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Project No. 112G00822

Mr. Curt Frye
Remedial Project Manager
Base Realignment and Closure
Program Management Office, Northeast
4911 South Broad Street
Philadelphia, PA 19112-1303

Reference: Contract No. N62467-04-D-0055
Contract Task Order (CTO) Number 418

Subject: ***Preliminary Alternatives Analysis Summary*** for
Installation Restoration Program (IRP) Site 16
Former Naval Construction Battalion Center, Davisville

Dear Mr. Frye:

Enclosed are 2 copies of the ***Preliminary Alternatives Analysis Summary*** for Installation Restoration Program (IRP) Site 16 at the Former Naval Construction Battalion Center (NCBC), Davisville. Copies of the document have been distributed as indicated below. It is anticipated that any comments received on this document will be addressed during the preparation of the Feasibility Study document for Site 16.

Please call me at 412-921-8887 if you have any questions regarding the enclosed document.

Sincerely,

Lee Ann Sinagoga
Contract Task Order (CTO) Manager

LAS/mlg
Enclosures (1)

cc: Mr. David Barney, BRAC Environmental Coordinator (1 copy)
Ms. Christine Williams, EPA Region I (4 copies)
Mr. Richard Gottlieb, RIDEM (1 copy)
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ALTERNATIVES ANALYSIS SUMMARY

This Alternatives Analysis Summary identifies the environmental media and Chemicals of Concern (COC) currently being evaluated in the on-going Feasibility Study (FS) for Site 16 and provides a preliminary screening of technologies and process options and a description of the remedial alternatives under consideration in the FS. This document is being forwarded to Region 1 of the United States Environmental Protection Agency (USEPA) and the State of Rhode Island Department of Environmental Management (RIDEM) to support and expedite risk management decisions for the Site 16.

1.0 EXPOSURE UNITS AND GENERAL CONCLUSIONS OF THE PHASE III RI

1.1 EXPOSURE UNITS

In the Phase III Remedial Investigation (RI) Report, risks at Site 16 were evaluated by dividing the site into exposure units (EUs). An EU is the area over which receptor activity is expected to occur and is medium specific. The risk for each EU was calculated using the contaminant concentrations present in the EU.

1.1.1 Soil Exposure Units

Based on the distribution of contaminants in soil, the North Central Area (NCA) was divided into two EUs: the northwest area (NWNCA) and the southeast area (SENCA). Therefore, including the Developed Area EU, three EUs were identified for evaluating exposures to soil in the Phase III RI.

- NWNCA - includes the former creosote dip tank area, former fire fighting training area, Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) Hot Spot Area, and the septic tank removal area.
- SENCA - includes the remainder of the Undeveloped Area.
- Developed Area - evaluated as a single EU, with the exception that the analytical results from one sample location south of former Building 41 (SB16-A3-12) were not included in the risk calculation. The polycyclic aromatic hydrocarbon (PAH) profile of the soil in the vicinity of this sample location is distinct from (and considerably higher than) concentrations reported for other locations in the Developed Area. The elevated concentrations of PAHs in the soil sample appear to be related to asphalt, and this location is pending further evaluation.

Surface soil and subsurface soil were evaluated separately for each of the three EUs. These EUs will be the units for which remedial decisions are based upon in the alternatives analysis.

1.1.2 Groundwater Exposure Units

Groundwater was evaluated as two EUs each consisting of the highly contaminated areas of the groundwater chlorinated Volatile Organic Compound (VOC) plume in the Developed Area and Undeveloped Area.

1.1.3 Soil Gas exposure Units

Soil gas was evaluated as three EUs: the Building E-107 area, the Undeveloped Area, and the former Building 41 area.

1.1.4 Sediment Exposure Units

Sediments in Allen Harbor were evaluated as a single EU.

1.2 CONCLUSIONS FROM THE RI

Conclusions of the Phase III RI for each media and exposure unit are summarized below. COCs for each medium and EU are described further in the following sections.

1.2.1 Soil

Based on risk, the area of contaminated soil warranting evaluation in the FS is limited to the NWNCA. There were no unacceptable risks associated with the soil in the SENCA and the Developed Area. The risks are summarized on the table below.

Area	Media	Exceeds USEPA's Target Risk Range of 10^{-4} to 10^{-6}	Exceeds RIDEM's Cumulative Risk Level of 10^{-5}
NWNCA	Surface Soil	No Exceedances	Lifelong Recreational Users
			Hypothetical Child Residents
			Hypothetical Lifelong Residents
	Subsurface Soil	Hypothetical Lifelong Residents	Industrial Workers
			Adult Recreational Users
			Lifelong Recreational Users
			Hypothetical Child Residents
			Hypothetical Adult Residents
			Hypothetical Lifelong Residents
SENCA	Surface Soil	No Exceedances	No Exceedances
	Subsurface Soil	No Exceedances	No Exceedances
Developed Area	Surface Soil	No Exceedances	No Exceedances
	Subsurface Soil	No Exceedances	No Exceedances

Note that waste material in the form of fragments of wood, metal, plastic, and ceramics were found dispersed through the soil in the NWNCA. This waste material appears to be well mixed with the soil and is not considered as a separate medium.

1.2.2 Groundwater

Unacceptable risk was identified for exposure to groundwater in both the Developed Area EU and the Undeveloped Area EU. However, because the groundwater VOC contamination is continuous through the entire site, the groundwater is evaluated as a single unit in the FS.

1.2.3 Soil Gas

The risk evaluation of soil gas data indicates that there is also potential for exposure to COCs migrating from groundwater to the indoor air of a building (e.g., a hypothetical further residence or industrial/commercial built atop the VOC plume). This exposure pathway must also be addressed in the FS. However, the VOC plume has not reached existing downgradient buildings; therefore, this exposure pathway is not currently complete.

1.2.4 Sediments

The potential for direct contact human exposure to sediments is very limited, so sediments are not considered as a medium of concern for the Site 16 FS.

1.2.5 Ecological Risk

No ecological receptors of concern for exposure to soil or groundwater were identified during the RI.

1.2.6 Summary

In summary, the FS addresses soil in the NWNCA and groundwater beneath the entire site.

2.0 SOIL

2.1 CHEMICALS OF CONCERN

COCs were selected based primarily on the cancer and noncancer risk estimates provided in the Human Health Risk Assessment (HHRA) section of the Phase III RI Report. Initially, receptors with cumulative cancer risk estimates exceeding 1.0×10^{-5} and/or target organ/target effect specific hazard indices exceeding 1 were identified. Then the detailed cancer and non-cancer risk estimates were examined to identify the risk drivers (i.e., chemicals contributing substantially to risk). For soil, Chemicals of Potential Concern (COPCs) were selected as COCs if their Incremental Lifetime Cancer Risks (ILCRs) were greater than 1.0×10^{-6} or if the chemical-specific hazard indices (HIs) contributed substantially to a total receptor HI greater than 1. It should be noted that the USEPA target cancer risk range is 1.0×10^{-6} to 1.0×10^{-4}; the RIDEM cumulative cancer risk benchmark ILCR is 1.0×10^{-5}. The cumulative non-cancer risk benchmark is 1 for both the USEPA and RIDEM (calculated on a target organ/effect specific basis).

The COCs initially selected for evaluation of soils in the FS are listed on Table 1-1 along with the chemical-specific clean-up goals currently under consideration in the FS. Both direct contact risks (as described above) and contaminant migration from soil to groundwater issues were considered in the selection of COCs to be addressed in the FS. For example, if a chemical was identified as COC for groundwater, the potential for chemical migration from soil to groundwater was also considered in the selection of soil COCs. The following items briefly summarize HHRA conclusions relevant to the FS for Site 16 (and selection of COCs) as well as the information presented in Table 1-1. Note that Site 16 is located in an area with an RIDEM groundwater classification of GB. (Groundwater with this classification may not be suitable for drinking water use without treatment due to known or presumed degradation.)

