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DETAILED ANALYSIS OF ALTERNATIVES REPORT

SITE 06 - SOLVENT DISPOSAL AREA
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1

NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE, RHODE ISLAND

Contract No. N62472-86-C-1282
April, 1994

Prepared For:
Northern Division
Naval Facilities Engineering Command
Lester, Pennsylvania

TRC
TRC Environmental Corporation

Draft

U.S. DEPARTMENT OF THE NAVY
INSTALLATION RESTORATION PROGRAM

DETAILED ANALYSIS OF ALTERNATIVES REPORT

VOLUME 1 - INTRODUCTION
VOLUME 2 - SITE 06 - SOLVENT DISPOSAL AREA
VOLUME 3 - SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

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EXECUTIVE SUMMARY

At the request of the U.S. Navy, TRC Environmental Corporation (TRC) has prepared this Detailed Analysis of Alternatives (DAA) Report for Site 06 - Solvent Disposal Area and Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1, at the Naval Construction Battalion Center in Davisville, Rhode Island (NCBC Davisville). The DAA is part of the Feasibility Study (FS) process and is being conducted under the Navy's Installation Restoration Program and in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

Introduction

Twelve sites at the NCBC facility are being investigated under a Remedial Investigation/Feasibility Study (RI/FS) program. Phase I and Phase II Remedial Investigations (RIs) have been conducted to investigate the physical characteristics of the sites, as well as to identify potential sources of contamination, determine the nature and extent of contamination, and characterize potential health risks and environmental impacts. Detailed site background information, results of the investigations, and a characterization of the potential risks to human health and the environment posed by the sites are presented within several separate Remedial Investigation Reports (TRC, 1993). Initial screenings of potential remedial alternatives were also conducted for the sites on the basis of Phase I RI results only within two Initial Screening of Alternatives (ISA) Reports (TRC, 1993). This DAA Report, which addresses only Sites 06 and 13, builds upon the analyses conducted within the ISA report, presenting remedial alternatives developed based on the results of the Phase I and Phase II RIs, and detailed analyses of those alternatives. A summary of the DAA Report for each site follows.

SITE 06 - SOLVENT DISPOSAL AREA

Background

Site 06 is a flat grassy area located between Building 67 and Warehouse 38, covering roughly a quarter of an acre. It is bounded to the east by a chain link fence bordering Exeter Street, and to the west by a paved parking lot. Subsurface utilities such as a water main, storm drain, leach field, and a septic tank are present at Site 06. A site map is provided in Figure ES-1. The area in which Site 06 is located has been designated for economic/industrial development under the Comprehensive Base Reuse Plan.

Site 06 was reportedly used from 1970 to 1972 for the disposal of waste chlorinated hydrocarbon solvents. Personnel from the Refrigeration Mechanics Section of the Public Works Department reportedly drained over a dozen 5-gallon cans of various liquid wastes in this area, about once every three weeks, for an estimated total disposal volume of 1,750 gallons. Disposal reportedly took place in approximately a 30-foot square area. Site 06 was a sandy area during the time of these disposal practices. The area was subsequently covered with approximately six inches of soil and re-seeded.

Site investigations have consisted of an Initial Assessment Study (Hart, 1984a), a Confirmation Study (TRC, 1987), the Phase I RI (TRC, 1991), and the Phase II RI (TRC, 1993). These investigations have included the collection of surface soil, subsurface soil and ground water samples for chemical analysis.

Based on the results of site investigations, the nature and extent of site contamination were defined, as were potential risks to human health and the environment. Surface soil contamination is limited to a small portion of the site where lead is present at one sample location (SS-8 - see Figure ES-1) at a level which exceeds the Rhode Island Department of Environmental Management (RIDEM) action level of 300 ppm but falls within the federal action level of 500 to 1,000 ppm. Adjacent surface soil sample lead levels did not exceed regulatory action levels. Surface soils present no unacceptable risks to human health under a future commercial/industrial site use scenario and no unacceptable ecological risks were identified for the site based on surface soil data. Potential ecological risks associated with the presence of PCBs and pesticides within the Hall Creek Watershed, in which Site 06 is located, do not appear

to be site-related, due to the absence of these contaminants in site environmental samples. Subsurface soil contamination does not appear to present a potential risk through contaminant leaching, based on the application of a leaching model. When ground water was sampled using a low-flow methodology to minimize the presence of suspended sediments, lead was detected in an upgradient well at levels exceeding the drinking water action level and manganese was detected at levels exceeding the risk-based preliminary remediation goal (PRG) at wells located throughout the site. Ground water at Site 06 is classified as GB, which indicates that it is not suitable for public or private drinking water use without treatment due to known or presumed degradation. Therefore, ingestion of ground water is not anticipated to be a significant potential exposure pathway, although there is no regulatory mechanism which prohibits the installation of an on-site potable well. Also to be considered is the possibility that lead and manganese are not site-related contaminants, based on the presence of lead within the upgradient well and the presence of manganese in upgradient wells at all NCBC Davisville sites evaluated during the RI.

Feasibility Study Summary

The first step of the Feasibility Study process, the ISA, was conducted for Site 06 on the basis of Phase I RI information only. The ISA report included the development of remedial action objectives, the screening of potential remedial technologies and process options, and the development and initial screening of remedial alternatives. This report incorporates the results of the Phase II RI, and presents the refinement of remedial response objectives, the refinement of remedial alternatives, and detailed individual and comparative analyses of the remedial alternatives.

Based on the nature and extent of contamination at Site 06 as well as potential human health and ecological risk considerations, remedial action objectives were developed as follows:

For soils:

- Minimize the potential for residential exposures to surface soil contaminants at levels which exceed ARARs/TBCs, as presented in Table 3-1 of the report.

Specifically, the remedial action objective for surface soils is to minimize potential residential exposures to lead at a level exceeding the RIDEM guidance level of 300 ppm.

For ground water:

- Prevent exposure, due to ground water ingestion, to contaminants which are present at levels exceeding acceptable ARARs/TBCs, as indicated in Table 3-2 of the report, or which exceed risk-based preliminary remediation goals, as indicated in Table 3-3 of the report.

Specifically, the remedial action objective for ground water is to minimize exposures due to ingestion of lead at levels exceeding the drinking water action level of 15 ppb or ingestion of manganese at levels exceeding the risk-based preliminary remediation goal of 510 ppb.

Remedial alternatives were developed for both soil and ground water and were evaluated in detail with respect to the evaluation criteria specified in the National Contingency Plan [40 CFR 300.430(e)(9)]. A list of the individual soil and ground water alternatives for which detailed analyses were conducted is presented in Table ES-1. The alternatives included:

- No Action (soil and ground water)
- Limited Action (soil and ground water)
- Extraction/Treatment/Discharge (ground water only)

Although the soil and ground water alternatives were evaluated separately within the report, the limited number of alternatives considered allows for a presentation of combined alternatives herein. A summary of the components which are included in each of the combined soil/ground water alternatives is presented in Table ES-2.

Alternative 1 - No Action

A comprehensive no action alternative would consist of no action with respect to soil and ground water. It would provide the least overall protection of human health and the environment because it would not limit future residential exposures to surface soil contaminants and would not prevent future installation of an on-site potable well, which could result in ingestion of ground water. It would not achieve remedial action objectives.

Alternative 2 - Limited Action

A comprehensive limited action alternative would consist of institutional controls for soil and ground water. It could consist of the following:

- Deed restrictions to limit future residential exposures to surface soil contaminants and to prevent future use of ground water as a potable water supply; and

- Long-term monitoring of ground water quality

This alternative would be protective of human health by preventing residential exposures to the limited area of surface soil lead contamination which exceeds the RIDEM guidance level and by preventing the potential installation of a potable on-site well and thereby preventing the development of a potential ground water ingestion pathway at the site. Due to the lack of significant ecological risks associated with the site, the limited action alternative would also be protective of the environment. The alternative would be compatible with future commercial/industrial use of the site, as specified in the Comprehensive Base Reuse Plan.

Alternative 3 - Ground Water Extraction/Treatment/Discharge

This active remedial alternative would consist of ground water extraction, treatment and discharge actions combined with institutional controls and long-term ground water monitoring. The alternative would consist of the following:

- Deed restrictions to limit future residential exposures to surface soil contaminants;
- Ground water extraction, inorganic ground water treatment and discharge of the treated water to surface water (Hall Creek); and
- Long-term monitoring of ground water quality

This alternative would provide overall protection of human health and the environment during its operation by providing active treatment of ground water contaminants. However, the presence of lead in the upgradient well at a level exceeding the drinking water action level indicates the potential presence of an upgradient source which could result in the re-occurrence of lead once the treatment is discontinued. Similarly, the apparent presence of manganese in ground water throughout the facility indicates that ground water treatment at Site 06 may not permanently address the potential human health risks associated with the ingestion of manganese in ground water. Residential exposures to contaminated surface soil materials would be addressed through the implementation of deed restrictions. Due to the lack of significant ecological risks associated with the site, the extraction/treatment/discharge alternative would also be protective of the environment. Long-term monitoring would allow for the identification of any changes in ground water quality. Implementation of this alternative would be compatible with future commercial/industrial site use.

Comparative Evaluation of Comprehensive Alternatives

A comparison of the three comprehensive remedial alternatives described above against the alternative evaluation criteria specified under the National Contingency Plan [40 CFR 300.430(e)(9)] is presented in Tables ES-3 through ES-9. Two of the criteria, State Acceptance and Community Acceptance, are evaluated later in the remedial decision-making process.

Recommendations and Conclusions

Based on the evaluation of soil and ground water remedial alternatives, the recommended remedial alternative for Site 06 consists of a limited action consisting of the following:

- Deed restrictions to prevent future residential exposures to surface soil and to prevent ground water from being used as a potable water source; and
- Long-term monitoring of ground water to identify any future changes in ground water quality.

This alternative would be protective of human health and the environment under the proposed future commercial/industrial site use based on the lack of unacceptable human health risks associated with such a future site use and the lack of unacceptable environmental risks associated with the site.

While there are no chemical-specific ARARs applicable to soil contamination at the site, the limited action alternative could be considered to comply with federal and state chemical-specific TBCs for lead, which are based on residential exposures to soils, by preventing future residential site use. It would also use institutional controls to limit exposures to ground water contaminants at levels exceeding drinking water action levels, which would be consistent with EPA's expectations for Superfund that allow the use of institutional controls when active remediation measures are determined not to be practicable, based on the balancing of trade-offs among alternatives. Considering the site's GB ground water classification which indicates that the ground water is not suitable for consumption without treatment, the presence of lead within the upgradient well which indicates that it could potentially be associated with an unidentified upgradient source, the minimal exceedance of the lead drinking water action level detected within the well (17.8 parts per billion detected versus the action level of 15 parts per billion), and the apparent presence of manganese in ground water throughout the facility, the balancing of trade-offs conducted among the ground water remedial alternatives indicates that active

ground water treatment would not be practicable to implement and may not be permanent with respect to maintaining ARARs upon discontinuation of treatment. The lack of ground water treatment at Site 06 is not expected to adversely effect the environment. The long-term monitoring would provide a means of identifying any changes in ground water quality which could potentially impact the environment in the future.

Implementation of deed restrictions requires an administrative effort which would be incorporated into the base closure property transfer process; thus no short-term effects would result from implementation. The monitoring program would have minimal short-term risks associated with its implementation and the limited action alternative would be effective in the long-term, provided deed restrictions are enforced. Due to the continued presence of contaminants at the site at levels which do not allow for unrestricted use, five-year reviews of the limited action decision would be required. If the results of the ground water monitoring program indicated that ground water quality was deteriorating, additional remedial measures could be implemented in the future. The alternative would complement future use of the site for commercial/industrial purposes, as specified in the Comprehensive Base Reuse Plan.

SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Background

Site 13 is approximately six acres in size and consists of a large grassy field bounded on three sides by paved roads. Several small devegetated areas are evident within the site area. The area is located northwest of Buildings W-3, W-4, and T-1. There are eight catch basins located within the site area. Two storm sewer drain pipes enter the site from two locations along "A" Street and join in the central portion of site, exiting at the northeast corner of the site near the intersection of Exeter Street and Foster Street. A site map is provided in Figure ES-2. The area in which Site 13 is located has been designated for economic/industrial development under the Comprehensive Base Reuse Plan.

From 1945 to 1955, the NCBC Davisville Construction and Equipment Department was located in Buildings W-3, W-4, and T-1. Overhaul and repair activities were conducted in these buildings, vehicles were stored in fields to the north and west, and drums of oils, thinners and solvents were stored adjacent to the buildings. Approximately 300 gallons of waste oils per month were reportedly spread on the fields northwest of the three buildings (Hart, 1984a).

Site investigations have consisted of an Initial Assessment Study (Hart, 1984a), a Confirmation Study (TRC, 1987), the Phase I RI (TRC, 1991), and the Phase II RI (TRC, 1993). These investigations have included the collection of surface soil, subsurface soil, ground water, and catch basin sediment samples for chemical analysis.

Based on the results of site investigations, the nature and extent of site contamination were defined, as were potential risks to human health and the environment. Surface soil contamination is limited to a relatively small portion of the site where PCBs are present at one surface soil sample location (SS13-9 - see Figure ES-2) at a level which exceeds TSCA and RIDEM PCB guidance levels. Surface soils also present a risk which exceeds the point of departure risk of 10^{-6} under a future commercial/industrial site use scenario. One surface soil sample (collected at the location of B-7) exhibits beryllium at a level which exceeds a preliminary risk-based remediation goal calculated on the basis of a 10^{-6} risk. No unacceptable ecological risks were identified for the site based on surface soil data. Subsurface soil contamination does not appear to present a potential risk due to contaminant leaching, based on

the application of a leaching model, although the elevated PCB level detected in surface soil sample SS13-9 could pose a potential leaching risk.

When ground water was sampled using a low-flow methodology to minimize the presence of suspended sediments, antimony was detected in one well (13MW-10S) at a level which exceeds the Maximum Contaminant Level (MCL) and manganese was detected at levels exceeding the risk-based preliminary remediation goal (PRG) at several wells located throughout the site. Pentachlorophenol was also detected in a single ground water sample (from 13MW-12S) at a level exceeding the MCL. Bis(2-ethylhexyl)phthalate was detected in well 13MW-4 during one of two Phase I RI sampling rounds at a level exceeding the MCL; its presence in Phase II ground water samples is considered to be attributable to the sampling methodology. Ground water at Site 13 is classified as GB, which indicates that it is not suitable for public or private drinking water use without treatment due to known or presumed degradation. Therefore, ingestion of ground water is not anticipated to be a significant potential exposure pathway, although there is no regulatory mechanism which prohibits the installation of an on-site potable well. The irregular detection of antimony and pentachlorophenol does not appear to be attributable to soil contamination at the site. Also to be considered is the potential that manganese is not a site-related contaminant, based on its presence in upgradient wells at all NCBC Davisville sites evaluated during the RI.

Sediments within the on-site catch basins exhibited PCB and pesticide contamination, although no ARARs/TBCs were identified for the catch basin sediments. Potential ecological risks associated with the presence of PCBs and pesticides have been identified within the Hall Creek Watershed, in which Site 13 is located, however, a direct relationship to Site 13 sediment contamination cannot be made on the basis of existing data. The presence of low-level surface soil contaminants at Site 13 must be considered with respect to the potential for erosion and contribution to catch basin sediment contaminant levels.

Feasibility Study Summary

The first step of the Feasibility Study process, the ISA, was conducted for Site 13 on the basis of Phase I RI information only. The ISA report included the development of remedial action objectives, the screening of potential remedial technologies and process options, and the

development and initial screening of remedial alternatives. This report incorporates the results of the Phase II RI, and presents the refinement of remedial response objectives, the refinement of remedial alternatives, and detailed individual and comparative analyses of the remedial alternatives.

Based on the nature and extent of contamination at Site 13 as well as potential human health and ecological risk considerations, remedial action objectives were developed as follows:

For soils:

- Minimize the potential for commercial/industrial exposures to surface soil contaminants at levels which exceed ARARs/TBCs, as presented in Table 3-1 of the report or which exceed risk-based preliminary remediation goals, as presented in Table 3-3 of the report;

- Minimize the potential migration of surface soil contaminants into the storm drainage system due to surface water runoff; and

- Minimize the potential migration of PCBs from surface soil into ground water.

Specifically, the surface soil contaminant which exceeds ARARs/TBC is the PCBs detected at SS13-9 and the contaminant which exceeds the risk-based preliminary remediation goal is beryllium at B-7.

For ground water:

- Prevent exposure, due to ground water ingestion, to contaminants which are present at levels exceeding acceptable ARARs/TBCs as indicated in Table 3-2 of the report, or which exceed risk-based preliminary remediation goals as indicated in Table 3-4 of the report.

Specifically, the ground water contaminants detected at levels exceeding ARARs/TBCs not attributable to the presence of sediments in the ground water sample or the sampling methodology include pentachlorophenol, bis(2-ethylhexyl)phthalate and antimony. Manganese is the only ground water contaminant detected at a level exceeding the risk-based preliminary remediation goal.

For catch basin sediments:

- Minimize the generation of contaminated sediments due to potential erosion of surface soil contaminants into the storm drainage system; and

- Minimize potential environmental impacts due to the presence of contaminated sediments within the storm drainage system.

Remedial alternatives were developed for each of the environmental media and evaluated in detail with respect to the evaluation criteria specified in the National Contingency Plan [40 CFR 300.430(e)(9)]. A list of the alternatives for which detailed analyses were conducted is presented in Table ES-10.

Because interactions between the environmental media at Site 13 could impact the selection of a final comprehensive remedial alternative for the site, five comprehensive alternatives were also assembled for a general evaluation. Based on the remedial alternatives evaluated for the individual environmental media at Site 13, numerous comprehensive alternatives consisting of various combinations of media-specific alternatives could be developed. While it is not possible to describe and evaluate each combination of alternatives, the five general alternatives evaluated include:

- No Action
- Limited Action
- Containment and Monitoring
- Containment, Off-Site Soil/Sediment Remediation and Monitoring
- Containment and On-Site Soil/Sediment and Ground Water Treatment

A summary of the components which are included in each of the comprehensive alternatives as evaluated is presented in Table ES-11.

Alternative 1 - No Action

A comprehensive no action alternative would consist of no action with respect to soil, ground water and catch basin sediments. It would not provide overall protection of human health and the environment, would not achieve remedial action objectives, and would not be protective in the long-term.

Alternative 2 - Limited Action

A comprehensive limited action alternative would consist of institutional controls for soil, ground water and catch basin sediments. It could consist of the following:

- Deed restrictions to limit future exposures to surficial soil contamination and contaminated ground water;
- Fencing to prevent human exposures to contaminated surface materials; and
- Long-term monitoring of ground water quality

While this alternative would be protective of human health in terms of limiting potential human exposures to soil and ground water contamination, it would not provide protection against the leaching of PCB contamination to the ground water, the potential migration of surficial soil contamination to the storm drainage system or the potential migration of catch basin sediments to Hall Creek. The presence of fencing and residual contamination would limit future commercial/industrial use of the site, the preferred future site use specified in the Comprehensive Base Reuse Plan.

Alternative 3 - Containment and Monitoring

A comprehensive containment alternative would consist of containment measures combined with institutional controls and long-term monitoring. A possible containment alternative would consist of the following:

- Excavation and consolidation of contaminated sediments beneath a single-barrier cap placed over the entire site area;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the capping system; and
- Long-term monitoring of ground water quality.

This alternative would provide overall protection of human health and the environment although it would not treat the principal threat posed by the elevated concentration of PCBs detected in one surface soil sample. Direct exposures to contaminated surface soils would be eliminated by the presence of the cap. The cap would also reduce the potential for leaching of PCB contaminants and erosion of surficial contaminants to the catch basins. By providing sediment excavation and consolidation beneath the cap, the potential for migration of existing sediments from the catch basins would be eliminated. Long-term monitoring would allow for the identification of any changes in ground water quality. Deed restrictions would prevent future potable use of the ground water as well as potential disruptions to the integrity of the capping system. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required to protect the integrity of the cap. It would not be incompatible with surrounding commercial/industrial site use, however.

Alternative 4 - Containment, Off-Site Soil/Sediment Remediation, Monitoring

This comprehensive alternative consists of containment features coupled with active soil remediation and ground water monitoring. It could consist of the following:

- PCB-contaminated soil and sediment excavation and off-site remediation (off-site disposal or incineration) and revegetation of the remainder of the site;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would provide a greater degree of protection of human health and the environment through the removal and off-site disposal or incineration of PCB-contaminated soils and catch basin sediments. The incineration option would provide treatment of the principal threat associated with the presence of PCBs in soils at concentrations greater than 500 ppm. Revegetation of the remainder of the site would limit the potential for erosion of surficial contaminants to the catch basins. Deed restrictions would limit future disruption of the revegetated areas and would prevent future potable use of the ground water. Long-term monitoring would allow for the identification of any future changes in ground water quality. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required to protect the integrity of the revegetated areas and to prevent future erosion of the underlying low-level surface soil contamination. It would not be incompatible with surrounding commercial/industrial site use, however.

Alternative 5 - Containment and On-site Soil/Sediment and Ground Water Treatment

This comprehensive alternative consists of containment features coupled with active soil, sediment and ground water remediation. It could consist of the following:

- PCB-contaminated soil and catch basin sediment excavation and remediation (on-site treatment) and revegetation of the remainder of the site;
- Ground water extraction, treatment and discharge;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would provide protection of human health and the environment through the on-site treatment of PCB-contaminated soils, catch basin sediments and ground water. The

on-site treatment options (solvent extraction and fungal degradation) would be expected to provide treatment of the principal threat associated with the presence of PCBs in soils at concentrations greater than 500 ppm, although they represent developing treatment technologies and are not well-proven in full-scale operation. Revegetation of the remainder of the site would limit the potential for future erosion of low-level surface soil contaminants to the catch basins. Ground water would be extracted, treated on-site for inorganics and organics, and discharged to surface water. When the active treatment of ground water would be discontinued, re-contamination of ground water at levels which are not protective of human health could occur, based on the detection of manganese in ground water throughout the facility. Deed restrictions would limit future disruption of the revegetated areas and would prevent future potable use of the ground water. Long-term monitoring would allow for the identification of any future changes in ground water quality. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required to protect the integrity of the revegetated areas and to prevent future erosion of the underlying low-level surface soil contamination. It would not be incompatible with surrounding commercial/industrial site use, however.

Comparative Evaluation of Comprehensive Alternatives

A comparison of the five comprehensive remedial alternatives described above against the alternative evaluation criteria specified under the National Contingency Plan [40 CFR 300.430(e)(9)] is presented in Tables ES-12 through ES-18. Two of the criteria, State Acceptance and Community Acceptance, are evaluated later in the remedial decision-making process.

Recommendations and Conclusions

Based on the analyses of soil, ground water and catch basin sediment remedial alternatives and the potential inter-media relationships, the recommended remedial alternative for Site 13 is Alternative 4, Containment, Off-Site Soil/Sediment Remediation and Monitoring, which consists of the following:

- PCB-contaminated soil and catch basin sediment excavation and off-site remediation (off-site disposal or incineration) and revegetation of the remainder of the site;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would be protective of human health and the environment, would be effective in the long-term, and would comply with location-specific and action-specific ARARs as well as chemical-specific ARARs applicable to soil contamination. It would use institutional controls to limit exposures to ground water contaminants at levels exceeding MCLs, which would be consistent with EPA's expectations for Superfund that allow the use of institutional controls when active remediation measures are determined not to be practicable, based on the balancing of trade-offs among alternatives. The potential direct-contact and leaching risks associated with the presence of surficial PCB contamination would be addressed through off-site remediation while the provision of a soil cover and its revegetation would prevent the erosion of existing low-level surface soil contamination. Long-term ground water monitoring would be utilized to monitor any changes in ground water quality over time. Deed restrictions would limit the potential for future disruption of the site surface and would prevent future potable use of the ground water. The presence of the revegetated area and associated deed restrictions could limit future use of the site for commercial or industrial development, as specified in the Comprehensive Base Reuse Plan, but the alternative would be compatible with commercial/industrial use of the surrounding area.

TABLE ES-1

ALTERNATIVES UNDERGOING DETAILED ANALYSIS
SOIL/GROUND WATER
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

Soil	**Ground Water**
Alternative S-1	Alternative GW-1
No Action	No Action
Alternative S-2	Alternative GW-2
Limited Action (Institutional Controls)	Limited Action (Institutional Controls)
A. Fencing/Deed Restrictions	A. Deed Restrictions/Ground Water Monitoring
	Alternative GW-3
	Extraction/Treatment/Discharge
	A. Interceptor Trench B. Precipitation C. Ion Exchange D. Discharge to Surface Water

TABLE ES – 2
DESCRIPTIONS OF GENERAL COMPREHENSIVE ALTERNATIVES
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	• No action
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	• Deed restrictions to limit future residential exposures to surface soil contaminants • Deed restrictions to prevent future use of ground water as potable water suuply • Long–term monitoring of ground water to identify any future changes in site conditions
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	• Deed restrictions to limit future residential exposures to surface soil contaminants • Interceptor trench to extract ground water • Inorganic treatment system (precipitation or ion exchange) • Discharge of treated ground water to Hall Creek • Long–term ground water monitoring

TABLE ES – 3
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Least protective alternative; Does not limit future potable use of ground water and does not monitor ground water quality; Provides protection of human health under the proposed future commercial/industrial site use scenario; However, no control of potential residential exposures to soil contamination is provided; Effective in the short–term and long–term provided residential exposures to soil and ingestion of ground water do not occur; Does not meet remedial response objectives
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Provides protection of human health by limiting potential future exposures to ground water and soil contaminants through the institution of deed restrictions limiting potable ground water use and residential site use; Does not provide compliance with drinking water standards through treatment; however, would prevent the development of a ground water ingestion exposure pathway; Does not meet the state chemical–specific TBC for lead in surface soil, but prevents residential exposures to lead contamination; Effective in the short–term and long–term by preventing residential exposures and ground water ingestion; Uses institutional controls to meet remedial action objectives; Long–term ground water monitoring would identify any future changes in ground water quality
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	Provides a reduction in potential future risks to human health associated with ground water ingestion through active treatment but remediation may not be permanent upon discontinuation of treatment; Would comply with chemical–specific ground water and action–specific ARARs; Does not meet the state chemical–specific TBC for lead in surface soil, but prevents residential exposures to lead contamination; Some increased short–term risks would result during implementation; Would be effective in the long–term as long as the treatment system is operational but permanence is not ensured; Long–term ground water monitoring would identify any future changes in ground water quality

TABLE ES – 4
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	CHEMICAL–SPECIFIC	LOCATION–SPECIFIC	ACTION–SPECIFIC
Alternative 1 – No Action	Lead present in ground water at a level exceeding the lead drinking water action level; Does not meet state chemical–specific TBC for lead, but falls within the acceptable federal range for lead	Not applicable	Not applicable
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Lead present in ground water at a level exceeding the lead drinking water action level; Does not meet state chemical–specific TBC for lead in surface soil, but falls within the acceptable federal range for lead	Not applicable	Monitoring would comply with RIDEM's Rules and Regulations for Ground Water Quality; No soil action–specific ARARs/TBCs apply
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	Treatment would meet ground water criteria; Does not meet state chemical–specific TBC for lead in surface soil, but falls within the acceptable federal range for lead	Not applicable	Extraction/treatment/discharge systems would comply with action–specific criteria; Monitoring would comply with RIDEM's Rules and Regulations for Ground Water Quality

TABLE ES – 5
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
LONG–TERM EFFECTIVENESS AND PERMANENCE
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Protective in long–term under proposed future commercial/industrial site use based on lack of identified unacceptable risks due to soil exposures; No controls provided to prevent future residential exposures to soil contaminants; Effective in the long–term provided ground water is not used as a drinking water supply; Provides no long–term monitoring of ground water quality; Requires five–year reviews
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Protective in long–term under proposed future commercial/industrial site use based on lack of identified unacceptable risks due to soil exposures; Utilizes institutional controls to limit future residential exposures to the site and to minimize the long–term risks associated with the potential construction and use of an on–site well as a source of drinking water; Monitoring program provides a means of monitoring potential changes in ground water quality; Deed restrictions would require long–term enforcement to ensure their protectiveness; Requires five–year reviews
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	Treatment effective in treating contaminants which exceed ARARs or risk–based PRGs and in preventing off–site migration of contaminants during operation; Permanent contaminant reduction would not necessarily result if ground water treatment is discontinued in the future; Requires long–term maintenance

TABLE ES – 6
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alt rnative 1 – No Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Provides no reduction in toxicity, mobility or volume through treatment; Deed restrictions would limit future site use under which potential contaminant exposure pathways could result in unacceptable risk
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	Provides a reduction in toxicity of ground water contaminants through treatment although reduction may not be permanent

TABLE ES – 7
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
SHORT–TERM EFFECTIVENESS
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	No remedial activities conducted, therefore, no short–term risks result; Does not provide any short–term reduction in potential risks to human health or the environment; Five–year reviews would provide the only means of ensuring compliance with remedial action objectives
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Implementation of deed restrictions would result in no short–term risks; Implementation of the monitoring program would have minimal short–term adverse impacts based on the use of existing wells for ground water monitoring purposes; Would meet remedial response objectives related to minimizing potential human exposures to contaminated ground water by preventing on–site potable well installation; Remedial response objectives would be achieved; Would meet remedial action objectives
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	No significant risks to on–site workers or off–site risks are anticipated; Degree of short–term risk would be dependent upon the individual options employed; Remedial response objectives would be achieved during operation of the treatment system but may not be maintained if treatment is discontinued

TABLE ES – 8
COMPARISON BETWEEN COMPREHENSIVE ALTERNATIVES
IMPLEMENTABILITY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Requires no implementation other than five–year reviews; Would not limit the implementation of other remedial actions
Alternative 2 – Deed Restrictions with Long–Term Ground Water Monitoring	Deed restrictions would have to be implemented as part of the base closure property transfer process; Deed restrictions limiting future installation of on–site potable wells and future residential use of the site would be compatible with future commercial/industrial use of the site; Implementation of deed restrictions or ground water monitoring would not limit the implementation of future remedial actions
Alternative 3 – Extraction/Treatment/Discharge with Deed Restrictions	Relatively easy to implement; Technical implementability would be dependent upon the individual alternative options selected; Some treatment technologies are more easily implemented than others; Services and materials should be readily available for the implementation of all options; Would not limit the implementation of future remedial actions

TABLE ES – 9
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COST
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST (1)	TOTAL PRESENT WORTH (2)
Alt mative 1 – No Action	--	--	--	Nominal (3)
Alt mative 2 – Deed Restrictions with Long–Term Ground Water Monitoring(4)	--	$7,700	$120,000	$140,000
Alt mative 3 – Extraction/Treatment/Discharge with Deed Restrictions				
Precipitation(5)	$185,000	$74,000	$630,000	$980,000
Ion Exchange(6)	$265,000	$33,000	$310,000	$700,000

(1) – Based on 5% discount rate
(2) – Includes 20% contingency on all components
(3) – The only cost associated with the implementation of Alternative GW–1 would be that associated with conducting five–year reviews of the no action decision. Deed restrictions would be implemented under the base closure property transfer process.
(4) – For costing purposes, Alternative 2 consists of Alternative GW–2.
(5) – For costing purposes, the precipitation option consists of Alternatives GW–2, GW–3A, GW–3B, and GW–3D.
(6) – For costing purposes, the precipitation option consists of Alternatives GW–2, GW–3A, GW–3C, and GW–3D.

