scale testing (Arsenic and NAPL)	2	EA	$ 75,000	$ 150,000			
Pilot-scale testing	1	LS	$ 150,000	$ 150,000			
SUBTOTAL				*$ 550,000*			
Replacement Monitoring Wells							
Soil borings	480	FT	$ 47	$ 22,320		Assumes 16 wells at 30-ft deep	
2-inch PVC well casing	320	FT	$ 31	$ 9,994	MEANS 33-23-0101	Assumes 10-ft screen	
2-inch PVC well screen	160	FT	$ 34	$ 5,398	MEANS 33-23-0256		
Well development	16	EA	$ 1,600	$ 25,600	Source 3		
Off-site disposal of soil cuttings from well installation	50	TN	$ 128	$ 6,400	MEANS 33-19-7270	Assumes material is disposed of as non-haz	
Off-site disposal of development and decontamination water	10,000	GAL	$ 1.00	$ 10,000	Source 3	Assumes water is non-hazardous	
SUBTOTAL				$ 79,712			
Mobilization/Demobilization	5%			$ 3,986	Source 3		
Subcontractor general conditions	20%			$ 15,942	Source 3		
SUBTOTAL				*$ 99,640*			
Subaqueous Reactive Barrier							
Site Preparation							
Erosion control	1	LS	$ 20,000	$ 20,000	Source 3		
Permitting	1	LS	$ 150,000	$ 150,000	Source 3		
Survey (pre and post installation)	2	EA	$ 2,500	$ 5,000	Source 3		
Staging pad	1	LS	$ 10,000	$ 10,000	Source 3		
Rental and operation of generator	1	MO	$ 17,050	$ 17,050	Source 3	$150/dy rent + $400/dy fuel = $550/dy	
Rental of frac tank	1	MO	$ 500	$ 500	Source 3		
Portadam® Barriers - setup, teardown, and one month rental	1,200	LF	$ 100	$ 120,000	Source 3		
Portadam® Barriers - additional rental	2	WK	$ 15,600	$ 31,200	Source 3		
Cut-off timber piles allowance	1	LS	$ 150,000	$ 150,000	Source 3		
SUBTOTAL				$ 503,750			
Mobilization/Demobilization	5%			$ 25,188	Source 3		
Subcontractor general conditions	20%			$ 100,750	Source 3		
SUBTOTAL				*$ 629,688*			
Excavate 2' of Impacted Sediment							
Pump out area within Portadams®	30	DY	$ 1,275	$ 38,250	Source 3	750 GPM Godwin Dri-Prime 6" Model CD150M	
Pump fuel and oil	1,500	GAL	$ 4	$ 6,000	Source 3	3.1 GPH Diesel Fuel x 24 hrs/day x 20 days	
Excavate 2' sediment from dewatered area	11,000	CY	$ 25	$ 275,000	Source 3	Assumed area 160' x 950'	
Transportation of material back to staging pad	11,000	CY	$ 4	$ 44,000	Source 3		
SUBTOTAL				$ 363,250			
Mobilization/Demobilization	5%			$ 18,163	Source 3		
Subcontractor general conditions	20%			$ 72,650	Source 3		
SUBTOTAL				*$ 454,063*			
Install RCM Mat & Armor Layer							
Organoclay RCM material	120	ROLL	$ 3,000	$ 360,000	Source 3	20% extra for overlap - 1,500 ft2/roll x $2.00/ft2	
Install organoclay RCM	170,000	SF	$ 0.50	$ 85,000	Source 3		
12" sand armor layer (material only)	6,000	CY	$ 20	$ 120,000	Source 3		
Install 12" sand armor layer	6,000	CY	$ 7	$ 42,000	Source 3		
SUBTOTAL				$ 607,000			
Mobilization/Demobilization	5%			$ 30,350	Source 3		
Subcontractor general conditions	20%			$ 121,400	Source 3		
SUBTOTAL				*$ 758,750*			
Cutoff Wall with Hydraulic Containment							
Cutoff Wall at Shoreline							
Remove concrete decking	2,500	SF	$ 15	$ 37,500	Envirocon ROM estimate		
Rip-rap removal	1,040	CY	$ 25	$ 26,000	Envirocon ROM estimate		
Barrier wall at 115 River Road (under building)	1	LS	$ 600,000	$ 600,000	Envirocon ROM estimate		
Sealed sheet piling - shoreline	42,000	SF	$ 127	$ 5,334,000	Envirocon ROM estimate		
SUBTOTAL				$ 5,997,500			
Mobilization/Demobilization	5%			$ 299,875	Source 3		
Subcontractor general conditions	20%			$ 1,199,500			
SUBTOTAL				*$ 7,496,875*			
Wastewater Treatment Plant to Treat Water						System to treat 50 gpm	
Pumping and Equalization of Influent Water							
8,000 gallon polypropylene equalization tanks	2	EA	$ 6,340	$ 12,679	MEANS 33-10-9661	Provides 8-hrs of storage at 100 gpm	
Sludge pump	1	EA	$ 3,820	$ 3,820	Source 3		
Off-gas pump	1	EA	$ 1,322	$ 1,322	Source 3		
Effluent pump	4	EA	$ 4,221	$ 16,883	Source 3	50 GPM effluent pump (MAX @ 65'TDH)	
NAPL pump	1	EA	$ 3,864	$ 3,864	Source 3		
Chemical feed systems (caustic and acid)	2	EA	$ 3,130	$ 6,260	Source 3		
SUBTOTAL				$ 44,829			
Mobilization/Demobilization	5%			$ 2,241	Source 3		
Subcontractor general conditions	20%			$ 8,966	Source 3		
SUBTOTAL				*$ 56,036*			
Removal of NAPLs and Solids							
Oil-water separator, 50 gpm	1	EA	$ 16,910	$ 16,910	ECHOS 19.04.0412		
Packaged 1,500 Gallon Steel Product Tank	1	EA	$ 4,950	$ 4,950	ECHOS 19.04.0604		
Packaged 20 gpm Oil Pump out unit w/controls	1	EA	$ 7,670	$ 7,670	ECHOS 33.13.1211		
Effluent pump	2	EA	$ 5,231	$ 10,462	MEANS 33-23-0555	50 GPM(one in operation and one in stand-by) (MAX@ 65'TDH)	
Chemical feed systems	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104	Caustic, acid, polymer, hydrogen peroxide, and ferric chloride	
SUBTOTAL				$ 55,642			
Mobilization/Demobilization	5%			$ 2,782	Source 3		
Subcontractor general conditions	20%			$ 11,128	Source 3		
SUBTOTAL				*$ 69,553*			
Advanced oxidation							
Flocculation tanks connected in series	4	EA	$ 4,572	$ 18,287	MEANS 33-10-9658		
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	$ 3,130	$ 15,650	ECHOS 33.32.0104		
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	$ 4,009	$ 8,018	MEANS 33-29-0120		
SUBTOTAL				$ 41,955			
Mobilization/Demobilization	5%			$ 2,098	Source 3		
Subcontractor General Conditions	20%			$ 8,391	Source 3		
SUBTOTAL				*$ 52,444*			
Solid-liquid Separation							
Inclined plate clarifier (0.25 GPM/SF of area)	3	EA	$ 26,520	$ 79,560	ECHOS 33.13.0414		
100 GPM effluent pump for use with plate clarifier	1	EA	$ 6,211	$ 6,211	Source 3		
Sludge pump for use with plate clarifier	1	EA	$ 3,130	$ 3,130	Source 3		
Bag filters	2	EA	$ 800	$ 1,600	Source 3		
Offgas pumps for use with bag filters	2	EA	$ 1,500	$ 3,000	Source 3		
Effluent pumps for use with bag filters	2	EA	$ 4,200	$ 8,400	Source 3		
Liquid waste pump for use with sludge settling tank	1	EA	$ 4,200	$ 4,200	Source 3		
Filter press, 95% removal efficiency	2	EA	$ 90,100	$ 180,200	ECHOS 33.33.3013	10 CF w/sludge tanks, pumps, mixers, sludge cart	
SUBTOTAL				$ 286,301			
Mobilization/Demobilization	5%			$ 14,315	Source 3		
Subcontractor general conditions	20%			$ 57,260	Source 3		
SUBTOTAL				*$ 357,877*			
Effluent Polishing							
Packaged 36,000 GPD water treatment plant	2	EA	$ 32,400	$ 64,800	ECHOS 19.01.0807	Includes GAC, pumps, tanks	