- The HHRA concluded that exposure to carcinogenic polynuclear aromatic hydrocarbons (cPAHs), dioxins/furans, and arsenic in surface soil in the NWNCA presents unacceptable risks to

hypothetical future residents and recreational users. Exposure to cPAHs and dioxins/furans in subsurface soil in the NWNCA also presents unacceptable risks to industrial workers, recreational users, and hypothetical future residents. cPAH and arsenic concentrations in NWNCA soils exceed RIDEM direct contact (DC) criteria for industrial/commercial (IC) receptors (i.e., RIDEM DC/IC criteria).

- Although dioxins/furans in soils were selected as COCs in the Phase III RI, they will not be further addressed in the Site 16 FS because the maximum detected dioxin/furan concentrations in soils do not exceed the USEPA goal of 1 µg/kg (expressed as 2,3,7,8-tetrachlorodibenzodioxin equivalents) presented in OSWER Directive 9200.4-26 (USEPA, 1998).

- Several additional soil contaminants (trichloroethene [TCE], tetrachloroethene, [PCE] cis-1,2-dichloroethene [cis-1,2-DCE], vinyl chloride [VC], benzene, lead, naphthalene, 2-methylnaphthalene, and total petroleum hydrocarbons [TPH]) were initially evaluated for inclusion in the FS even though they were not identified as direct contact risk COCs in the Phase III RI. TCE, PCE, cis-1,2-DCE, and VC are primary groundwater COCs and/or TCE degradation products. These VOCs and naphthalene and 2-methylnaphthalene (also selected as GW COCs) were detected at maximum concentrations exceeding RIDEM LC (GA) but not RIDEM LC (GB). These organics in soils are not further addressed in the FS.

- The Phase III RI identified the BTEX Hot Spot Area in the NWNCA. In the BTEX Hot Spot Area, concentrations of benzene, toluene, ethylbenzene, xylenes, and lead were much greater than in other parts of the NWNCA. Therefore, the evaluation of remedial alternatives in the BTEX Hot Spot Area needs to consider these contaminants. In the BTEX Hot Spot Area, benzene and lead were also identified as COCs. Benzene was selected as a groundwater COC, was detected at a maximum concentration exceeding the RIDEM LC (GB), and is selected for further evaluation in the FS. The lead results in the BTEX Hot Spot Area were evaluated with the IBUEK lead model. This evaluation showed that risk estimates for lead in soils in the immediate vicinity of the Hot Spot Area would exceed acceptable levels when a hypothetical future resident is evaluated as the receptor of concern. In addition, the highest concentrations of lead detected in the BTEX Hot Spot Area at concentrations exceed the RIDEM DC/IC criterion.

- Total petroleum hydrocarbons (TPHs) were detected at concentrations exceeding RIDEM DC/IC and LC criteria. (It should be noted that the groundwater table at Site 16 is shallow. Most VOC concentrations exceeding LC criteria were actually reported for soil samples collected in the saturated zone.)

In summary, the following soil COCs for each EU will be addressed by remedial alternatives in the FS based on the unacceptable risk estimates for the NWNCA and exceedances of RIDEM DC/IC and/or RIDEM GB criteria:

NWNCA (excluding BTEX Hot Spot Area)

- cPAHs (as benzo(a)pyrene equivalents)
- Arsenic

BTEX Hot Spot Area)

- cPAHs (as benzo(a)pyrene equivalents)
- Arsenic
- Lead
- Benzene

SENCA

- No COCs – not further evaluated in the FS based on exposure to soil.

Developed Area

- No COCs – not further evaluated in the FS based on exposure to soil.

TPH will also be considered in the NWNCA, including the BTEX Hot Spot Area. Although TPH is not a contaminant under CERCLA, there are several locations where TPH concentrations are greater than RIDEM direct exposure and leachability criteria. In most of these locations, other COCs are present at concentrations requiring remediation.

The current land use for Developed Area of Site 16 is commercial/industrial. The anticipated future land use for the Undeveloped Area of Site 16 is also commercial/industrial. Consequently, RIDEM DC/IC or RIDEM LC (GB) criteria are currently being evaluated as potential cleanup goals (Table 1-1 for soils).

2.2 SOIL REMEDIAL ACTION OBJECTIVES

To protect the public from potential current and future health risks, as well as to protect the environment, the following Remedial Action Objectives (RAOs) have been developed for soil in the NWNCA and the BTEX Hot Spot Area at Site 16.

NWNCA (excluding BTEX Hot Spot Area)

Soil RAO No. 1: Prevent exposure of industrial workers to surface and subsurface soil in the NWNCA (excluding the BTEX Hot Spot Area) containing concentrations of COCs (cPAHs and arsenic) and TPH that cause unacceptable risk (total site ILCR greater than 1×10^{-5} or HI greater than 1).

Soil RAO No. 2: Prevent exposure of hypothetical residential users to surface and subsurface soil in the NWNCA (excluding the BTEX Hot Spot Area) containing concentrations of COCs (cPAHs and arsenic) and TPH that cause unacceptable risk (total ILCR greater than 1×10^{-5} or HI greater than 1).

BTEX Hot Spot Area

Soil RAO No. 3: Prevent exposure of industrial workers to surface and subsurface soil in the BTEX Hot Spot Area containing concentrations of COCs (cPAHs, lead, and arsenic) and TPH that cause unacceptable risk (total site ILCR greater than 1×10^{-5} or HI greater than 1).

Soil RAO No. 4: Prevent migration of surface and subsurface soil contaminants (benzene) in the BTEX Hot Spot Area to groundwater that would result in concentrations greater than acceptable groundwater criteria (i.e., RIDEM GB classification).

Soil RAO No. 5: Prevent exposure of hypothetical residential users to surface and subsurface soil in the BTEX Hot Spot Area containing concentrations of COCs (cPAHs, lead, and arsenic) and TPH that cause unacceptable risk (total ILCR greater than 1×10^{-5} or HI greater than 1).

There are no RAOs for soil for the SENCA and the Developed Area, although LUCs will be continued to maintain the site for industrial uses only.

2.3 SCREENING OF TECHNOLOGY AND PROCESS OPTIONS

Technologies and process options for soil were screened based on implementation with respect to site conditions and COCs. The screening was first conducted at a preliminary level to focus on relevant

technologies and process options, then the screening was conducted at a more detailed level based on certain evaluation criteria. The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening were effectiveness, implementability, and cost. Finally, process options are selected to represent the technologies that have passed the detailed evaluation and screening.

Table 2-1 summarizes the preliminary screening of technologies and process options applicable to soil. The table presents the general response actions (GRAs), identifies the technologies and process options, and provides a brief description of each process option followed by screening comments. Process options and technologies retained from preliminary screening were evaluated further in the detailed screening step.

After detailed screening, the following technologies and process options, under the GRAs as noted, were retained for the development of soil remedial alternatives:

- No Action
- Limited Action: Land Use Controls (LUCs)
- Containment: Cover and/or Cap
- Removal: Excavation
- Ex-Situ Treatment: Size Reduction and Screening
- Disposal: Off-Site Non-Hazardous Landfill (Off-Site Hazardous Waste Landfill, if needed)

2.4 ALTERNATIVES

Based on the detailed screening of soil technologies and process, the following soil remedial alternatives are being evaluated in the Site 16 FS. For all alternatives, the active remediation components (e.g., excavation) apply only to the contaminated soil in the NWNCA.