TABLE ES-10

ALTERNATIVES UNDERGOING DETAILED ANALYSIS
SOIL/GROUND WATER/SEDIMENT
SITE 13 - DISPOSAL AREA NORTHWEST

Soil

Alternative S-1

No Action

Alternative S-2

Limited Action (Institutional Controls)

A. Fencing/Deed Restrictions

Alternative S-3

Containment

A. Revegetation
B. Single-Barrier Cap

Alternative S-4

Soil Treatment/Disposal

A. Soil Excavation and Disposal
B. Soil Excavation and Off-Site Incineration
C. Soil Excavation and On-Site Solvent Extraction
D. Soil Excavation and In-Situ Fungal Degradation

Ground Water

Alternative GW-1

No Action

Alternative GW-2

Limited Action (Institutional Controls)

A. Deed Restrictions/Ground Water Monitoring

Alternative GW-3

Extraction/Treatment/Discharge

A. Interceptor Trench
B. Carbon Adsorption
C. Precipitation
D. Discharge to Surface Water

Catch Basin Sediment

Alternative SD-1

No Action

Alternative SD-2

Removal and Treatment/Disposal

A. Physical Removal
B. Off-Site Disposal
C. Off-Site Treatment
D. On-Site Treatment

TABLE ES-11
DESCRIPTIONS OF GENERAL COMPREHENSIVE ALTERNATIVES
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternativ 1 – No Action	• No action
Alternative 2 – Limited Action	• Deed restrictions to limit future exposures to surficial soil and ground water contamination • Fencing to prevent human exposures to contaminated surface materials • Long-term monitoring of ground water quality
Alternative 3 – Containment and Monitoring	• Sediment excavation and consolidation on-site beneath a single-barrier cap • Deed restrictions to limit future exposures to surficial soil and ground water contamination • Long-term monitoring of ground water quality
Alternative 4 – Containment, Off-Site Soil/ Sediment Remediation, Monitoring	• PCB-contaminated soil and sediment excavation and remediation off-site (off-site disposal or incineration) • Revegetation of the remainder of the site • Deed restrictions to limit future exposures to ground water contamination and to prevent disruption of revegetated areas • Long-term ground water monitoring
Alternative 5 – Containment and On-Site Soil/ Sediment and Ground Water Treatment	• PCB-contaminated soil and sediment excavation and on-site treatment (solvent extraction or fungal degradation) • Revegetation of the remainder of the site • Ground water extraction, treatment and discharge • Deed restrictions to limit future exposures to ground water contamination and to prevent disruption of revegetated areas • Long-term ground water monitoring

TABLE ES-12
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Provides no overall protection of human health and the environment; Does not meet remedial action objectives; Not effective in the long-term
Alternative 2 – Limited Action	Provides protection of human health but not the environment; Does not address potential leaching of PCB-contamination from site soil or potential migration of surface soil contaminants to storm drainage system or migration of catch basin sediments to Hall Creek; Does not meet remedial action objectives; Not effective in the long-term
Alternative 3 – Containment and Monitoring	Protective of human health and the environment; Limits potential exposures to human receptors through physical containment and deed restrictions; Limits potential erosion and contaminant migration through physical containment of contaminated surface soils and sediments; Potential contaminant migration due to leaching is minimized by presence of cap; Does not treat principal threat; Provides long-term monitoring to identify any changes in ground water quality in the future
Alternativ 4 – Containment, Off-Site Soil/ Sediment Remediation, Monitoring	Protective of human health and the environment; Limits potential exposures to human receptors and potential for contaminant leaching through removal and disposal or treatment of PCB-contaminated soils and sediments; Limits potential erosion of low-level surficial contamination through physical containment; Incineration would provide treatment of principal threat; Provides long-term monitoring to identify any changes in ground water quality in the future; Limits potential exposures to ground water through deed restrictions which would prohibit installation of an on-site potable well
Alternative 5 – Containment and On-Site Soil/ Sediment and Ground Water Treatment	Protective of human health and the environment; Limits potential exposures to human receptors and potential for contaminant leaching through removal and treatment of PCB-contaminated soils and sediments; Limits potential erosion of low-level surficial contamination through physical containment; Provides treatment of principal threat; Provides active treatment of ground water; Protection against contaminated ground water migration may not be permanent following treatment system discontinuation

TABLE ES-13
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative 1 – No Action	Does not meet ARARs/TBCs applicable to PCBs in soil or MCLs in ground water	Meets criteria; involves no actions which impact potential archaeologically significant areas	Not applicable
Alternative 2 – Limited Action	Does not meet ARARs/TBCs applicable to PCBs in soil or MCLs in ground water but limits potential exposures through deed restrictions and fencing	Construction of fencing would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring
Alternative 3 – Containment and Monitoring	Meets ARARs/TBCs applicable to PCBs in soil through containment; Does not achieve MCLs in ground water but limits potential exposures through deed restrictions	Capping would be conducted in coordination with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring; EPA Guidance on Remedial Actions for Superfund Sites with PCB Contamination would be considered in design and implementation of cap
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Meets ARARs/TBCs applicable to PCBs in soil through off-site disposal or treatment; Does not achieve MCLs in ground water but limits potential exposures through deed restrictions	Soil excavation would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring, hazardous waste characterization, waste generation, transport, off-site disposal or incineration
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Meets ARARs/TBCs applicable to PCBs in soil through off-site disposal or treatment; Achieves MCLs in ground water through treatment	Soil excavation and on-site treatment system construction would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring, hazardous waste characterization, waste generation, transport, and treatment or disposal

TABLE ES-14
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Residual risk to human health and the environment remains; Provides no long-term protection; 5-year reviews required
Alternativ 2 – Limited Action	May be effective in the long-term in reducing risks to humans but residual risk to the environment remains; Provides no long-term protection against leaching of PCBs, migration of surficial soil contamination to the storm drainage system or migration of catch basin sediments to Hall Creek; Monitoring would identify any changes in ground water quality; 5-year reviews required
Alternative 3 – Containment and Monitoring	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as limiting potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of cap area required; Long-term monitoring would provide a means of monitoring any changes in ground water; 5-year reviews required
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as eliminating potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of revegation area required; Long-term monitoring would provide a means of monitoring any changes in ground water quality; 5-year reviews required
Alternativ 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as eliminating potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of revegetation area required; Effective in the treatment of ground water contaminants; Long-term maintenance of treatment systems required; Long-term ground water monitoring would provide a means of monitoring any changes in ground water once treatment is discontinued; Permanence in eliminating future re-contamination of ground water is not ensured once treatment is discontinued; 5-year reviews required

TABLE ES-15
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Provides no reduction of contaminant toxicity, mobility or volume through treatment
Alternativ 2 – Limited Action	Provides no reduction of contaminant toxicity, mobility or volume through treatment
Alternative 3 – Containment and Monitoring	Provides no reduction in contaminant toxicity, mobility or volume through treatment; Reduces contaminant mobility through containment features
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Provides a reduction in soil and sediment contaminant mobility through off-site disposal or a reduction in toxicity through off-site incineration; Incineration would treat principal threat associated with PCB contamination; provides no reduction of ground water toxicity, mobility or volume through treatment
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Provides a reduction in soil and sediment contaminant mobility through on-site treatment; Treats principal threat associated with PCB contamination; Reduces mobility and toxicity of ground water contaminants through treatment

TABLE ES-16
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 - No Action	Effective in short-term; However, remedial action objectives are not achieved
Alternative 2 - Limited Action	Effective in short-term; However, remedial action objectives are not achieved
Alternative 3 - Containment and Monitoring	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments; Remedial action objectives achieved
Alternative 4 - Containment, Off-Site Soil/Sediment Remediation, Monitoring	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments; Remedial action objectives achieved
Alternative 5 - Containment and On-Site Soil/Sediment and Ground Water Treatment	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments and operation of on-site treatment systems; Remedial action objectives achieved

TABLE ES-17
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
IMPLEMENTABILITY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Requires no implementation other than five-year reviews; Would not limit the implementation of other remedial actions
Alternative 2 – Limited Action	Long-term monitoring program and fencing easily implemented; Deed restrictions would be incorporated into the base closure property transfer process; Would not limit the implementation of other remedial actions; Would limit feasibility of utilizing the site for future commercial/industrial uses, as specified within the Base Reuse Plan
Alternative 3 – Containment and Monitoring	Materials and services readily available; Cap construction requires special materials and installation expertise; Could limit future site development although it would not be incompatible with surrounding commercial/industrial site use; Presence of cap could impact implementation of other remedial actions, if required; Deed restrictions would be incorporated into the base closure property transfer process
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Materials and services readily available; Could limit future site development although it would not be incompatible with surrounding commercial/industrial site use; Not expected to limit the implementation of other remedial actions, if required; Deed restrictions would be incorporated into the base closure property transfer process
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Innovative soil/sediment treatment technologies would require treatability studies and utilize technologies which are not widely available; Ground water treatment technologies fairly easily implemented; Not expected to limit the implementation of other remedial actions, if required Deed restrictions would be incorporated into the base closure property transfer process

TABLE ES–18
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COST
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST (1)	TOTAL PRESENT WORTH (2)
Alternative 1 – No Action	--	--	--	Nominal (3)
Alternative 2 – Limited Action (4)	$51,000	$49,000	$740,000	$950,000
Alt mative 3 – Containment and Monitoring (5)	$1,300,000	$54,000	$820,000	$2,600,000
Alt mative 4 – Containment, Off–Site Soil/Sediment Remediation, Monitoring (6)				
Off–Site Disposal	$590,000	$49,000	$750,000	$1,600,000
Off–Site Incineration	$2,200,000	$49,000	$750,000	$3,600,000
Alternative 5 – Containment and On–Site Soil/Sediment and Ground Water Treatment (7)				
Solvent Extraction	$950,000	$150,000	$2,300,000	$3,900,000
Fungal Degradation	$1,000,000	$150,000	$2,300,000	$4,000,000

Note: Costs are presented based on a combination of individual alternative costs as presented in Section 4 tables.
(1) – Based on 5% discount rate
(2) – Includes 20% contingency on all components
(3) – The only cost associated with the implementation of Alternative 1 would be that associated with conducting five–year reviews of the no action decision.
(4) – For costing purposes, Alternative 2 consists of Alternatives S–2 and GW–2
(5) – For costing purposes, Alternative 3 consists of Alternatives S–3B and GW–2
(6) – For costing purposes, Alternative 4 consists of Alternatives S–3A and GW–2 combined with Alternatives S–4A or S–4B
(7) – F[illegible]osting purposes, Alternative 5 consists of Alternatives S–3A, GW–[illegible]d GW–3 combined with Alternatives S–4C or S–4D

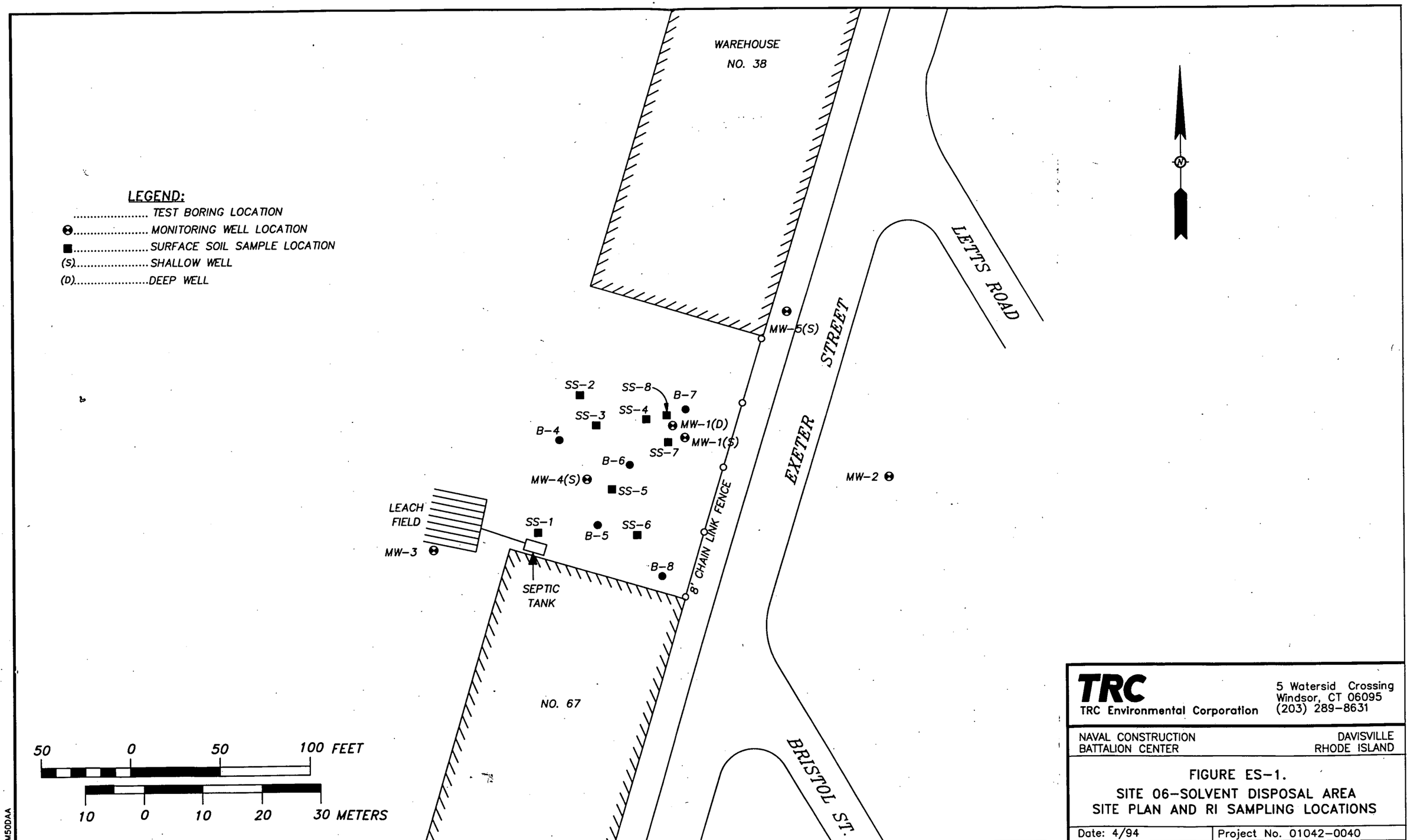

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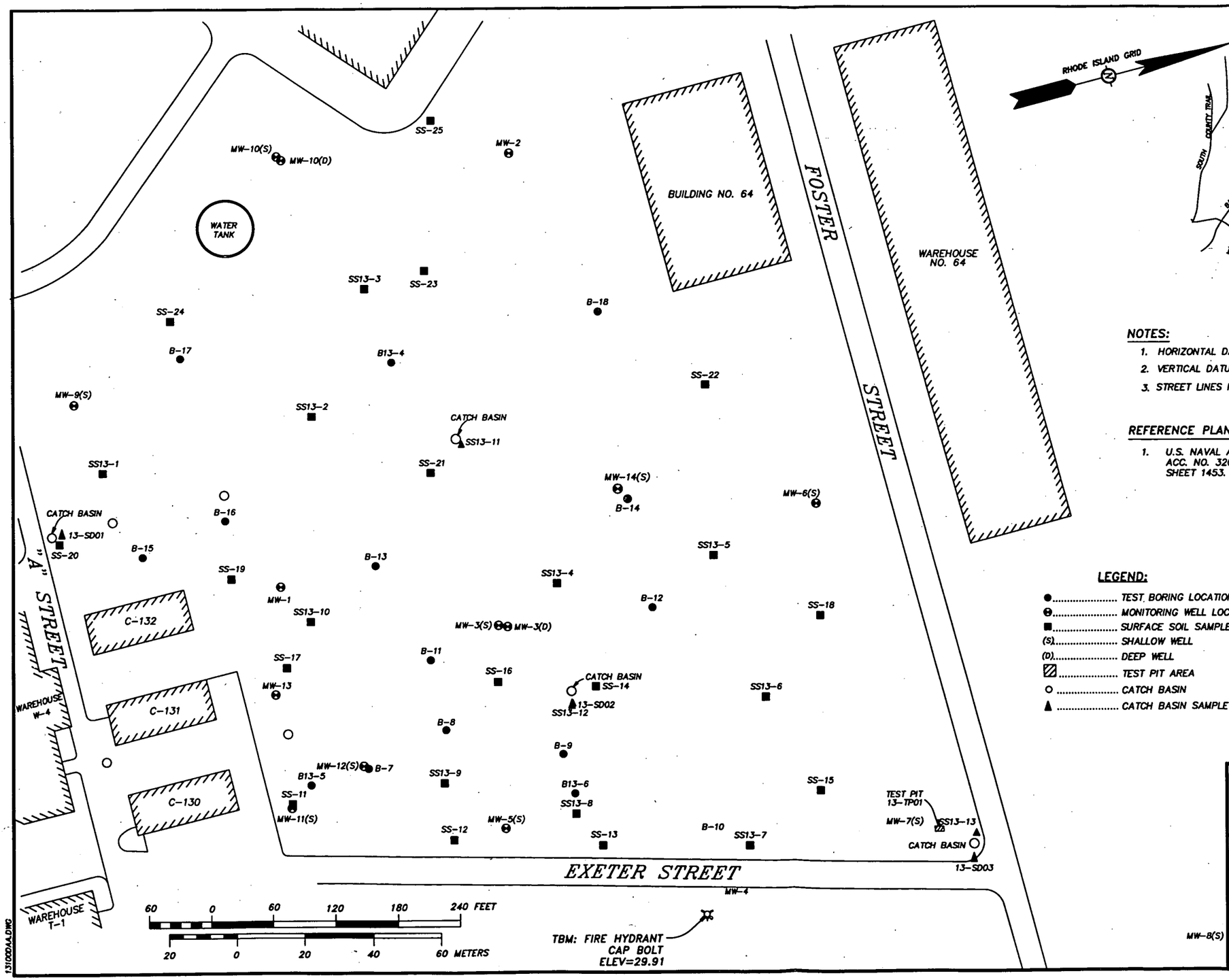
FIGURE ES-1.
SITE 06-SOLVENT DISPOSAL AREA
SITE PLAN AND RI SAMPLING LOCATIONS

Date: 4/94
Project No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517866.3
MW-14(S)	28.15	30.15	190819.2	518196.6

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FIGURE ES-2.

SITE 13-DISPOSAL AREA NORTHWEST
SITE PLAN AND RI SAMPLING LOCATIONS

Date: 4/94 | Project No. 01042-0040

131000AA.DWG

Detailed Analysis of Alternatives
Site 06 - Solvent Disposal Area
Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1
Naval Construction Battalion Center

Volume I
Introduction

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1.0 INTRODUCTION

TRC Environmental Corporation (TRC) is conducting a Remedial Investigation/Feasibility Study (RI/FS) at the Naval Construction Battalion Center, located in the northeast section of the town of North Kingstown, Rhode Island (NCBC Davisville). The RI/FS is being conducted under the Navy's Installation Restoration Program and in accordance with the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). The study is being performed by TRC under Contract N62472-85-C-1026 for NORTHNAVFACENGCOM.

The Feasibility Study process was formulated by the U.S. Environmental Protection Agency (USEPA) to properly implement CERCLA. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 CFR Part 300) establishes the framework for performing Feasibility Studies. Further definition of the FS process is provided in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988a).

Previous investigations under which environmental data for the NCBC Davisville facility were developed include the following:

- Initial Assessment Study (IAS) (Hart, 1984a);
- Verification Step Report (part of a Confirmation Study) (TRC, 1987); and
- Phase I RI Draft Final Report (TRC, 1991).

Based on these studies, twelve sites were identified at NCBC Davisville for which Feasibility Study efforts were initiated. The site numbers were assigned during the IAS and have been retained under this investigation for consistency. The twelve sites were initially grouped for the purposes of conducting Feasibility Studies as follows:

- Group I Sites
  - Site 05 - Transformer Oil Disposal Area
  - Site 06 - Solvent Disposal Area
  - Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1
- Group II Sites
  - Site 08 - DPDO Film Processing Disposal Area

- Group III Sites
  - Site 12 - Building 316, DPDO Transformer Oil Spill Area
  - Site 14 - Building 38, Transformer Oil Leak Area
- Group IV Sites
  - Site 02 - CED, Battery Acid Disposal Area
  - Site 03 - CED, Solvent Disposal Area
- Group V Sites
  - Site 07 - Calf Pasture Point
  - Site 09 - Allen Harbor Landfill
- Group VI Sites
  - Site 10 - Camp Fogarty Disposal Area
- Group VII Sites
  - Site 11 - Fire Fighting Training Area

Figure 1-1 provides a summary of the approach being used in this investigation to formulate appropriate remedial responses for the NCBC Davisville sites. The FS is being conducted in phases. The first step of the Feasibility Study process, the Initial Screening of Alternatives or ISA, was conducted for the twelve sites on the basis of Phase I RI information. Two ISA reports were prepared (TRC, 1993a and 1993b), one which addressed the Group I, Group II, Group III and Group VI sites and the second which addressed the remaining groups of sites. The ISA reports incorporate the following steps:

- Introduction/Background Information
- Assessment of Applicable or Relevant and Appropriate Requirements (ARARs)
- For each group of sites:
  - Site-Specific Information
  - General Response Actions
  - Identification and Screening of Technologies
  - Development and Initial Screening of Alternatives
- References

Subsequent to the initiation of the Feasibility Study activities, the Group III Sites, Sites 12 and 14, were addressed separately through the development of a Risk Assessment Technical

Memo (TRC, 1993c), a Proposed Plan for additional remedial activities, and the development and signature of a Record of Decision (ROD).

Also subsequent to the development of the ISA Reports, the Phase II Remedial Investigation was conducted, with the results presented in a series of draft reports (TRC, 1993d, 1993e, 1993f). Included in the Phase II RI are a Human Health Risk Assessment, which considers both Phase I and Phase II RI data in the evaluation of potential risks to human health, and an Ecological Risk Assessment, which evaluates the potential risks to the environment posed by the investigated sites.

This document, the Detailed Analysis of Alternatives (DAA), assesses the need for the application of potential remedial technologies at Site 06 - Solvent Disposal Area and Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1, as defined by existing site information. It builds upon the evaluation conducted in the ISA (TRC, 1993a) and incorporates the results of the Phase II RI in the evaluation of potential remedial technologies for Sites 06 and 13. The format followed within this DAA generally follows the original ISA format, with facility background information followed by a site-specific evaluation of the nature and extent of contamination, and the potential risks to human health and the environment posed by the site. The report presents the refinement of remedial response objectives, originally proposed within the ISA, the refinement of remedial alternatives, and detailed individual and comparative analyses of the remedial alternatives.

1.1 Facility Location and Description

NCBC Davisville is located in the northeast section of the town of North Kingstown, Rhode Island, approximately 18 miles south of Providence. A site location map is provided in Figure 1-2. NCBC-Davisville is composed of three areas including the Main Center, the West Davisville storage area, and Camp Fogarty, a training facility located approximately 4 miles west of NCBC-Davisville. A significant portion of NCBC Davisville is contiguous with Narragansett Bay. These areas are noted in Figure 1-3.

Adjoining NCBC-Davisville's boundary on the south is the decommissioned Naval Air Station (NAS) Quonset Point that was declared excess to the Navy in April, 1973. The Quonset Point area is currently owned by the Rhode Island Port Authority (RIPA) and the Rhode Island

Department of Transportation (RIDOT), along with some private companies. Hereafter, this area will be referred to as NAS Quonset Point, to distinguish it from NCBC Davisville.

1.2 NCBC Davisville History

Quonset Point was the location of the first annual encampment of the Brigade Rhode Island Militia in 1893. During World War I, it was designated for the mobilization and training of troops and later was the home of the Rhode Island National Guard. In the 1920s and 1930s, Quonset Point functioned as a summer resort.

In 1939, Quonset Point was acquired by the Navy to establish a Naval Air Station (NAS), and construction began in 1940. During construction, millions of cubic yards of sediment were dredged to create a ship basin and channel.

By 1942, the operations at NAS Quonset Point had expanded into what is now called NCBC Davisville. Land at Davisville adjacent to NAS Quonset Point was designated the Advanced Base Depot, and the first of two piers was constructed. Later that year the Naval Construction Training Center (NCTC), known as Camp Endicott, was established to train the newly established construction battalions.

After World War II, activities at NAS Quonset Point remained the same, providing an operating base for aircraft and ships. After 1947, NAS Quonset Point was a site of carrier-based jet aviation. The Antarctic Development Squadron Six was moved to NAS Quonset Point in 1956. A Naval Air Rework Facility (NARF) was created there in 1967. The Naval Hospital was established in 1968.