Concrete Wet Well, 12'x36"	4	EA	$ 9,200	$ 36,800	ECHOS 19.02.0304		
Packaged Lift Station (70 gpm)	4	EA	$ 9,950	$ 39,800	ECHOS 19.02.0304		
Ion exchange units	2	EA	$ 10,000	$ 20,000	Source 3	One in operation and one standby/regeneration phase	
SUBTOTAL			$ 25,000	$ 161,400			
Mobilization/Demobilization	5%			$ 8,070	Source 3		
Subcontractor general conditions	20%			$ 32,280	Source 3		
SUBTOTAL				*$ 201,750*			
Building & Controls							
Building / HVAC / Electrical	1	EA	$ 300,000	$ 300,000	Source 3		
SCADA computer control system/Instrumentation	1	LS	$ 400,000	$ 400,000	Source 3		
SUBTOTAL				$ 700,000			
Mobilization/Demobilization	5%			$ 35,000	Source 3		
Subcontractor general conditions	20%			$ 140,000	Source 3		
SUBTOTAL				*$ 875,000*			
Piping, Instrumentation, & Equipment Installation							
2-inch schedule 80 PVC piping and fittings	3,000	LF	$ 24	$ 72,000	Source 3		
2-inch carbon steel piping	1,000	LF	$ 67	$ 67,000	Source 3		
Pipe supports and misc metals	1	LS	$ 30,000	$ 30,000	Source 3		
Install equipment	30	CD	$ 3,000	$ 90,000	Source 3		
Plumbing and fire suppression	1	LS	$ 40,000	$ 40,000	Source 3		
Lighting and misc electrical	1	LS	$ 25,000	$ 25,000	Source 3		
Chemical reagents	1	LS	$ 20,000	$ 20,000	Source 3		
Chemical storage tanks	5	EA	$ 8,000	$ 40,000	Source 3	550 Gallon double walled tanks	
Chemical feed system I&C	1	LS	$ 100,000	$ 100,000	Source 3	Metering pumps, gauges, valves, and flow-meters	
Installation of discharge point to surface water	1	LS	$ 80,000	$ 80,000			
SUBTOTAL				$ 564,000			
Mobilization/Demobilization	5%			$ 28,200	Source 3		
Subcontractor general conditions	20%			$ 112,800	Source 3		
SUBTOTAL				*$ 705,000*			
System Startup	1	LS	$ 150,000	*$ 150,000*	Source 3		
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	6	MO	$ 1,043	$ 6,255	Source 4		
Air monitoring	30	DY	$ 718	$ 21,525	Source 4 + CH2M H&S		
PPE provisions for workers (initial)	8	EA	$ 252	$ 2,015	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor	
PPE provisions for workers (worker-days)	1,056	EA	$ 106	$ 111,904	Source 4 + CH2M H&S		
SUBTOTAL				$ 154,471			
CAPITAL SUBTOTAL - GROUNDWATER				$ 12,611,145			
Contingency	25%			$ 3,152,786	10% Scope + 15% Bid		
SUBTOTAL				$ 15,763,932			
Project Management	5%			$ 788,197	**USEPA 2000, p. 5-13, $2-$10M**		
Remedial Design	8%			$ 1,261,115	**USEPA 2000, p. 5-13, $2-$10M**		
Construction Management	6%			$ 945,836	**USEPA 2000, p. 5-13, $2-$10M**		
SUBTOTAL				$ 2,995,147			
Contractor Fees							
ODC & Subs	5%		$ 15,763,932	$ 788,197			
Labor	10%	max	$ 2,995,147	$ 299,515			
SUBTOTAL				$ 1,087,711			
TOTAL CAPITAL COST - GROUNDWATER				**$ 19,850,000**			
VAPOR							
Vapor Mitigation							
Preconstruction Investigations							
Evaluate building systems	1	LS	$ 10,000	$ 10,000	Radiation Data Quote Phase 1		
SUBTOTAL				*$ 10,000*			
Install Sub Slab Depressurization System							
Install new french drain system	1	LS	$ 50,000	$ 50,000	Source 3		
Upgrade dewatering equipment	1	LS	$ 50,000	$ 50,000	Source 3		
Add carbon and bag filter system	1	LS	$ 120,000	$ 120,000	Source 3		
Install sub slab depressurization system	1	LS	$ 65,000	$ 65,000	Radiation Data Quote Phase 2		
SUBTOTAL				$ 285,000			
Mobilization/Demobilization	5%			$ 14,250			
Subcontractor general conditions	20%			$ 57,000			
SUBTOTAL				*$ 356,250*			
CAPITAL SUBTOTAL - VAPOR				$ 366,250			
Contingency	25%			$ 91,563	10% Scope + 15% Bid		
SUBTOTAL				$ 457,813			
Project Management	8%			$ 36,625	**USEPA 2000, p. 5-13, $100K - $500K**		
Remedial Design	15%			$ 68,672	**USEPA 2000, p. 5-13, $100K - $500K**		
Construction Management	10%			$ 45,781	**USEPA 2000, p. 5-13, $100K - $500K**		
SUBTOTAL				$ 151,078			
Contractor Fees							
ODC & Subs	5%		$ 457,813	$ 22,891			
Labor	10%	max	$ 151,078	$ 15,108			
SUBTOTAL				$ 37,998			
TOTAL CAPITAL COST - VAPOR				**$ 650,000**			
TOTAL CAPITAL COST				**$ 185,200,000**			

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
Capping						
Cap Repair	1	LS	$ 25,344	$ 25,344		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$ 100	$ 10,000		Biennial Report to NJDEP
SUBTOTAL				$ 35,344		
Contingency	25%			$ 8,836	10% Scope + 15% Bid	
SUBTOTAL				$ 44,179		
Project Management	10%			$ 4,418	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%			$ 8,836	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%			$ 6,627	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL				$ 19,881		
Contractor Fees						
ODC & Subs	5%		$ 44,179	$ 2,209		
Labor	10%	max	$ 19,881	$ 1,988		
SUBTOTAL				$ 4,197		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)				**$ 70,000**		

Alternative 6a: NAPL and Arsenic Excavation — COST ESTIMATE SUMMARY - DRAFT

NAPL

NAPL Recovery Wells							
Routine Operations, Maintenance, Monitoring	240	HR	$	100	$	24,000	Assumes part time operator performs duties for NAPL system (5 days/month)
Parts Replacement / Consumables	1	LS	$	1,000	$	1,000	
Reporting	100	HR	$	100	$	10,000	
Off-site Disposal of NAPL	180	GAL	$	9.00	$	1,620	
SUBTOTAL					$	36,620	
Mobilization/Demobilization	5%				$	1,831	
Subcontractor general conditions	25%				$	9,155	
SUBTOTAL					*$*	*47,606*	
Contingency	25%				$	11,902	10% Scope + 15% Bid
SUBTOTAL					$	59,508	
Project Management	8%				$	4,761	**USEPA 2000, p. 5-13, $100K - $500K**
Remedial Design	15%				$	8,926	**USEPA 2000, p. 5-13, $100K - $500K**
Construction Management	10%				$	5,951	**USEPA 2000, p. 5-13, $100K - $500K**
SUBTOTAL					$	19,637	
Contractor Fees							
ODC & Subs	5%		$	59,508	$	2,975	
Labor	10%	max	$	19,637	$	1,964	
SUBTOTAL					$	4,939	
TOTAL ANNUAL O&M COST - NAPL Recovery Wells					**$**	**84,084**	
TOTAL ANNUAL O&M COST - NAPL (Year 1)					**$**	**84,084**	
TOTAL ANNUAL O&M COST - NAPL (Year 2)					**$**	**84,084**	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)					**$**	**84,084**	Assumes NAPL recovery will cease after 10 years