- Alternative S-1: No Action
- Alternative S-2: Soil Cover and/or Cap, Monitoring, and LUCs
- Alternative S-3: Excavation, Off-site Treatment and Disposal, and LUCs
- Alternative S-4: Soil Cover, Selected Excavation and Disposal, and LUCs

Alternative S-1 was analyzed to serve as a baseline for comparison to other alternatives, as required by Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). Alternative S-2 was developed as the least aggressive alternative that minimizes exposure pathways. Alternative S-3 was developed and analyzed to provide removal of COC concentrations greater than RIDEM DC/IC Exposure and GB LC. Alternative S-4 was developed to provide removal of soil with contaminant concentrations greater than leachability criteria, removal of contaminants to a depth of 2 feet to maintain existing ground surface contours after placement of cover, and exposure pathway and LUC minimization. Table 2-2 summarizes the soil alternatives.

An alternative for unrestrictive property use was not considered. A significant portion of Site 16, has already been transferred (i.e., the Developed Area), and the current/anticipated future uses of the site is industrial/commercial. The NCA already has LUCs to prevent residential development. Such controls will be a component of any future, land-transfer documentation prepared for Site 16 and will be included as part of the soil alternatives.

3.0 GROUNDWATER

3.1 CHEMICALS OF CONCERN

COCs were selected based primarily on the cancer and noncancer risk estimates provided in the HHRA section of the Phase III RI Report. Initially, receptors with cumulative cancer risk estimates exceeding 1.0×10^{-5} and/or target organ/target effect specific hazard indices exceeding 1 were identified. Then the detailed cancer and non-cancer risk estimates were examined to identify the risk drivers (i.e., chemicals contributing substantially to risk). For groundwater, a COPC was selected as a COC if the ILCR was greater than 1.0×10^{-6}, if the concentration was greater than the Safe Drinking Water Act (SDWA) Maximum Contaminant Level (MCL), or if the chemical-specific HIs contributed substantially to a total receptor HI greater than 1. It should be noted that the USEPA target cancer risk range is 1.0×10^{-6} to 1.0×10^{-4}; the RIDEM cumulative cancer risk benchmark ILCR is 1.0×10^{-5}. The cumulative non-cancer risk benchmark is 1 for both the USEPA and RIDEM (calculated on a target organ/effect specific basis).

The COCs initially selected for evaluation of groundwater in the FS are listed on Table 1-2 along with the chemical-specific clean-up goals currently under consideration in the FS. Direct contact risks issues were considered in the selection of groundwater COCs. The following items briefly summarize HHRA conclusions relevant to the FS for Site 16 (and selection of COCs) as well as the information presented in Table 1-2. Note that Site 16 is located in an area with an RIDEM groundwater classification of GB.

(Groundwater with this classification may not be suitable for drinking water use without treatment due to known or presumed degradation.)

- Undeveloped Area EU - the HHRA concluded that exposure to PCE, TCE, vinyl chloride, cPAHs, 2-methylnaphthalene, naphthalene, hexachlorobenzene, aluminum, arsenic, lead, and manganese in groundwater presents unacceptable risks to hypothetical future residential receptors that may use the groundwater as a domestic water supply source.

- Developed Area EU - the HHRA concluded that exposure to 1,2-dichloroethane (DCA), benzene, chloroform, PCE, TCE, vinyl chloride, aluminum, antimony, arsenic, iron, lead, manganese, silver, and thallium in groundwater also present unacceptable risks to hypothetical residential users. Many (but not all) of these chemicals were also detected at concentrations exceeding SDWA MCLs or RIDEM GA criteria. TCE was detected at a maximum concentration exceeding RIDEM GB criteria. TCE and VC were also selected as COCs for the vapor intrusion pathway (i.e., the migration of vapors from the subsurface into the indoor air of a hypothetical building).

- Although several metals were identified as COCs in groundwater, most elevated metal concentrations appear to be the result of elevated suspended solids concentrations in unfiltered groundwater samples. In most cases where total (unfiltered) metals concentrations were elevated, the corresponding dissolved (filtered) metal concentrations were less than screening criteria or SDWA MCLs. Based on this consideration, the only metal in groundwater with dissolved concentrations consistently greater than MCLs is arsenic in shallow groundwater in the NCA.

- Of the COCs in groundwater identified in the Phase III RI, several will not be further addressed in the FS for Site 16. All concentrations of 1,2-DCA and chloroform are less than their respective SDWA MCLs. Hexachlorobenzene was only detected in one well at an estimated concentration equal to its SDWA MCL. All Benzo(a)Pyrene (BaP) and Benzo(a)Pyrene equivalent (BaP Eq) concentrations are less than the SDWA MCL. Dissolved arsenic concentrations were less than the MCL in the Developed Area EU.

In summary, the following groundwater COCs will be addressed by remedial alternatives developed in the FS:

Undeveloped Area EU

- PCE
- TCE
- cis-1,2-DCE
- VC
- 2-Methylnaphthalene
- Naphthalene
- Arsenic

Developed Area EU

- PCE
- TCE
- cis-1,2-DCE
- VC
- Benzene

Note that cis-1,2-DCE has been included as a COC because it is a degradation product of TCE, and the potential concentration of cis-1,2-DCE could be greater than the RIDEM GB criterion.

The FS will address the chlorinated VOC plume beneath most of the site and the locations of high arsenic concentrations located in the shallow groundwater in the NCA.

As noted, Site 16 is located in an area with an RIDEM groundwater classification of GB. Consequently, for most chemicals, RIDEM GB criteria are currently being evaluated as potential cleanup goals (Table-2 or groundwater).

LUCs are required to address the hypothetical future residential land use and the migration of subsurface vapors into the indoor air of a hypothetical structure built atop the chlorinated VOC groundwater plume.

3.2 REMEDIAL ACTION OBJECTIVES

To protect the public from potential current and future health risks, as well as to protect the environment, the following RAOs have been developed for groundwater at Site 16.

Groundwater RAO No. 1: Prevent exposure of industrial workers and hypothetical residents to groundwater containing concentrations of COCs that cause unacceptable risk (total ILCR greater than 1×10^{-5} or HI greater than 1).

Groundwater RAO No. 2: Ensure that the discharge of groundwater to Allen Harbor and Narragansett Bay continues to pose no unacceptable risks.

Groundwater RAO No. 3: Prevent exposure of industrial workers and hypothetical residents to VOCs resulting from vapor intrusion into buildings that cause unacceptable risk (total ILCR greater than 1×10^{-5} or HI greater than 1).

3.3 SCREENING OF TECHNOLOGY AND PROCESS OPTIONS

Technologies and process options for groundwater were screened based on implementation with respect to site conditions and COCs. The screening was first conducted at a preliminary level to focus on relevant technologies and process options, then the screening was conducted at a more detailed level based on certain evaluation criteria. The evaluation criteria for detailed screening of technologies and process options that have been retained after the preliminary screening were effectiveness, implementability, and cost. Finally, process options are selected to represent the technologies that have passed the detailed evaluation and screening.

Table 3-1 summarizes the preliminary screening of technologies and process options applicable to groundwater. The table presents the GRAs, identifies the technologies and process options, and provides a brief description of each process option followed by screening comments. Process options and technologies retained from preliminary screening were evaluated further in the detailed screening step.