The NCBC Davisville area was inactive between World War II and the Korean Conflict. In 1951 it became the Headquarters Construction Battalion Center (CBC). In 1974, the NAS and NARF at Quonset Point were decommissioned, and operations at Davisville were greatly reduced. In 1980, RIPA purchased NAS Quonset Point and the two Davisville piers from the Navy. In 1989, the closure of Davisville was announced, and all operations at Davisville were phased down to the present staffing levels for Public Works, Maintenance, Security and Navy Personnel. The facility will be officially closed on April 1, 1994, and subsequently held under caretaker status by the Naval Facilities Engineering Field Division (Northern Division). Under

caretaker status, a civilian presence will be maintained at or near NCBC Davisville to monitor and provide oversight for all identified hazardous waste sites.

A Base Reuse Committee was established to develop a Comprehensive Reuse Plan to guide future use and development of the NCBC Davisville facility following closure. The proposed land uses defined under the Reuse Plan have been used as the basis for evaluation of future site uses in the RI/FS evaluations.

1.3 History of Facility Response Actions at NCBC Davisville

1.3.1 Previous Investigations - U.S. Navy

In 1983, Fred C. Hart Associates, Inc. (Hart) conducted an Initial Assessment Study (IAS) under contract to the Navy Assessment and Control of Installation Pollutants (NACIP) Office, with the purpose of identifying areas where potential contamination from past waste storage, handling or disposal practices at NCBC Davisville could pose threats to human health and the environment. The IAS identified a total of 14 potentially contaminated sites at NCBC Davisville (Hart, 1984a) Based on regulatory review of the IAS report, seven additional areas were added for a total of 21 potential areas of contamination at NCBC Davisville.

A Confirmation Study (CS) - Verification Step was initiated by TRC Environmental Consultants, Inc. (TRC) in March 1985. The purpose of the CS was to assess the nature and extent of contamination at 13 of the 21 sites identified in the IAS. The sites investigated during the Verification Step program included:

- Site 02 - CED Battery Acid Disposal Area;
- Site 03 - CED Solvent Disposal Area;
- Site 04 - CED Asphalt Disposal Area;
- Site 05 - Transformer Oil Disposal Area;
- Site 06 - Solvent Disposal Area;
- Site 07 - Calf Pasture Point;
- Site 08 - DPDO Film Processing Disposal Area;
- Site 09 - Allen Harbor Landfill;
- Site 10 - Camp Fogarty Disposal Area;
- Site 11 - Fire Fighting Training Area;
- Site 12 - DPDO Transformer Oil Spill Area;
- Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1; and
- Site 14 - Building 38, Transformer Oil Leaks.

1.3.2 Previous Investigations - USEPA

NCBC Davisville was proposed by the USEPA for inclusion on the National Priority List (NPL) in July 1989. NCBC Davisville was added to the NPL on November 21, 1989. USEPA developed a Hazard Ranking System (HRS) scoring package to support the proposed and final listings. The HRS package was based on existing information; a Preliminary Assessment/Site Investigation was not performed.

The HRS package noted that of the 24 potential sites which were identified in a combined study of NCBC Davisville, West Davisville, Camp Fogarty, and the decommissioned Quonset Point, the most serious sites of concern, and the sites which were aggregated to form the basis of the ranking package, are Site 09 - Allen Harbor Landfill and Site 07 - Calf Pasture Point.

Of the 24 potential sites listed in the HRS package, the areas designated 1 through 14 coincide with the 14 areas identified in the Navy's IAS. The remaining potential areas, 15 through 24, were identified by the EPA from an "Off-Site Activity Investigation" report (Hart, 1984b). The HRS package notes that areas 15 through 24 are on property not currently owned or operated by the U.S. Navy and are not included as part of the NPL site. Several of these areas are being investigated by the Army Corps of Engineers' program aimed at former defense facilities.

1.3.3 Current Remedial Investigation

In 1988, the Navy's three-phase NACIP Program was restructured to conform with USEPA's four-phase program. This change was predicated by the Superfund Amendments and Reauthorization Act (SARA) of 1986. The U.S. Navy changed its NACIP Program to closely parallel the USEPA requirements for remedial actions at Superfund sites. The Navy's program is now called the Installation Restoration (IR) Program. Under the IR Program, current investigations at NCBC-Davisville are in the Remedial Investigation/Feasibility Study (RI/FS) phase.

In March 1988, TRC was tasked by the Navy to implement recommendations of the Confirmation Study - Verification Step by developing a Plan of Action as a NACIP Confirmation Study - Characterization Step to conduct more extensive sampling. Shortly after initiating this task, the Navy requested TRC to develop a Remedial Investigation (RI) Work Plan conforming

to the newly-established Navy IR Program, and to the extent possible, conforming to current EPA requirements under the NCP and the USEPA draft RI guidance (USEPA, 1988a). The resulting Phase I RI/FS Work Plan included a Field Sampling Plan, a Health and Safety Plan, a Quality Assurance Project Plan and a Data Management Plan (TRC, 1988). The Phase I RI field investigations were conducted from September 1989 to March 1990 and the Phase I RI Draft Final Report was submitted to the Navy in May 1991.

A Phase II RI/FS Work Plan was developed by TRC in 1992 and was implemented in the field over a period spanning from December 1992 through September 1993. The results of the Phase I and Phase II RIs are presented in a series of technical reports for the various sites (TRC, 1993d, 1993e, 1993f).

1.4 Regional Geology, Hydrogeology and Hydrology

The regional and site-specific geology, hydrogeology and hydrology are briefly discussed in the following sections. More comprehensive descriptions are provided in the Remedial Investigation Technical Report (TRC, 1993d).

1.4.1 Regional Geology

The area of Narragansett Bay, including the surrounding lowlands and islands in the Bay, overlies the Narragansett Basin. This geologic structure is a complex syncline of Pennsylvanian Age metasedimentary rocks about 12 miles wide and up to 12,000 feet deep. The Narragansett Basin's western limit is about 3 miles west of NCBC Davisville, and its eastern edge is close to Fall River, Massachusetts. All of the NCBC-Davisville sites, except Site 10 - Camp Fogarty, overlie the Narragansett Basin. The bedrock is overlain by various glacial deposits up to 200 feet thick that have left the basin area relatively flat compared to the surrounding areas (Schafer, 1961).

The bedrock forming the basin is comprised of five formations which consist chiefly of non-marine conglomerates, sandstones, and shales. The principal unit is the Rhode Island Formation, which consists of a gray-greenish fine to coarse conglomerate, sandstone, lithic graywacke, graywacke, arkose, shale, and a minor amount of meta-anthracite and anthracite.

According to Johnson and Marks (1959), in the vicinity of NCBC Davisville, the bedrock is more than 90 feet below sea level in the West Passage of Narragansett Bay, greater than 70 feet below sea level just west of Frys Pond, nearly 50 feet below sea level near the West Davisville facility, and nearly 100 feet above sea level near Camp Fogarty. The Geologic Map and Sections of the Wickford Quadrangle, Rhode Island (Williams, Bulletin 1158-C, 1964) and visual observations identify a major bedrock outcrop just west of Frys Pond (approximately 300 yards east of Site 05).

The unconsolidated soils overlying the bedrock consist of three general types of glacial deposits: till, water-laid deposits, and wind-deposited material. In the Davisville area, till is exposed along highlands such as Lippitt Hill, the hillside due west of the rifle and pistol range at Camp Fogarty, and along the hillside of the ridge between West Davisville and NCBC Davisville. Just northeast of Site 02, there is an end moraine deposit which controlled the pro-glacial melt water drainage system.

Most of the surficial geologic soils in the Davisville area are water-laid deposits. Melt water streams flowing along the west side of the end moraine near Site 02 deposited a sequence of sands and silts over most of NCBC Davisville, including Sites 02, 03, 05, 06, 11, 13, and 14. Melt water streams also deposited layers of sand and silt near West Davisville (Sites 08 and 12) and the Allen Harbor Landfill (Site 09). Fine-grained glaciolacustrine soils underlie Calf Pasture Point (Site 07). At Camp Fogarty (Site 10), the rifle and pistol range overlies a kame terrace consisting of sand and gravel deposited by melt water streams which flowed alongside the glacier which moved through the Hunt River valley.

Wind deposited materials in the Davisville area are loose, heterogeneous, and relatively thin in comparison to the other glacial deposits in the area [10 feet at the higher elevations, and over 150 feet thick in some portions of the bedrock valleys (Schafer, 1961)].

1.4.2 Regional Hydrogeology

Ground water hydrogeology in the Davisville area is controlled by the geographic and geologic setting. The underlying bedrock units have primary porosities (pore openings between the grains of mineral crystals forming the rock) of less than 1 percent and very low secondary porosities (joints, fractures and openings along bedding planes). The only openings capable of

yielding significant amounts of ground water are the secondary openings. In general, well yields from the bedrock formations are generally low, about 22 gallons per minute (gpm) from an average depth of approximately 225 feet. Flow from the secondary openings is greatest in the top 250 to 300 feet of bedrock (Rhode Island Development Council, 1952). In the Davisville area, the bedrock is not the principal aquifer and, therefore, is penetrated by only a small portion of wells.

The glacial soils in the Davisville area generally consist of stratified sand/gravel interbedded with very fine sand and silt; glacial till (a heterogeneous mixture of silt, sand, clay, and gravel), and stratified sand or gravel interbedded with varying amounts of glacial till. All of these materials will yield ground water, but only the stratified sands or gravels are permeable enough to yield large quantities of water for development. These very permeable materials form the Hunt Ground Water Reservoir or Hunt River Aquifer (previously known as the Potowomut-Wickford Aquifer), which is the principal source of potable water in the area. The specific yield capacities can range between 5 and 300 gallons per minute per foot drawdown (gpm/ft), with some wells yielding as much as 2,700 gpm. A hydrologic review of the aquifer recharge and discharge shows the long-term sustained safe yield of the entire Hunt Ground Water Reservoir is about 8 million gallons per day (mgd) (GZA, 1992).

Ground water in the Davisville area is unconfined; therefore, movement of the ground water is in direct response to gravity. The direction of regional ground water flow in the Davisville area is west to east, from the highlands towards Narragansett Bay. For small localized areas, the direction of ground water flow will be to the nearest downhill discharge area.

Ground water quality beneath the Davisville area is classified by the RIDEM as GAA-NA (Sites 08, 10, and 12) and GB (Sites 02, 03, 05, 06, 07, 09, 11, 13 and 14). GAA ground water is considered to be suitable for public drinking water use without treatment. Non-attainment areas (NA) are those areas that have pollutant concentrations greater than ground water quality standards for the applicable classification; a goal of restoration to ground water quality consistent with the standards is applicable to such areas. GB ground water is not suitable for public or private drinking water use. Areas were classified as GB because of known or presumed ground water degradation due to urbanization and/or identified waste disposal sites.

Rhode Island regulations do not require cleanup to drinking water standards, but if RIDEM determines resultant impacts need to be addressed or if contaminant levels pose a risk or contaminants migrate off-site, the Department can require remediation. The need for cleanups are determined on a site-by-site basis.

The ground water quality of the Hunt Ground Water Reservoir is suitable for most purposes. It generally contains less than 70 ppm of dissolved solids and the pH is slightly acidic to neutral, with a range of 5.5 to 7.0. The principal anions in the ground water are bicarbonate, sulfate, chloride and nitrate, all usually present at concentrations less than 25 ppm. In the vicinity of Narragansett Bay, the chloride concentration may exceed 250 ppm, due to salt water intrusion. The principal cations in the ground water are calcium, sodium, magnesium and potassium, each generally present at concentrations less than 10 ppm, resulting in soft water. Iron and manganese usually do not exceed drinking water standards (Rosenshein, Gonthiel and Allen, 1968).

1.4.3 Area Water Use

Available information (Personal Communication, Cohen, Smith, 1992) indicates that potable water in the Davisville area is supplied by either the North Kingstown Water Department or the Rhode Island Port Authority.

The North Kingstown Water Department supplies the non-military portion of Davisville and North Kingstown with water. North Kingstown operates three wells located in the Hunt Ground Water Reservoir and has proposed an additional well location (GZA, 1992). The locations of these wells are indicated in Figure 1-4.

The Rhode Island Port Authority (RIPA) supplies water on a wholesale basis to the Navy and some private users on Quonset Point (Personal Communication, Cohen, 1992). RIPA obtains its water from a series of three ground water supply wells located in the Hunt Ground Water Reservoir, as indicated in Figure 1-4. The Kent County Water Authority, which supplies water to towns north of North Kingstown, also maintains a ground water production well in the Hunt Ground Water Reservoir, also shown in Figure 1-4.

No active ground water supply wells exist at NCBC-Davisville on Navy property (Personal Communication, Cohen, 1992).

As part of the Phase II RI, a search of potential private well locations was conducted within one-mile radii of the main center of NCBC Davisville, of Camp Fogarty and of the vicinity of Sites 07 and 09. The search area was located within the Town of North Kingstown and within the Town of East Greenwich (Camp Fogarty). Following an identification of street names within the study areas, specific street addresses were identified based upon a review of town tax records, and addresses at which water service is provided were identified based upon a review of town water department records. To identify potential addresses where private wells could be in use, the town tax addresses were compared with the water service addresses. From this comparison, an initial list of potential private well users was compiled. Tax codes noted for each address on the town tax list indicate the use of the property. These codes were used to eliminate all vacant lots from further consideration, thereby reducing the list of potential addresses where private wells could be in use. All tax codes that described property uses that could potentially utilize a potable water source were retained.

For Sites 02, 03, 06, 11 and 13, and Sites 07 and 09, addresses located on twelve streets were identified as potentially using private wells in this evaluation. The street locations are highlighted in Figure 1-5. As shown, three of the streets, Mountview Avenue, Pettee Avenue and Coolidge Avenue are located to the north of Sites 07 and 09. Fletcher Road, Newcomb Road, Northrup Road, and Signal Rock Road are located west of Sites 07 and 09 and north of Sites 02, 03, 06, 11 and 13. Boyer Street and Tidal Drive are located southeast of the Sites 07 and 09 and northeast of Sites 02, 03, 06, 11 and 13, adjacent to the eastern side of Allen Harbor. Genoa Drive, Smith Street, and Spinnaker Street are located south of Sites 02, 03, 06, 11 and 13.

For Site 10, addresses located on ten streets were identified as potentially using private wells in this evaluation. The street locations are highlighted in Figure 1-6. Cartier Court, Cavalier Drive, Ezechiel Carre Road and Frenchtown Road are all located north of Site 10. Meadowbrook Road, King Phillip Trail, Pequot Trail and South County Trail are located east and northeast of Site 10. South Road and Tillinghast Road are located south and west of Site 10, respectively.

1.4.4 Regional Hydrology

All of the investigated sites lie within the Hunt River drainage basin. The basin is about 60 square miles in area and is divided into four smaller sub-basins (Figure 1-7). Camp Fogarty and West Davisville lie within the Potowomut River basin, and the Main Center of NCBC Davisville lies within the Coastal River basin. All stream flow and river flow eventually discharges into Narragansett Bay (Figure 1-7). Surface water features in the immediate vicinity of NCBC Davisville are indicated in Figure 1-8. During most of the year, a part of the stream flow consists of water discharged from detention storage in natural, as well as man-made impoundments. The remaining flow is from direct runoff of precipitation and from base runoff consisting largely of ground water discharge. The ground water contributes close to 50 percent of the average annual stream flow.

Annual precipitation in the area has ranged from 24.8 to 66.2 inches with an average of 42.3 inches. The frequency of measurable precipitation events (0.01 inch or greater) averages once every 3 days and is evenly distributed throughout the year. The average snowfall is almost 40 inches and has varied from 11.3 to 75.6 inches. Roughly 36 percent of the precipitation actually recharges the ground water system; the other 64 percent runs off into streams or is lost through evapotranspiration (GZA, 1992).

The surface water and ground water quality are similar since ground water contributes a major portion to stream flow. The principal anions are bicarbonate, sulfate, chloride, and nitrate. The principal cations are calcium, sodium, magnesium, and potassium. The pH ranges between 5.5 and 7.0. The iron concentrations in stream water vary from 0.03 to 3.7 ppm with the higher concentrations detected in Sandhill Brook, the lower reach of Hunt River, and the Potowomut River. Manganese concentrations range between less than 0.01 and 0.54 ppm (Rosenshein, Gonthiel, and Allen, 1968).

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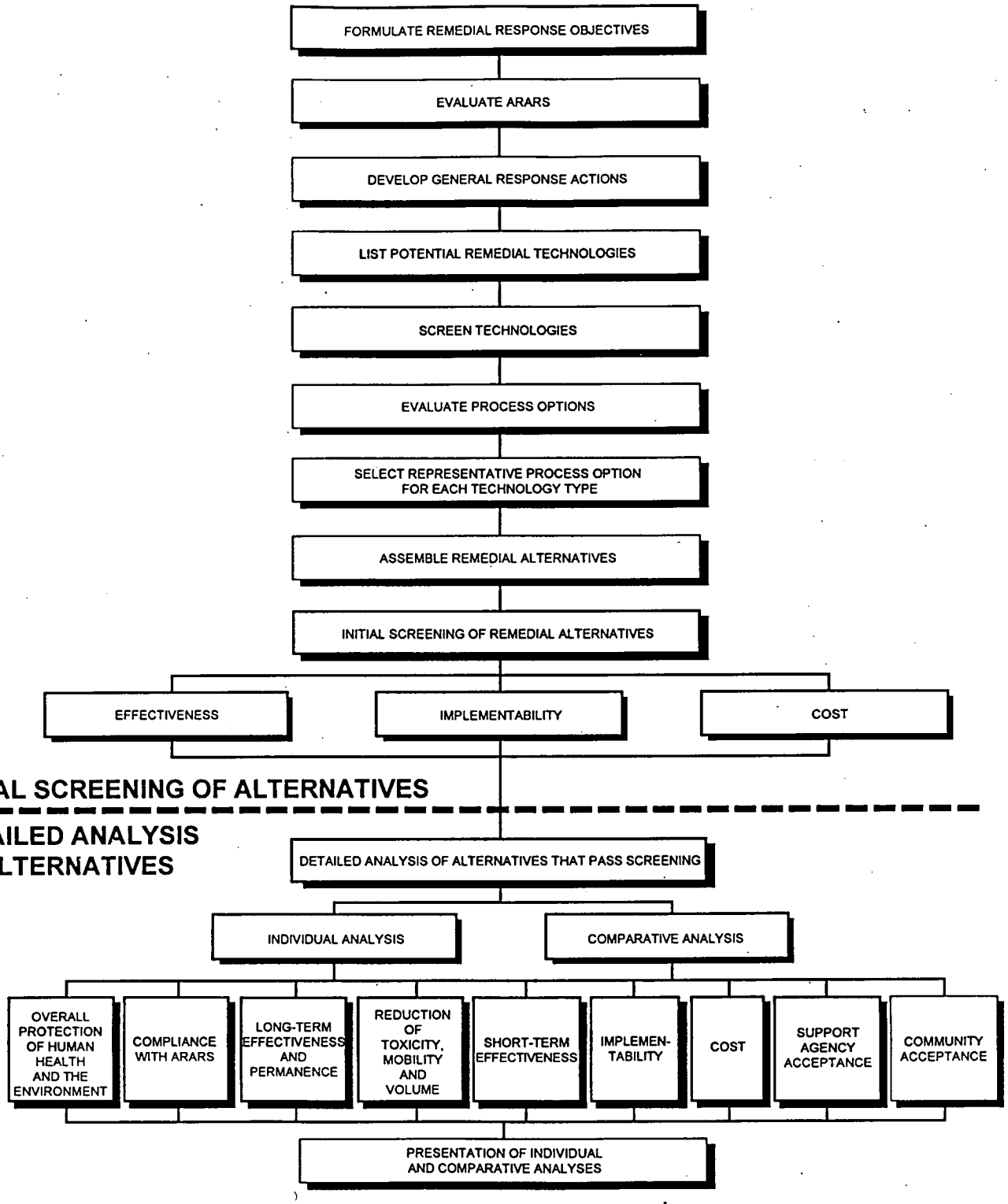


SOURCE: USEPA

TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631

NAVAL CONSTRUCTION BATTALION CENTER

DAVISVILLE RHODE ISLAND

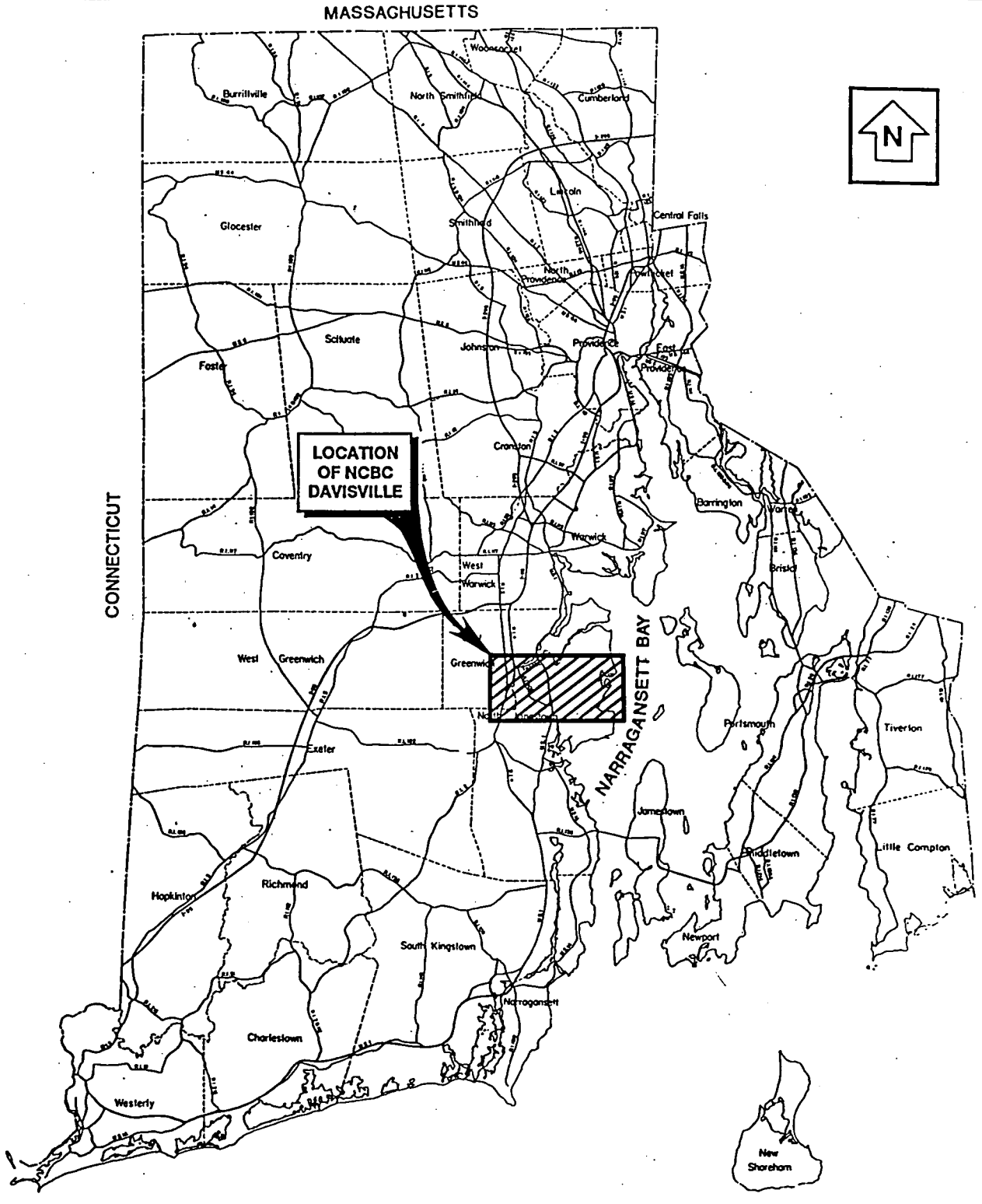
FIGURE 1-1.

FEASIBILITY STUDY APPROACH

Date: 4/94

Project No. 01042-0040

01042020



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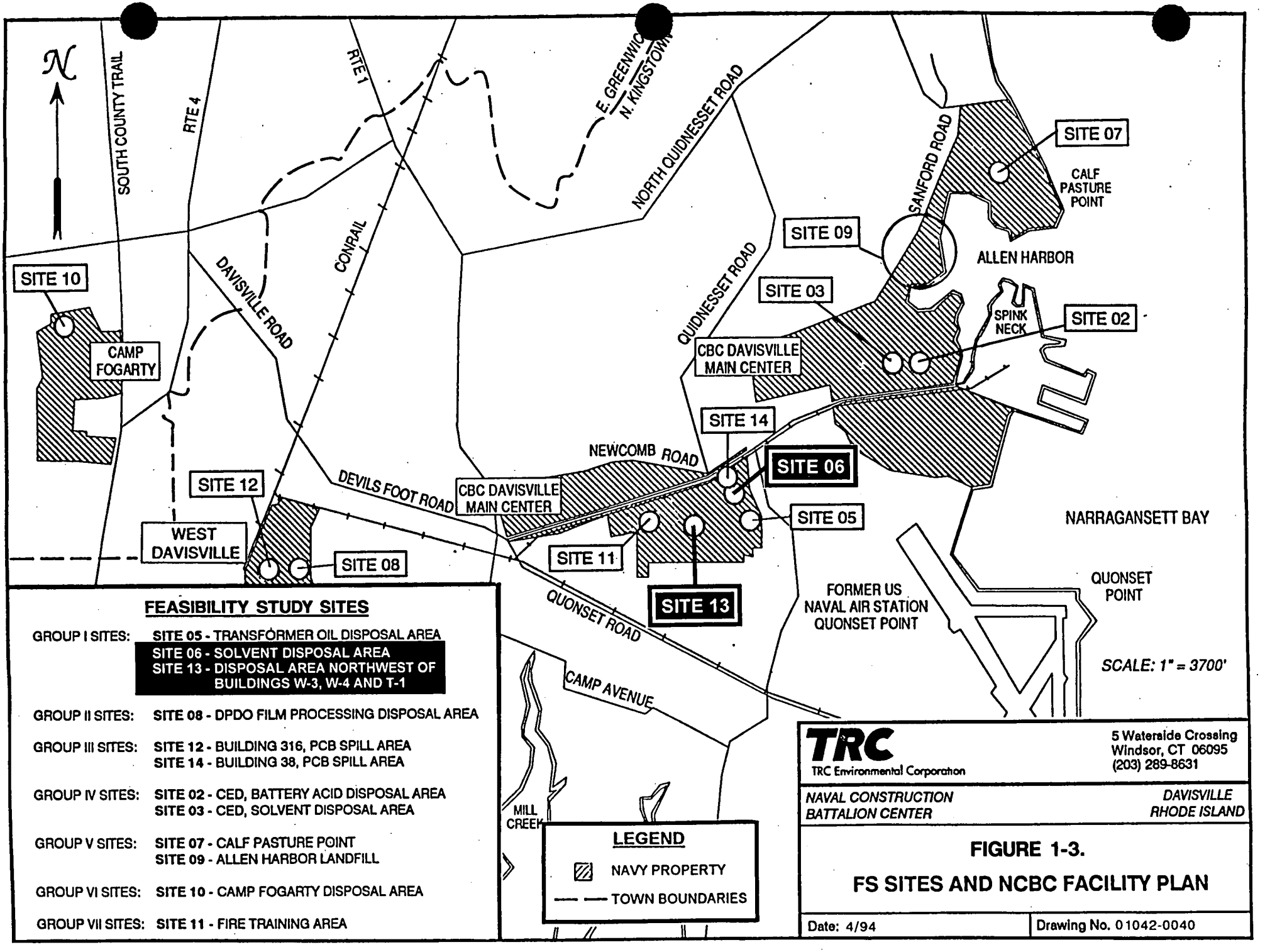
DAVISVILLE RHODE ISLAND

FIGURE 1-2.