GROUNDWATER

Inspection of Subaqueous Reactive Barrier (SRB)								
Sampling of barrier during low tide	1	LS	$	15,000	$	15,000		Excavator onsite for 5 days--expose 5% of barrier every 10 years
Barrier replacement	1	LS	$	227,625	$	227,625		30% of barrier every 10 years
Allowance for Misc. Items	1	LS	$	48,525	$	48,525		Assumes 20% of capital cost
SUBTOTAL					$	291,150		
Mobilization/Demobilization	5%				$	14,558		
Subcontractor general conditions	25%				$	72,788		
SUBTOTAL					*$*	*378,495*		
Contingency	25%				$	94,624	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL					$	473,119		
Project Management	8%				$	37,850	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%				$	70,968	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%				$	47,312	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL					$	156,129		
Contractor Fees								
ODC & Subs	5%		$	473,119	$	23,656		
Labor	10%	max	$	156,129	$	15,613		
SUBTOTAL					$	39,269		
TOTAL ANNUAL O&M COST - SRB					**$**	**668,517**		
Groundwater Treatment System O&M	**Only During Excavation**							
Misc. Electrical Site Usage	12	MO	$	215	$	2,584	MEANS 33-42-0106	
Routine Operations, Maintenance, Monitoring	2,080	HR	$	80	$	166,400		40 hrs/week for one operator
Chemicals / Consumables	12	MO	$	10,000	$	120,000		
Electricity	394,200	KWH	$	0.10	$	39,420		
Replace Filters/ Carbon	12	MO	$	5,000	$	60,000		
Sampling and Analysis	12	MO	$	1,055	$	12,665	Source 4	Assumes one compliance sample per month
Reporting	200	HR	$	100	$	20,000	CH2M Est.	
Allowance for Misc. Items	1	LS	$	84,214	$	84,214		Assumes 20% of the capital costs
SUBTOTAL					$	505,283		
Subcontractor general conditions	25%				$	126,321		
SUBTOTAL					*$*	*631,603*		
Contingency	25%				$	157,901	10% Scope + 15% Bid	
SUBTOTAL					$	789,504		
Project Management	6%				$	47,370	**USEPA 2000, p. 5-13, $500K - $2M**	
Remedial Design	12%				$	94,741	**USEPA 2000, p. 5-13, $500K - $2M**	
Construction Management	8%				$	63,160	**USEPA 2000, p. 5-13, $500K - $2M**	
SUBTOTAL					$	205,271		
Contractor Fees								
ODC & Subs	5%		$	789,504	$	39,475		
Labor	10%	max	$	205,271	$	20,527		
SUBTOTAL					$	60,002		
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M					**$**	**1,054,778**		
Groundwater Monitoring								
Groundwater Samples	40	EA	$	1,000	$	39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals
QC Samples	5	EA	$	1,000	$	4,998		
Groundwater Sampling, Level D								
Labor	300	HR	$	80	$	24,000		Assumes 3 persons for 5 days
Equipment - meters	1	LS	$	2,000	$	2,000	Source 3	
Consumables	1	LS	$	3,000	$	3,000	Source 3	
Data Validation	96	HR	$	100	$	9,600		
Reporting	240	HR	$	100	$	24,000		
Allowance for Misc. Items	1	LS	$	10,758	$	10,758		Assumes 10% of the capital costs
SUBTOTAL					$	118,340		
Mobilization/Demobilization	5%				$	5,917		
Subcontractor general conditions	25%				$	29,585		
SUBTOTAL					*$*	*153,842*		
Contingency	25%				$	38,461	10% Scope + 15% Bid	
SUBTOTAL					$	192,303		
Project Management	8%				$	15,384	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%				$	28,845	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%				$	19,230	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL					$	63,460		
Contractor Fees								
ODC & Subs	5%		$	192,303	$	9,615		
Labor	10%	max	$	63,460	$	6,346		
SUBTOTAL					$	15,961		
TOTAL ANNUAL O&M COST - Groundwater Monitoring					**$**	**271,724**		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)					**$**	**2,141,672**	Quarterly for first year (Four GW sampling events)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)					**$**	**1,326,501**	Annual for Years 2 to 30 (one GW sampling event per year)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)					**$**	**668,517**	Additional cost for years 10, 20, 30	

VAPOR

Vapor Intrusion Operation Bldg 115								
Routine Operations, Maintenance, Monitoring	240	HR	$	80	$	19,200		Assumes part time operator performs duties 5 days/month
Parts Replacement / Consumables	1	LS	$	2,000	$	2,000	Source 3	
Electricity	13,140	KWH	$	0.10	$	1,314	Source 3	
Replace bag filters and carbon media	4	EA	$	2,500	$	10,000		Assume carbon replacement every 3 months -
Reporting	80	HR	$	80	$	6,400	CH2M Est.	
SUBTOTAL					$	38,914		
Mobilization/Demobilization	5%				$	1,946		
Subcontractor general conditions	25%				$	9,729		
SUBTOTAL					*$*	*50,588*		
Contingency	25%				$	12,647	10% Scope + 15% Bid	
SUBTOTAL					$	63,235		
Project Management	10%				$	6,324	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%				$	12,647	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%				$	9,485	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL					$	28,456		

Alternative 6a: NAPL and Arsenic Excavation

COST ESTIMATE SUMMARY - DRAFT

Contractor Fees						
ODC & Subs	5%		$	63,235	$	3,162
Labor	10%	max	$	28,456	$	2,846
SUBTOTAL					$	6,007
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)					**$**	**100,000**

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 32,850,000	$ 32,850,000	1.000	$ 32,850,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 131,850,000	$ 131,850,000	1.000	$ 131,850,000	
CAPITAL COST - GROUNDWATER	0	$ 19,850,000	$ 19,850,000	1.000	$ 19,850,000	
CAPITAL COST - VAPOR	0	$ 650,000	$ 650,000	1.000	$ 650,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 84,084	$ 84,084	0.935	$ 78,583	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 84,084	$ 84,084	0.873	$ 73,442	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 10	$ 672,673	$ 84,084	5.216	$ 438,546	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 2,141,672	$ 2,141,672	0.935	$ 2,001,563	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 38,468,536	$ 1,326,501	11.474	$ 15,220,888	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	10	$ 668,517	$ 668,517	0.508	$ 339,840	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	20	$ 668,517	$ 668,517	0.258	$ 172,757	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	30	$ 668,517	$ 668,517	0.131	$ 87,821	
TOTAL ANNUAL O&M COST - VAPOR (Year 1 - 30)	1 to 30	$ 3,000,000	$ 100,000	12.409	$ 1,240,904	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 234,277,600			$ 205,919,039	

TOTAL PRESENT VALUE OF ALTERNATIVE 6a $ 205,920,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

Site: Quanta Resources Site-Edgewater, New Jersey
Media Ground water, Soil and NAPL
Phase: draft Final Feasibility Study
Base Year: 2010
Date: 6/18/2010

Description:

NAPL	NAPL present in NZ-1, NZ-2, NZ-5, small portion of NZ-3, and tar boils would be excavated and disposed of off-site. Buildings on the 115 River Road will be demolished. Excavation would require dewatering to achieve depths greater than 4 feet, and may require shoring near existing structures. Water generated from dewatering activities would be treated on site prior to discharge to the Hudson River. Following excavation the site would be backfilled and compacted with clean material to grade. A sheet pile cut off wall will be installed along NZ-2 and NZ-5 shoreline.
Arsenic	Prinicipal threat arsenic and HCAA will be excavated. Institutional controls would be established to document and limit use of areas with COCs remaining in place.
Residual Soil	Existing River/Gorge Road surfaces would be maintained and institutional controls would remain in place. Residual soils would be capped. Institutional controls would be established to place restrictions on future land use and control future construction and redevelopment activities.
Vapor	Institutional controls would be established and maintained to prevent vapor intrusion in other buildings and to inspect/maintain controls at 115 River Road. Vapor intrusion mitigation would be installed in the other occupied buildings, as needed.
Groundwater	A subaqueous reactive barrier, which consists of a reactive material encapsulated between carrier textiles, would be placed over the sediments in OU2 to treat groundwater discharging to the river. Institutional controls restricting groundwater use would be established.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	COSTING BASIS	ASSUMPTIONS
SOIL						
General Site Work						
Site Establishment						
Survey	50	DY	$ 1,500	$ 75,000	Source 3	
Utility survey, geophysical survey	1	LS	$ 190,000	$ 190,000	Vendor quote	
Fencing	4,000	LF	$ 15	$ 60,000	Source 3	
Trailer installation & setup	2	EA	$ 3,000	$ 6,000	Source 3	Tie-downs, stairs, power
Support area establishment and site offices	30	MO	$ 4,300	$ 129,000	Source 3	Includes shed, utilities, lavatories
SUBTOTAL				*$ 460,000*		
Institutional Controls (Quanta, 115 River Road, Edgewater, Former Lever Bros, Block 93 North, Block 93 Central, Block 93 South, River Road ROW, Gorge Road ROW)						
Deed notices (1 for each property)	9	LS	$ 25,000	$ 225,000	CH2M Est.	Draft deed covenant, coordination with regulators, public involvement, professional services, and filing deed covenant
Security service	30	MO	$ 12,000	$ 360,000	CH2M Est.	
SUBTOTAL				*$ 585,000*		
Vegetation Clearing and Debris Disposal						
Site Clearing & Disposal (Quanta Property)						
Temporary erosion controls (silt fencing)	2,624	LF	$ 1.95	$ 5,123	MEANS 31.25.13.10.1100	Surrounding property boundary
Clear and grub heavy brush and trees	4.4	AC	$ 2,492	$ 10,901	MEANS 31.11.10.10.0260	Clear & grub brush, including stumps, includes chipper, assumes 80% of Quanta requires clearing
Tank pad, concrete & debris removal @ NZ-1 and NZ-2	14,653	CY	$ 173	$ 2,530,367	MEANS 02.41.13.17.5500	Demolition of debris in top 4-ft in NZ-2 and 2-ft throughout NZ-1 (assumes 1.65 ton/cy)
Transportation and offsite disposal of concrete	26,376	TN	$ 128	$ 3,376,101	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	2,646	SY	$ 3.76	$ 9,950	Source 3	Assumes 3" thick asphalt to be cleared from 10% of Quanta
Transportation and offsite disposal/recycling of asphalt	480	TN	$ 15	$ 7,275	Source 3	
Subsurface piping abandonment	1	LS	$ 250,000	$ 250,000	CH2M Est.	
Dust suppression	15	DY	$ 567	$ 8,506	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 6,198,224		
Mobilization/Demobilization	5%			$ 309,911	Source 3	
Subcontractor general conditions	20%			$ 1,239,645	Source 3	
SUBTOTAL				*$ 7,747,780*		
Site Clearing & Disposal (115 River Road)						
Temporary erosion controls (silt fencing)	2,279	LF	$ 1.95	$ 4,450	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	5,648	SY	$ 3.76	$ 21,235	Source 3	Assumes 3" thick asphalt to be cleared from 80% of 115 River Road
Transportation and offsite disposal/recycling of asphalt	1,025	TN	$ 15	$ 15,525	Source 3	
Dust suppression	5	DY	$ 567	$ 2,835	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 44,045		
Mobilization/Demobilization	5%			$ 2,202	Source 3	
Subcontractor general conditions	20%			$ 8,809	Source 3	
SUBTOTAL				*$ 55,056*		
Site Clearing & Disposal (Arsenic Liner Area)						
Temporary erosion controls (silt fencing)	1,500	LF	$ 1.95	$ 2,929	MEANS 31.25.13.10.1100	Surrounding arsenic liner area
Concrete removal & sizing to less than 2'	6,061	TN	$ 173	$ 1,046,577	MEANS 02.41.13.17.5500	Concrete demolition of access ramp (curbs)
Transportation and offsite disposal of concrete	10,909	CY	$ 128	$ 1,396,378	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	6,361	SY	$ 3.76	$ 23,918	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area above the arsenic liner
Transportation and offsite disposal/recycling of asphalt	1,155	TN	$ 15	$ 17,500	Source 3	
Dust suppression	25	DY	$ 567	$ 14,177	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	2	DY	$ 5,000	$ 10,000	Source 3	
Excavation and stockpile of 10-ft of soils above the existing arsenic liner	21,204	CY	$ 30	$ 629,754	Source 3	Assumes material can be replaced following the completion of remedial activities, assumes 1.65 ton/cy
Temporary access	1	allow	$ 65,000	$ 65,000	Source 3	
SUBTOTAL				$ 3,206,232		
Mobilization/Demobilization	5%			$ 160,312	Source 3	
Subcontractor general conditions	20%			$ 641,246	Source 3	
SUBTOTAL				*$ 4,007,790*		
Site Clearing & Disposal (Edgewater - NZ-5)						
Temporary erosion controls (silt fencing)	495	LF	$ 1.95	$ 966	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Asphalt removal	1,508	SY	$ 3.76	$ 5,669	MEANS 02.41.13.17	Assumes 3" thick asphalt to be cleared from area
Transportation and offsite disposal/recycling of asphalt	274	CY	$ 15	$ 4,150	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DY	$ 5,000	$ 5,000	Source 3	
Excavation and stockpile of 10-ft of backfill	5,025	CY	$ 30	$ 149,254	MEANS 17-03-0276	Assumes material can be replaced following the completion of remedial activities
SUBTOTAL				$ 165,605		
Mobilization/Demobilization	5%			$ 8,280	Source 3	
Subcontractor general conditions	20%			$ 33,121	Source 3	
SUBTOTAL				*$ 207,007*		
Site Clearing & Disposal (Lever Brothers)						
Temporary erosion controls (silt fencing)	700	LF	$ 1.95	$ 1,367	MEANS 31.25.13.10.1100	Surrounding NAPL zone
Concrete removal & sizing to less than 2'	74	CY	$ 173	$ 12,791	MEANS 02.41.13.17.5500	Tank pad assumed to be 12-inches thick
Transportation and offsite disposal of concrete	133	TN	$ 128	$ 17,067	MEANS 33-19-7270	Assumes non-HW landfill more than 50 miles from the site
Asphalt removal	1,833	SY	$ 3.76	$ 6,893	Source 3	Assumes 3" thick asphalt to be cleared from 50% of NZ-1 on this property
Transportation and offsite disposal of asphalt	202	CY	$ 15	$ 3,061	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Dig permits & utility markout	1	DAY	$ 5,000	$ 5,000	Source 3	
SUBTOTAL				$ 46,746		
Mobilization/Demobilization	5%			$ 2,337	Source 3	
Subcontractor general conditions	20%			$ 9,349	Source 3	
SUBTOTAL				*$ 58,432*		
Site Clearing & Disposal (Block 93 North and Central)						
Temporary erosion controls (silt fencing)	2,081	LF	$ 1.95	$ 4,064	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	6,568	SY	$ 3.76	$ 24,696	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	1191	TN	$ 15	$ 18,050	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 47,377		
Mobilization/Demobilization	5%			$ 2,369	Source 3	
Subcontractor general conditions	20%			$ 9,475	Source 3	
SUBTOTAL				*$ 59,222*		
Site Clearing & Disposal (Block 94)						
Temporary erosion controls (silt fencing)	22,736	LF	$ 1.95	$ 44,398	MEANS 31.25.13.10.1100	Surrounding property boundary
Asphalt removal	2,322	SY	$ 1.95	$ 4,535	Source 3	Assumes 3" thick asphalt to be cleared from 50% of Block 93 North and 80% of Block 93 Central
Transportation and offsite disposal/recycling of asphalt	421	TN	$ 15	$ 6,375	Source 3	
Dust suppression	1	DY	$ 567	$ 567	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
SUBTOTAL				$ 55,875		
Mobilization/Demobilization	5%			$ 2,794	Source 3	
Subcontractor general conditions	20%			$ 11,175	Source 3	
SUBTOTAL				*$ 69,843*		
Demolition of 115 River Road Buildings						
Temporary relocation of tenants	1	LS	$ 2,000,000	$ 2,000,000	Assumes 60 businesses moved twice - cost provided by Honeywell real estate group	
Loss of rent	1	LS	$ 7,000,000	$ 7,000,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Differential in rent for tenants	1	LS	$ 500,000	$ 500,000	Assumes 3 yrs - cost provided by Honeywell real estate group	
Building demolition	1	LS	$ 2,000,000	$ 2,000,000	Assumes bldg 86,000 ft^2 - cost provided by Honeywell real estate group	
Building reconstruction	1	LS	$ 39,000,000	$ 39,000,000	Cost provided by Honeywell real estate group	
SUBTOTAL				$ 50,500,000		
Mobilization/Demobilization	5%			$ 2,525,000	Source 3	
Subcontractor general conditions	20%			$ 10,100,000	Source 3	
SUBTOTAL				*$ 63,125,000*		