After detailed screening, the following technologies and process options, under the GRAs as noted, were retained for the development of groundwater remedial alternatives:

- No Action
- Limited Action: LUCs, Monitoring, Monitored Natural Attenuation (MNA)
- Removal: Extraction
- In-Situ Treatment: Enhanced Bioremediation, Chemical Oxidation, Permeable Reactive Barrier (PRB)
- Ex-Situ Treatment: Filtration, Air Stripping, Liquid-Phase Granular Activated Carbon (GAC) Adsorption, Vapor-Phase GAC Adsorption, pH Adjustment
- Disposal: Surface Water Discharge

3.4 ALTERNATIVES

Based on the detailed screening of groundwater technologies and process options, the following groundwater remedial alternatives are being evaluated in the Site 16 FS:

- Alternative G-1: No Action.
- Alternative G-2: MNA and LUCs.
- Alternative G-3: In-Situ Chemical Oxidation (High-TCE Concentration Areas), MNA, and LUCs.
- Alternative G-4: Enhanced Bioremediation (High-TCE Concentration Areas), MNA, and LUCs.
- Alternative G-5: PRBs (Overburden High-TCE Concentration Areas), In-Situ Enhanced Bioremediation (Bedrock and Remote High-TCE Concentration Areas), MNA, and LUCs.
- Alternative G-6: Groundwater Extraction and Treatment (High-TCE Concentration Areas), MNA, and LUCs.

Alternative G-1 was developed and analyzed to serve as a baseline for comparison to other alternatives, as required by CERCLA and the NCP. Alternative G-2 was developed as a limited action approach. Alternatives G-3 through G-6 were developed and analyzed to evaluate active remediation of the areas with the highest TCE concentrations. The high-TCE concentration area treatment in Alternatives G-4 and G-5 would last several years as groundwater flows through the treatment zones, and treatment of high-TCE concentration areas in Alternative G-3 would be completed in less than 1 year. The duration of treatment in Alternative G-6 is expected to be shorter than Alternatives G-4 and G-5 but longer than G-3. The high concentrations of arsenic are addressed by MNA in Alternatives G-2 through G-6. Table 3-2 summarizes groundwater alternatives.

TABLE 1-1

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR SOILS
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk?	COC Based on Migration from Soils to Groundwater Concerns (i.e., Chemical is a GW COC AND is present in soil at concentrations > RIDEM Leachate Criteria)?	COC Based on Professional Judgment?	Background Concentration (mg/kg)	Risk-Based Clean-up (RBC) Goals - Industrial/Commercial (mg/kg)	RIDEM Direct Contact (DC) Criteria - Industrial/Commercial (mg/kg)	RIDEM Leachability Criteria (LC) (mg/kg)	Comments
Carcinogenic PAHs	X			NA	1E-06 to 1E-04 Cancer Risk Range: 0.21 to 21	0.8 (The RIDEM guidance indicates that this is not strictly a risk-based goal.)	240 A	**COC addressed in FS.** Primary risk driver for surface and shallow subsurface soils in the North-Central Area. RIDEM DC I/C criterion is being evaluated as the potential clean-up goal (approximates 1E-05 RBC Goal and is below leachability criteria).
Dioxins/Furans	X			NA	1E-06 to 1E-04 Cancer Risk Range: 1.8E-05 to 1.8E-03 Non-cancer RBC (Hazard Index =1): 8.5E-04 (ORNL RSLs presented.)	NA	NA	**COC not further addressed in the FS.** Concentrations detected do not exceed the USEPA goal of 1 ug/kg (OSWER Directive 9200.4-26, 1998).
Arsenic	X			Formal background soils study has not been conducted for Site 16. However, a limited NCBC Basewide background dataset is available.	1E-06 to 1E-04 Cancer Risk Range: 1.6 to 160 Non-cancer RBC (Hazard Index =1): 260 (ORNL RSLs presented.)	7 (The RIDEM guidance indicates that this is representative background for the State of Rhode Island.)	NA	**COC addressed in FS.** A primary risk driver for surface and shallow subsurface soils in the North-Central Area. A formal background study has not been conducted for Site 16 soils. However, the RIDEM DC I/C criterion is similar to the maximum detected concentration reported for 7 Base-wide soil samples historically identified as background for NCBC Davisville. The RIDEM DC I/C criterion is being evaluated as the potential clean-up goal and appears to be in general agreement with available background information for NCBC and Site 16.
Lead			X	Formal background soils study has not been conducted for Site 16. However, a limited NCBC Basewide background dataset is available.	Typical industrial worker: 800 (Assumes 250 days/year) 1000 (Assumes 150 days/year) Construction worker: (Assumes 250 days/year) 500 (Assumes 150 days/year) 800	500	NA	**COC addressed in FS.** Although lead was not formally identified as a COC in the RI, elevated lead concentrations in subsurface soils are associated with the BTEX "hot spot" area in the North-Central portion of Site 16 and lead is the most obvious site-related metal contaminant in Site 16 soils. Conservatively, lead will be included in the FS evaluation pending further delineation of the BTEX "hot spot" and associated areas and pending SPLP evaluations of the potential for leaching. It should be noted that the currently available groundwater data do not indicate significant lead migration from soils to groundwater. The RIDEM DC I/C criterion is recommended as the clean-up goal; it is similar to the RBC goal calculated for a construction worker assuming 250 days/year exposure frequency. (Note: The Site 16 risk assessment assumed 150 days/year.)

TABLE 1-1

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR SOILS
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk?	COC Based on Migration from Soils to Groundwater Concerns (i.e., Chemical is a GW COC AND is present in soil at concentrations > RIDEM Leachate Criteria)?	COC Based on Professional Judgment?	Background Concentration (mg/kg)	Risk-Based Clean-up (RBC) Goals - Industrial/Commercial (mg/kg)	RIDEM Direct Contact (DC) Criteria - Industrial/Commercial (mg/kg)	RIDEM Leachability Criteria (LC) (mg/kg)	Comments
Benzene		X		NA	1E-06 to 1E-04 Cancer Risk Range: 5.6 to 560 Non-cancer RBC (Hazard Index =1): 470 (ORNL RSLs presented)	200	0.2 A **4.3 B**	**COC addressed in FS.** Benzene was selected as a GW COC in the RI. Although not identified as a DC COC for soils, the RI documented that benzene was detected in soils of the BTEX "hot spot" area at concentrations exceeding the SSLs for GW protection and the RIDEM GB Leachability Criteria. The RIDEM GB Leachability Criteria approximates the 1E-06 RBC goal, addresses a primary contaminant pathway of concern, and is being evaluated as the potential clean-up goal. Only the maximum benzene concentration detected (4.8 mg/kg) exceeds the recommended clean-up goal.
Naphthalene		X		NA	1E-06 to 1E-04 Cancer Risk Range: 20 to 2000 Non-cancer RBC (Hazard Index =1): 670 (ORNL RSLs presented.)	10,000	0.8 A Not calculated B	**COC not further addressed in FS.** Naphthalene was selected as a GW COC in the RI. Although not identified as a DC COC for soils, the RI documented that naphthalene was detected in soils of the North-Central area at concentrations exceeding SSLs for GW protection and the RIDEM GA Leachability Criterion. In several cases, naphthalene contamination is co-located with CPAH contamination and soils containing naphthalene concentrations greater than 0.8 mg/kg are already targeted for "action" because of the presence of the CPAH contamination.
2-Methyl Naphthalene				NA	Non-cancer RBC (Hazard Index =1): 4100 (ORNL RSLs presented.)	10,000	Not calculated A, B.	**COC not further addressed in FS.** 2-Methyl naphthalene was selected as a GW COC in the RI. The compound was not identified as a DC COC for soils. There are no published RIDEM GA or GB Leachability Criterion for 2-methyl naphthalene. This contaminant appears to be generally co-located with CPAH contamination.
Trichloroethene (TCE)		X		NA	1E-06 to 1E-04 Cancer Risk Range: 14 to 1400 (ORNL RSLs presented.)	520	0.2 A 20 **B**	**COC not further addressed in FS.** TCE is the predominant groundwater COC for the RI at Site 16. However, the vast majority of the residual CVOC contamination has migrated to the saturated zone/groundwater. The RIDEM GB Leachability criteria approximates the 1E-06 RBC goal, addresses a primary contaminant migration pathway of concern, and was evaluated as the potential clean-up goal. None of the Site 16 concentrations exceed the recommended goal. However, the TCE concentration at location SB16-A3-06 (17 mg/kg) does approach the GB criterion.