NCBC FACILITY LOCATION PLAN

Date 4/94

Project No. 01042-0040



FEASIBILITY STUDY SITES

GROUP I SITES: SITE 05 - TRANSFORMER OIL DISPOSAL AREA
SITE 06 - SOLVENT DISPOSAL AREA
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

GROUP II SITES: SITE 08 - DPDO FILM PROCESSING DISPOSAL AREA

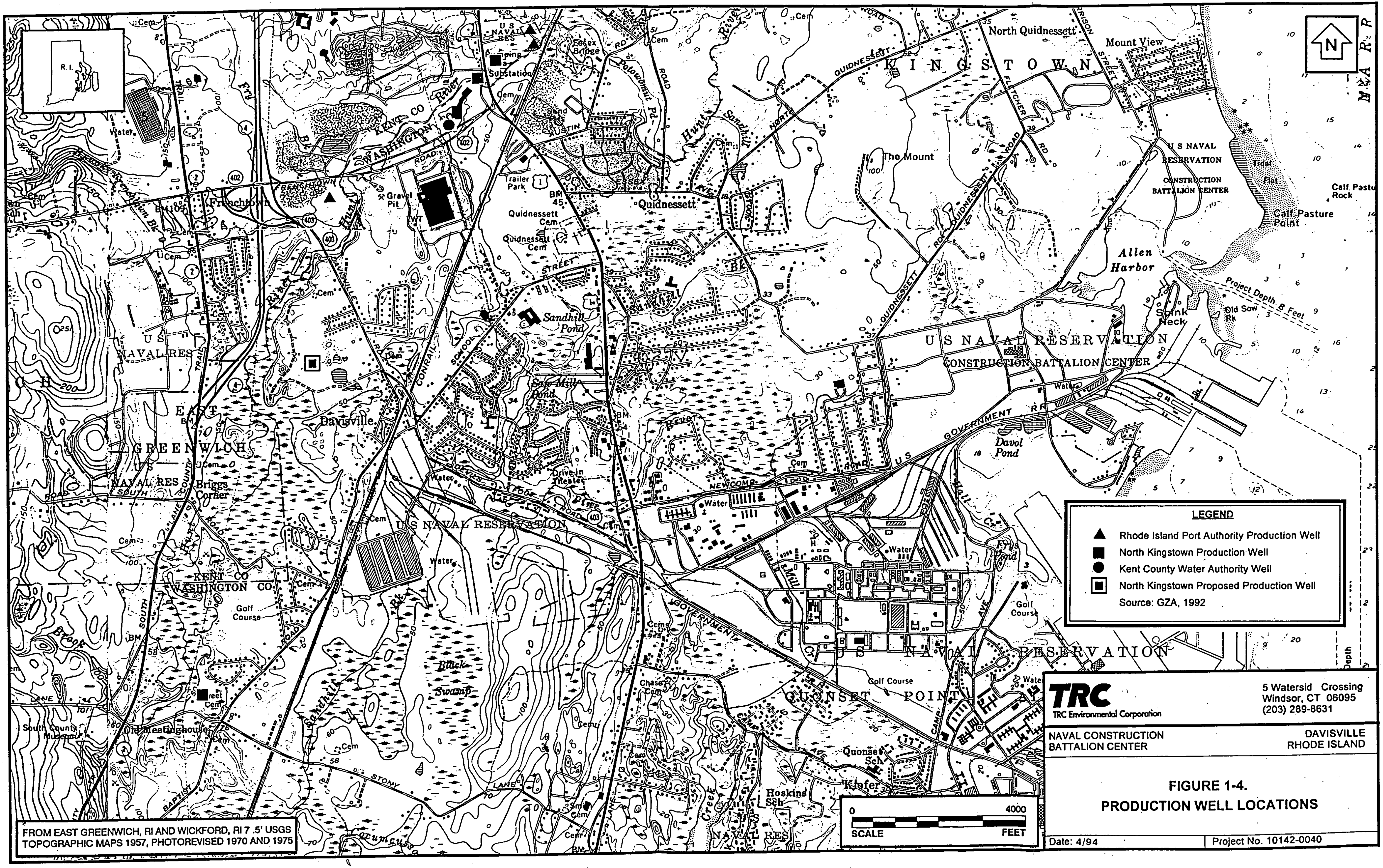
GROUP III SITES: SITE 12 - BUILDING 316, PCB SPILL AREA
SITE 14 - BUILDING 38, PCB SPILL AREA

GROUP IV SITES: SITE 02 - CED, BATTERY ACID DISPOSAL AREA
SITE 03 - CED, SOLVENT DISPOSAL AREA

GROUP V SITES: SITE 07 - CALF PASTURE POINT
SITE 09 - ALLEN HARBOR LANDFILL

GROUP VI SITES: SITE 10 - CAMP FOGARTY DISPOSAL AREA

GROUP VII SITES: SITE 11 - FIRE TRAINING AREA



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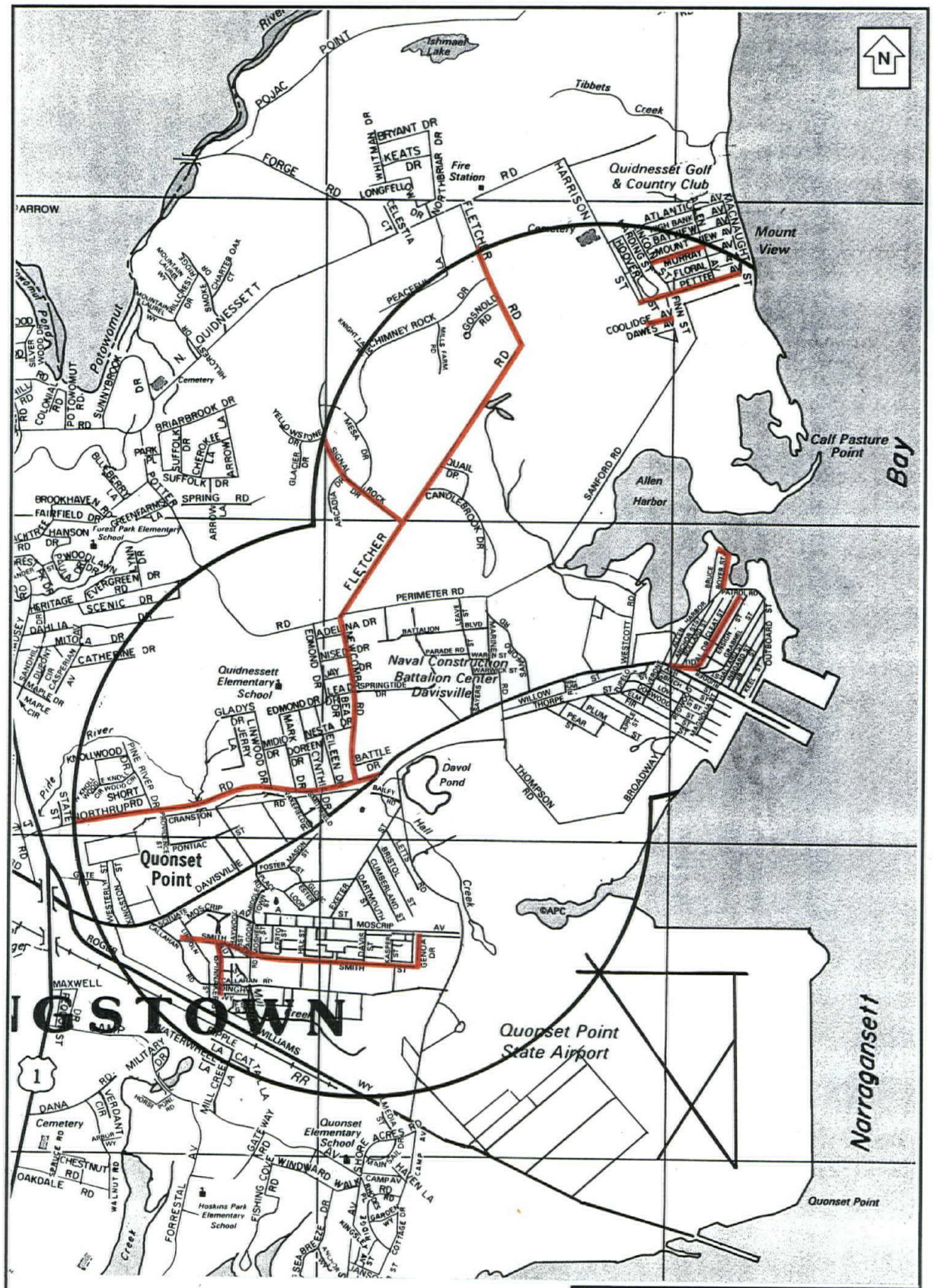
NAVAL CONSTRUCTION
BATTALION CENTER

DAVISVILLE
RHODE ISLAND

FIGURE 1-4.
PRODUCTION WELL LOCATIONS

Date: 4/94 | Project No. 10142-0040



0 .5 1 MILE
SCALE

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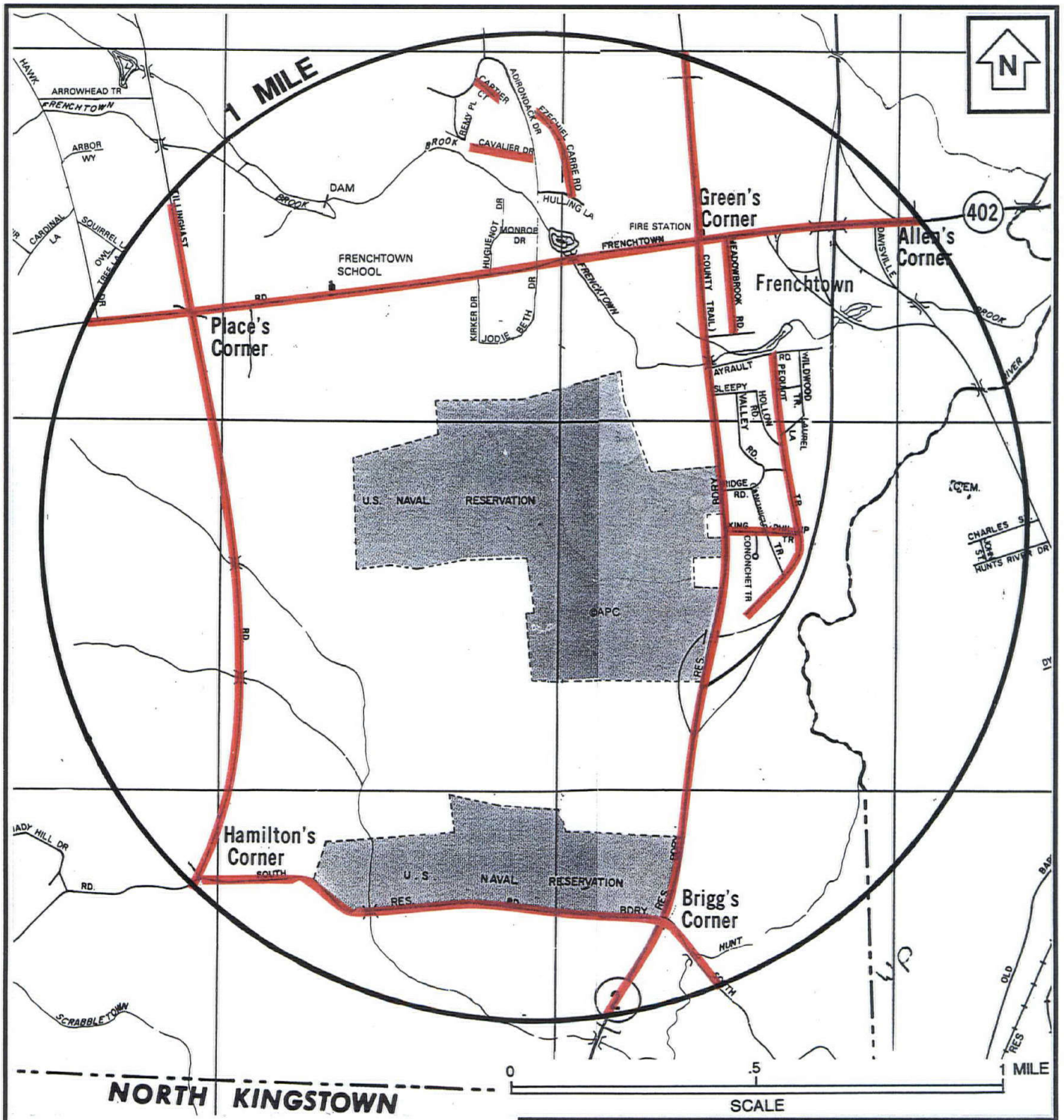
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 1-5.
NCBC DAVISVILLE
STREET LOCATIONS FOR
POTENTIAL PRIVATE WELL USERS

Date 4/94 | Project No. 01042-0040



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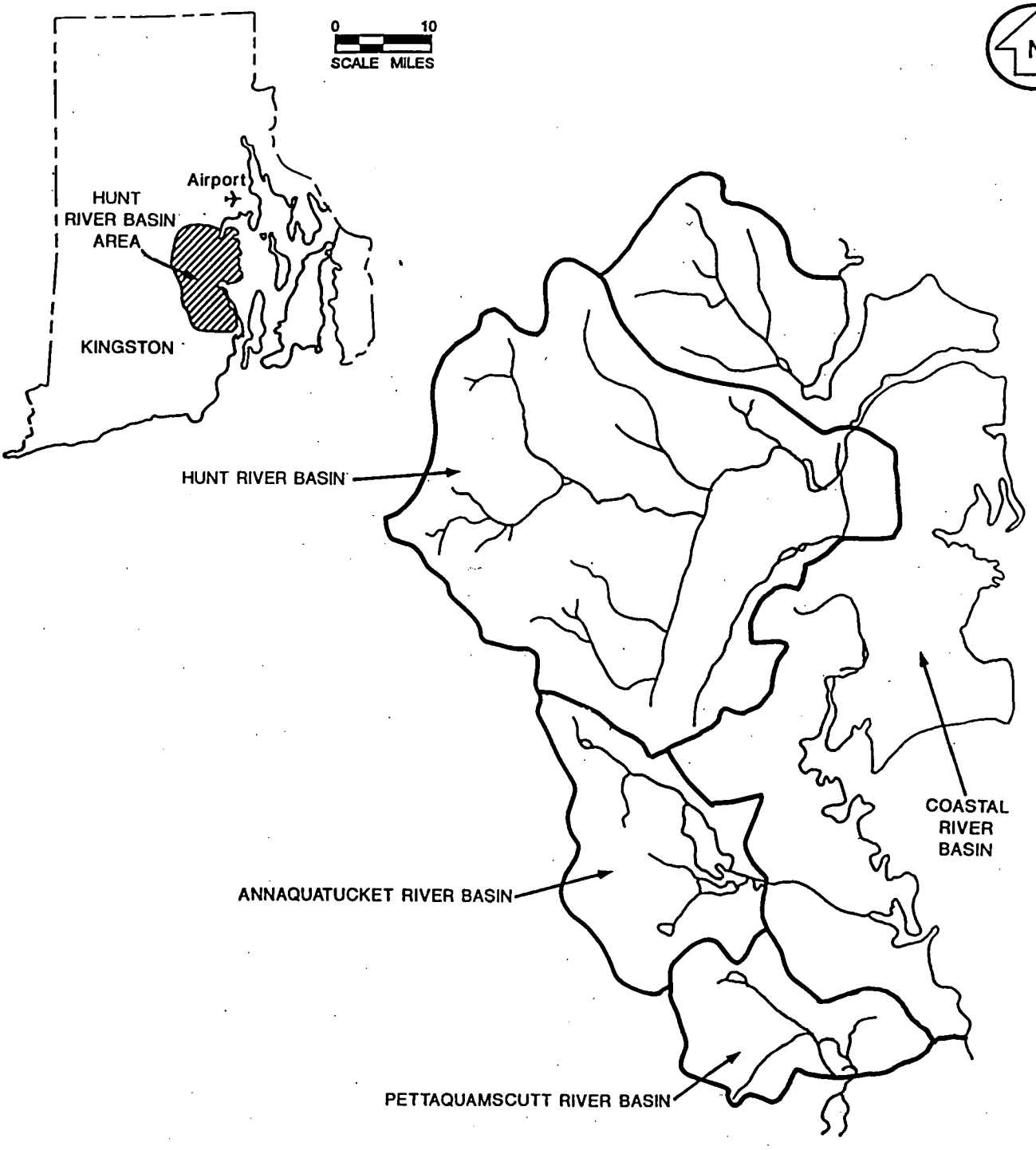
NAVAL CONSTRUCTION BATTALION CENTER

DAVISVILLE RHODE ISLAND

FIGURE 1-6.
SITE 10 - CAMP FOGARTY
STREET LOCATIONS FOR
POTENTIAL PRIVATE WELL USERS

Date 4/94

Project No. 01042-0040



0 1 2
SCALE MILES

LEGEND

BASIN BOUNDARY

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NAVAL CONSTRUCTION BATTALION CENTER

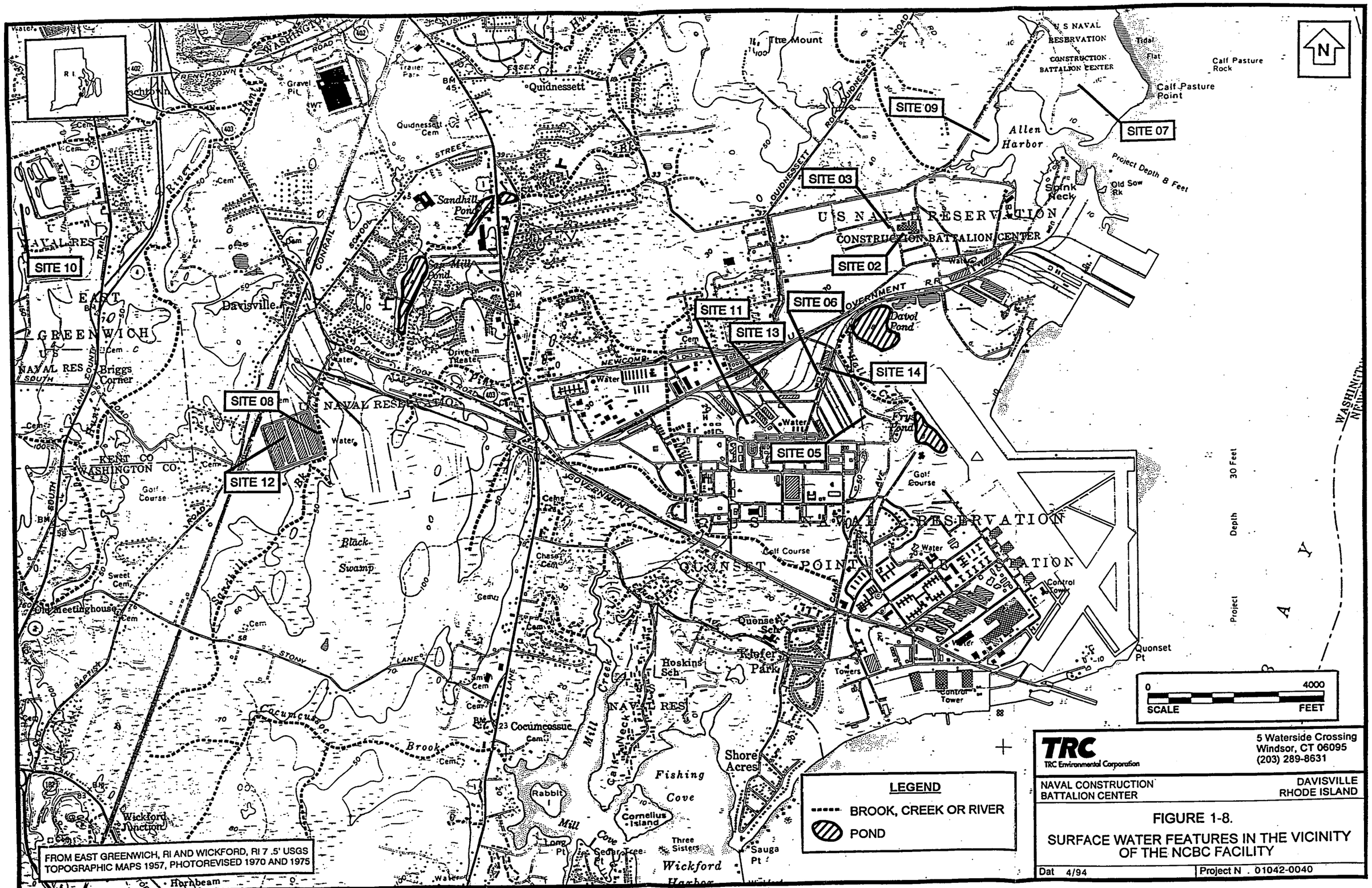
DAVISVILLE RHODE ISLAND

FIGURE 1-7.

HUNT RIVER DRAINAGE BASIN

Date 4/94

Project No. 01042-0040


SITE 01
SITE 02
SITE 03
SITE 05
SITE 06
SITE 07
SITE 08
SITE 09
SITE 10
SITE 11
SITE 12
SITE 13
SITE 14
U S NAVAL RESERVATION
CONSTRUCTION BATTALION CENTER
QUONSET POINT
Davisville
Quidnessett
Allen Harbor
Sandhill Pond
Saw Mill Pond
Davol Pond
Fry Pond
Black Swamp
Cocumcussoc Brook
Fishing Cove
Wickford Harbor
Wickford Junction
Old Meetinghouse
Briggs Corner
Shore Acres
Quonset Pt
Calf Pasture Rock
Calf Pasture Point
Project Depth 8 Feet
Old Sow Rk
Spink Neck
Tidal Flat
Golf Course
Control Tower
Towers
Hoskins Sch
Quonset Sch
Kiefer Park
Cornelius Island
Three Sisters
Rabbit I
Sauga Pt
Long Pt
Cedar Tree Pt
Mill Cove
Mill Creek
Gale Neck
Drive-in Theater
Trailer Park
Gravel Pit
Sweet Cem
Chase Cem
Smith Cem
Quidnessett Cem
Cocumcussoc
Hornbeam
30 Feet
Project Depth
0
4000
SCALE
FEET
N
LEGEND
BROOK, CREEK OR RIVER
POND
FROM EAST GREENWICH, RI AND WICKFORD, RI 7 .5' USGS TOPOGRAPHIC MAPS 1957, PHOTOREVISED 1970 AND 1975
TRC
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NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 1-8.
SURFACE WATER FEATURES IN THE VICINITY OF THE NCBC FACILITY
Dat 4/94
Project N . 01042-0040

Detailed Analysis of Alternatives
Naval Construction Battalion Center

Volume II
Site 06 - Solvent Disposal Area

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1.0 INTRODUCTION

Volume II addresses the Detailed Analysis of Alternatives for Site 06 - Solvent Disposal Area. The location of Site 06 relative to the Davisville facility is presented on Figure 1-1. The following sections provide background information and a description of the site, followed by a summary of remedial response objectives and cleanup criteria, general response actions, identification and screening of technologies and process options, a refinement of remedial alternatives previously developed in the ISA, and a detailed analysis of the remedial alternatives. It builds upon the evaluation conducted in the ISA (TRC, 1993a) and incorporates the results of the Phase II RI in the evaluation of potential remedial technologies for Site 06.

2.0 SITE CHARACTERIZATION

2.1 Site Location and Description

Site 06 is a flat grassy area located between Building 67 and Warehouse 38, covering roughly a quarter of an acre. It is bounded to the east by a chain link fence bordering Exeter Street, and to the west by a paved parking lot. Subsurface utilities such as a water main, storm drain, leach field, and a septic tank are present at Site 06. A site map is provided in Figure 2-1.

The Comprehensive Reuse Plan for NCBC Davisville specifies the area in which Site 06 is located is to be used for economic/industrial development.

2.2 Site History Overview

Site 06 was reportedly used from 1970 to 1972 for the disposal of waste chlorinated hydrocarbon solvents. Personnel from the Refrigeration Mechanics Section of the Public Works Department reportedly drained over a dozen 5-gallon cans of various liquid wastes in this area, about once every three weeks, for an estimated total disposal volume of 1,750 gallons. Disposal reportedly took place in approximately a 30-foot square area. Site 06 was a sandy area during the time of these disposal practices. The area was subsequently covered with approximately six inches of soil and re-seeded.

2.3 Site Geology, Hydrogeology, and Hydrology

2.3.1 Site Geology

The soil boring activities performed as part of this investigation provided information on the site geology. The subsurface soil investigation activities included drilling and sampling at five test boring and three monitoring well boring locations across the site. The Phase I and Phase II RI investigation locations are shown on Figures 2-2 and 2-3, respectively.

In the "Interim Soil Survey Report for North Kingstown, Rhode Island" (USDA, 1973), the Site 06 surface soils are mapped as Quonset gravelly sandy loam. The Phase II surface soil sample descriptions indicate that the surface soils on this site consist predominantly of native fine to medium sand with variable silt, coarse sand and gravel content. The descriptions of the surface soil samples were consistent with the mapped surface soils at Site 06.

According to the USGS surficial geologic map of the Wickford, Rhode Island quadrangle (Schafer, 1961), overlying the bedrock at Site 06 are surficial overburden deposits of Pleistocene glacial water-laid ice-contact sediments, consisting of sand, gravel and silt. The Phase II soil boring results indicate that the overburden deposits on this site consist of native fine to medium sand with variable silt, with coarse sand layers. No fill was encountered at this site. The descriptions of the Phase II soil boring samples were consistent with the mapped surficial overburden materials at Site 06. Overburden thicknesses ranged from 14.0 feet to 20.4 feet.

Competent bedrock was encountered at the Site 06 shallow and deep monitoring well locations at elevations ranging from 13.0 feet below mean sea level (msl) to 11.3 feet above msl. The bedrock surface at Site 06 is variable in elevation; it appears to be highest in the northeast (06-MW5S), dropping to the southeast (06-MW1D), then increasing (06-MW4S) and dropping again (06-MW3D) to its lowest point. A weathered bedrock layer was encountered just above competent bedrock at three of the monitoring wells. The weathered bedrock thicknesses ranged from 1.0 feet to 5.5 feet.

Two seismic refraction survey lines were completed at Site 06; these investigations indicated that the competent bedrock at Site 06 is located approximately 12 feet below ground surface, and appears to exhibit a relatively flat topography. Apparent competent bedrock elevations from the seismic refraction survey at Site 06 ranged from 13.5 feet msl to 17.3 feet msl.

According to the USGS bedrock geologic maps of the Wickford, Rhode Island quadrangle (Williams, 1964), Site 06 is underlain at depth by bedrock belonging to the Pennsylvanian Rhode Island Formation. Nx rock cores were collected of competent bedrock at three monitoring well borings. The rock cores indicate that the bedrock at Site 06 consists of interbedded dark grey argillaceous shale/phyllite and light to medium grey, fine- to medium-grained meta-sandstone gneiss. The shale zones are brittle and largely shattered, with shale partings; the gneiss is massive and competent. The gneiss in one core contained several thin anastomosing quartz veins and some vein-healed natural fractures while the gneiss in a second core contained some iron oxide-stained natural fractures.

2.3.2 Site Hydrogeology

Contour maps of the shallow ground water elevations as measured in Site 06 monitoring wells on August 13, 1993 and September 17, 1993 are presented as Figures 2-3 and 2-4, respectively. The ground water contour maps indicate that the site ground water is flowing generally to the northeast, toward Hall Creek.

Vertical hydraulic gradients were calculated at the 06-MW1S/D set of paired monitoring wells, as presented in Table 2-1. A positive hydraulic gradient indicates a potential for upward flow and a negative gradient indicates a potential for downward flow of ground water.

For the two measuring events, the calculated vertical gradients ranged from -1.81×10^{-3} ft/ft to -2.84×10^{-3} ft/ft. The negative vertical hydraulic gradients (downward) observed at Site 06 are low in magnitude; this indicates that vertical transport would appear to have little impact on contaminant migration at the site. Other factors such as ground water contaminant specific density and aquifer heterogeneity may be expected to play a greater role in contaminant transport.