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

Capping								
New Vegetative Cap (Quanta)								
Rough grading	26,463	SY	$	1.75	$	46,264	MEANS 17-03-0101	
Fine grading	26,463	SY	$	1.22	$	32,311	MEANS 17-03-0101	
Fill to match grade in adjacent properties	2,511	CY	$	19	$	47,188	MEANS 17-03-0423	
Protective layer, 6" compacted soil subgrade	4,410	CY	$	19	$	82,871	MEANS 17-03-0423	
HDPE Liner, 40 mil thick	26,463	SY	$	15	$	408,321	ECHOS 33.08.0572	
Drainage layer, 6" granular soil (assume gravel)	4,410	CY	$	54	$	239,301	MEANS 32.11.23.23.1511	
Grade, place geotextile filter fabric	26,463	SY	$	2.00	$	52,926	Source 3	
Hydroseed	238,200	SF	$	0.07	$	16,674	Source 3	
SUBTOTAL					$	925,855		
Mobilization/Demobilization	5%				$	46,293	Source 3	
Subcontractor general conditions	20%				$	185,171	Source 3	
SUBTOTAL					*$*	*1,157,318*		
Upgrade Asphalt Cap (115 River Road)								
Fine grading	7,059	SY	$	1.22	$	8,620	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,180	CY	$	54	$	64,031	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	
Asphalt stabilized binder course, 2" thick	7,059	SY	$	11	$	80,441	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	7,059	SY	$	11	$	80,441	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,279	LF	$	6	$	13,058	MEANS 32.16.19.10.0150	
SUBTOTAL					$	316,416		
Mobilization/Demobilization	5%				$	15,821	Source 3	
Subcontractor general conditions	20%				$	63,283	Source 3	
SUBTOTAL					*$*	*395,519*		
Replacement of Access Ramp and Parking Lots (Edgewater)								
Surveying	10	DY	$	1,500	$	15,000		
Backfilling and compaction of excavated clean fill material	21,204	CY	$	19	$	398,453	MEANS 17-03-0423	
Rough site grading	6,361	SY	$	1.75	$	11,121	MEANS 17-03-0101	Assume no fill needed for grading
Fine grading	6,361	SY	$	1.22	$	7,767	MEANS 17-03-0101	Assume no fill needed for grading
Surface course (2-inch)	6,361	SY	$	11	$	72,484	MEANS 32.12.16.13.0120	Asphalt pricing includes haul
Stabilized base course (2.5-inch)	6,361	SY	$	13	$	80,979	MEANS 32.12.16.13.0380	Concurrent site activities/dust control
Dense graded aggregate base course (4-inch)	6,361	SY	$	30	$	191,407	Source 3	
Replace access ramp	2,099	CY	$	1,200	$	2,519,015	CH2M Hill Estimate	
Dust suppression	20	DY	$	567	$	11,341	MEANS 32.12.16.13.0120	
Storm water control (3' x 3' culverts, rip-rap)	2	EA	$	11,638	$	23,275	MEANS 32.12.16.13.0380	
Concrete curb on perimeter	2,500	LF	$	22	$	55,000	MEANS 32.xx	Concrete curb and island
SUBTOTAL					$	3,385,844		
Mobilization/Demobilization	5%				$	169,292		
Subcontractor general conditions	20%				$	677,169		
SUBTOTAL					*$*	*4,232,305*		
Asphalt Cap (Edgewater - NZ-5)								
Backfilling and compaction of excavated clean fill material	5,025	CY	$	19	$	94,435	MEANS 17-03-0423	
Rough grading	1,508	SY	$	1.75	$	2,636	MEANS 17-03-0101	Replacement of removed material
Fine grading	1,508	SY	$	1.22	$	1,841	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	250	CY	$	54	$	13,566	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	1	EA	$	11,638	$	11,638	Source 4	
Asphalt stabilized binder course, 2" thick	1,508	SY	$	11	$	17,179	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	1,508	SY	$	11	$	17,179	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	495	LF	$	6	$	2,835	MEANS 32.16.19.10.0150	
SUBTOTAL					$	161,308		
Mobilization/Demobilization	5%				$	8,065	Source 3	
Subcontractor general conditions	20%				$	32,262	Source 3	
SUBTOTAL					*$*	*201,635*		
Upgrade Asphalt Cap (Block 93 North and Central)								
Fine grading	11,532	SY	$	1.22	$	14,081	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	1,920	CY	$	54	$	104,186	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	Included 2 storm water control systems per capped property
Asphalt stabilized binder course, 2" thick	11,532	SY	$	11	$	131,408	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	11,532	SY	$	11	$	131,408	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,081	LF	$	6	$	11,927	MEANS 32.16.19.10.0150	
SUBTOTAL					$	462,836		
Mobilization/Demobilization	5%				$	23,142	Source 3	
Subcontractor general conditions	20%				$	92,567	Source 3	
SUBTOTAL					*$*	*578,544*		
Upgrade Asphalt Cap (Block 94)								
Fine grading	2,322	SY	$	1.22	$	2,835	MEANS 17-03-0101	Assume no fill needed for grading
Gravel base, 6 inches	390	CY	$	54	$	21,163	MEANS 32.11.23.23.1511	
Storm water control (3' x 3' culverts, rip-rap)	6	EA	$	11,638	$	69,826	Source 4	
Asphalt stabilized binder course, 2" thick	2,322	SY	$	11	$	26,461	MEANS 32.12.16.13.0120	
Asphalt wear course, 2" thick	2,322	SY	$	11	$	26,461	MEANS 32.12.16.13.0380	
Install asphalt curb/berm on perimeter	2,500	LF	$	6	$	14,326	MEANS 32.16.19.10.0150	
SUBTOTAL					$	161,073		
Mobilization/Demobilization	5%				$	8,054	Source 3	
Subcontractor general conditions	20%				$	32,215	Source 3	
SUBTOTAL					*$*	*201,341*		
Compliance Monitoring and Health & Safety								
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$	12,772	Source 4	
Decon shed	24	MO	$	1,043	$	25,021	Source 4	
Air monitoring	90	DY	$	718	$	64,575	Source 4 + CH2M H&S	
PPE provisions for workers (Initial)	20	EA	$	252	$	5,038	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (Worker·Days)	10,560	EA	$	106	$	1,119,039	Source 4 + CH2M H&S	
SUBTOTAL					*$*	*1,226,445*		
CAPITAL SUBTOTAL - SOIL					$	84,368,237		
Contingency	25%				$	21,092,059	10% Scope + 10% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL					$	105,460,296		
Project Management	5%				$	5,273,015	**USEPA 2000, p. 5-13, >$10M**	
Remedial Design	6%				$	6,327,618	**USEPA 2000, p. 5-13, >$10M**	
Construction Management	6%				$	6,327,618	**USEPA 2000, p. 5-13, >$10M**	
SUBTOTAL					$	17,928,250		
Contractor Fees								
ODC & Subs	5%		$	105,460,296	$	5,273,015		
Labor	10%	max	$	17,928,250	$	1,792,825		
SUBTOTAL					$	7,065,840		
TOTAL CAPITAL COST - SOIL					**$**	**130,450,000**		
NAPL and ARSENIC								
NAPL Recovery								
NAPL Recovery in existing monitoring wells								
Product recovery pumps	3	EA	$	4,000	$	12,000		Positive displacement piston pump, 1HP motor, 0-7 GPM
SUBTOTAL					$	12,000		
Mobilization/Demobilization	5%				$	600		
Subcontractor general conditions	20%				$	2,400		
SUBTOTAL					*$*	*15,000*		
Excavation, Backfilling, & Soil Disposal								
Excavation of Tar Boils & NAPL Zones NZ-1 and portion of NZ-3								
Dig permits & utility markout	5	DAY	$	5,000	$	25,000	Source 3	
Excavation of soils (includes NAPL comingled with arsenic)	66,020	CY	$	30	$	1,960,796	Source 3	Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	79,224	CY	$	19	$	1,488,745	MEANS 17-03-0423	Assumes 1.2x excavated material required for compaction
Dust suppression	70	DY	$	567	$	39,695	MEANS 31.23.23.18.4500	Concurrent site activities/dust control
Odor suppression equipment rental	3	MO	$	10,000	$	30,000	Vendor	Assumes two rental units
Odor suppression material	37	DRUM	$	350	$	12,988	Vendor	Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	108,933	TN	$	70	$	7,625,317	Source 3	Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	108,933	TN	$	128	$	13,943,437	MEANS 33-19-7270	Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	132	EA	$	3,735	$	493,129	Source 4	1 sample per 500 cy of excavated material
Shoring around building	1,200	LF	$	62	$	74,400	Source 3	4'-5' depth
SUBTOTAL					$	25,693,508		
Mobilization/Demobilization	5%				$	1,284,675		
Subcontractor general conditions	20%				$	5,138,702		
SUBTOTAL					*$*	*32,116,884*		