TABLE 1-1

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR SOILS
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk?	COC Based on Migration from Soils to Groundwater Concerns (i.e., Chemical is a GW COC AND is present in soil at concentrations > RIDEM Leachate Criteria)?	COC Based on Professional Judgment?	Background Concentration (mg/kg)	Risk-Based Clean-up (RBC) Goals - Industrial/Commercial (mg/kg)	RIDEM Direct Contact (DC) Criteria - Industrial/Commercial (mg/kg)	RIDEM Leachability Criteria (LC) (mg/kg)	Comments
Tetrachloroethene (PCE)		X		NA	1E-06 to 1E-04 Cancer Risk Range: 2.7 to 270 Non-cancer RBC (Hazard Index =1): 2400 (ORNL RSLs presented.)	110	0.1 A 4.2 B	**COC not further addressed in FS.** PCE is a groundwater COC for the RI at Site 16. (However, the vast majority of the residual CVOC contamination has migrated to the saturated zone/groundwater). The RIDEM GB Leachability criteria approximates the 1E-06 RBC goal, addresses a primary contaminant migration pathway, and was evaluated as the potential clean-up goal. None of the residual PCE concentrations in Site 16 soils exceed the GB criterion. The maximum concentration in the BTEX "hot spot" area does exceed the GA criterion.
cis-1,2-Dichloroethene			X	NA	Non-cancer RBC (Hazard Index =1): 10,000 (ORNL RSLs presented.)	10,000	1.7 A 60 B	**COC not further addressed in FS.** Cis-1,2-DCE was selected as a groundwater COC at Site 16 because it is a major degradation product for TCE. (However, the vast majority of the residual CVOC contamination has migrated to the saturated zone/groundwater.) The RIDEM GB Leachability criterion addresses a primary contaminant migration pathway of concern and was evaluated as the potential clean-up goal. None of the Site 16 soil concentrations exceed GB criterion. Few exceed the GA criterion.
Vinyl Chloride				NA	1E-06 to 1E-04 Cancer Risk Range: 1.7 to 170 Non-cancer RBC (Hazard Index =1): 400 (ORNL RSLs presented.)	3	0.3 A	**COC not further addressed in FS.** VC is one of the groundwater contaminants at Site 16 and a degradation product for TCE. (However, the vast majority of the residual contamination has migrated to the saturated zone/groundwater.) The RIDEM GA Leachability criterion not exceeded.
Total Petroleum Hydrocarbons (TPH)			X	NA	Not calculated. Toxicity criteria (cancer slope factors and reference doses) have not been published by the EPA.	2500	2500	**COC addressed in FS.** TPH is an obvious site-related contaminant for Site 16; TPH and PAH contamination are typically co-located. Although cancer and non-cancer risks are not typically calculated for TPH. The RIDEM DC criterion is being evaluated as the potential clean-up goal as there are no EPA recommended toxicity criteria for this parameter (i.e., an RBC goal cannot be calculated.)

TABLE 1-2

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk (i.e., Domestic Use of Groundwater)?	COC Based on Vapor Intrusion Pathway ?	COC Based on Professional Judgment?	Background Concentration (ug/L)	Risk-Based Clean-up (RBC) Goals - Residential Land Use Scenario (ug/L)	RIDEM GA/GB (ug/L)	Safe Drinking Water Act Maximum Contaminant Level (SDWA MCL) (ug/L)	Comments
Trichloroethene (TCE)	X	X		NA	1E-06 to 1E-04 Cancer Risk Range: 4.6 to 460	5/540 Calculated goal based for industrial worker based on vapor intrusion model: 250 (1E-05 Cancer risk goal).	5	**COC addressed in FS.** Primary CVOC in the groundwater underlying Site 16. The calculated risk-based goal for the vapor intrusion pathway is more conservative than the RIDEM GB goal and, thus, is being evaluated as a potential clean-up goal. Institutional controls will be recommended to prevent domestic use of groundwater and to require certain engineering controls on buildings to mitigate vapor intrusion into hypothetical future buildings. (If the groundwater was designated GA, the recommended clean-up goal would be 5, the current SDWA MCL.)
cis-1,2-Dichloroethene			X	NA	Non-cancer RBC (Hazard Index =1): 145	70/2,400	70	**COC addressed in FS.** Cis-1,2-DCE was not selected as a GW COC in the RI. However, cis-1,2-DCE is a primary degradation product of TCE, the primary site contaminant. The current RIDEM GB criterion is being evaluated as a potential clean-up goal. Institutional controls will be recommended to prevent domestic use of groundwater. (If the groundwater was designated as GA, the recommended clean-up goal would be 70, the current SDWA MCL.)
Vinyl Chloride	X	X		NA	1E-06 to 1E-04 Cancer Risk Range: 0.09 to 9 Non-cancer RBC (Hazard Index =1): 46	2/- Calculated goal based for industrial worker based on vapor intrusion model: 12 (1E-05 Cancer risk goal)	2	**COC addressed in FS.** VC was selected as a GW COC in the RI. A GB criterion has not been published; the calculated risk-based goal for the vapor intrusion pathway is being evaluated as a potential clean-up goal. Institutional controls will be recommended to prevent domestic use of groundwater and to require certain engineering controls to mitigate vapor intrusion into hypothetical future buildings. (If the groundwater was designated as GA, the recommended clean-up goal would be 2, the current SDWA MCL.)
Tetrachloroethene	X			NA	1E-06 to 1E-04 Cancer Risk Range: 0.09 to 9 Non-cancer RBC (Hazard Index =1): 120	5/150	5	**COC addressed in FS.** PCE was selected as a GW COC in the RI. The current RIDEM GB clean-up criteria is being evaluated as a potential clean-up goal. Institutional controls will be recommended to prevent domestic use of groundwater. (If the groundwater was designated as GA, the recommended clean-up goal would be 5, the current SDWA MCL.)

TABLE 1-2

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk (i.e., Domestic Use of Groundwater)?	COC Based on Vapor Intrusion Pathway ?	COC Based on Professional Judgment?	Background Concentration (ug/L)	Risk-Based Clean-up (RBC) Goals - Residential Land Use Scenario (ug/L)	RIDEM GA/GB (ug/L)	Safe Drinking Water Act Maximum Contaminant Level (SDWA MCL) (ug/L)	Comments
Benzene	X			NA	1E-06 to 1E-04 Cancer Risk Range: 1.1 to 110 Non-cancer RBC (Hazard Index =1): 130	5/140	5	**COC formally addressed in FS.** Benzene was selected as a GW COC in the RI. The current RIDEM GB clean-up criteria is being evaluated as a potential clean-up goal. Institutional controls will be recommended to prevent domestic use of groundwater. (If the groundwater was designated as GA, the recommended clean-up goal would be 5, the current SDWA MCL.)
1,2-Dichloroethane (1,2-DCA)	X			NA	1E-06 to 1E-04 Cancer Risk Range: 0.72 to 72	5/110	5	**COC not further addressed in FS.** All 1,2-DCA concentrations are less than current SDWA MCL.
Chloroform	X			NA	1E-06 to 1E-04 Cancer Risk Range: 2 to 200	NA	80	**COC not further addressed in FS.** All detected chloroform concentrations are less than current SDWA MCL.
Naphthalene	X			NA	Non-cancer RBC (Hazard Index =1): 230	20/2,600 (calculated)	NA	**COC formally addressed in FS.** Naphthalene was selected as a GW COC in the RI. The calculated RIDEM GB goal being evaluated as a potential clean-up goal.
2-Methyl Naphthalene	X			NA	Non-cancer RBC (Hazard Index =1): 36	GB = To be calculated.	NA	**COC formally addressed in FS.** 2-Methyl naphthalene was selected as a GW COC in the RI. The calculated RIDEM GB goals is being evaluated as a potential clean-up goal.
Carcinogenic PAHs	X			NA	1E-06 to 1E-04 Cancer Risk Range: 0.003 to 0.3	0.2/-	0.2	**COC not further addressed in FS.** All benzo(a)pyrene and BaP Eq concentrations are less than SDWA MCL.
Hexachlorobenzene	X			NA	1E-06 to 1E-04 Cancer Risk Range: 0.01 to 1 Non-cancer RBC (Hazard Index =1): 3.5	1/-	1	**COC not further addressed in FS.** Hexachlorobenzene was only detected in one well at an estimated concentration equal to its SDWA MCL.
Arsenic	X			See Phase III RI.	1E-06 to 1E-04 Cancer Risk Range: 0.045 to 4.5 Non-cancer RBC (Hazard Index =1): 4.7	NA	10	**COC formally addressed in FS.** Arsenic was selected as a COC for Site 16 soils. Filtered arsenic concentrations (particularly in the North Central area) exceed the current SDWA MCL and background concentrations. Arsenic in soils may have been mobilized as a result of reducing conditions created by site-related contamination. There is no RIDEM GB criterion for this non-volatile chemical. The SDWA MCL is recommended as the clean-up goal. However, the groundwater underlying Site 16 is classified as GB; institutional controls will be recommended to prevent receptor exposure/risk. It should be noted that other metals (particularly iron and manganese) may be mobilized by conditions in the North Central area. However, the risk-based concentrations for arsenic are among the most conservative values available for metals.