Horizontal hydraulic gradients were also calculated from the water level measurements at the site. Representative average horizontal gradients for both the shallow and deep ground water were determined for several areas on the site, and are provided in Table 2-2. Average horizontal gradients for the shallow ground water ranged from 1.35×10^{-3} ft/ft to the northeast to 1.63×10^{-2} ft/ft to the northeast.

The calculated average horizontal hydraulic gradients, hydraulic conductivity and estimated effective porosity values were used to calculate average linear ground water flow velocity values at the site. The average linear velocity values, calculated on the basis of a shallow hydraulic conductivity of 16 ft/d (derived from Phase II RI slug tests) and an assumed effective porosity of 20% for the silty sands, are presented in Table 2-2. Average linear velocities of the shallow ground water ranged from 0.11 ft/d to 1.3 ft/d.

2.3.3 Site Hydrology

The topography of Site 06 is relatively flat and covered with grass. Site soils consist of fine to coarse grained sand with varying amounts of silt, thus suggesting the soils are well

drained. Runoff is expected to be minimal due to the flat surface, light vegetation, and well drained soils.

2.4 Ecological Setting

RIDEM has classified ground water in the vicinity of Site 06 as Class GB. Ground water classified GB encompasses those resources designated as not suitable for public or private drinking water use without treatment due to known or presumed degradation. GB classified ground water is primarily located at highly urbanized areas or in the vicinity of disposal sites for solid waste, hazardous waste or sewage sludge.

No surface water bodies exist within or adjacent to Site 06. However, Site 06 is located within the Hall Creek Watershed. Sites 02, 03, 05, and 13 are also located within Hall Creek Watershed. The ecological assessment activities conducted as part of the Phase II RI for NCBC Davisville for the Hall Creek Watershed were focused upon the portion of the Watershed between Davol Pond and Frys Pond. An assessment of terrestrial risks considered site surface soil data.

Based on the observations made during the ecological risk assessment, Hall Creek Watershed appears to support a diverse avian fauna, exhibits signs of small mammals, and supports fish species in abundance (enough to provide a food source for piscivorous birds in the tidal reaches of the watershed). Observed were several frogs, painted turtles, and small unidentified fish in the freshwater sections of the Hall Creek Watershed. Thirteen species of birds in the freshwater reach of the Hall Creek Watershed and 21 species around Frys Pond were observed during the ecological risk assessment activities.

The benthos of Hall Creek appear to support a diverse insect and non-insect fauna in the freshwater sections. The numerical dominance is shared between an insect family, *Chironomidae*, and non-insect organisms. Diversity and abundance decrease in the brackish water portions. Observed in the brackish water portions were *Paleomonetes, Nassarius, Fundulus*, post-larval fish, polychaetes, and shells of *Mya arenaria*. The deeper sediments in Frys Pond appear to be anoxic, supporting no living organisms.

The State of Rhode Island (RIDEM, 1989) conducted an endangered species survey of East Davisville, also referred to as the Main Center. It describes the area as having fringing

saline and brackish marsh which does not provide suitable habitat for rare species, and upland areas which are slowly reverting to natural communities of shrubs.

2.5 Site Investigation Overview

2.5.1 Initial Assessment Study and Confirmation Study

In 1983, Site 06 was identified in the Initial Assessment Study (IAS) as a possible site of hazardous waste disposal. However, the IAS concluded that the risk posed by Site 06 to human health and the environment was minimal and that no further investigation was necessary. Therefore, no samples were taken at Site 06 during the initial sampling round of the Confirmation Study completed in 1985. However, at the request of RIDEM, the site was included in the Verification Step of the Confirmation Study.

Verification Step field investigations conducted at Site 06 during the Confirmation Study included geophysical and OVA surveys, surface soil sampling, and ground water sampling. One composite surface soil sample, composited from five sample locations, and one ground water sample were both analyzed for petroleum based hydrocarbons and scanned for purgeable organics. In 1986, another surface soil sample and ground water sample were collected and analyzed for petroleum based hydrocarbons and scanned for purgeable organics.

2.5.2 Phase I Remedial Investigation

The Phase I RI, conducted from September 1989 to March 1990, included a soil gas survey, collection of three surface and three subsurface soil samples (2 samples from each of 3 boring locations), as well as the installation and sampling of two ground water monitoring wells and the sampling of an existing on-site well (see Figure 2-2 for sample locations).

All six soil samples were analyzed for full TCL/TAL analyses, and two subsurface soil samples were submitted for TCLP extraction and analysis. All ground water samples were also analyzed for full TCL/TAL analyses.

2.5.3 Phase II Remedial Investigation

The scope of the Phase II RI was developed on the basis of the Phase I results and included activities to further delineate the horizontal and vertical extent of contamination

associated with former disposal activities at Site 06. The investigations also provided a basis for the evaluation of contaminant fate and transport mechanisms, human health risks, and ecological risks.

The field investigation activities were conducted at Site 06 from December 1992 to August 1993. Field activities included the completion of a seismic refraction survey and completion of a soil gas survey on a 25-foot grid. Fifteen surface soil samples were collected from eight surface soil locations, five test boring locations (0-2'), and two monitoring well locations (0-2'). Five test borings and three monitoring well borings were completed across the site and eight subsurface soil samples were taken from the borings. After the completion of the monitoring well borings, two shallow wells and one deep well were installed. In addition, three bedrock cores were collected during the drilling activities. The Phase II sample locations are shown on Figure 2-3.

All of the Phase II soil gas samples were subjected to dual analyses on a portable gas chromatograph (GC). One analysis was conducted according to EPA Method 601 (modified) and other analysis was conducted according to EPA Method 602 (modified). The surface soil samples were analyzed for full TCL and TAL parameters, less pesticides/PCBs. The subsurface soil samples were also analyzed for full TCL and TAL parameters, less pesticides/PCBs. Two subsurface soil samples from Site 06 were also collected for TCLP analyses.

Ground water samples were collected from the five shallow wells and one deep well. Ground water samples were analyzed in the field for the water quality parameters of pH, specific conductance, Eh, temperature, and turbidity and in the laboratory for TCL and TAL parameters, less pesticides/PCBs. In addition, three ground water samples were analyzed for filtered metals, BOD, COD and TSS.

Eighteen background surface soil samples were collected across NCBC Davisville during the Phase II RI to provide a range of background soil quality for NCBC Davisville soils. All eighteen samples were analyzed for full TCL and TAL compounds. Only inorganic and semi-volatile background results are pertinent to Site 06. The applicable background soil quality results are summarized in Table 2-3 and are considered in the evaluation of contaminant levels presented below.

2.6 Nature and Extent of Contamination

The nature and extent of contamination based on the RI investigations are presented by chemical class below. Where appropriate, Confirmation Study results are also referenced.

2.6.1 Volatile Organic Compounds (VOCs)

Surface Soils

Results of the Verification Step indicate the presence of petroleum-based hydrocarbons at a concentration of 124 ppm and volatile organics at about 5 ppm in the composite surface soil sample. No volatile organics were detected in a second round of surface soil sampling.

Low concentrations of VOCs were present in Phase I RI surface soil samples. Chloroform was detected in each of the three samples at concentrations ranging from 1 ppb to 2 ppb, and acetone was detected in two of three samples at concentrations of 23 ppb and 45 ppb. In addition, 1,1,1-trichloroethane was detected in surface soil sample B-06-01 at an estimated concentration of 1 ppb.

Methylene chloride, acetone and toluene were each detected in at least one of the Phase II RI surface soil samples. Methylene chloride was detected in surface soil samples 06-SS01 through 06-SS07 at estimated concentrations ranging from 7 ppb to 9 ppb. Acetone was detected in five samples at concentrations ranging from 12 ppb to 45 ppb. A surface soil sample (06-B08-01) collected from an area of elevated soil gas readings indicated only the presence of 32 ppb acetone. Toluene was detected in four surface soil samples at estimated concentrations ranging from 3 ppb to 7 ppb, respectively.

Subsurface Soils

During the Phase I RI, the three subsurface soil samples collected at Site 06 each contained acetone at concentrations ranging from 19 to 70 ppb. Chloroform was detected in subsurface soil samples B-06-02 and B-06-03 at an estimated concentration of 1 ppb. 2-Butanone was also detected in sample B-06-03 at an estimated concentration of 1 ppb.

Results of the Phase II subsurface soil analysis indicated the presence of low levels of acetone and toluene. In addition, one subsurface soil sample (06-B07-02) contained elevated levels of ethylbenzene (340 ppb) and total xylenes (1,900 ppb). Sample 06-B07-02 was collected from the 2- to 4-foot interval at the location of a Phase I soil gas "hot spot". The level of

acetone detected in five of the eight subsurface soil samples ranged from 22 ppb to 71 ppb. Toluene was detected in three of the subsurface soil samples at estimated concentrations ranging from 3 ppb to 11 ppb.

Ground Water

No VOCs were detected during sampling of the one shallow monitoring well present during the Verification Step of the Confirmation Study, the sampling of the three shallow monitoring wells present during the Phase I RI, or the sampling of the five shallow or one deep monitoring wells present during the Phase II RI.

2.6.2 Semi-Volatile Organic Compounds (SVOCs)

Surface Soils

During the Verification Step, fluoranthene was detected at 40 ppb, bis(2-ethylhexyl)phthalate was detected at 51 ppb, and benzo(k)fluoranthene was detected at 87 ppb. No other semi-volatile compounds were detected.

A subset of SVOCs, polynuclear aromatic hydrocarbons (PAHs) were detected in two of the Phase I surface soil samples. The PAH compounds were detected at estimated concentrations, with the highest total PAH concentration being 667 ppb at B-06-02. Bis(2-ethylhexyl)phthalate was also detected in each of the three surface soil samples collected during the Phase I RI at estimated concentrations ranging from 37 ppb to 46 ppb.

During the Phase II RI, only five of the fifteen surface soil samples collected at Site 06 contained detectable concentrations of PAHs. In addition, 4-chloro-3-methylphenol was detected in surface soil sample 06-SS04 at an estimated concentration of 290 ppb. This was the only SVOC detected in sample 06-SS04.

The PAHs detected in Site 06 surface soils were all detected at estimated concentrations with the exception of surface soil sample 06-SS02 which exhibited a total PAH concentration of 5,770 ppb. Of the remaining surface soil samples which contained PAHs (SS03, SS06, SS07, and SS09 which was a duplicate of SS05), the total PAH levels ranged from 680 ppb to 1,280 ppb. Based on the locations of the above five sample locations, there does not appear to be any consistent distribution of SVOCs across the Site 06 surface soils.

The SVOCs detected in the surface soil samples collected during both the Phase I and Phase II RIs were compared to the background samples collected throughout the NCBC facility (see Table 2-3). Bis(2-ethylhexyl)phthalate was the only SVOC surface soil contaminant detected below the NCBC background ranges.

Subsurface Soils

During the Phase I RI, SVOCs were detected in two of the three subsurface soil samples collected at the site. At soil boring B-06-01-02, only bis(2-ethylhexyl)phthalate was detected at an estimated concentration of 54 ppb. At soil boring B-06-03-02, concentrations of naphthalene (630 ppb) and 2-methylnaphthalene (1,600 ppb), as well as an estimated concentration of dibenzofuran (66 ppb) were detected in the 2- to 4-foot interval. No other SVOCs were detected in Site 06 subsurface soils during the Phase I RI.

Only one SVOC was detected at one location during the Phase II RI subsurface soil sampling at Site 06. 2-Methylnaphthalene was detected at soil boring sample 06-B07-02 (2- to 4-foot interval) at a concentration of 8,100 ppb. Soil boring 06-B07 is located approximately 15 feet to the northeast of the Phase I RI soil boring B-06-03. This would indicate that some near-surface soil contamination may exist in this portion of the site.

No SVOC analytes were detected in subsurface soils at concentrations greater than the NCBC background concentration ranges, as shown on Table 2-3.

Ground Water

Phase I RI ground water samples exhibited no SVOCs.

Only one SVOC was detected in the Phase II RI ground water samples. Bis(2-ethylhexyl)phthalate was detected in each of the ground water samples collected during the Phase II RI at concentrations ranging from 95 ppb to 590 ppb. The detection of this phthalate compound is not believed to be due to its presence in the site ground water but rather, due to the leaching of this compound from the equipment used during the low flow ground water sampling collection, as discussed in the Phase II RI Technical Report (TRC, 1993b).

2.6.3 Pesticides/PCBs

Surface Soils

Pesticides/PCBs were not detected in any of the three surface soil samples collected during the Phase I RI. Phase II RI surface soil samples were not analyzed for pesticides/PCBs.

Subsurface Soils

No pesticides or PCBs were detected in subsurface soils collected during the Phase I RI. Phase II RI subsurface soil samples were not analyzed for pesticides/PCBs.

Ground Water

Pesticides/PCBs were not detected in either of the Phase I ground water sampling rounds. Phase II RI ground water samples were not analyzed for pesticides/PCBs.

2.6.4 Inorganics

Surface Soils

During the Verification Step of the Confirmation Study, inorganics were detected in surface soils at concentrations ranging from non-detectable to 51 ppm (lead) and 54 ppm (zinc).

Arsenic, chromium, lead, and zinc were among the inorganics detected in each of the Phase I RI surface soil samples at similar concentrations.

The inorganic analytes detected in Site 06 surface soils during the Phase II RI were compared with background sample results from surface soil samples collected throughout the NCBC Davisville facility. A comparison of the observed surface soil concentration ranges at Site 06 to the NCBC background samples is presented in Table 2-3.

Ten inorganic analytes were detected in Site 06 surface soils at concentrations greater than the NCBC background concentration ranges. These inorganics include barium, cadmium, calcium, chromium, iron, lead, magnesium, manganese, silver, and zinc.

Subsurface Soils

The inorganic analytes detected in the surface soils during the Phase I RI were also detected in the subsurface soils, but at lower concentrations.

The inorganic analytes detected in the seven subsurface soil samples collected during the Phase II investigation were compared to the background samples collected throughout the NCBC facility (see Table 2-3). Only three inorganic analytes, calcium, magnesium, and potassium,

were detected at concentrations above the NCBC background ranges. These three analytes were all detected in subsurface soil sample 06-MW5-03.

Ground Water

Results of the Phase I ground water sampling indicated that beryllium and lead were present in Site 06 ground water at elevated levels. Beryllium was detected in monitoring well 06-MW1S at 7.3 ppb. Lead was detected at levels ranging from 14.2 ppb to 63.2 ppb.

The inorganic analytes detected in the Phase II ground water samples include aluminum, barium, calcium, cobalt, iron, lead, magnesium, manganese, potassium, selenium, sodium, and zinc. Comparison of the Phase I and Phase II analytical data reveals a significant reduction in analyte concentrations, which may be attributed to the low flow sampling methodology employed during the Phase II ground water sampling program.

Inorganic analyses were also conducted on three filtered ground water samples collected from monitoring wells 06-MW1S, 06-MW1D, and 06-MW2S. Comparison of the filtered vs. non-filtered sample results indicate that the inorganic concentrations of the filtered samples are equivalent to or slightly less than the concentration of the non-filtered samples. Only in monitoring well 06-MW2S was there a significant difference in results and this only occurred for the aluminum and iron analytes.

2.6.5 TCLP Analysis

During the Phase I RI, two subsurface soil samples were subjected to TCLP analysis. Ethylbenzene and total xylenes were detected in the TCLP analysis of subsurface soil sample 06-B07-02. The two compounds, which were also detected during the TCL VOC analysis of this interval, were detected at concentrations of 3 ppb and 14 ppb, respectively, although neither of these compounds was detected in the ground water samples collected during the Phase II RI. 2-Methylnaphthalene and naphthalene were detected in TCLP sample B-06-03-02-S at concentrations of 19 ppb and 21 ppb, respectively. Benzoic acid was detected in the same sample at 26 ppb. No pesticides/PCBs were detected in the TCLP analysis of soil samples. TCLP extraction results for the subsurface soil samples indicated the presence of arsenic, beryllium, copper, lead, and zinc in the TCLP leachate.

During the Phase II RI, low leachable levels of naphthalene (90 ppb) and 2-methylnaphthalene (86 ppb) were detected in subsurface soil sample 06-B07-02, although neither of these compounds was detected in the ground water samples collected from nearby monitoring wells 06-MW1S or 06-MW1D. The TCLP extraction results for subsurface soil sample B-06-03-02 indicated the presence of arsenic, beryllium, copper, lead, and zinc in the TCLP leachate. Barium was detected at an elevated level of 100 mg/l.

2.7 Summary of Contaminant Fate and Transport

A contaminant fate and transport analysis was initially conducted as a part of the Phase I RI and incorporated in the Initial Screening of Alternatives (TRC, 1993a). Subsequently, information obtained during the Phase II RI was incorporated into the contaminant fate and transport analysis and a revised discussion was presented in the Draft Phase II RI Technical Report (TRC, 1993b).

Potential routes of migration, contaminant persistence and observed contaminant migration were considered in evaluating the fate and transport of the site contaminants identified during the RI investigations.

In general, of the environmental media investigated at Site 06, surface soil and ground water contaminants have the greatest potential for off-site migration. Typically, contaminants in surface soils can migrate or be carried off-site by surface runoff (resulting from precipitation), by being sorbed to windblown dust, and by site visitors via adherence to vehicle tires, shoes, etc.

Based on current site use, dust generation and surface runoff at Site 06 are expected to be limited given the flat, grass-covered surface. Contaminants can also migrate from the surface soils through leaching (by the infiltration of precipitation) and subsequent transport by ground water, by volatilization to ambient air, or by uptake by plants or animals.

Subsurface soils are unlikely to be transported off-site unless exposed by excavation. The primary mode of transport of chemicals in subsurface soil would be leaching and ground water transport. Contaminants in ground water may potentially migrate to the northeast, toward Hall Creek.

The following sections examine the presence of Contaminants of Concern (COCs), as identified during the Human Health Risk Assessment process (TRC, 1993b), across the site in combination with the potential migration pathways to provide an understanding of contaminant persistence and potential for migration at the site. The discussions below are presented with respect to individual contaminants or contaminant groups based on environmental fate data such as water solubility, vapor pressure, Henry's Law constants, organic carbon-water partition coefficients (K_{oc}), octanol-water partition coefficients (K_{ow}), and half-life in water.

Volatile Organic Compounds

In general, VOCs were detected infrequently and at low concentrations in soils at Site 06. Eight VOCs detected in surface or subsurface soil samples were identified as COCs. The principal mechanism for the natural removal of VOCs is through volatilization based on vapor pressures (@ approximately 25°C) ranging from 10 mmHg (ethylbenzene and xylenes) to 270 mmHg (acetone) and Henry's Law Constants ranging from 4.3×10^{-5} atm-m^3/mol (acetone) to 8.1×10^{-3} atm-m^3/mol (ethylbenzene).

The role of biodegradation in the natural attenuation of these compounds is compound-specific. Similarly, the role of adsorption is compound-specific (e.g., 2-butanone has less tendency to be retained by soils than xylenes, as evidenced by its smaller log K_{oc}). With the exception of xylenes, all of the volatile COCs are fairly soluble in water, with solubilities of 150 mg/l (ethylbenzene) to being miscible (acetone). The tendency of these constituents to partition from organic media into water varies, with log K_{ow}s ranging from 3.2 (for xylenes which are lipophilic) to -0.24 (for acetone which is highly water soluble). With the possible exception of xylenes, the volatile COCs in surface and subsurface soil are not expected to persist in these media. The primary migration pathways from soil for these constituents are expected to be volatilization and leaching through soil into water.

No VOCs were identified as COCs in ground water.

Semi-Volatile Organic Compounds

Eleven SVOCs were identified as COCs in surface soil at Site 06. In subsurface soil, an additional three SVOCs were selected as COCs. The SVOC COCs include twelve PAHs, one phthalate, and one phenol. Phenol was identified as a COC in surface but not subsurface soil. In general, the PAHs and phthalates were detected at the highest frequencies and

concentrations. It should be noted that phthalates are common laboratory contaminants and are widespread in the environment (ATSDR, 1987; ATSDR, 1989).

SVOCs, particularly PAHs, are persistent in the environment due to their complex chemical nature. While some of the lighter PAHs (with fewer aromatic rings) are subject to biodegradation or volatilization, chemical persistence generally increases with increasing number of aromatic rings. SVOCs are generally characterized by high boiling point, low vapor pressure, and low solubility (except for lower molecular weight PAHs, phenols).

PAHs generally exhibit a very low solubility (i.e., as low as 5×10^{-4} mg/l), with higher solubilities for the smaller PAHs (e.g., 30 mg/l for naphthalene). The solubility of bis(2-ethylhexyl)phthalate is 0.4 mg/l.

SVOCs, in general, have moderate to high log K_{oc} and log K_{ow} values, indicating a relative affinity for organic materials in solid (e.g., soil) and liquid (e.g., octanol) phases. The log K_{oc}s and log K_{ow}s of PAHs and phthalates are generally greater than 3, with many ranging from 4 to 6. While the log K_{oc} and log K_{ow} values for 4-chloro-3-methylphenol were not available, phenols generally have a much greater tendency for partitioning into water than do either the PAHs or phthalates.

No SVOC COCs were identified in ground water.

Migration of SVOCs from soil to ground water is not likely to be a primary route of concern. Off-site transport of these less soluble SVOCs may be possible through dust generation at the soil surface and through soil transport in surface water runoff. SVOCs in soil are more likely to persist than VOCs, but are less likely to persist than inorganics.

Pesticides/PCBs

No pesticides/PCBs were detected in soils or ground water at Site 06.

Inorganic Analytes

Many metals have a strong affinity for soils (particularly clay particles and organic matter in soils) which reduces their mobility. Under extremes of pH, some metals can be rendered mobile. The presence of the inorganic analytes at Site 06, particularly the naturally occurring elements, was examined in the context of facility background concentrations, as presented in Table 2-3. Site background samples were collected as composite samples from background locations at Sites 02, 07, 09, 10 and wooded areas east of Sites 06, 11 and 13 during the Phase

II RI. The inorganic COCs in surface soil which appear elevated above site background in one or more samples include arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, nickel, silver, thallium and zinc. The inorganic COCs which appear elevated above site background in subsurface soil include beryllium, cobalt, manganese, nickel, and thallium.

The inorganic COCs in ground water include aluminum, arsenic, barium, beryllium, chromium, cobalt, copper, cyanide, lead, manganese, nickel, selenium, vanadium, and zinc. The presence of a number of these inorganics in surface and subsurface soils indicates migration from soil to ground water may have occurred. However, it is important to note that a comparison of Phase I and Phase II results indicates a considerable decrease in the concentration of inorganics in Phase II. This decrease is believed to be due to the sampling methodology utilized in Phase II which incorporated a low flow sampling rate, which decreased the turbidity of the ground water samples. Thus, the Phase II ground water data are thought to be more reflective of the actual concentrations of inorganics than the Phase I data.

TCLP Analyses

The results of the TCLP analyses indicates that there were no soil samples which exhibited contaminants above the regulatory action levels as identified on the TCLP list (40 CFR 261.24). However, one constituent (barium) was detected at the regulatory action level for the TCLP list (40 CFR 261.24). The analytical results of both TCLP samples indicated that barium was present at levels of 100 mg/l, which is equal to the TCLP list regulatory level.

2.8 Summary of Human Health Risk Assessment

The Human Health Risk Assessment conducted for Site 06 (TRC, 1993b) evaluated the contaminants of potential concern, assessed potential exposure pathways and chemical toxicity, and characterized potential risks to human health posed by the site. Both Phase I RI and Phase II RI data were used to characterize the human health risks. Exposure doses were developed based on the geometric mean of chemical concentrations (mean) as well as on the basis of the maximum detected chemical concentration (Reasonable Maximum Exposure or RME). Potential human health exposure scenarios evaluated include the following:

- Scenario 1 (Future Construction Worker) - Exposure of adult workers to subsurface soils (via dermal contact, ingestion and inhalation) for a one-year period, assuming construction of commercial or residential buildings; and

- Scenario 2 (Future Commercial/Industrial Worker) - Exposure of adult employees to surface soils (via dermal contact and ingestion) and ingestion of ground water through future use of the site.

Human health risks were presented with regard to potential cancerous or non-cancerous (systemic) effects from the contaminants of concern. Cancer risks are presented in scientific notation, where a lifetime risk of 1×10^{-4} represents a lifetime risk of one in ten thousand. The calculated cancer risk is compared to the acceptable cancer risk range (1×10^{-4} to 1×10^{-6}) for evaluating the need for remediation, as stated in 40 CFR Part 300. A cancer risk of 1×10^{-6} is considered as the point of departure for determining risk-based remediation goals. Non-carcinogenic risks are represented by a summation of hazard quotients, which is referred to as the hazard index (HI). HI values exceeding unity (1) indicate the potential for non-cancer health effects. Therefore, the cancer risk and HI ratios that constitute a potential concern are those greater than 1×10^{-6} and 1, respectively.

Cancer and non-cancer risk estimates for Site 06 are summarized in Table 2-4. Cancer and non-cancer risk estimates were less than the potential levels of concern for subsurface soil exposures under Scenario 1 (construction scenario). Surface soil exposures under Scenario 2 (commercial/industrial) indicated a potential cancer risk range of 3×10^{-6} (mean) to 5×10^{-6} (RME) and a non-cancer HI below 1. Exposure to arsenic, beryllium, and carcinogenic PAHs accounts for the majority of the estimated cancer risks.

Ground water exposures under Scenario 2 (commercial/industrial scenario) indicated a potential cancer risk range of 2×10^{-5} (mean) to 1×10^{-4} (RME) and non-cancer HIs ranging from 2 (mean) to 6 (RME). Exposure to arsenic and beryllium accounts for the majority of these estimated risks.

2.9 Summary of Ecological Risk Assessment

Ecological risks were assessed based on an evaluation of potential receptors identified through the ecological characterization of the Hall Creek Watershed, and the detected levels and bioavailability of contaminants in environmental media. Terrestrial risks were characterized

based on site-specific biological observations and surface soil data. Aquatic risk was assessed for the watershed. A "weight of evidence" approach was used in which information generated from exposure and ecological effects assessments, field observations and a toxicity quotient (TQ) evaluation are used to provide an overall weight of evidence concerning the nature of risks. As with the human health HI ratios, when the calculated TQ value exceeds unity (one), a potential for environmental risks exists.

Risks to benthic invertebrates were assessed based on sediment quality criteria derived from equilibrium partitioning on a station-by-station basis; an estimate of metal bioavailability based on a ratio of Simultaneously Extracted Metal (SEM) to Acid Volatile Sulfide (AVS); a comparison to NOAA ER-L and ER-M values; and direct observations on the freshwater benthos in the watershed. Risks to water column organisms were estimated based on a comparison to ambient water quality criteria. An exposure model was used to estimate risks to mink from exposure to PCBs in the sediments. Risks to small mammals and birds were estimated on the basis of calculated TQ values.

The ecological assessment concluded that Site 06 and the developed areas of the Hall Creek Watershed pose little likelihood of ecological risk due to exposure to metals in the Hall Creek Watershed because:

- sediment metals are generally within naturally occurring levels;
- SEM and AVS data generally indicate that metals in the sediment of the brook have low bioavailability, except at watershed sample station 13, which was a course-grained environment where AVS was below detection; and,
- sediment metals concentrations were generally below or near their respective ER-Ls.

There is some potential for risk due to exposure to PCBs, based on the mink exposure model. However, this potential is qualified somewhat by the fact that sediment PCB concentrations generally fall below NOAA ER-M levels, the toxicity quotient based on comparison to sediment quality criteria is less than 1, and the results of the tern foraging model indicate little risk to terns foraging in the Frys Pond area (Frys Pond is the downstream sink for materials from Hall Creek).

There is also some potential for risk due to DDT, DDE, and DDD within the Hall Creek Watershed. This conclusion is based on the comparison to NOAA criteria (ER-Ms for DDT, DDE, and/or DDD were exceeded at all stations) and the comparison to station-specific sediment quality criteria (toxicity quotients within the 10 to 100 range were calculated for pesticides at stations in Hall Creek and Frys Pond).