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

Excavation of NAPL Zones NZ-2 and NZ-5							Removal of top 10-ft fill material covered above
Dig permits & utility markout	3	DAY	$ 5,000	$ 15,000	Source 3		
Excavation of soils	62,299	CY	$ 30	$ 1,850,284	Source 3		Assumes direct loading of materials
Certified clean fill for backfilling excavated areas	74,759	CY	$ 19	$ 1,404,838	MEANS 17-03-0423		Assumes 1.2x excavated material required for compaction
Dust suppression	70	DY	$ 567	$ 39,695	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
Odor suppression equipment rental	2	MO	$ 10,000	$ 23,333	Vendor		Assumes two rental units
Odor suppression material	24	DRUM	$ 350	$ 8,375	Vendor		Assumes 3-inch thick spray covering over treatment area (450 gal drum will cover 4000 ft3)
On-site stabilization of excavated soils with Portland Cement	102,794	TN	$ 70	$ 7,195,549	Source 3		Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil	102,794	TN	$ 128	$ 13,157,575	MEANS 33-19-7270		Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	125	EA	$ 3,735	$ 465,336	CH2M HILL Est.		1 sample per 500 cy of excavated material
Shoring around building	600	LF	$ 62	$ 37,200	CH2M HILL Est.		4'-5' depth
SUBTOTAL				$ 24,197,184			
Mobilization/Demobilization	5%			$ 1,209,859			
Subcontractor general conditions	20%			$ 4,839,437			
SUBTOTAL				*$ 30,246,480*			
Excavation of Arsenic Areas and HCAA							
Dig Permits & Utility Markout	5	DAY	$ 5,000	$ 25,000	Source 3		
Excavation of soil	38,263	CY	$ 30	$ 1,136,412	MEANS 17-03-0276		Assumes direct loading of materials, depths at 10ft - HCAA, 10ft for AA-1, 2ft for AA-7
Certified clean fill for backfilling excavated areas	45,916	CY	$ 19	$ 862,827	MEANS 17-03-0423		Assumes 1.2x excavated material required for compaction
Dust suppression	45	DY	$ 567	$ 25,518	MEANS 31.23.23.18.4500		Concurrent site activities/dust control
On-site stabilization of excavated soils with Portland Cement	63,134	TN	$ 70	$ 4,419,379	Source 3		Includes material & cost to incorporate so that soils meet TCLP limits for non-hazardous landfill, assume 1.65 tons/cy
Disposal of stabilized soil - Non-Haz Waste	63,134	TN	$ 128	$ 8,081,150	MEANS 33-19-7270		Assumes 100% of material for disposal as non-hazardous waste after stabilization (15% increase in volume from stabilization material)
Confirmation sampling	77	EA	$ 3,735	$ 285,801	CH2M HILL Est.		1 sample per 500 cy of excavated material
Sheet piling	12,600	SF	$ 62	$ 781,200	Source 3		Assumed sheet piling required along roadside for excavation
Shoring around building	10,080	LF	$ 62	$ 624,960	Source 3		4'-5' depth
SUBTOTAL				$ 16,242,247			
Mobilization/Demobilization	5%			$ 812,112			
Subcontractor general conditions	20%			$ 3,248,449			
SUBTOTAL				*$ 20,302,809*			
Compliance Monitoring and Health & Safety							
Install decon shed for workers (mobilization & demobilization)	1	LS	$ 12,772	$ 12,772	Source 4		
Decon shed	24	MO	$ 1,043	$ 25,021	Source 4		
Air monitoring based on air monitoring plan	30	MO	$ 20,000	$ 600,000	Source 4 + CH2M H&S		Assumes 8 stations
PPE provisions for workers (initial)	30	EA	$ 252	$ 7,557	Source 4		10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	15,840	EA	$ 106	$ 1,678,558	Source 4 + CH2M H&S		
SUBTOTAL				$ 2,323,908			
CAPITAL SUBTOTAL - NAPL and ARSENIC				$ 89,237,386			
Contingency	25%			$ 22,309,347	10% Scope + 10% Bid, USEPA 2000, p.5-10 & 5-11		
SUBTOTAL				$ 111,546,733			
Project Management	5%			$ 5,577,337	**USEPA 2000, p. 5-13, >$10M**		
Remedial Design	6%			$ 6,692,804	**USEPA 2000, p. 5-13, >$10M**		
Construction Management	6%			$ 6,692,804	**USEPA 2000, p. 5-13, >$10M**		
SUBTOTAL				$ 18,962,945			
Contractor Fees							
ODC & Subs	5%		$ 111,546,733	$ 5,577,337			
Labor	10%	max	$ 18,962,945	$ 1,896,294			
SUBTOTAL				$ 7,473,631			
TOTAL CAPITAL COST - NAPL and ARSENIC				**$ 137,980,000**			
GROUNDWATER							
General							
Preconstruction Investigations							
Pump test	1	LS	$ 230,000	$ 230,000			
Updates to the groundwater model	1	LS	$ 20,000	$ 20,000			
Bench-scale testing (Arsenic and NAPL)	2	EA	$ 75,000	$ 150,000			
Pilot-scale testing	1	LS	$ 150,000	$ 150,000			
SUBTOTAL				*$ 550,000*			
Replacement Monitoring Wells							
Soil borings	480	FT	$ 47	$ 22,320			Assumes 16 wells at 30-ft deep
2-inch PVC well casing	320	FT	$ 31	$ 9,994	MEANS 33-23-0101		Assumes 10-ft screen
2-inch PVC well screen	160	FT	$ 34	$ 5,398	MEANS 33-23-0256		
Well development	16	EA	$ 1,600	$ 25,600	Source 3		
Off-site disposal of soil cuttings from well installation	50	TN	$ 128	$ 6,400	MEANS 33-19-7270		Assumes material is disposed of as non-haz
Off-site disposal of development and decontamination water	10,000	GAL	$ 1.00	$ 10,000	Source 3		Assumes water is non-hazardous
SUBTOTAL				$ 79,712			
Mobilization/Demobilization	5%			$ 3,986	Source 3		
Subcontractor general conditions	20%			$ 15,942	Source 3		
SUBTOTAL				*$ 99,640*			
Subaqueous Reactive Barrier							
Site Preparation							
Erosion control	1	LS	$ 20,000	$ 20,000	Source 3		
Permitting	1	LS	$ 150,000	$ 150,000	Source 3		
Survey (pre and post installation)	2	EA	$ 2,500	$ 5,000	Source 3		
Staging pad	1	LS	$ 10,000	$ 10,000	Source 3		
Rental and operation of generator	1	MO	$ 17,050	$ 17,050	Source 3		$150/dy rent + $400/dy fuel = $550/dy
Rental of frac tank	1	MO	$ 500	$ 500	Source 3		
Portadam® Barriers - setup, teardown, and one month rental	1,200	LF	$ 100	$ 120,000	Source 3		
Portadam® Barriers - additional rental	2	WK	$ 15,600	$ 31,200	Source 3		
Cut-off timber piles allowance	1	LS	$ 150,000	$ 150,000	Source 3		
SUBTOTAL				$ 503,750			
Mobilization/Demobilization	5%			$ 25,188	Source 3		
Subcontractor general conditions	20%			$ 100,750	Source 3		
SUBTOTAL				*$ 629,688*			
Excavate 2' of Impacted Sediment							
Pump out area within Portadams®	30	DY	$ 1,275	$ 38,250	Source 3		750 GPM Godwin Dri-Prime 6" Model CD150M
Pump fuel and oil	1,500	GAL	$ 4	$ 6,000	Source 3		3.1 GPH Diesel Fuel x 24 hrs/day x 20 days
Excavate 2' sediment from dewatered area	11,000	CY	$ 25	$ 275,000	Source 3		Assumed area 160' x 950'
Transportation of material back to staging pad	11,000	CY	$ 4	$ 44,000	Source 3		
SUBTOTAL				$ 363,250			
Mobilization/Demobilization	5%			$ 18,163	Source 3		
Subcontractor general conditions	20%			$ 72,650	Source 3		
SUBTOTAL				*$ 454,063*			
Install RCM Mat & Armor Layer							
Organoclay RCM material	120	ROLL	$ 3,000	$ 360,000	Source 3		20% extra for overlap - 1,500 ft2/roll x $2.00/ft2
Install organoclay RCM	170,000	SF	$ 0.50	$ 85,000	Source 3		
12" sand armor layer (material only)	6,000	CY	$ 20	$ 120,000	Source 3		
Install 12" sand armor layer	6,000	CY	$ 7	$ 42,000	Source 3		
SUBTOTAL				$ 607,000			
Mobilization/Demobilization	5%			$ 30,350	Source 3		
Subcontractor general conditions	20%			$ 121,400	Source 3		
SUBTOTAL				*$ 758,750*			
Cutoff Wall with Hydraulic Containment							
Cutoff Wall at Shoreline							
Remove concrete decking	2,500	SF	$ 15	$ 37,500	Envirocon ROM estimate		
Rip-rap removal	1,040	CY	$ 25	$ 26,000	Envirocon ROM estimate		
Barrier wall at 115 River Road (under building)	1	LS	$ 600,000	$ 600,000	Envirocon ROM estimate		
Sealed sheet piling - shoreline	42,000	SF	$ 127	$ 5,334,000	Envirocon ROM estimate		
SUBTOTAL				$ 5,997,500			
Mobilization/Demobilization	5%			$ 299,875	Source 3		
Subcontractor general conditions	20%			$ 1,199,500			
SUBTOTAL				*$ 7,496,875*			
Wastewater Treatment Plant to Treat Water							System to treat 50 gpm
Pumping and Equalization of Influent Water							
8,000 gallon polypropylene equalization tanks	2	EA	$ 6,340	$ 12,679	MEANS 33-10-9661		Provides 8-hrs of storage at 100 gpm
Sludge pump	1	EA	$ 3,820	$ 3,820	Source 3		
Off-gas pump	1	EA	$ 1,322	$ 1,322	Source 3		
Effluent pump	4	EA	$ 4,221	$ 16,883	Source 3		50 GPM effluent pump (MAX @ 65'TDH)
NAPL pump	1	EA	$ 3,864	$ 3,864	Source 3		
Chemical feed systems (caustic and acid)	2	EA	$ 3,130	$ 6,260	Source 3		
SUBTOTAL				$ 44,829			
Mobilization/Demobilization	5%			$ 2,241	Source 3		
Subcontractor general conditions	20%			$ 8,966	Source 3		
SUBTOTAL				*$ 56,036*			