TABLE 1-2

CANDIDATE CHEMICALS OF CONCERN AND CLEAN-UP GOALS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Chemical	COC Based on Direct Contact (DC) Risk (i.e., Domestic Use of Groundwater)?	COC Based on Vapor Intrusion Pathway ?	COC Based on Professional Judgment?	Background Concentration (ug/L)	Risk-Based Clean-up (RBC) Goals - Residential Land Use Scenario (ug/L)	RIDEM GA/GB (ug/L)	Safe Drinking Water Act Maximum Contaminant Level (SDWA MCL) (ug/L)	Comments
Aluminum, Antimony, Chromium, Lead, Iron, Manganese, Silver, and Thallium	X			See Phase III RI.	Not calculated because these metals were not selected as COCs for evaluation in the FS.	Not provided because these metals were not selected as COCs for evaluation in the FS.	Not provided because these metals were not selected as COCs for evaluation in the FS.	**Metal COCs not addressed in FS.** Although these metals were identified as COCs for groundwater in the human health risk assessment prepared for Site 16, metals concentrations in low-turbidity and filtered samples generally do not exceed SDWA MCLs. The metals concentrations in the unfiltered/high turbidity samples appear to be primarily a consequence of suspended particulate matter in the groundwater samples. The pattern of metals concentrations across Site 16 suggests that the metals concentrations reported in the Site 16 groundwater are not site-related.

TABLE 2-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at the site to address contamination.	Required by law. Retain for baseline comparison to other technologies.
Limited Action	LUCs	Engineered Controls: Physical Barriers/ Security Guards	Fencing, markers, warning signs, and monitoring to restrict site access.	Eliminate. Site is anticipated to be reused for commercial activities. Full site must still be accessible.
		Administrative Controls: Deed or Site Use Restrictions	Administrative action using land use prohibitions to restrict future land use to industrial/commercial activities.	Retain. Prohibiting future residential land use will help to prevent unacceptable risks from exposure to contaminated soil. Existing LUCs (MARAD agreement and LIFOC) would be used.
	Monitoring	Sampling and Analysis	Sampling and analysis of soil to evaluate if additional remedial actions would be warranted.	Eliminate. Soil COCs with low mobility, and groundwater would be monitored to warn of migration from soil.
	Natural Attenuation	Naturally Occurring Biodegradation and Dispersion	Monitoring of soil to assess the reduction in concentrations of COCs through natural processes.	Eliminate. Soil COCs (PAHs and metals) are not reduced effectively by biological processes.
Containment	Cover/Barrier	Soil Cover/Multi-Media Cap	Use of semi-permeable or impermeable barriers to minimize direct exposure to contaminants and potential migration from soil to groundwater.	Retain. Surface covering or capping of contaminated areas would reduce exposure of human and animal receptors to site contaminants and prevent infiltration. Cover and cap systems could be incorporated into overall site reuse.
	Erosion Control	Rip-Rap Cover/Vegetation	Use of gravel/cobbles or dense plant growth to minimize migration of contaminated soil.	Eliminate. Site 16 is not steeply sloped, and erosion is not a concern.

TABLE 2-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Removal	Excavation	Mechanical	Means for removal of contaminated soil by backhoe, bulldozer, loader, etc.	Retain. Would be effective to remove contaminated soil.
In-Situ Treatment	Thermal	Vitrification	Use of high-temperature melting to fuse inorganic contaminants into a glass matrix within vadose zone or the use of moderate temperature heating to volatilize contaminants and remove them from the vadose zone.	Eliminate because vitrified mass would impact reuse of site. Use of this technology is typically limited to highly contaminated or radioactive materials.
		Radio Frequency Heating	Use of radio-frequency energy to heat soil and cause volatilization of contaminants	Eliminate. The shallow depth to groundwater combined with sandy soil renders this technology difficult to implement at the site. Not effective for treatment of PAHs and metals.
		Electrical Resistance Heating	Use of an electrical blanket or electrical heating elements within slotted pipes to volatilize contaminants	Eliminate. The shallow depth to groundwater combined with sandy soil renders this technology difficult to implement at the site. Not effective for treatment of PAHs and metals.
	Physical/ Chemical	Soil Flushing/ Chemical Extraction	Use of water/solvents to remove contaminants from the vadose zone by flushing and collecting the contaminated wastewater in the saturated zone followed by above-ground pumping and treatment.	Eliminate. Increases potential for migration of contaminants from soil to groundwater. Absence of confining layer at the site would make recovery of flushing solution difficult.
		Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well.	Eliminate. Impractical in regard to cost versus mass removal. Limited vadose zone would make vapor extraction difficult. Not effective for treatment of PAHs and metals.

TABLE 2-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
In-Situ Treatment (Continued)	Physical/ Chemical (Continued)	SVE	Use of vacuum and possibly air sparging to volatilize contaminants.	Eliminate. PAHs and metals are not highly volatile, and the effectiveness of SVE would be limited.
		Chemical Fixation/ Solidification	Mixing of chemical agents in the vadose zone to chemically bind, solidify, and reduce contaminant mobility.	Eliminate. Mobility of PAHs and metals is not a concern at this site. Moreover, the treated material would not be suitable for reuse.
	Chemical	Chemical Oxidation	Injection of oxidizer such as Fenton's Reagent into vadose zone soil to oxidize PAHs.	Eliminate. Difficult to distribute solution in heterogeneous soil. Thin layer of soil and shallow injection depth would also interfere with application of method.
	Biological	Biodegradation	Nutrients and amendments are added to surface soil to promote biodegradation of PAHs.	Eliminate. Low solubility of PAHs, strong tendency of PAHs to bind to soil organic matter, and slow degradation rate for multi-ringed PAHs makes this an unfavorable technology. Not effective for metals. Distribution and application issues similar to chemical oxidation.
		Phytoremediation	Use of selected plants for enhancement of biodegradation of organic contaminants and uptake of metals by indigenous microorganisms in the root zone or transpiration process in trees.	Eliminate. Growth and maintenance of trees and plants would limit reuse of site for commercial purposes.