However, the potential for risk suggested by some of the above analyses does not appear to be reflected in the functional value of Hall Creek wetland, based on the analysis for pollutant reduction (i.e. sediment stabilization, sediment/toxicant retention, nutrient removal/transformation) functions. In addition, the benthic and wildlife observations in Hall Creek Watershed indicate a diverse and functioning ecosystem.

3.0 SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF ALTERNATIVES

Based on the available site information, potential remedial actions can be identified. Initially, remedial action objectives are developed in order to set goals for protecting human health and the environment early in the alternative development process. General response actions are then developed to address the objectives. Remedial technologies and process options associated with the general response actions are identified and screened to eliminate those that are not technically implementable and to identify those that offer the optimum combination of effectiveness, implementability, and cost.

3.1 Development of Preliminary Remediation Goals (PRGs)

Prior to the development of remedial action objectives, preliminary remediation goals (PRGs) are developed and evaluated with respect to site contaminant levels. Existing contaminant levels are compared to Applicable or Relevant and Appropriate Requirements (ARARs), To-Be-Considered guidance (TBCs), and risk-based PRGs to identify the extent of contamination requiring remediation. Also included in the evaluation is the role of environmental risks and the application of models to predict the potential for migration of soil contaminants to the ground water.

3.1.1 Comparison of Contaminants to ARARs/TBCs

Soil and ground water must be considered in the development of potential remedial actions at Site 06. The soil and ground water contaminants are evaluated separately against appropriate chemical-specific ARARs/TBCs below. A more detailed identification and evaluation of potential chemical-specific ARARs/TBCs is presented in Appendix A.

Soil Contamination

In evaluating soil contaminant levels, available state and federal standards and guidance levels were used as ARARs/TBCs. Only a limited number of standards are applicable to soil contamination. The only identified standards and guidance levels were those applicable to PCB and lead contamination. Therefore, these levels were used as the basis for this evaluation.

As presented in Table 3-1, TSCA includes a PCB Spill Cleanup Policy (Subpart G, 40 CFR 761.120 through 761.135) which establishes a PCB cleanup level of 10 ppm for soils to

a minimum depth of 10 inches in nonrestricted access areas. This level is applicable to spills of materials containing PCBs at concentrations of 50 ppm or greater which occurred after May 4, 1987. While not applicable to Site 06, this cleanup level is to be considered in the remedial evaluation of any surface soils which exhibit PCB contamination at the site. The State of Rhode Island Department of Environmental Management (RIDEM) Rules and Regulations for Solid Waste Management Facilities define solid waste as including any soil, debris, or other material with a concentration of 10 ppm or greater PCBs, while the Rules and Regulations for Hazardous Waste Management define Type 6 - extremely hazardous waste as including waste which contains 50 ppm or greater PCBs. These definitions are also considered with respect to soil contamination at Site 06.

With respect to lead contamination, the USEPA has developed an Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02) which sets forth an interim lead soil cleanup level of 500 to 1,000 ppm, based on residential exposures. RIDEM considers a safe lead level in soil to be under 300 ppm. These guidance values will be considered in the evaluation of surface soil contamination at the site.

Table 3-1 provides a comparison of maximum detected surface soil contaminant levels to associated guidance levels. During the Phase II RI, the concentration of lead in surface soil sample 06-SS08 was 616 ppm, exceeding the state guidance levels and falling within the range of the federal guidance level. No other samples exhibited lead at concentrations exceeding the state or federal guidance levels. With respect to PCBs, Phase I surface soil samples exhibited no detectable levels of PCBs. Phase II RI soil samples were not analyzed for PCBs.

The location of the single surface soil sample (06-SS08) which contained lead at a level exceeding regulatory guidance levels is presented on Figure 3-1.

Ground Water Contamination

For ground water which is a potential source of drinking water, MCLs, MCLGs, state drinking water requirements or other health-based levels generally are appropriate for consideration as PRGs. Also considered in the evaluation are the Rhode Island Ground Water Quality Standards as amended by RIDEM in July 1993 for Class GAA and Class GA ground waters. For those detected contaminants for which RIDEM maximum contaminant levels and Ground Water Quality Standards have been established, the standards mirror the federal MCLs.

The maximum concentrations of ground water contaminants that exceed state and federal MCLs for the Phase I and Phase II RIs are presented by well location on Figure 3-2. Table 3-2 presents a comparison of maximum detected ground water contaminant levels to associated federal and state standards and guidelines.

One organic contaminant was detected at Site 06 at concentrations exceeding its federal MCL. Bis(2-ethylhexyl)phthalate was detected in all six Phase II RI ground water samples at concentrations exceeding the federal MCL of 6 ppb. Concentrations in the ground water samples ranged from 95 ppb in well 06-MW1D to 590 ppb in well 06-MW5S. However, as noted in Section 2.6.2, the presence of bis(2-ethylhexyl)phthalate in the Phase II RI samples is suspected to be attributable to the sampling methodology and not representative of actual ground water quality. This is further supported by the fact that bis(2-ethylhexyl)phthalate was not detected in Phase I RI ground water samples.

Two inorganic contaminants were detected in ground water samples at levels exceeding either federal or state standards. During the Phase I investigation, the beryllium concentration exceeded the federal MCL of 4 ppb in well 06-MW1S (7.3 ppb). However, during the Phase II RI, in which the low flow sampling methodology was used to minimize the presence of suspended sediments in the samples, beryllium was not detected in any of the monitoring wells. The federal and state action levels for lead in drinking water are each 15 ppb, and the state Ground Water Quality Standard for lead is also 15 ppb. The concentrations of lead from four of the six ground water samples collected during the Phase I RI exceeded 15 ppb. One sample from the Phase II RI exceeded the 15 ppb standard (06-MW3S at 17.8 ppb). It should be noted that this well location is upgradient of the site.

3.1.2 Human Health Risk-Based Considerations

As described in the National Contingency Plan [40 CFR 300.43(e)(2)(i)(A)(2)], "The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available...". The 10^{-6} starting point indicates U.S. EPA's preference for setting cleanup levels at the more protective end of the acceptable 10^{-4} to 10^{-6} risk range for Superfund remedial actions. Site-specific and remedy-specific factors are then taken into consideration in the determination of where within the 10^{-4} to 10^{-6} risk range the cleanup

standard for a given contaminant will be established. For the purposes of this evaluation, preliminary remediation goals (PRGs) which correspond to a 10^{-6} risk are calculated. Site-specific and remedy-specific factors which may affect the determination of the final cleanup level will be addressed in subsequent portions of this document.

Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim, RAGs, Volume I, Part B, (USEPA, 1991a) provides additional guidance on the development of preliminary remediation goals (PRGs). One of the initial steps in development of PRGs is the identification of the most appropriate future land use for the site so that the appropriate exposure pathways, parameters and equations can be used to calculate PRGs. At Site 06, based on the Comprehensive Base Reuse Plan, the most appropriate future land use is as an economic/industrial development area. Therefore, the risk assessment scenario (Scenario 2) which evaluated risks to commercial/industrial workers based on exposures to surface soils and ground water will be used in the development of PRGs.

As a further guide to determining the media and chemicals of potential concern at a site, the OSWER directive "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (USEPA, 1991b) states that "where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts."

At Site 06, the cumulative carcinogenic risk to an individual based on reasonable maximum exposure to surface soils under the future commercial/industrial site use scenario does not exceed 10^{-4} and the cumulative hazard index (HI) value does not exceed unity (1). Therefore, risk-based preliminary remediation goals will not be calculated for Site 06 surface soils.

For ground water, the cumulative carcinogenic risk to an individual based on reasonable maximum exposure to ground water under the future commercial/industrial site use scenario is 1×10^{-4} and the non-cancer HI value is 6. Therefore, risk-based PRGs were calculated for ground water contaminants which contribute an individual cancer risk of greater than 1×10^{-6} to the overall cancer risk estimate or present a non-cancer HI greater than 1 under the reasonable

maximum exposure scenario for future commercial/industrial use, as presented in the human health risk assessment portion of the Phase II RI Report (TRC, 1993b), and for which an ARAR/TBC has not been identified. At Site 06, the presence of manganese in ground water is associated with an estimated non-cancer HI of 5.2, exceeding the point of departure of unity (1). No other compounds or analytes detected in the ground water for which no ARARs/TBCs have been identified pose an individual cancer risk greater than 1×10^{-6} or an HI greater than 1. A ground water PRG of 510 ppb was calculated for manganese based on an HI of 1, as presented on Table 3-3. Additional information used in the development of risk-based PRGs is presented in Appendix A.

The Phase I and Phase II RI manganese levels for each monitoring well location at Site 06 were compared to the risk-based PRG presented in Table 3-3. The monitoring well locations at which the manganese PRG was exceeded are shown on Figure 3-3. During the Phase I RI, five of six ground water samples had manganese concentrations exceeding the PRG of 510 ppb. In the samples which exceeded the PRG, manganese concentrations ranged from 733 ppb (06-MW2S) to 2,680 ppb (06-MW3S). Three of the Phase II RI ground water samples also had manganese concentrations which exceeded the 510 ppb limit. The sample locations and associated concentrations were 06-MW1D at 991 ppb, 06-MW3S at 1,270 ppb, and 06-MW4S at 1,300 ppb. Based on the presence of manganese in the upgradient well (06-MW3S) at levels exceeding the PRG, the elevated concentrations detected in other site wells may not be site-related. Further indicating that manganese is not site-related is the fact that manganese was found to be associated with an elevated hazard index value (i.e., greater than 1) at each site for which risks were characterized (i.e., Sites 02, 03, 06, 07, 09, 10, 11 and 13), and the manganese PRG is within the range of manganese concentrations detected in upgradient wells (34 ppb to 2,200 ppb) during the Phase II RI at these sites.

3.1.3 Environmental Risk-Based Considerations

As discussed in the ecological risk assessment (TRC, 1993b), a potential for environmental risk due to exposure to pesticides/PCBs in the Hall Creek Watershed has been identified based on a weight of evidence approach to risk evaluation. Since the Hall Creek Watershed is comprised of a large area, including Sites 02, 03, 05, 06, and 13, an evaluation

of the potential impacts associated with Site 06 alone is important in determining PRGs for the site. No pesticides/PCBs have been detected in soils or ground water at Site 06. Therefore, Site 06 is expected to pose little ecological risk to the Hall Creek Watershed and ecological considerations will not play a significant role in the development of PRGs for the site.

3.1.4 Contaminant Migration Considerations

Another consideration in the development of remedial action objectives and PRGs is the potential for contaminant migration, especially as it applies to soil contamination. Since exposures to subsurface soils are not included in the expected future use exposure scenario (commercial/industrial use) for the site, potential leaching of contaminants to the ground water is the greatest concern with respect to subsurface soil contaminants. To evaluate the potential for contaminant leaching to be a major factor in contaminant migration, the "Unnamed Model" described in Determining Soil Response Action Levels Based on Potential Contaminant Migration to Ground Water: A Compendium of Examples (USEPA, 1989a) was applied to existing site data.

The unnamed model is a variation of the Summers Model, also described in the above-referenced document. The Summers Model is basically a mass balance in which the concentration of contaminant leached from a contaminated area multiplied by the volumetric rate of infiltration over the area of contamination plus the upgradient (incoming) ground water contaminant concentration (assumed to be equal to zero) multiplied by the volumetric rate of ground water flow entering the site will equal the ground water contaminant concentration exiting the site multiplied by the volumetric rate of ground water flow exiting the site (which is equal to the volumetric rate of infiltration plus the volumetric rate of ground water flow into the site). The Summers Model is applied to the entire area of the site, assuming that the entire site area is equally contaminated.

The unnamed model uses the same approach but applies it to a unit area of the site. Therefore, the rate of infiltration is applied to a 1-square-foot area in determining the volumetric rate of infiltration and the ground water flow velocity is applied to an area which is a unit dimension wide (1 foot) but equal to the saturated thickness of the aquifer in terms of height.

This approach is more applicable to the characteristics of Site 06 where specific areas may exhibit higher levels of contamination which are not characteristic of the site as a whole.

In both models, the maximum allowable ground water contaminant concentration leaving the site (or the unit area) is assumed to equal the Maximum Contaminant Level. The volumetric flow rate of infiltration is estimated based on known precipitation and infiltration values and the volumetric flow rate of ground water entering the site is estimated based on information obtained during the Phase I and II RIs. Using published octanol-water partition coefficients (K_{ow}) and organic carbon soil concentrations measured during the RI, the maximum allowable concentration of a contaminant in the ground water (equal to the MCL) can be related to the maximum allowable contaminant concentration in the soil in the saturated zone. The maximum concentration of a contaminant adsorbed to the soil in the unsaturated zone can then be back-calculated using the mass-balance approach described above.

The calculations conducted for Site 06 are described in detail in Appendix C. When final MCLs were unavailable for COCs, proposed or tentative MCLs were utilized to allow for a broader evaluation of soil contaminants. At boring locations B6-06-03 and 06-B07, 2-methylnaphthalene and naphthalene were both detected in unsaturated subsurface soil samples. However, MCLs do not exist for these contaminants. To determine the potential impact of naphthalene and 2-methylnaphthalene on the ground water, risk-based ground water PRGs were developed (although these contaminants were not detected in ground water) and used in the model in place of MCLs.

The results of the unnamed model calculations for Site 06, as presented in Appendix C and summarized in Table 3-4, indicate that none of the contaminants detected in unsaturated surface and subsurface soil samples exceed the estimated maximum allowable contaminant concentration in unsaturated soils which is protective of ground water quality (based on use of MCLs or PRGs as the maximum allowable ground water concentrations). No soil samples were collected from the saturated zone during either the Phase I RI or Phase II RI for TCL/TAL analysis.

Another consideration in the evaluation of the potential migration of contaminants from subsurface soils is the information provided by the Toxicity Characteristic Leaching Procedure (TCLP) analyses conducted during both the Phase I and Phase II RIs on subsurface soil samples.

Of the four samples collected and analyzed for TCLP (Phase I RI samples B-06-02-02-S and B-06-03-02-S and Phase II RI samples 06-B07-02 and 06-B08-03), no detected constituents exceeded maximum allowable TCLP levels. Therefore, available TCLP analyses support the unnamed model results in indicating that minimal leaching of contaminants from subsurface soils could be expected, especially considering that the leaching conditions at Site 06 would be expected to be less severe than those employed in the TCLP analysis.

3.2 Remedial Action Objectives

The remedial action objectives developed to guide the implementation of a remedial response at Site 06 are presented by environmental medium below.

3.2.1 Soils

The Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02) states that the federal guidance level for lead, 500 to 1,000 ppm, is protective for direct contact at residential settings. Only one surface soil sample (06-SS08) exhibited a lead concentration (616 ppm) within the guidance level range. The OSWER directive also adopts the recommendation contained in the 1985 Centers for Disease Control (CDC) statement that reads, "...lead in soil and dust appears to be responsible for blood levels in children increasing above background levels when the concentration in the soil or dust exceeds 500 to 1000 ppm." Since the Comprehensive Reuse Plan for NCBC Davisville specifies the area in which Site 06 is located as being used for commercial/industrial use, not residential use, exposures to children would not be anticipated. Although the detected lead concentration at 06-SS08 exceeded the RIDEM guidance level of 300 ppm, the areal extent of elevated lead concentrations is small, with other surface soil samples collected within 10 to 20 feet of 06-SS08 exhibiting significantly lower lead levels (101 ppm at 06-SS04 and 92.5 ppm at 06-SS07) which are within the guidance levels.

Therefore, based on the analysis presented above, the lack of human health risks associated with exposures to surface soil contaminants under future commercial/industrial site use, the lack of environmental risks associated with Site 06 soil contaminants, and the lack of

potential impact to ground water as indicated by the results of the leaching model evaluation, the remedial action objective for Site 06 soils is as follows:

- Minimize the potential for residential exposures to surface soil contaminants at levels which exceed ARARs/TBCs, as presented in Table 3-1.

3.2.2 Ground Water

While ground water is classified GB and would not provide a suitable potable water source, no regulatory means of preventing installation of a potable well and subsequent exposures exist. Based on the presence of inorganic contaminants at levels exceeding ARARs/TBCs and PRGs, the remedial action objective for ground water is as follows:

- Prevent exposure, due to ground water ingestion, to contaminants which are present at levels exceeding acceptable ARARs/TBCs as indicated in Table 3-2, or which exceed risk-based preliminary remediation goals as indicated in Table 3-3.

3.3 General Response Actions

General response actions are those remedial actions which will satisfy the remedial action objectives. The first step in determining appropriate general response actions for Site 06 is an initial determination of the areas or volumes to which the general response actions may be applied. In determining these volumes/areas of media, consideration has been given to site conditions, the nature and extent of contamination, acceptable exposure levels and potential exposure routes.

As indicated in Section 3.2.1, the remedial action objective for soils at Site 06 is to eliminate potential residential exposures to contaminated surface soils. Existing soil quality does not pose a significant concern under the proposed commercial/industrial site use. Therefore, the estimation of soil volumes is not applicable to Site 06 and the general response actions identified for the site are as follows:

- No Action
- Institutional Control

In order to provide a preliminary estimate of the volume of ground water requiring remediation, the extent of ground water contamination at levels exceeding ground water

ARARs/TBCs and risk-based cleanup standards must be evaluated. As discussed in Section 3.1.1 and 3.1.2, inorganic constituents present in ground water samples at Site 06 exceed MCLs or risk-based PRGs. The area of ground water containing inorganics at levels exceeding MCLs and risk-based PRGs was estimated to encompass approximately 37,000 square feet (including Site 06, from upgradient well 06-MW3 to downgradient well 06-MW2). Using an estimated saturated thickness of 8.5 feet, and assuming a conservative effective porosity of 20%, the volume of ground water containing inorganics at levels exceeding MCLs or risk-based PRGs at Site 06 is on the order of 468,000 gallons. The uncertainty associated with this estimate is high, based on the presence of both lead (at a level which exceeds the drinking water action level) and manganese (at a level which exceeds the risk-based PRG) in the upgradient well.

A listing of general response actions developed for ground water at Site 06 is provided below.

- No Action
- Institutional Control
- Extraction/Treatment/Discharge

3.4 Identification and Screening of Technologies and Process Options

The general response actions are developed further through the identification and screening of remedial technologies which could potentially meet the remedial action objectives and PRGs. Following a screening of the remedial technologies on the basis of technical implementability, the process options associated with each technology are screened based on effectiveness, implementability and cost. Representative process options are chosen for inclusion in the remedial alternatives developed for the sites.

While technology and process option screenings were conducted in the Initial Screening of Alternatives Report (TRC, 1993a), the screening process is re-evaluated herein based on the results of the Phase II RI and the impact of those results on the remedial action objectives for the site.

3.4.1 Technology Screening

The technology screening performed for Site 06 is presented for soil in Table 3-5 and for ground water in Table 3-6. The table includes brief descriptions of the individual technologies or process options, and comments on their technical implementability. Technologies which are screened from further consideration are shaded in the technology screening tables. More detailed descriptions of the screening process and the technologies considered are provided in Appendix D.

3.4.2 Process Option Screening

Upon identification of those technologies which are technically implementable, the process options are further evaluated to allow the selection of representative process options to be used in the development of remedial alternatives. The process options are evaluated on the basis of effectiveness, implementability, and cost. The process option screening is presented for soil and ground water in Tables 3-7 and 3-8, respectively. The selected representative process options are indicated with a bullet in the process option screening tables. Table 3-9 summarizes the technologies and process options which passed the technology screening, with selected representative process options indicated with an asterisk. More details on the representative process option selection process are provided in Appendix D.

3.5 Remedial Alternative Development

The selected technologies and process options identified in Section 3.4.2 are combined as appropriate in this section to form remedial alternatives. The developed range of alternatives is intended to provide a streamlined evaluation of possible remedial actions. The alternatives presented herein have been developed in accordance with the expectations of the Superfund program, as outlined within the NCP. Rather than combining alternatives for the various media, the alternatives developed for each media will be evaluated separately to allow greater flexibility in determining the overall remedial action for the site. The remedial alternatives developed for soil and ground water at Site 06 are presented in Table 3-10.

Within the Initial Screening of Alternatives Report (TRC, 1993a), remedial alternatives were developed for Sites 05, 06 and 13 combined. Due to the lack of soil contamination

indicated by Phase I RI data for Site 06, no soil remedial alternatives were developed. Similarly, due to the lack of sufficient data to clearly support the delineation of ground water contamination at Sites 06 and 13, no ground water remedial alternatives were developed. Therefore, the alternatives presented within this report have been developed on the basis of Phase I and Phase II RI data combined. All developed alternatives will undergo a detailed analysis herein.

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Each of the remedial alternatives developed for the site, as presented in Section 3.5, are further defined and then undergo a detailed analysis. Following the detailed analysis of individual alternatives, a comparative analysis is conducted between alternatives.

4.1 Evaluation Criteria

The NCP defines nine evaluation criteria to be considered in the detailed analysis of alternatives. The evaluation criteria are divided into three groups; threshold criteria, which relate to statutory requirements that each alternative must satisfy; balancing criteria, which are the technical criteria that are considered during the detailed analysis; and modifying criteria, which are formally assessed after the public comment period. The nine criteria include the following:

Threshold Criteria

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirements (ARARs);

Balancing Criteria

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;

Modifying Criteria

- Community acceptance; and
- State acceptance.

When evaluating alternatives in terms of overall protection of human health and the environment, consideration is given to the manner in which site-related risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. Long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs are given major consideration in determining the overall protection offered by each alternative.

The alternatives are assessed to determine whether they attain applicable or relevant and appropriate requirements (ARARs) under federal environmental laws and state environmental laws and state environmental or facility siting laws. The identification of ARARs in a site-specific process which is dependent on the specific hazardous substances, pollutants, and contaminants at a site, the physical characteristics of a site, and the remedial actions under consideration at a site. Therefore, it is an iterative process which requires re-examination throughout the RI/FS process, until a Record of Decision (ROD) is issued. A preliminary ARARs analysis is presented in Appendix A of this document. In the following alternative analysis, the individual remedial alternatives will be evaluated in detail to determine their compliance with ARARs/TBCs which are applicable to the specific media being addressed by the remedial action, and the potential impacts of ARARs/TBCs on the alternative's implementation.

An alternative that does not meet an ARAR may be selected as a remedial action under several circumstances, including the following:

- If the alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
- If compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- If compliance with the requirement is technically impracticable from an engineering perspective;
- If the alternative will attain an equivalent standard of performance through the use of another method or approach; or
- If the ARAR is a state requirement that the state has not consistently applied in similar circumstances.

Each alternative is also evaluated for long-term effectiveness and permanence, in which the magnitude of residual risk remaining from untreated waste or treatment residuals and the adequacy and reliability of containment systems and institutional controls is evaluated. The degree to which alternatives employ recycling or treatment to reduce toxicity, mobility, or volume is assessed, including how treatment is used to address the principal threats at the site.

The short-term effectiveness evaluation takes into consideration the short-term risks that might be posed to on-site workers, the surrounding community, or the environment during implementation, as well as the time until protection is achieved. The analysis of implementability considers the technical feasibility and administrative feasibility of implementation, as well as the availability of required materials and services. The cost analysis evaluates capital (direct and indirect) costs and annual operation and maintenance (O&M). The net present value of capital and O&M costs is presented for each alternative.

In selecting a remedial action, the following criteria must be considered. Each selected remedial action shall meet the threshold criteria, and thereby be protective of human health and the environment. Provided the remedy meets the threshold criteria, it shall also be cost effective. The overall effectiveness of an alternative is determined by evaluating long-term effectiveness and permanence, reduction of toxicity, mobility, or volume through treatment, and short-term effectiveness. The alternative is then evaluated with regard to cost to ensure that it is cost-effective. Each remedial action shall also utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. This requirement is fulfilled by selecting the alternative that satisfies the threshold criteria and provides the best balance of trade-offs among alternatives in terms of the five balancing criteria, with an emphasis on long-term effectiveness and reduction of toxicity, mobility, and toxicity through treatment.

4.2 Soil Alternative Individual Descriptions and Evaluations

4.2.1 Alternative S-1 - No Action Alternative Description

The NCP requires consideration of the no action alternative to, at a minimum, provide a baseline for comparison with other alternatives. The no action alternative would involve no remedial response activities with respect to soil at Site 06. A small area of soil contaminated with lead at a level exceeding guidance levels would remain. The need for five-year reviews of the no action decision would require a risk management decision, since the limited area of contamination exceeds the RIDEM lead guidance level.

An evaluation of the no action alternative with respect to federal and state chemical-specific ARARs/TBCs is presented in Table 4-1. Since there are no actions involved with this

alternative, action-specific ARARs do not apply. No location-specific ARARs/TBCs were identified for Site 06.

An evaluation of the no action alternative with respect to the evaluation criteria is presented below.

4.2.2 Alternative S-1 - No Action Alternative Evaluation

Overall Protection of Human Health and the Environment - The no action alternative would be protective to human health and the environment under the proposed future commercial/industrial site use based on the lack of identified human health risks and environmental risks associated with the site soils and the lack of potential impact to ground water, as indicated by the leaching model evaluation. It does not limit future use of the site, and therefore does not limit the potential for future residential exposures. However, the limited areal extent of contamination limits the risks associated with future residential use. Alternative S-1 not meet state chemical-specific TBCs for lead but falls within the federal TBC lead range.

Compliance with ARARs - Since this alternative does not address lead in soils, it does not meet state chemical-specific TBCs; it falls within the federal action level range for lead. No state or federal location-specific ARARs/TBCs were identified for Site 06. Since there are no actions involved in this alternative, action-specific ARARs/TBCs do not apply.

Long-Term Effectiveness and Permanence - The no action alternative would be effective in the long-term under the proposed future commercial/industrial site use based on the lack of identified unacceptable risks to human health and the environment. The need for five-year reviews of the no action decision would require a risk management decision since a limited area of contamination exceeds the RIDEM lead guidance level.

Reduction of Toxicity, Mobility, or Volume through Treatment - The no action alternative does not include any treatment methods. The alternative offers no significant reductions in the toxicity, mobility, or volume of contamination through treatment. However, based on the limited extent and nature of contamination, reduction of toxicity, mobility, or volume may not be required.

Short-Term Effectiveness - The no action alternative does not result in any increased short-term risks due to the lack of activities associated with its implementation and the minimal potential risks to human health or the environment posed by the site soils.

Implementability - The no action alternative would require no implementation other than potential five-year reviews of the no action decision. Its implementation would not limit the future implementation of additional remedial actions.

Cost - The cost associated with the no action alternative would be the nominal cost associated with conducting the five-year reviews, if necessary.

4.2.3 Alternative S-2 - Limited Action Alternative Description

Alternative S-2 was developed as a limited action option in which a fence would be placed around the site and/or deed restrictions would be implemented. A chain-link fence would be placed around the perimeter of the site to limit site access. Warning signs would be placed on the fence to warn any trespassers of the potential hazards associated with existing site conditions. Deed restrictions would be implemented to restrict future residential site use.

An evaluation of Alternative S-2 with respect to federal and state chemical-specific ARARs/TBCs is presented in Table 4-1. No location-specific or action-specific ARARs/TBCs were identified for this alternative.

An evaluation of the limited action alternative with respect to the evaluation criteria is presented below.

4.2.4 Alternative S-2 - Limited Action Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative S-2 would protect human health and the environment under the proposed future commercial/industrial site use scenario based on the lack of identified human health risks environmental risks. The limited action would also limit the potential for future residential exposures by restricting the future use of the site. Through fencing, the action would limit potential exposures due to direct contact with the soils at the site. However, the fencing would limit future use of the site under the commercial/industrial site use scenario. Deed restrictions would prevent future residential site

use and development, and would thereby prevent exposures upon which the chemical-specific TBCs are based.