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

Removal of NAPLs and Solids								
Oil-water separator, 50 gpm	1	EA	$	16,910	$	16,910	ECHOS 19.04.0412	
Packaged 1,500 Gallon Steel Product Tank	1	EA	$	4,950	$	4,950	ECHOS 19.04.0604	
Packaged 20 gpm Oil Pump out unit w/controls	1	EA	$	7,670	$	7,670	ECHOS 33.13.1211	
Effluent pump	2	EA	$	5,231	$	10,462	MEANS 33-23-0555	50 GPM(one in operation and one in stand-by) (MAX@ 65'TDH)
Chemical feed systems	5	EA	$	3,130	$	15,650	ECHOS 33.32.0104	Caustic, acid, polymer, hydrogen peroxide, and ferric chloride
SUBTOTAL					$	55,642		
Mobilization/Demobilization	5%				$	2,782	Source 3	
Subcontractor general conditions	20%				$	11,128	Source 3	
SUBTOTAL					*$*	*69,553*		
Advanced oxidation								
Flocculation tanks connected in series	4	EA	$	4,572	$	18,287	MEANS 33-10-9658	
Chemical feed systems (caustic, acid, polymer, hydrogen peroxide, and ferric chloride)	5	EA	$	3,130	$	15,650	ECHOS 33.32.0104	
Waste sludge pumps (Non-clogging with double vortex impellers to handle heavy sludge)	2	EA	$	4,009	$	8,018	MEANS 33-29-0120	
SUBTOTAL					$	41,955		
Mobilization/Demobilization	5%				$	2,098	Source 3	
Subcontractor General Conditions	20%				$	8,391	Source 3	
SUBTOTAL					*$*	*52,444*		
Solid-liquid Separation								
Inclined plate clarifier (0.25 GPM/SF of area)	3	EA	$	26,520	$	79,560	ECHOS 33.13.0414	
100 GPM effluent pump for use with plate clarifier	1	EA	$	6,211	$	6,211	Source 3	
Sludge pump for use with plate clarifier	1	EA	$	3,130	$	3,130	Source 3	
Bag filters	2	EA	$	800	$	1,600	Source 3	
Offgas pumps for use with bag filters	2	EA	$	1,500	$	3,000	Source 3	
Effluent pumps for use with bag filters	2	EA	$	4,200	$	8,400	Source 3	
Liquid waste pump for use with sludge settling tank	1	EA	$	4,200	$	4,200	Source 3	
Filter press, 95% removal efficiency	2	EA	$	90,100	$	180,200	ECHOS 33.33.3013	10 CF w/sludge tanks, pumps, mixers, sludge cart
SUBTOTAL					$	286,301		
Mobilization/Demobilization	5%				$	14,315	Source 3	
Subcontractor general conditions	20%				$	57,260	Source 3	
SUBTOTAL					*$*	*357,877*		
Effluent Polishing								
Packaged 36,000 GPD water treatment plant	2	EA	$	32,400	$	64,800	ECHOS 19.01.0807	Includes GAC, pumps, tanks
Concrete Wet Well, 12'x36"	4	EA	$	9,200	$	36,800	ECHOS 19.02.0304	
Packaged Lift Station (70 gpm)	4	EA	$	9,950	$	39,800	ECHOS 19.02.0304	
Ion exchange units	2	EA	$	10,000	$	20,000	Source 3	One in operation and one standby/regeneration phase
SUBTOTAL			$	25,000	$	161,400		
Mobilization/Demobilization	5%				$	8,070	Source 3	
Subcontractor general conditions	20%				$	32,280	Source 3	
SUBTOTAL					*$*	*201,750*		
Building & Controls								
Building / HVAC / Electrical	1	EA	$	300,000	$	300,000	Source 3	
SCADA computer control system/Instrumentation	1	LS	$	400,000	$	400,000	Source 3	
SUBTOTAL					$	700,000		
Mobilization/Demobilization	5%				$	35,000	Source 3	
Subcontractor general conditions	20%				$	140,000	Source 3	
SUBTOTAL					*$*	*875,000*		
Piping, Instrumentation, & Equipment Installation								
2-inch schedule 80 PVC piping and fittings	3,000	LF	$	24	$	72,000	Source 3	
2-inch carbon steel piping	1,000	LF	$	67	$	67,000	Source 3	
Pipe supports and misc metals	1	LS	$	30,000	$	30,000	Source 3	
Install equipment	30	CD	$	3,000	$	90,000	Source 3	
Plumbing and fire suppression	1	LS	$	40,000	$	40,000	Source 3	
Lighting and misc electrical	1	LS	$	25,000	$	25,000	Source 3	
Chemical reagents	1	LS	$	20,000	$	20,000	Source 3	
Chemical storage tanks	5	EA	$	8,000	$	40,000	Source 3	550 Gallon double walled tanks
Chemical feed system I&C	1	LS	$	100,000	$	100,000	Source 3	Metering pumps, gauges, valves, and flow-meters
Installation of discharge point to surface water	1	LS	$	80,000	$	80,000		
SUBTOTAL					$	564,000		
Mobilization/Demobilization	5%				$	28,200	Source 3	
Subcontractor general conditions	20%				$	112,800	Source 3	
SUBTOTAL					*$*	*705,000*		
System Startup	1	LS	$	150,000	*$*	*150,000*	Source 3	
Compliance Monitoring and Health & Safety								
Install decon shed for workers (mobilization & demobilization)	1	LS	$	12,772	$	12,772	Source 4	
Decon shed	6	MO	$	1,043	$	6,255	Source 4	
Air monitoring	30	DY	$	718	$	21,525	Source 4 + CH2M H&S	
PPE provisions for workers (initial)	8	EA	$	252	$	2,015	Source 4	10 labor, 4 operator, 4 trucks, 2 supervisor
PPE provisions for workers (worker·days)	1,056	EA	$	106	$	111,904	Source 4 + CH2M H&S	
SUBTOTAL					$	154,471		
CAPITAL SUBTOTAL - GROUNDWATER					$	12,611,145		
Contingency	25%				$	3,152,786	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL					$	15,763,932		
Project Management	5%				$	788,197	**USEPA 2000, p. 5-13, $2-$10M**	
Remedial Design	8%				$	1,261,115	**USEPA 2000, p. 5-13, $2-$10M**	
Construction Management	6%				$	945,836	**USEPA 2000, p. 5-13, $2-$10M**	
SUBTOTAL					$	2,995,147		
Contractor Fees								
ODC & Subs	5%		$	15,763,932	$	788,197		
Labor	10%	max	$	2,995,147	$	299,515		
SUBTOTAL					$	1,087,711		
TOTAL CAPITAL COST - GROUNDWATER					**$**	**19,850,000**		
TOTAL CAPITAL COST					**$**	**288,280,000**		

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST		TOTAL		COSTING BASIS	ASSUMPTIONS
SOIL								
Capping								
Cap Repair	1	LS	$	25,344	$	25,344		Assumes 1% of initial capping cost to make repairs annually
Cap Inspection and Repair Report	100	HR	$	100	$	10,000		Biennial Report to NJDEP
SUBTOTAL					$	35,344		
Contingency	25%				$	8,836	10% Scope + 15% Bid	
SUBTOTAL					$	44,179		
Project Management	10%				$	4,418	**USEPA 2000, p. 5-13, <$100K**	
Remedial Design	20%				$	8,836	**USEPA 2000, p. 5-13, <$100K**	
Construction Management	15%				$	6,627	**USEPA 2000, p. 5-13, <$100K**	
SUBTOTAL					$	19,881		
Contractor Fees								
ODC & Subs	5%		$	44,179	$	2,209		
Labor	10%	max	$	19,881	$	1,988		
SUBTOTAL					$	4,197		
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)					**$**	**70,000**		
NAPL								
NAPL Recovery Wells								
Routine Operations, Maintenance, Monitoring	240	HR	$	100	$	24,000	Assumes part time operator performs duties for NAPL system (5 days/month)	
Parts Replacement / Consumables	1	LS	$	1,000	$	1,000		
Reporting	100	HR	$	100	$	10,000		
Off-site Disposal of NAPL	180	GAL	$	9.00	$	1,620		
SUBTOTAL					$	36,620		
Mobilization/Demobilization	5%				$	1,831		
Subcontractor general conditions	25%				$	9,155		
SUBTOTAL					*$*	*47,606*		
Contingency	25%				$	11,902	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL					$	59,508		
Project Management	8%				$	4,761	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%				$	8,926	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%				$	5,951	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL					$	19,637		

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

Contractor Fees						
ODC & Subs	5%		$ 59,508	$ 2,975		
Labor	10%	max	$ 19,637	$ 1,964		
SUBTOTAL				$ 4,939		
TOTAL ANNUAL O&M COST - NAPL Recovery Wells				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 1)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 2)				**$ 84,084**		
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)				**$ 84,084**	Assumes NAPL recovery will cease after 10 years	