TABLE 2-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment	Physical/ Chemical	Soil Washing/ Chemical Extraction	Use of solubilization and chemical (oxidation/reduction/neutralization) processes to remove contaminants from the solid phase and convert them into more concentrated forms or less toxic forms in the liquid phase.	Eliminate. Eliminated due to the cost associated with low treatment volumes. This technology is more cost effective for larger soil treatment areas than those present at Site 16.
		Chemical Fixation/ Solidification	Mixing of chemical agents to bind, solidify, and reduce contaminant mobility.	Eliminate. Mobility of PAHs and metals is not a concern at this site.
	Biological	On-Site Landfarming	Tilling of contaminated soil and waste in layers to remove PAHs and biodegrade organics.	Eliminate. Biological processes are not very effective for treating PAHs and metals. Also, large land area is required for landfarming, which would affect site reuse.
		Bioslurry Treatment	Treatment of soil in a slurry reactor under controlled conditions using microorganisms to biodegrade organics.	Eliminate. Biological processes are not very effective for treating PAHs and metals.
	Thermal	Off-Site Incineration	Use of high temperatures to pyrolize or oxidize organic contaminants into less toxic gases.	Eliminate. This technology is more cost effective for larger contaminant volumes than those present at Site 16. Process is not effective for metals.

TABLE 2-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Remedial Technology	Process Option	Description	Screening Comment
Ex-Situ Treatment (continued)	Thermal (continued)	Off-Site Thermal Desorption	Use of moderate temperatures to volatilize contaminants and remove them from the solid phase into the gaseous phase.	Eliminate. This technology is more cost effective for larger contaminant volumes than those present at Site 16. Process is not effective for metals.
		On-Site Incineration or Thermal Desorption	Mobile equipment is brought to site for incineration or thermal desorption.	Eliminate. Process has high cost and is usually applied to sites with high contaminant concentrations. Would not be effective for treatment of metals.
	Solids Processing	Size Reduction	Crushing/grinding/shredding of wastes as a preliminary process to aid in downstream treatment.	Retain. May need to be used in conjunction with excavation and off-site disposal.
		Screening	Removal/segregation of material based on size as a preliminary process to aid in downstream treatment.	Retain. May need to be used in conjunction with excavation and off-site disposal.
Disposal	Off-Site	Landfilling	Disposal of excavated material at a permitted off-site landfill. Recycling can be incorporated if scrap metal is present.	Retain. Disposal is a viable option for addressing soil contamination. Soil is expected to be a non-hazardous waste.
	On-Site	Consolidation	Excavation and relocation of contaminated soil to minimize space and closure requirements.	Eliminate. Leaving contaminated soil on site would limit site reuse.
		Beneficial Reuse	Reuse of treated soil as fill material.	Eliminate. No soil treatment processes are proposed.

LIFOC - Lease in Furtherance of Conveyance.
LUC - Land use control.
MARAD - Maritime Administration.
PAH - Polynuclear aromatic hydrocarbon.
SVE - Soil vapor extraction.

TABLE 2-2

REMEDIAL ALTERNATIVES FOR SOIL
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Alternative Number	Alternative Components	Alternative Component Descriptions
Alternative S-1	No Action	• No Action.
Alternative S-2	Soil Cover and/or Cap, Monitoring, and Land Use Controls (LUCs)	• Install a 2-foot thick soil cover over the limits of contaminated soil greater than Industrial Direct Contact Criteria in the Northwest Undeveloped Area. • Install caps with a 2-foot thick soil layer and low permeability liner over the limits of contaminated soil greater than Leachability Criteria to eliminate infiltration in the Northwest Undeveloped Area. • Monitor groundwater to verify effectiveness of caps. • Application of LUCs to restrict use to industrial uses only and prohibit digging within the boundaries of contaminated soil greater than Industrial Direct Contact Criteria. LUCs would also require inspection and maintenance of the caps.
Alternative S-3	Excavation, Off-site Treatment and Disposal, and LUCs	• Physical removal of contaminated soil greater than Industrial Direct Contact and Leachability Criteria in the Northwest Undeveloped Area. • Transport offsite for disposal. (If any soil is hazardous, treatment may be needed to meet Land Disposal Requirements.) • Application of LUCs to restrict use to industrial uses only.
Alternative S-4	Soil Cover, Selected Excavation and Disposal, and LUCs	• Physical removal of contaminated soil greater than Leachability Criteria and contaminated soil greater than Industrial Direct Contact Criteria to a depth of 2 feet in the Northwest Undeveloped Area. • Transport offsite for disposal. (If any soil is hazardous, treatment may be needed to meet Land Disposal Requirements.) • Install a 2-foot thick soil cover over the limits of contaminated soil greater than Industrial Direct Contact Criteria in the Northwest Undeveloped Area. • Application of LUCs to restrict use to industrial uses only and prohibit digging within the boundaries of contaminated soil greater than Industrial Direct Contact Criteria. LUCs would also require inspection and maintenance of the cover.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
No Action	None	Not Applicable	No activities conducted at site to remedy or monitor contamination. Site is released for unrestricted development.	Retain. No action is retained as a baseline for comparison with other technologies.
Limited Action	Monitoring	Sampling and Analysis	Periodic sampling and analysis of groundwater to track changes in the extent of contamination.	Retain. This technology could assess natural attenuation and/or migration of contaminants and evaluate progress of active remediation.
	LUCs	Active Controls: Physical Barriers/ Security Guards	Fencing, markers, and warning signs to restrict site access.	Eliminate. Restricted access would not reduce risk of exposure to groundwater. Physical barriers would affect site reuse.
		Passive Controls: Deed and Land Use Restrictions	Administrative action using LUCs to restrict future site use and to prohibit use of groundwater as a source of drinking water.	Retain. Groundwater is currently not used as a drinking water source and classified as GB. This technology will limit all future uses of groundwater and thus limit human exposure to groundwater. Existing LUCs (MARAD agreement and LIFOC) would be used.
	Natural Attenuation	Naturally Occurring Biodegradation and Dilution	Monitoring groundwater to assess the reduction in concentrations of COCs through natural processes.	Retain. This technology may decrease concentrations of TCE and other VOCs over time.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Containment	Vertical Barriers	Slurry Wall	Low-permeability wall formed in a perimeter trench to restrict horizontal migration of groundwater.	Eliminate. This technology would not restore groundwater quality. Groundwater treatment would still be needed. Difficult to apply to fractured bedrock.
		Sheet Piling	Metal sheet piling driven into the ground to restrict horizontal migration of groundwater.	Eliminate. This technology would not restore groundwater quality. Groundwater treatment would still be needed. Difficult to apply to bedrock.
		Grout Curtain	Pressure injection of grout to form a low-permeability perimeter wall to restrict horizontal migration of groundwater.	Eliminate. This technology would not restore groundwater quality. Groundwater treatment would still be needed.
		Hydraulic Barrier	Use of extraction wells and/or collection trenches to restrict horizontal migration of groundwater.	Eliminate. This technology would not restore groundwater quality. Groundwater treatment would still be needed. Heterogeneity would affect capture of groundwater.
	Horizontal Barriers	Physical Barrier	Injection of bottom-sealing slurry beneath source to minimize vertical migration of groundwater.	Eliminate. Not applicable. Contaminants extend through surficial groundwater to confining unit (unfractured bedrock) below. Confining unit prevents further downward migration of contaminants.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Removal	Groundwater Extraction	Extraction Wells	Series of conventional pumping wells used to remove contaminated groundwater.	Retain. May be effective in reducing concentrations to relatively high GB criteria in combination with ex-situ treatment. Requires BRAC PMO-level approval for implementation.
		Collection Trench	A permeable trench used to intercept and collect groundwater.	Eliminate. A deep trench would be needed to capture the full depth of the plume, and a trench would not be effective in capturing the bedrock plume.
In-Situ Treatment	Biological	Anaerobic/ Aerobic	Enhancement of biodegradation of organics in an anaerobic (oxygen-deficient) or aerobic (oxygen-rich) environment by injection of electron-donor compounds or oxygen source. Microorganism cultures may need to be added.	Retain. Anaerobic reductive dechlorination is effective at removing TCE and other chlorinated VOCs.
	Physical/ Biological	AS or AS/SVE	Volatilization and enhancement of biodegradation of organic compounds by supply of air with or without capture and treatment of volatilized compounds.	Eliminate. The heterogeneous subsurface would make effective implementation of this method difficult.
		Dynamic Underground Stripping	Steam injection at the periphery of the contaminated area resulting in the vaporization of volatile compounds bound to soil and the movement of contaminants to a centrally located extraction well.	Eliminate. The heterogeneous subsurface would make effective implementation of this method difficult.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
In-Situ Treatment (continued)	Chemical	Chemical Oxidation	Chemical destruction of organic COCs through oxidation with hydrogen peroxide and ferrous iron (Fenton's Reagent), catalyzed percarbonate (RegenOx™), or potassium permanganate.	Retain. This technology could remove the chlorinated VOCs, although the subsurface heterogeneity would affect the distribution of the chemical. A pilot study is typically needed. Also, oxidation might also be effective in immobilizing arsenic.
		PRBs	Use of a permeable barrier with zero-valent iron, which allows the passage of groundwater and reacts with the contaminants.	Retain. Size and depth of contaminant plume would make construction of PRB difficult, but this option is retained for further consideration. Could not be applied to bedrock at the site.
	Thermal	Electrical Resistance Heating	Volatilization of organic COCs through groundwater and soil heating with electrical electrodes in combination with vacuum extraction of volatilized material.	Eliminate. Large volume would be costly to treat with this process. Low concentrations of VOCs are more readily removed by other processes.
Ex-Situ Treatment	Biological	Aerobic/ Anaerobic	Natural degradation of organic COCs via microorganisms in an aerobic (oxygen-rich) or anaerobic (oxygen-deficient) environment.	Eliminate. Biological treatment of low concentrations of contaminants would not be cost-efficient.
	Physical	Filtration	Separation of suspended solids from water via entrapment in a bed of granular media or membrane.	Retain. May be useful in combination with other ex-situ treatment options.
		Air Stripping	Contact of water with an air stream to remove VOCs.	Retain. Proven treatment method for VOC removal.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Ex-Situ Treatment (Continued)	Physical (Continued)	GAC Adsorption	Separation of dissolved contaminants from water or air streams via adsorption onto GAC.	Retain. Proven treatment method for VOC removal from contaminated groundwater and air stripper off-gas.
		Solvent Extraction	Separation of contaminants from a solution by contact with an immiscible liquid with a higher affinity for the COCs.	Eliminate. Not proven to be cost-effective for VOC removal.
		Sedimentation	Separation of solids from water via gravity settling.	Eliminate. Large quantities of suspended solids are not present and are not likely to be generated.
	Chemical	Coagulation/ Flocculation	Use of chemicals to neutralize surface charges and promote attraction of colloidal particles to facilitate settling.	Eliminate. Large quantities of suspended solids are not present and are not likely to be generated.
		Neutralization/pH Adjustment	Use of acid or base to counteract high or low pH conditions.	Retain. May be needed for final pH adjustment prior to discharge to surface water.
		Chemical Precipitation	Use of reagents to convert soluble compounds into insoluble compounds.	Eliminate. This process is not used for VOC removal.
		Ion Exchange	Removal of dissolved ions through exchange with similarly charged ions held on the active sites of a synthetic resin that is contacted with the liquid to be treated.	Eliminate. This process is not used for VOC removal.
		Enhanced Oxidation	Use of oxidizers such as ozone, hydrogen peroxide, or potassium permanganate to break down certain organic compounds.	Eliminate. Treatment costs are much higher compared to typical treatment methods for VOCs, such as air stripping.