Compliance with ARARs - Alternative S-2 complies with federal and state chemical-specific TBCs for lead by preventing future residential site development. No state or federal location-specific ARARs/TBCs were identified for Site 06. No action-specific ARARs/TBCs were identified for the construction of a perimeter fence.

Long-Term Effectiveness and Permanence - Alternative S-2 relies on the limitation of future residential site use to reduce risk from direct contact. Deed restrictions on access/development would require long-term enforcement to ensure their protectiveness. Residual lead contamination will remain on-site at a level above the state TBC. However, since no unacceptable human health risks or environmental risks were identified under the future commercial/industrial site use scenario, the limited action alternative would have good long-term effectiveness in protecting human health and the environment. A risk management evaluation would be required to determine if five-year reviews of Alternative S-2 are required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-2 provides no treatment of site contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume. Site access or development restrictions would prevent the potential for exposure associated with future residential site use.

Short-Term Effectiveness - Minimal short-term risks would result from the implementation of Alternative S-2. Routine construction activities would be required to install the perimeter fence. Since no unacceptable human health risks have been identified under the construction future use scenario at Site 06, no unacceptable short-term risks would be expected due to construction of the perimeter fence. No increased off-site risks would result from the implementation activities. Implementation is estimated to require less than one month.

Implementability - The construction of a fence would be easy to implement, since associated materials and equipment are readily available, and the site is flat and small in areal extent. Deed restrictions would have to be incorporated into the property transfer process following base closure. The Comprehensive Reuse Plan specifies that Site 06 be set aside for economic/industrial development. While deed restrictions limiting site use to commercial/industrial uses would correspond to the proposed future site use, implementation of

access restrictions could restrict commercial/industrial development options at the site. Implementation of Alternative S-2 would not be expected to limit the implementation of future remedial actions, if necessary.

Cost - Costs associated with the implementation of S-2 would be those associated with fence placement and the establishment of land use restrictions. The cost of implementation for Alternative S-2 is estimated to include $9,500 in direct capital costs, $1,300 in indirect capital costs, and $300 in annual operation and maintenance costs ($4,600 net present value). The net present worth value of this alternative, including contingency, is estimated at $18,500. A detailed cost estimate is presented in Appendix E.

4.3 Soil Alternatives Comparative Evaluation

A comparative analysis is conducted to evaluate the differences between the soil remedial alternatives based on the threshold and balancing criteria. Tabular comparisons of the two alternatives based on the seven evaluation criteria are presented in Tables 4-2 through 4-8.

4.3.1 Overall Protection of Human Health and the Environment

A comparative analysis of the remedial alternatives with respect to their overall protection of human health and the environment is presented in Table 4-2.

Based on existing site contamination, Alternative S-2 provides protection of human health under the proposed commercial/industrial site use by limiting potential exposures to site soils through fencing and/or deed restrictions. While fencing would limit access to the site, deed restrictions would prevent future residential use of the site, thereby reducing the potential for residential exposures to site soils. Alternative S-2 is effective in both the short-term and the long-term.

The no action alternative would also be considered protective of human health under the proposed future commercial industrial site use scenario. However, Alternative S-1 would not provide a means of limiting future use of the site, and therefore would not limit the potential for future residential exposures. Alternative S-1 is effective in both the short-term and the long-term, provided residential exposures do not occur.

4.3.2 Compliance with ARARs

A comparative analysis of the remedial alternatives with respect to their compliance with ARARs is presented in Table 4-3.

Both alternatives provide the same degree of compliance with chemical-specific ARARs. Neither alternative provides direct remediation of site soils; therefore, lead would remain on site at levels which do not meet the state chemical-specific TBC for lead, but which fall within the acceptable federal TBC range. No location-specific ARARs/TBCs were identified for Site 06 and no action-specific ARARs/TBCs were identified as being applicable to these alternatives.

4.3.3 Long-Term Effectiveness and Permanence

A comparative analysis of the remedial alternatives with respect to long-term effectiveness and permanence is presented in Table 4-4.

Both alternatives would be effective in the long-term under the proposed future commercial/industrial site use, based on the lack of identified unacceptable risks to human health and the environment.

Alternative S-2 relies on institutional controls to limit potential future residential exposures to site contamination. The alternative would require long-term maintenance of site fencing and/or deed restrictions to maintain its effectiveness. Alternative S-1 would not provide the same degree of long-term effectiveness as Alternative S-2 since no fencing or deed restrictions would be implemented to limit potential future residential exposures to site contamination.

4.3.4 Reduction of Toxicity, Mobility and Volume through Treatment

A comparative analysis of the remedial alternatives with respect to reduction of toxicity, mobility and volume through treatment is presented in Table 4-5.

Alternative S-1 and Alternative S-2 provide no active remediation of site soils; therefore neither alternative offers reductions in the toxicity, mobility or volume of contamination on-site. However, based on the limited extent and nature of contamination, a reduction of toxicity, mobility or volume may not be required.

4.3.5 Short-Term Effectiveness

A comparative analysis of the remedial alternatives with respect to short-term effectiveness is presented in Table 4-6.

Alternative S-1 would not result in any increased short-term risks due to the lack of activities associated with its implementation and it would not meet remedial action objectives. Minimal short-term risks are associated with the implementation of fence installation under Alternative S-2, since only routine construction activities would be required. Alternative S-2 would meet remedial action objectives within a short time frame.

4.3.6 Implementability

A comparative analysis of the remedial alternatives with respect to implementability is presented in Table 4-7.

Alternative S-1 requires no implementation other than five-year reviews. Alternative S-2 is easily implemented from a technical standpoint, requiring the implementation of deed restrictions and/or construction and maintenance of site fencing. The restriction of access due to site fencing could hinder the proposed commercial/industrial future site use specified under the Base Reuse Plan. Deed restrictions would have to be incorporated under the base closure property transfer process. Alternative S-2 would also require five-year reviews. Neither alternative would limit the implementation of other remedial actions.

4.3.7 Cost

A comparative analysis of the remedial alternatives with respect to cost is presented in Table 4-8.

The no action alternative is the least costly alternative, the only cost being the nominal cost associated with the five-year reviews. Alternative S-2 has a total estimated present worth cost of $18,000.

4.4 Ground Water Alternative Individual Descriptions and Evaluations

Three ground water remedial alternatives were developed, as described below.

4.4.1 Alternative GW-1 - No Action Alternative Description

The NCP requires consideration of the no-action alternative; at a minimum it provides a baseline for comparison with other alternatives. This alternative would involve no remedial response activities with respect to ground water. No removal or treatment of ground water which contains lead at levels exceeding the drinking water action level or manganese at levels exceeding the risk-based PPG would be conducted. Because remaining contamination would not allow for unlimited future use of the site (i.e., potable ground water use), five-year reviews of the no action decision would be required.

An evaluation of the no action alternative with respect to federal and state chemical-specific ARARs/TBCs is presented in Table 4-9. No location-specific ARARs were identified for Site 06. Since the alternative involves no actions, no action-specific ARARs/TBCs were identified for this alternative.

4.4.2 Alternative GW-1 - No Action Alternative Evaluation

Overall Protection of Human Health and the Environment - The no action alternative does not address potential risks through the elimination, reduction, or control through treatment of the contaminated ground water. Lead and manganese would remain in the ground water on-site at levels exceeding ARARs and PRGs. However, based on the site's GB ground water classification, the minimal exceedance of the lead action level in the one upgradient well during the Phase II RI, the presence of manganese in upgradient wells at all of the Phase II RI sites, and the lack of unacceptable environmental risks within the downgradient Hall Creek Watershed, the lack of ground water treatment would not be expected to result in significant risks to human health and the environment unless a potable water supply well was installed at the site. This alternative does not limit future use of the site, and therefore does not limit the potential for future exposures due to changes in site use (e.g., installation of a potable well on-site). Should ground water in the site area ever be considered for potable use, protection of human health may not be provided under the no action alternative. This alternative is not expected to result in adverse impacts to the environment, based on the current lack of significant environmental risks associated with metals in the Hall Creek Watershed, although it provides no means of identifying

potential environmental impacts, should they occur in the future. Implementation of this alternative results in no short-term impacts to the site.

Compliance with ARARs - Based on the presence of lead at a level exceeding the lead drinking water action level in the upgradient well during the Phase II RI, this alternative would not meet chemical-specific ARARs, as listed in Table 4-9. No action-specific or location-specific ARARs/TBCs were identified for this alternative.

Long-Term Effectiveness and Permanence - The no action alternative would be effective in the long-term provided ground water is not used as a drinking water supply. Potential impacts to the environment are not expected based on the current lack of significant environmental risks attributable to metals within the Hall Creek Watershed. However, no controls would be provided to verify the lack of future environmental impacts. Due to the potential residual risk (should ground water be used as drinking water supply) which would be associated with the no action alternative, five-year reviews of the no action decision would be required under the NCP.

Reduction of Toxicity, Mobility, or Volume through Treatment - The no action alternative does not include any treatment methods other than naturally occurring degradation or attenuation processes. Therefore, the alternative offers no significant reductions in the toxicity, mobility, or volume of inorganic ground water contaminants through treatment.

Short-Term Effectiveness - The no action alternative does not present any increased short-term risks due to the lack of activities associated with its implementation. The five-year reviews would provide the only means of ensuring continued compliance with remedial action objectives.

Implementability - The no action alternative would require no implementation other than the five-year reviews of the no action decision. Its implementation would not limit the future implementation of additional remedial actions.

Cost - The cost associated with the no action alternative would be the nominal cost associated with the five-year reviews.

4.4.3 Alternative GW-2 - Limited Action Alternative Description

Alternative GW-2 consists of the institution of ground water use restrictions and/or ground water monitoring. Ground water use restrictions would provide no active ground water

remediation but would limit potential risks to human health through the implementation of institutional controls, such as deed restrictions, to limit future potable ground water use on site. While ground water at Site 06 is classified as GB and is expected to have no value as a potable water source, there is no regulatory mechanism which limits the potential installation of a drinking water supply well at the site. Therefore, deed restrictions may be appropriate.

Long-term (30-year) ground water monitoring, consisting of annual monitoring of the existing monitoring wells, is included in the limited action alternative. The long-term monitoring would provide a means of identifying any ground water quality changes over time.

An evaluation of Alternative GW-2 with respect to federal and state chemical-specific ARARs/TBCs is presented in Table 4-9. No location-specific ARARs were identified for Site 06. Action-specific ARARs/TBCs are presented in Table 4-10.

4.4.4 Alternative GW-2 - Limited Action Alternative Evaluation

Overall Protection to Human Health and the Environment - Implementation of the limited action option would protect human health by limiting potential future exposures to inorganics in the ground water which could occur should a drinking water supply well be installed on site. This alternative is not expected to result in adverse impacts to the environment, based on the current lack of significant environmental risks associated with metals in the Hall Creek Watershed. Ground water monitoring would provide a means of identifying changes in ground water quality and potential resultant impacts to the environment. While this alternative would not provide compliance with drinking water standards through treatment, it would prevent the development of a ground water ingestion exposure pathway.

Compliance with ARARs - Based on the presence of lead at a level exceeding the lead drinking water action level in the upgradient well during the Phase II RI, this alternative would not achieve chemical-specific ARARs, as listed in Table 4-9. No location-specific ARARs/TBCs were identified for Site 06. Ground water monitoring would be conducted in accordance with RIDEM's Rules and Regulations for Ground Water Quality, as indicated in Table 4-10.

Long-Term Effectiveness and Permanence - Provided deed restrictions are enforced, they can be effective in minimizing the long-term risks associated with the potential construction and use of an on-site well as a source of drinking water. Since contaminants will remain on site at

levels which do not allow for unlimited use and unrestricted exposure, five-year reviews of Alternative GW-2 would be required. The monitoring program would provide a means of monitoring potential changes in ground water quality. If monitoring indicated that ground water quality was deteriorating, additional remedial measures could be implemented.

Reduction of Toxicity, Mobility or Volume through Treatment - Alternative GW-2 provides no treatment nor associated reduction in contaminant toxicity, mobility or volume.

Short-Term Effectiveness - Since implementation of deed restrictions is an administrative effort, no short-term risks would result from implementation of this option. This option would meet remedial response objectives related to minimizing potential human exposure to contaminated ground water due to on-site potable water supply well installation. Implementation of the monitoring program would have minimal short-term adverse impacts based on the use of existing wells for ground water monitoring purposes.

Implementability - Deed restrictions would have to be implemented as part of the base closure property transfer process. Deed restrictions limiting future installation of on-site monitoring wells would not be expected to prevent future commercial/industrial use of the site. Implementation of deed restrictions or ground water monitoring would not limit the implementation of future remedial actions.

Cost - The costs associated with the implementation of deed restrictions would primarily be limited to legal costs and could be incorporated into the base closure property transfer process. The costs associated with ground water monitoring include the long-term sampling, analysis and reporting costs. The overall cost includes $7,700 in annual operation and maintenance costs ($120,000 net present value). The present worth value of this alternative, including contingency, is estimated at $140,000. A detailed cost estimate is provided in Appendix E.

4.4.5 Alternative GW-3 - Extraction/Treatment/Discharge Alternative Description

Alternative GW-3 consists of active remediation of the ground water to meet chemical-specific ARARs and risk-based PRGs. The alternative would provide hydraulic control of the ground water at the site, thereby reducing potential off-site migration, but would not address the

source of the lead detected in the upgradient well or the presence of manganese in ground water throughout the facility.

The extraction/treatment/discharge alternative would consist of separate options which would be combined to form a complete alternative. These options are described in detail in Sections 4.4.7 through 4.4.14. This discussion and the evaluation presented in Section 4.4.6 focus on the extraction/treatment/discharge alternative in general terms, and will provide a basis for alternative comparisons.

The main contaminants of concern are manganese and lead. The results of the Phase I RI ground water sampling also indicate the presence of beryllium at a level exceeding the MCL. However, during the Phase II RI, in which the low flow sampling methodology was used to minimize the presence of suspended sediments in the samples, beryllium was not detected above the MCL in any of the Phase II monitoring wells. The presence of beryllium in the Phase I RI ground water samples will not be considered indicative of ground water quality and, therefore, will not be considered in the evaluation of the extraction/treatment/discharge options.

Bis(2-ethylhexyl)phthalate was detected in all six Phase II RI ground water samples at concentrations exceeding its federal MCL. As noted in Section 2.6.2, the presence of bis(2-ethylhexyl)phthalate in the Phase II RI samples is suspected to be attributable to the sampling methodology and not representative of actual ground water quality. This is further supported by the fact that bis(2-ethylhexyl)phthalate was not detected in Phase I RI ground water samples. Therefore, the presence of bis(2-ethylhexyl)phthalate in the Phase II RI ground water samples will not be considered in the evaluation of the extraction/treatment/discharge options.

Lead was detected at levels exceeding the drinking water action level of 15 ppb in each of the three wells sampled during the Phase I RI; however, it was present in only the upgradient well (06-MW3S) at a level (17.8 ppb) exceeding the federal action level during the Phase II RI, when the low flow sampling methodology was used. Although lead contamination may not be site-related, it will still be considered in the evaluation of the extraction/treatment/discharge options.

Manganese, the other inorganic contaminant of concern, was present in each of the three wells sampled during the Phase I RI at levels exceeding the risk-based PRG, and was present in three of the wells (including the upgradient well) sampled during the Phase II RI at levels

exceeding the PRG. However, as previously discussed in Section 3.1.2, the manganese PRG is within the range of manganese concentrations detected in upgradient wells at all of the Davisville sites and, therefore, is not considered to be a site-related contaminant. Treatment of manganese will be considered in the evaluation of extraction/treatment/discharge options, however.

An evaluation of Alternative GW-3 and its associated options with respect to federal and state chemical-specific and action-specific ARARs/TBCs is presented in Tables 4-11 and 4-12, respectively. No location-specific ARARs were identified for Section 06.

4.4.6 Alternative GW-3 - Extraction/Treatment/Discharge Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3 would provide active treatment of ground water at Site 06 and therefore, would provide a reduction in potential future risks to human health and the environment which could be associated with ground water ingestion or migration. Its long-term effectiveness would be good as long as the treatment system was operational. If treatment was discontinued, however, manganese or lead could return to the site based on their presence in the upgradient well. The extraction/treatment/discharge options would be designed to comply with action-specific ARARs/TBCs.

Compliance with ARARs - Alternative GW-3 would be designed to treat ground water contaminants present at levels exceeding ARARs, as indicated in Table 4-11. The extraction, treatment and discharge systems would be operated in accordance with action-specific ARARs as indicated in Table 4-12. A more detailed identification of the action-specific ARARs applicable to this alterative is provided in the individual options evaluations which follow.

Long-Term Effectiveness and Permanence - Ground water treatment would be effective in treating inorganic contaminants which exceed ARARs or risk-based PRGs and in preventing off-site migration of these contaminants during operation but would not necessarily result in a permanent contaminant reduction if ground water treatment is discontinued at some point in the future. Long-term ground water monitoring would be required to evaluate the effectiveness of the alternative after operations cease. Since contaminants would be present on-site during the

operating period at levels which do not allow for unlimited use and unrestricted exposure, five-year reviews of Alternative GW-3 would be required.

Reduction of Toxicity, Mobility or Volume through Treatment - Alternative GW-3 would utilize treatment to reduce the toxicity and mobility of existing contaminated ground water.

Short-Term Effectiveness - No significant risks to on-site workers or off-site risks are anticipated as a result of implementation of this alternative. The degree of short-term risk would be dependent upon the individual options employed. Remedial response objectives would be achieved during operation of the treatment system but may not be maintained if treatment is discontinued.

Implementability - Implementation of a ground water extraction, treatment, and discharge system would be relatively easy, with the possible exception of the discharge component. The technical implementability would be dependent upon the individual alternative options selected, with some treatment technologies more easily implemented than others. Services and materials should be readily available for the implementation of all options.

Cost - The cost of this alternative is dependent on the operational period as well as the individual options utilized in the final alternative. Based on the individual option evaluations presented in the following sections, the total cost of Alternative GW-3 is estimated to range from $555,000 for ion exchange to $835,000 for precipitation.

4.4.7 Alternative GW-3A - Ground Water Extraction via Interceptor Trench Option Description

An interceptor trench would be an effective means of extracting ground water at Site 06, based on the shallow depth to bedrock and the small areal extent of the site. Ground water modeling was conducted to determine optimum trench location and design. Modeling efforts are presented in Appendix F. Two separate trenches would be installed, on the northeast portion of the site, both elongated northwest-southeast. The proposed trench locations would be placed downgradient of the site as shown on Figure 4-1. Both trenches would be approximately 60-feet long, 3- to 4-feet wide, and 20-feet deep. A typical cross-section through the interceptor trench is provided as Figure 4-2. The drain itself would consist of a perforated pipe placed at an incline within a trench. The trench would be filled with a highly-permeable gravel up to a depth

of 8 feet below grade. Prior to backfilling with the gravel, the trench would be lined with a geotextile fabric filter to prevent silt from clogging the drain. Excavated soil would be backfilled above the gravel layer. The ground water would flow by gravity into and through the pipe to pre-cast manhole sumps where it would be lifted by means of a submersible pump to the surface for treatment. Ground water would be extracted at a rate of approximately 1 gpm from each trench for a total extraction rate of 2 gpm. For ground water treatment alternative evaluations, a maximum treatment rate of 10 gpm has been assumed. Also incorporated into this alternative is the installation and monitoring of piezometers, to evaluate the effectiveness of the interceptor trenches. The installation of one piezometer upgradient and downgradient of each interceptor trench has been assumed for this evaluation.

4.4.8 Alternative GW-3A - Ground Water Extraction via Interceptor Trench Option Evaluation

Overall Protection of Human Health and the Environment - Use of an interceptor trench to remove ground water for treatment would be protective of both human health and the environment. Ground water would be pumped from the interceptor trench and piped directly to an on-site treatment system. The extraction system would be effective and reliable in the long-term and would have minimal short-term risks associated with its installation.

Compliance with ARARs - The proposed ground water extraction system has been developed to capture ground water containing lead at levels exceeding drinking water action levels and manganese at levels exceeding PRGs. Therefore, it has been developed to provide compliance with chemical-specific ARARs, as presented in Table 4-11. No action-specific ARARs were identified as being applicable to the implementation of an interceptor trench ground water extraction system.

Long-Term Effectiveness and Permanence - An interceptor trench would be an effective and reliable means of extracting ground water at Site 06 since the average depth to bedrock is only 20 feet. Interceptor trenches are well-proven in their performance and can function with minimal maintenance. Long-term monitoring of the piezometers would be required.

Reduction of Toxicity, Mobility or Volume through Treatment - The ground water extraction option does not provide treatment although it would be combined with a treatment

option in a final alternative. By extracting contaminated ground water, the potential mobility of ground water contaminants is reduced.

Short-Term Effectiveness - Installation of an interceptor trench would present minimal short-term risks to on-site workers and would not be expected to result in any increased off-site risks to human health or the environment. The installation of an interceptor trench could be implemented with a minimal time frame.

Implementability - The implementability of a ground water extraction system is expected to be good. Materials and services are readily available and minimal technical or administrative obstacles to implementation would be anticipated.

Cost - The major cost component associated with implementation of Alternative GW-3A is the cost of installation of the interceptor trench. The estimated cost of Alternative GW-3A consists of $24,000 in direct capital costs, $3,400 in indirect capital costs, and $4,800 in annual operation and maintenance costs (($36,000 net present value). The present worth value of this alternative, including contingency. is estimated at $76,000. A detailed cost estimate is presented in Appendix E.

4.4.9 Alternative GW-3B - Precipitation Inorganic Treatment Option Description

Alternative GW-3B involves the treatment of inorganic ground water contaminants using chemical reduction and precipitation. Chemical precipitation is an inorganic removal method often used in industrial as well as ground water remediation applications.

For this evaluation, it is assumed that the chemical precipitation treatment system will include a filtration unit to remove gross solids prior to treatment and a flow equalization tank. The provision of an initial filtration system could result in reduced reagent costs and smaller equipment sizing for the remainder of the treatment system. A typical precipitation system includes the following:

- Reaction tank including mixers and pH control instrumentation;
- Chemical feed system, including a storage tank, mixers, level instrumentation, and metering equipment;
- Clarifier;
- pH adjustment tank;

Filter; and
Solidification/stabilization system.

A schematic of a typical system is provided on Figure 4-3.

The extracted ground water flows from the filtration system, through the equalization tank, and into the reaction tank. In the reaction tank, a reagent is added to adjust the pH of the wastestream to the level required for optimum precipitation. The selection of an applicable precipitation reagent is dependent upon the flow rate, pH, pollution loading, and waste/reagent compatibility.

Following the reaction tank, a flocculent such as anionic or cationic polymer is added and the solution flocculated to aid in the settling of the metal precipitate. In the clarifier, flow is decreased to the point where solids with a specific gravity greater than that of the liquid settle to the bottom. The supernatant is drawn off and discharged to a pH adjustment tank for neutralization. The solids are discharged to a holding tank for subsequent dewatering. Dewatering is accomplished using mechanical dewatering equipment such as a filter press. Once dewatered, the sludge is stabilized prior to off-site landfill disposal in accordance with federal and state disposal requirements.

In precipitation processes, lead is normally precipitated as a carbonate ($PbCo_3$) or as a hydroxide ($Pb(OH)_2$). These compounds have low solubilities at elevated pHs and the formation of these compounds is effective in reducing lead concentrations. Lime is commonly used as a lead treatment chemical. Manganese can also be removed at a pH above 9.4 using lime soda type treatment. Removal of manganese generally results in the simultaneous removal of iron, since the conditions under which high soluble iron levels occur are essentially the same as those for soluble manganese.

4.4.10 Alternative GW-3B - Precipitation Inorganic Treatment Option Evaluation

Overall Protection of Human Health and the Environment - Option GW-3B is expected to provide overall protection of human health and the environment through treatment of inorganic ground water contaminants. The long-term effectiveness and permanence and short-term effectiveness are expected to be good, and the system would be operated in compliance with ARARs/TBCs.

Compliance with ARARs - The ability of a chemical precipitation treatment system to treat inorganics such as lead and manganese is expected to be good. Treatment system operation would be conducted in compliance with action-specific ARARs, as listed in Table 4-12. Chemical precipitation generates a sludge which requires subsequent disposal off-site. If the sludge is characterized as a hazardous waste, federal RCRA hazardous waste generator and transporter requirements as well as state hazardous waste management regulations will be followed in the handling of the sludge. If not hazardous, the residuals would be handled in accordance with state solid waste management regulations. The treatment system would be required to treat the inorganic contaminants sufficiently to meet the applicable discharge requirements, also listed in Table 4-12.

Long-Term Effectiveness and Permanence - The long-term risks associated with chemical precipitation will be minimal based on the system's ability to treat lead and manganese contamination. However, the treatment system does produce a sludge that will require hazardous waste characterization and appropriate disposal. Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties.

Reduction of Toxicity, Mobility or Volume Through Treatment - This alternative will provide a reduction in the toxicity of identified inorganic ground water contaminants through treatment. The volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated sludge residual.

Short-Term Effectiveness - Short-term risks to workers under Alternative GW-3B are not expected to be significant. Maintenance of chemical supplies and sludge handling are the major operation and maintenance activities associated with the chemical precipitation system. No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation.

Implementability - A chemical precipitation system should be easily implemented. Start-up is not expected to result in unanticipated technical problems. Its implementation is not expected to impact the implementation of any future remedial actions. Operational activities include maintenance of the chemical supplies and sludge handling. Administrative feasibility is also expected to be good.

Cost - The major costs associated with the precipitation treatment system are the capital costs associated with the construction of a chemical precipitation unit and associated operation and maintenance costs, including chemical supply costs. The overall estimated cost includes $130,000 in direct costs, $26,000 in indirect capital costs, and $54,000 in annual operation and maintenance costs ($420,000 net present value). The present worth value of this alternative, including contingency, is estimated at $680,000. A detailed cost estimate is provided in Appendix E.

4.4.11 Alternative GW-3C - Ion Exchange Inorganic Treatment Option Description

Ion exchange is a reversible chemical separation process in which a resin is used to remove metal ions from solutions such as wastewaters or leachate. As a solution passes through a bed of resin, ions attached to the surface of the resin are replaced by ions in the solution that have similar charge. The ions removed from the solution may either be positively charged cations or negatively charged anions depending on the nature of the resin. After the exchange capacity of the resin is exhausted, a regenerant solution is pumped through the bed to restore the resin to its original condition. The metal ions desorb from the resin and are flushed from the system for subsequent recovery or disposal.

Ion exchange is sensitive to interference from competing ions, dissolved or suspended solids, and organics. Therefore, pretreatment of the wastewater stream using filtration may be required. Metal removal efficiencies of greater than 95% are typically achieved in properly operated ion exchange systems. See Figure 4-4 for a schematic of a typical ion exchange system.

For the treatment of lead, strongly acid cation exchange resins have been demonstrated to be effective. Ion exchange is also effective in the removal of manganese. The non-selective removal of other ions, however, can rapidly increase operational costs. Also, if air is present, manganese and iron can oxidize and clog the ion exchange bed. A filtration pre-tratment system has been assumed to minimize the potential for clogging of the ion exchange bed.

4.4.12 Alternative GW-3C - Ion Exchange Inorganic Treatment Option Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3C would provide overall protection of human health and the environment when combined with ground water extraction and treatment. The long-term effectiveness and permanence of this option are expected to be good and the treatment system would operated in compliance with ARARs/TBCs.

Compliance with ARARs - An ion exchange system is expected to be able to treat the inorganics of concern. Treatment system operation would be conducted in compliance with action-specific ARARs, as listed in Table 4-12. Backwash of the treatment system would result in the production of a concentrated brine solution which would require off-site disposal/treatment. If the brine is characterized as a hazardous waste, it will be handled in accordance with the applicable federal and state hazardous waste management regulations. The treatment system would be required to treat the inorganics contaminants sufficiently to met the applicable discharge requirements, also listed in Table 4-12.