GROUNDWATER

Groundwater Treatment System O&M	**Only During Excavation**					
Misc. Electrical Site Usage	12	MO	$ 215	$ 2,584	MEANS 33-42-0106	
Routine Operations, Maintenance, Monitoring	2,080	HR	$ 80	$ 166,400		40 hrs/week for one operator
Chemicals / Consumables	12	MO	$ 10,000	$ 120,000		
Electricity	394,200	KWH	$ 0.10	$ 39,420		
Replace Filters/ Carbon	12	MO	$ 5,000	$ 60,000		
Sampling and Analysis	12	MO	$ 1,055	$ 12,665	Source 4	Assumes one compliance sample per month
Reporting	200	HR	$ 100	$ 20,000	CH2M Est.	
Allowance for Misc. Items	1	LS	$ 84,214	$ 84,214		Assumes 20% of the capital costs
SUBTOTAL				$ 505,283		
Subcontractor general conditions	25%			$ 126,321		
SUBTOTAL				*$ 631,603*		
Contingency	25%			$ 157,901	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL				$ 789,504		
Project Management	6%			$ 47,370	**USEPA 2000, p. 5-13, $500K - $2M**	
Remedial Design	12%			$ 94,741	**USEPA 2000, p. 5-13, $500K - $2M**	
Construction Management	8%			$ 63,160	**USEPA 2000, p. 5-13, $500K - $2M**	
SUBTOTAL				$ 205,271		
Contractor Fees						
ODC & Subs	5%		$ 789,504	$ 39,475		
Labor	10%	max	$ 205,271	$ 20,527		
SUBTOTAL				$ 60,002		
TOTAL ANNUAL O&M COST - Groundwater Treatment System O&M				**$ 1,054,778**		
Groundwater Monitoring						
Groundwater Samples	40	EA	$ 1,000	$ 39,984	Source 4	MNA, VOCs, PCBs, SVOCs, metals
QC Samples	5	EA	$ 1,000	$ 4,998		
Groundwater Sampling, Level D						
Labor	300	HR	$ 80	$ 24,000		Assumes 3 persons for 5 days
Equipment - meters	1	LS	$ 2,000	$ 2,000	Source 3	
Consumables	1	LS	$ 3,000	$ 3,000	Source 3	
Data Validation	96	HR	$ 100	$ 9,600		
Reporting	240	HR	$ 100	$ 24,000		
Allowance for Misc. Items	1	LS	$ 10,758	$ 10,758		Assumes 10% of the capital costs
SUBTOTAL				$ 118,340		
Mobilization/Demobilization	5%			$ 5,917		
Subcontractor general conditions	25%			$ 29,585		
SUBTOTAL				*$ 153,842*		
Contingency	25%			$ 38,461	10% Scope + 15% Bid, USEPA 2000, p.5-10 & 5-11	
SUBTOTAL				$ 192,303		
Project Management	8%			$ 15,384	**USEPA 2000, p. 5-13, $100K - $500K**	
Remedial Design	15%			$ 28,845	**USEPA 2000, p. 5-13, $100K - $500K**	
Construction Management	10%			$ 19,230	**USEPA 2000, p. 5-13, $100K - $500K**	
SUBTOTAL				$ 63,460		
Contractor Fees						
ODC & Subs	5%		$ 192,303	$ 9,615		
Labor	10%	max	$ 63,460	$ 6,346		
SUBTOTAL				$ 15,961		
TOTAL ANNUAL O&M COST - Groundwater Monitoring				**$ 271,724**		
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)				**$ 2,141,672**	Quarterly for first year (Four GW sampling events)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)				**$ 1,326,501**	Annual for Years 2 to 30 (one GW sampling event per year)	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)				**$ 668,517**	Additional cost for years 10, 20, 30	

PERIODIC COST

SOIL, NAPL, GROUNDWATER, and VAPOR

DESCRIPTION	YEAR	QTY	UNIT	UNIT COST	TOTAL	NOTES
Reapplication for the CEA (Deed)	2	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	4	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	5	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	6	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	8	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	10	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	10	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	12	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	14	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	15	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Asphalt Cap Replacement	15	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	15	1	LS	$ 8,000	$ 8,000	
Reapplication for the CEA (Deed)	16	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	18	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	20	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	20	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	22	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	24	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	25	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	26	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Reapplication for the CEA (Deed)	28	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
5 year Review	30	1	LS	$ 15,000	$ 15,000	CH2M HILL support to EPA Review Document Preparation
Reapplication for the CEA (Deed)	30	1	LS	$ 25,000	$ 25,000	State- Classification Exemption Area
Asphalt Cap Replacement	30	1	LS	$ 20,000	$ 20,000	
Replace Fans/ Equipment @ 115 River Road	30	1	LS	$ 8,000	$ 8,000	
				Total	$ 521,000	
TOTAL PERIODIC COST					**$ 520,000**	

Alternative 6b: NAPL and Arsenic Excavation with Demolition of the 115 River Road Buildings — COST ESTIMATE SUMMARY - DRAFT

PRESENT VALUE

SOIL, NAPL, GROUNDWATER, and VAPOR

Discount Rate = 7.0%

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
CAPITAL COST - SOIL	0	$ 130,450,000	$ 130,450,000	1.000	$ 130,450,000	
CAPITAL COST - NAPL and ARSENIC	0	$ 137,980,000	$ 137,980,000	1.000	$ 137,980,000	
CAPITAL COST - GROUNDWATER	0	$ 19,850,000	$ 19,850,000	1.000	$ 19,850,000	
TOTAL ANNUAL O&M COST - SOIL (Year 1 - 30)	1 to 30	$ 2,100,000	$ 70,000	12.409	$ 868,633	
TOTAL ANNUAL O&M COST - NAPL (Year 1)	1	$ 84,084	$ 84,084	0.935	$ 78,583	
TOTAL ANNUAL O&M COST - NAPL (Year 2)	2	$ 84,084	$ 84,084	0.873	$ 73,442	
TOTAL ANNUAL O&M COST - NAPL (Year 3 - 10)	3 to 30	$ 2,354,355	$ 84,084	10.601	$ 891,377	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 1)	1	$ 2,141,672	$ 2,141,672	0.935	$ 2,001,563	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 2 - 30)	2 to 30	$ 38,468,536	$ 1,326,501	11.474	$ 15,220,888	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	10	$ 668,517	$ 668,517	0.508	$ 339,840	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	20	$ 668,517	$ 668,517	0.258	$ 172,757	
TOTAL ANNUAL O&M COST - GROUNDWATER (Year 10, 20, 30)	30	$ 668,517	$ 668,517	0.131	$ 87,821	
PERIODIC COST	2	$ 25,000	$ 25,000	0.873	$ 21,836	
PERIODIC COST	4	$ 25,000	$ 25,000	0.763	$ 19,072	
PERIODIC COST	5	$ 15,000	$ 15,000	0.713	$ 10,695	
PERIODIC COST	6	$ 25,000	$ 25,000	0.666	$ 16,659	
PERIODIC COST	8	$ 25,000	$ 25,000	0.582	$ 14,550	
PERIODIC COST	10	$ 40,000	$ 40,000	0.508	$ 20,334	
PERIODIC COST	12	$ 25,000	$ 25,000	0.444	$ 11,100	
PERIODIC COST	14	$ 25,000	$ 25,000	0.388	$ 9,695	
PERIODIC COST	15	$ 43,000	$ 43,000	0.362	$ 15,585	
PERIODIC COST	16	$ 25,000	$ 25,000	0.339	$ 8,468	
PERIODIC COST	18	$ 25,000	$ 25,000	0.296	$ 7,397	
PERIODIC COST	20	$ 40,000	$ 40,000	0.258	$ 10,337	
PERIODIC COST	22	$ 25,000	$ 25,000	0.226	$ 5,643	
PERIODIC COST	24	$ 25,000	$ 25,000	0.197	$ 4,929	
PERIODIC COST	25	$ 15,000	$ 15,000	0.184	$ 2,764	
PERIODIC COST	26	$ 25,000	$ 25,000	0.172	$ 4,305	
PERIODIC COST	28	$ 25,000	$ 25,000	0.150	$ 3,760	
PERIODIC COST	30	$ 68,000	$ 68,000	0.131	$ 8,933	
		$ 336,039,282			$ 308,210,967	

TOTAL PRESENT VALUE OF ALTERNATIVE 6b — $ 308,210,000

SOURCE INFORMATION

1. United States Environmental Protection Agency. July 2000. A Guide to Preparing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. (USEPA, 2000).
2a. R.S. Means Company. 2004. Environmental Remediation Cost Data - Unit Price, 10th Edition. R.S. Means Company and Talisman Partners, Ltd. Kingston, MA. (Includes materials, equipment, and labor)
2b. R.S. Means Company. Heavy Construction 2008. 22nd Edition.
2c. ECHOS (Environmental Cost Handling Options and Solutions). 2006. 12th Edition.
3. Historical CH2M HILL project cost information
4. Calculations using Historical CH2M HILL project cost information (separate worksheet)
5. R.S. Means Costworks 2010