TABLE 3-1

PRELIMINARY SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

General Response Action	Technology	Process Options	Description	Screening Comment
Discharge/ Disposal	Surface Discharge	Direct Discharge	Discharge of treated water to surface water.	Retain. Treatment of other constituents, such as metals, may be required to meet effluent limitation requirements.
		Indirect Discharge	Discharge of collected/treated water to local sewage treatment plant.	Eliminate. No publicly owned treatment works sewers are nearby.
		Off-Site Treatment Facility	Treatment and disposal of water at an off-site treatment works.	Eliminate. Separate facility not available. Large volume of water would be too costly to transport by tanker.
	Subsurface Discharge	Reinjection	Use of injection wells, spray irrigation, or infiltration to discharge of treated groundwater underground.	Eliminate. Injection field or infiltration gallery would limit development of site. Because of relatively shallow depth to groundwater, mounding may reach ground surface.

BRAC PMO – Base Realignment and Closure Program Management Office.
COC - Chemical of concern.
GAC - Granular activated carbon.
LIFOC - Lease in Furtherance of Conveyance.
MARAD - Maritime Administration.
PRB - Permeable reactive barrier.
STP - Sewage treatment plant.
TCE - Trichloroethene.
VOC - Volatile organic compound.

TABLE 3-2

REMEDIAL ALTERNATIVES FOR GROUNDWATER
SITE 16 FEASIBILITY STUDY ALTERNATIVES ANALYSIS SUMMARY
NCBC DAVISVILLE
NORTH KINGSTOWN, RHODE ISLAND

Alternative Number	Alternative Components	Alternative Component Descriptions
Alternative G-1	No Action	• No Action.
Alternative G-2	Monitored Natural Attenuation (MNA) and Land Use Controls (LUCs)	• MNA would be conducted until cleanup goals are achieved. • Groundwater use prohibitions would be incorporated into LUCs until cleanup goals are achieved.
Alternative G-3	In-Situ Chemical Oxidation (High-Concentration Areas), MNA, and LUCs	• Inject sodium permanganate to chemically treat the chlorinated VOC high-concentration areas. • MNA would be conducted until cleanup goals are achieved. • Groundwater use prohibitions would be incorporated into LUCs until cleanup goals are achieved. • Groundwater with elevated arsenic concentrations would be addressed through MNA.
Alternative G-4	Enhanced Bioremediation (High-Concentration Areas), MNA, and LUCs	• Inject oil-based electron donor substrates as barriers to stimulate biological degradation of chlorinated VOCs as the groundwater passes through the barriers. • MNA would be conducted until cleanup goals are achieved. • Groundwater use prohibitions would be incorporated into LUCs until cleanup goals are achieved. • Groundwater with elevated arsenic concentrations would be addressed through MNA.
Alternative G-5	PRBs (Overburden High-Concentration Areas), In-Situ Enhanced Bioremediation (Bedrock and Remote High-Concentration Areas), MNA, and LUCs	• Install ZVI PRBs at overburden high-concentration areas to treat groundwater as it passes through the barrier. • Inject oil-based electron donor substrates as barriers in bedrock and remote areas to stimulate biological degradation of chlorinated VOCs as the groundwater passes through the barriers. • MNA would be conducted until cleanup goals are achieved. • Groundwater use prohibitions would be incorporated into LUCs until cleanup goals are achieved. • Groundwater with elevated arsenic concentrations would be addressed through MNA.
Alternative G-6	Groundwater Extraction and Treatment (High-Concentration Areas), MNA, and LUCs	• Pump water from high-concentration areas until concentrations meet RIDEM GB Groundwater objectives. • Treat groundwater by air stripping and GAC. Treated groundwater would be discharged to Narragansett Bay. • MNA would be conducted until cleanup goals are achieved. • Groundwater use prohibitions would be incorporated into LUCs until cleanup goals are achieved. • Groundwater with elevated arsenic concentrations would be addressed through MNA.