Long-Term Effectiveness and Permanence - The long-term effectiveness of this alternative is expected to be good, with the addition of a filtration pretreatment process, based on the system's ability to treat the inorganic contaminants of concern. However, the regeneration of the resin material produces strong acids and bases as a waste material which would require hazardous waste characterization and appropriate disposal. Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties, although manganese and iron can cause clogging of the exchange resin.

Reduction of Toxicity, Mobility or Volume through Treatment - This alternative will provide a reduction in the toxicity of inorganic ground water contaminants through treatment. The volume of contaminated media is reduced through the removal of the inorganic ions from the ground water and subsequent production of a concentrated brine residual. Also, the addition of the filtration pretreatment process would produce a filter cake that would require disposal.

Short-Term Effectiveness - Short-term risks to workers under this alternative are not expected to be significant. Maintenance of chemical supplies and brine handling are the main operation and maintenance activities associated with ion exchange treatment system. No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation.

Implementability - The technical implementability of Alternative GW-3C is good, based on the availability of the technology, although it requires the construction of an on-site treatment facility. Start-up is not expected to result in any unanticipated technical problems. Its implementation is not expected to impact the implementation of any future remedial actions. Operational activities include maintenance of the chemical supplies and sludge handling. Administrative feasibility is also expected to be good.

Cost - The major costs associated with the ion exchange treatment system are the capital costs associated with the construction of an ion exchange unit, the installation of a pretreatment filtration unit, and associated operation and maintenance costs, including chemical supply costs. The overall estimated cost includes $190,000 in direct costs, $38,000 in indirect capital costs, and $13,000 in annual operation and maintenance costs ($100,000 net present value). The present worth value of this alternative, including contingency, is estimated at $400,000. A detailed cost estimate is provided in Appendix E.

4.4.13 Alternative GW-3D - Discharge to Surface Water Option Description

Alternative GW-3D involves the discharge of treated ground water to surface water, which in this case would be Hall Creek, which flows into Frys Pond. The discharge would be piped from the site to the discharge location, an approximate distance of 600 feet. The discharge rate would be equal to the extraction rate, estimated at 2.0 gpm. Implementation of discharge to the surface water is expected to have little, if any, effect on the ground water extraction and treatment system.

4.4.14 Alternative GW-3D - Discharge to Surface Water Option Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3E would provide overall protection of human health and the environment when combined with ground water extraction and treatment. The long-term effectiveness and permanence of this option are expected to be good, due to its simplicity, and the treatment system would operated in compliance with ARARs/TBCs.

Compliance with ARARs/TBCs - The water quality of the treatment process effluent would be required to comply with state and federal surface water discharge criteria, including

ambient water quality criteria as listed in Table 4-11 and surface water discharge regulations listed in Table 4-12.

Long-Term Effectiveness and Permanence - The long-term risks associated with the discharge to surface water will be minimal, provided the treatment system is operating properly. Long-term operation and maintenance of the discharge piping is not expected to pose any major technical problems. Long-term monitoring of the discharge water quality will be required.

Reduction in Toxicity, Mobility or Volume through Treatment - This alternative is not expected to significantly impact the extraction or treatment system; therefore, it has little impact on the toxicity, mobility or volume of contamination.

Short-Term Effectiveness - Short-term risks to workers under this alternative are not expected to be significant, involving only the construction of the discharge piping. Maintenance of the system will require maintenance of the piping and discharge monitoring. No significant added risks to the adjacent community or the environment are anticipated.

Implementability - The technical implementation of a discharge to surface water system is affected by the distance to a discharge point. The estimated distance to Hall Creek from Site 06 is approximately 600 feet to the northeast. Maintenance of the system will be limited. Continued monitoring of the discharged water quality will be required. The administrative feasibility of discharging treated ground water to surface water depends on the treatment system's ability to meet surface water discharge criteria.

Cost - The major costs associated with Alternative GW-3D are the on-going maintenance and discharge monitoring costs associated with its implementation. The overall estimated cost includes $7,000 in direct capital costs, $1,000 in indirect capital costs, and $7,400 in annual operation and maintenance costs ($57,000 net present value). The present worth value of this alternative, including contingency, is estimated at $79,000. A detailed cost estimate is provided in Appendix E.

4.5 Ground Water Alternative Comparative Evaluation

A comparative analysis of the ground water alternatives is conducted to evaluate the significant differences between the alternatives based on the threshold and balancing criteria.

Tables 4-13 through 4-19 comparatively summarize the alternative evaluations conducted strictly on the basis of ground water considerations for each of the evaluation criteria.

4.5.1 Overall Protection of Human Health and the Environment

A comparative analysis of the remedial alternatives with respect to their overall protection of human health and the environment is presented in Table 4-13.

The no action alternative would be considered protective of human health under the proposed future commercial/industrial site use scenario provided ground water is not utilized for potable use. However, Alternative GW-1 would not provide a means of limiting future use of the site, and therefore does not limit the potential for future installation of a potable well on-site. Therefore, remedial action objectives are not met.

Alternative GW-2 also provides protection of human health and the environment under the proposed commercial/industrial site use. In addition, Alternative GW-2 would also provide future protection of human health and the environment by applying deed restrictions which would not allow the future installation of a potable well on-site.

Alternative GW-3, ground water extraction/treatment/discharge, would provide the greatest degree of overall protection of human health and the environment through its active remediation of ground water contamination; however its permanence once treatment is discontinued is not ensured. For the treatment options evaluated under this alternative, both options provided relatively comparable protection of human health and the environment. The extraction and discharge options would also be protective of human health and the environment.

4.5.2 Compliance with ARARs

A comparative analysis of the remedial alternatives with respect to their compliance with ARARs is presented in Table 4-14.

Alternatives GW-1 and GW-2 would not comply with chemical-specific ARARs since neither alternative provides for the treatment of contaminated ground water. By providing direct remediation of contaminated ground water, Alternative GW-3 would achieve chemical-specific ARARs. The precipitation and ion exchange options would be effective in meeting chemical-

specific ARARs. However, long-term maintenance of reduced levels for these contaminants is not guaranteed once operation of the treatment system is discontinued.

Alternative GW-2 and Alternative GW-3 would be implemented in accordance with action-specific criteria. No location-specific ARARs/TBCs were identified which apply to Site 06.

4.5.3 Long-Term Effectiveness and Permanence

A comparative analysis of the remedial alternatives with respect to long-term effectiveness and permanence is presented in Table 4-15.

Alternative GW-2 would be expected to be effective in the long-term. The limited action alternative would provide a means of monitoring the site over the long-term to identify any changes in ground water quality and would limit the potential for future use of the ground water as a potable water supply. The extraction, treatment, and discharge options are all expected to be effective in the long-term. Both the precipitation (GW-3B) and ion exchange (GW-3C) options are effective and easily operated and maintained. However, after treatment operations cease, ground water monitoring would be required to evaluate the permanence of Alternative GW-3. The no action alternative offers the least long-term effectiveness and permanence.

4.5.4 Reduction of Toxicity, Mobility and Volume through Treatment

A comparative analysis of the remedial alternatives with respect to reduction of toxicity, mobility and volume through treatment is presented in Table 4-16.

Alternative GW-3 is the only alternative which provides for a reduction in contaminant toxicity, mobility, and volume through treatment. Alternatives GW-1 and GW-2 provide no reduction in toxicity, mobility, or volume through treatment.

4.5.5 Short-Term Effectiveness

A comparative analysis of the remedial alternatives with respect to short-term effectiveness is presented in Table 4-17.

Alternative GW-2 is the most effective alternative in the short-term, providing a means of monitoring compliance with remedial action objectives but resulting in no increase in short-

term risks. The limited action alternative allows for the long-term monitoring of ground water and meets remedial action objectives with respect to minimizing future human exposures to contaminated ground water. Alternative GW-1 also poses no increased short-term risks, but does not ensure compliance with remedial action objectives.

Alternative GW-3 also provides a means of complying with remedial action objectives within a short time frame with minimal risk incurred. The precipitation (GW-3B) and ion exchange (GW-3C) options would be effective in the short-term since both treatment systems are readily available. Both options would require the handling of waste materials, but the ion exchange process would produce more hazardous waste materials since the handling and use of strong acids and bases is required in the ion exchange treatment system. Both ground water extraction (GW-3A) and discharge to surface water (GW-3D) could be quickly implemented and effective in the short-term.

4.5.6 Implementability

A comparative analysis of the remedial alternatives with respect to implementability is presented in Table 4-18.

Alternative GW-1 would be the most implementable since it requires no action other than five-year reviews. Alternative GW-2 would be next in terms of implementability, requiring initiation of long-term monitoring and deed restrictions but no on-site construction activities. Neither Alternative GW-1 nor GW-2 would limit the implementation of other remedial actions at the site.

Alternative GW-3 would require the disruption of the site for implementation. However, none of the options of Alternative GW-3 would pose difficulty in implementation. For Alternative GW-3, precipitation (GW-3B) and ion exchange (GW-3C) would both be easily implemented due to their commercial availability, although the precipitation option would be more easily operated than the ion exchange option. Ground water extraction (GW-3A) and discharge to surface water (GW-3D) would both be easily implemented.

4.5.7 Cost

A comparative analysis of the remedial alternatives with respect to cost is presented in Table 4-19.

The no action alternative is the least costly alternative, with the only cost being the nominal cost associated with five-year reviews. Alternative GW-2 follows, with a total estimated present worth cost of $140,000. Alternative GW-3 would be the most costly. The total estimated present cost for combined ground water extraction/treatment/discharge ranges from $555,000 (ion exchange) to $835,000 (chemical precipitation). The present worth costs for individual options include: $76,000 for extraction (GW-3A); $680,000 for chemical precipitation (GW-3B); $400,000 for ion exchange; and $79,000 for discharge to surface water.

4.6 Sensitivity Analysis

A sensitivity analysis was conducted to assess the effect that variations in specific assumptions made during alternative development and assessment could have on the total estimated remedial cost. The main uncertainty factors which are applicable to the remedial alternatives and associated options are the uncertainties associated with the discount factor over the life of the remedy and over the remediation period for the ground water treatment alternatives. The resultant impacts to remedial costs are summarized in Table 4-20.

The discount rate can vary from the 5% rate used in the cost evaluation. Alternatives with large O&M cost components and extended remedial periods can be significantly impacted by a variation in the discount rate. The sensitivity analysis has been conducted assuming a variation in the annual discount rate, with total present worth costs estimated for each alternative at annual discount rates of 3% and 10%. The long-term ground water monitoring option (GW-3A) and long-term treatment options with high operation and maintenance (GW-3B) are impacted the greatest by variations in the discount rate.

Variations in the estimated remediation period also impacted the ground water remedial alternatives. Option GW-3B was the most affected due to its high operation and maintenance costs.

5.0 RECOMMENDATIONS AND CONCLUSIONS

Based on the evaluation of soil and ground water remedial alternatives presented in Section 4, the recommended remedial alternative for Site 06 is a limited action, consisting of the following:

- Deed restrictions to prevent future residential exposures to surface soil and to prevent ground water from being used as a potable water source.
- Long-term monitoring of ground water to identify any future changes in ground water quality.

This alternative would be protective of human health and the environment under the proposed future commercial/industrial site use based on the lack of unacceptable human health risks associated with such a future site use and the lack of unacceptable environmental risks associated with the site.

While there are no chemical-specific ARARs applicable to soil contamination at the site, the limited action alternative could be considered to comply with federal and state chemical-specific TBCs for lead, which are based on residential exposures to soils, by preventing future residential site use. It would also use institutional controls to limit exposures to ground water contaminants at levels exceeding drinking water action levels, which would be consistent with EPA's expectations for Superfund that allow the use of institutional controls when active remediation measures are determined not to be practicable, based on the balancing of trade-offs among alternatives. Considering the site's GB ground water classification which indicates that the ground water is not suitable for consumption without treatment, the presence of lead within the upgradient well, which indicates that it could potentially be associated with an unidentified upgradient source, and the minimal exceedance of the drinking water action level detected within the well (17.8 ppb versus the action level of 15 ppb), and the apparent presence of manganese in ground water throughout the facility, the balancing of trade-offs conducted among the ground water remedial alternatives indicates that active ground water treatment would not be practicable to implement and would not offer any guarantee of permanence with respect to maintaining ARARs upon discontinuation of treatment. The lack of ground water treatment at Site 06 is not expected to adversely effect the environment. The long-term monitoring would provide a means

of identifying any changes in ground water quality which could potentially impact the environment in the future.

Implementation of deed restrictions is an administrative effort which would be incorporated into the base closure property transfer process, thus no short-term effects would result from implementation. The monitoring program would have minimal short-term risks associated with its implementation and, provided deed restrictions are enforced, the limited action alternative would be effective in the long-term. Due to the continued presence of contaminants at the site at levels which do not allow for unrestricted use, five-year reviews of the limited action decision would be required. If the results of the ground water monitoring program indicated that ground water quality was deteriorating, additional remedial measures could be implemented. The alternative would complement future use of the site for commercial/industrial purposes, as specified in the Base Reuse Plan.

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TABLE 2–1

Site 06 – Solvent Disposal Area
Vertical Hydraulic Gradients

Well Cluster Number	Vertical Distance (ft) (1)		Head Difference (ft) (2)		Gradient (ft/ft)	
	8/13/93	9/17/93	8/13/93	9/17/93	8/13/93	9/17/93
06–MW1	11.07	10.55	–0.02	–0.03	-1.81×10^{-3}	-2.84×10^{-3}

NOTES: (1) The vertical distance is the difference in elevation between the water table in the shallow well and the middle of the screened interval in the deep well.

(2) The head difference is the elevation of the deep well piezometric level minus the water table elevation. Thus, negative signs represent downward gradients.

TABLE 2–2

Site 06 – Solvent Disposal Area
Average Horizontal Hydraulic Gradients and Linear Velocities

Location	Average Horizontal Gradient (ft/ft) 8/13/93	Average Horizontal Gradient (ft/ft) 9/17/93	Average Linear Velocity (ft/d) 8/13/93	Average Linear Velocity (ft/d) 9/17/93
Shallow Wells				
10–MW1S to 10–MW5S	4.71×10^{-3}	4.16×10^{-3}	0.38	0.34
10–MW3S to 10–MW1S	1.06×10^{-2}	1.03×10^{-2}	0.86	0.84
10–MW3S to 10–MW4S	1.63×10^{-2}	1.59×10^{-2}	1.33	1.30
10–MW3S to 10–MW5S	8.64×10^{-3}	8.22×10^{-3}	0.70	0.67
10–MW4S to 10–MW1S	1.52×10^{-3}	1.35×10^{-3}	0.12	0.11
10–MW4S to 10–MW5S	3.56×10^{-3}	3.14×10^{-3}	0.29	0.26

NOTES: The shallow hydraulic conductivity for the site (16.3 ft/d) is the median value derived from the Phase II RI slug tests.
An effective porosity of 0.20 for silty sands (EPRI, 1985) was assumed.

TABLE 2-3

Site 06 - Solvent Disposal Area
Comparison of Background Soils to Surface and Subsurface Soil Samples
Range of Semivolatile Organic Compounds Detected

Compound	Surface Soil Range (µg/kg)	Subsurface Soil Range (µg/kg)	Background Range (µg/kg)
Phenol	ND	ND	ND
bis(2-Chloroethyl)ether	ND	ND	ND
2-Chlorophenol	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND
1,2-Dichlorobenzene	ND	ND	ND
2-Methylphenol	ND	ND	ND
2,2'-Oxybis(1-chloropropane)	ND	ND	ND
4-Methylphenol	ND	ND	ND
N-Nitroso-di-n-propylamine	ND	ND	ND
Hexachloroethane	ND	ND	ND
Nitrobenzene	ND	ND	ND
Isophorone	ND	ND	ND
2-Nitrophenol	ND	ND	ND
2,4-Dimethylphenol	ND	ND	ND
bis(2-Chloroethoxy)methane	ND	ND	ND
2,4-Dichlorophenol	ND	ND	ND
1,2,4-Trichlorobenzene	ND	ND	ND
Naphthalene	ND	ND	ND
4-Chloroaniline	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND
4-Chloro-3-methylphenol	ND-290	ND	ND
2-Methylnaphthalene	ND	ND-8,100	ND
Hexachlorocyclopentadiene	ND	ND	ND
2,4,6-Trichlorophenol	ND	ND	ND
2,4,5-Trichlorophenol	ND	ND	ND
2-Chloronaphthalene	ND	ND	ND
2-Nitroaniline	ND	ND	ND
Dimethyl phthalate	ND	ND	ND
Acenaphthylene	ND	ND	ND
2,6-Dinitrotoluene	ND	ND	ND
3-Nitroaniline	ND	ND	ND
Acenaphthene	ND	ND	ND
2,4-Dinitrophenol	ND	ND	ND
4-Nitrophenol	ND	ND	ND
Dibenzofuran	ND	ND	ND
2,4-Dinitrotoluene	ND	ND	ND
Diethyl phthalate	ND	ND	ND
4-Chlorophenyl phenyl ether	ND	ND	ND
Fluorene	ND	ND	ND
4-Nitroaniline	ND	ND	ND
4,6-Dinitro-2-methylphenol	ND	ND	ND
N-Nitrosodiphenylamine(1)	ND	ND	ND
4-Bromophenyl phenyl ether	ND	ND	ND
Hexachlorobenzene	ND	ND	ND
Pentachlorophenol	ND	ND	ND
Phenanthrene	ND-730	ND	ND - 140
Anthracene	ND-200	ND	ND
Carbazole	ND	ND	ND
Di-n-butyl phthalate	ND	ND	ND - 67
Fluoranthene	ND-960	ND	ND - 250
Pyrene	ND-940	ND	ND - 260
Butyl benzyl phthalate	ND	ND	ND - 380
3,3'-Dichlorobenzidine	ND	ND	ND
Benzo(a)anthracene	ND-500	ND	ND - 110
Chrysene	ND-600	ND	ND - 190
bis(2-Ethylhexyl)phthalate	ND-240	ND	ND - 580
Di-n-octyl phthalate	ND	ND	ND
Benzo(b)fluoranthene	ND-640	ND	ND - 270
Benzo(k)fluoranthene	ND-570	ND	ND - 73
Benzo(a)pyrene	ND-440	ND	ND - 77
Indeno(1,2,3-cd)pyrene	ND	ND	ND - 52
Dibenzo(a,h)anthracene	ND	ND	ND
Benzo(g,h,i)perylene	ND	ND	ND

ND = Not Detected

TABLE 2–3

Site 06 – Solvent Disposal Area
Background, Surface, and Subsurface Soil Samples
Comparison of Background Soils to Surface and Subsurface Soil Samples
Range of Inorganics Detected

ELEMENT	Surface Soil Ranges (mg/kg)	Subsurface Soil Ranges (mg/kg)	Background Surface Soil Ranges (mg/kg)
Aluminum	2,910–10,600	4,010–6,080	1,710 – 12,600
Antimony	ND–3	ND	ND – 3
Arsenic	0.52–3.1	0.8–1.3	0.59 – 8.1
Barium	11.3–127	10.6–16.5	5.6 – 19.8
Beryllium	0.29–0.69	0.38–0.46	ND – 0.77
Cadmium	ND–0.75	ND–0.37	ND – 0.46
Calcium	ND–2,250	215–1,790	62.7 – 628
Chromium	4.4–11.7	3.8–6.9	3.5 – 11
Cobalt	1.5–4.1	2.8–4.5	ND – 4.6
Copper	5.1–10.8	4.7–8.6	ND – 14.8
Iron	4,560–14,600	6,610–9,440	5,960 – 13,200
Lead	6.9–616	3.7–7.1	3.4 – 55.9
Magnesium	492–1,600	724–1,480	325 – 1,220
Manganese	60.2–250	58.8–135	23.3 –150
Mercury	ND	ND	ND – 0.12
Nickel	2–7.2	3–5.3	ND – 7.5
Potassium	261–688	287–802	ND – 728
Selenium	ND–0.63	ND	ND – 0.77
Silver	ND–0.59	ND	ND – 0.22
Sodium	ND	ND	ND – 161
Thallium	ND–0.28	ND–0.38	ND – 0.96
Vanadium	4.7–14.1	5–9.5	3.3 – 24.6
Zinc	18.2–329	18.4–53.4	10.3 – 172
Cyanide	ND–0.25	ND	ND – 0.60

TABLE 2-4
SITE 06 – SOLVENT DISPOSAL AREA
SUMMARY OF CANCER AND NON-CANCER RISK ESTIMATES
FOR ALL SCENARIOS

Pathway	CANCER RISKS			
	Scenario 1 (Construction Worker)		Scenario 2 (Commercial/Industrial Worker)	
	Geometric Mean	RME	Geometric Mean	RME
Incidental ingestion of soil	2E-07	5E-07	3E-06	5E-06
Dermal contact with soil	NA	NA	NA	NA
Inhalation of particulates	1E-11	2E-11	–	–
Ingestion of ground water	–	–	2E-05	1E-04

= Cancer risk > 1E-6

Pathway	NON-CANCER HAZARD INDICES			
	Scenario 1 (Construction Worker)		Scenario 2 (Commercial/Industrial Worker)	
	Geometric Mean	RME	Geometric Mean	RME
Incidental ingestion of soil	2E-02	4E-02	4E-03	1E-02
Dermal contact with soil	4E-05	4E-05	2E-05	4E-05
Inhalation of particulates	1E-06	2E-06	–	–
Ingestion of ground water	–	–	2E+00	6E+00

= Cancer risk > 1E+0

TABLE 3–1

Site 06 – Solvent Disposal Area
Comparison of Soil Contaminant Levels to Action Levels

Parameter	Maximum Concentration Detected (ppm) Surface Soils (0–2') Phase I RI	Phase II RI	Federal Action Level (ppm)	State Action Level (ppm)
LEAD	43.9	616	500–1,000(1)	300(2)
PCBs	ND	NA	10(3)	10/50(4)

(1) USEPA, OSWER Directive 9355.4–02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites.
(2) RIDEM and RI Dept. of Health–Risk Assessment Guidance Level.
(3) TSCA (40 CFR 761); Requirements for decontaminating spills in nonrestricted areas.
(4) RIDEM Rules and Regulations for Solid Waste Management Facilities defines solid waste as including any soil debris or other material with a concentration of 10 ppm or greater PCBs.
RIDEM Rules and Regulations for Hazardous Waste Management defines Type 6 – extremely hazardous waste as including waste which contains 50 ppm or greater PCBs.

NA – No Phase II soil samples were analyzed for PCBs
ND – No PCBs were detected in in Phase I surface soil samples.

TABLE 3–2

Site 06 – Solvent Disposal Area
Comparison of Detected Ground Water Contaminants to
Applicable or Relevant and Appropriate Requirements (ARARs) or To–be–Considered Requirements (TBCs)

	Maximum Concentration Detected in Ground Water		– FEDERAL ARARs/TBCs –		RHODE ISLAND ------ ARARs/TBCs -----	
Parameter	Phase I (ppb)	Phase II (ppb)	MCL(1) (ppb)	MCLG(2) (ppb)	MCL(3) (ppb)	Ground Water(4) Quality Standards (ppb)
V latiles						
None Detected						
Semivolatiles						
Bis(2–ethylhexyl)phthalate	ND	590	6	0		
Inorganics						
Arsenic	2.1	0.9	50	–	50	50
Beryllium	7.3	ND	4	4		
Chromium	81.6	ND	100	100	100	100
Copper	85.8	4.1	1300*			
Lead	63.2	17.8	15*		15	15
Nickel	67.9	ND	100	100		
Zinc	279	ND				
Barium	171	24.4	2000	2000	2000	2000
Iron	113000	32900				
Manganese	2860	1300				
Vanadium	156	ND				
Aluminum	47900	215				
Cobalt	61.5	7.1				
Magnesium	17700	5590				
Calcium	15300	20600				
Sodium	89600	106000				
Potassium	12400	8230				
Selenium	NA	1.1	50	50	50	
Cyanide	31.5	ND				

1. MCL – Maximum Contaminant Level. National Primary Drinking Water Regulations.
2. MCLG– Maximum Contaminant Level Goal, based on health considerations only.
3. Rhode Island Maximum Contaminant Level. Rules and Regulations Pertaining to Public Drinking Water (R46–13–DWQ) Sections 6.80(c), 16.1, 16.2(a), and 16.2(b).
4. Water Quality Standards, Class GAA and Class GA ground waters, Rhode Island Regulation DEM–GW–01–92, May 1992. Site 06 is located in a Class GB area.

*–Action levels representative of drinking water quality at the tap, U.S. EPA, May 7, 1991.
ND – Not detected
NA – Not analyzed

TABLE 3–3

Summary of Risk–Based Preliminary Remediation Goals – Ground Water
Site 06 – Solvent Disposal Area

Parameter	Ground Water Maximum Detected Concentration (ppm)	Estimated (1) Non–Cancer Based Hazard Index	Risk–Based (2) Preliminary Remediation Goal (ppm)
Manganese	2.7	5.2	0.51

(1) – Risk estimate represents total non–cancer hazard index ratio due to ingestion of ground water under future commercial/industrial use, as presented in the Draft Remedial Investigation Report (TRC, 1993).

(2) – See Appendix B for discussion of risk–based preliminary remediation goal calculations.

TABLE 3-4

Site 06 – Solvent Disposal Area
Comparsion of Soil Contaminant Levels to Calculated Leaching Model Levels

Constituent	Maximum Modeled[1] Unsaturated Concentration (ppm)	Maximum Concentration Detected in Unsaturated Soils (ppm)
Volatile Organics		
Chloroform	90	0.002
Toluene	4958	11
Ethylbenzene	9970	340
Xylenes	101000	1900
1,1,1-Trichloroethane	600	0.001
Semivolatiles		
Chrysene	496	0.60
Benzo(a)pyrene	1920	0.44
Benzo(a)anthracene	410	0.5
Benzo(b)fluoranthene	13575	0.64
Benzo(k)fluoranthene	14000	0.57
Bis(2-ethylhexyl)phthalate	6100	0.19
2-Methylnaphthalene	352600	8.1
Naphthalene	36000	0.63

(1) See Appendix C for model description and associated calculations.

TABLE 3–5

SOIL REMEDIAL TECHNOLOGY SCREENING
SITE 06 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
No Action	None	Not Applicable	No action.	Required for consideration under the NCP.
Institutional Control	Site Use Restrictions	Deed Restrictions	Deed for site would be revised to include restrictions on future site use or development, limiting future exposures to soil contaminants.	Potentially applicable.
		Fencing	Fencing and posting of warning signs to limit public access and exposure to soil contaminants.	While public access to Davisville facility is currently limited, additional fencing could limit future access base closure.

TABLE 3–6

GROUND WATER REMEDIAL TECHNOLOGY SCREENING
SITE 06 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

Screened On Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
No Action	None	Not Applicable	No action.	Fulfills NCP requirement for consideration of no action alternative.
Institutional Control	Ground Water Monitoring	Not Applicable	Continued ground water monitoring.	Would provide monitoring of water quality and potential contaminant migration.
	Ground Water Use Restrictions	Deed Restrictions	Legal restrictions on ground water use in the contaminated area.	Would prevent future exposures to existing ground water contamination by restricting future installation of on–site potable wells.
		Alternate Water Supply	Provision of alternate water supply to receptors impacted by ground water contamination.	No potable water receptors have been impacted.
Extraction/ Treatment/ Discharge	Extraction	Extraction Wells	Wells and pumping system used for extraction of contaminated ground water.	Potentially viable, proven technology; silty soils could limit effectiveness.
		Well Points	Manifold system of extraction points connected to common collection source.	Potentially viable, proven technology; silty soils could limit effectiveness.
		Interceptor Trench	Placement of trench with high permeability materials, used to divert ground water flow.	Potentially viable, proven technology, suitable for shallow ground water extraction only.
	Off–Site Treatment	Off–site POTW	Extracted ground water discharged to local POTW for treatment.	Regulations often prohibit discharge of subsurface water to sewer systems; preliminary evaluation indicates POTW will not be amenable to accepting extracted ground water.
		Off–site RCRA Facility	Extracted ground water discharged to licensed RCRA facility for treatment and/or disposal.	High ground water extraction rates can prohibit feasibility of this treatment option.

TABLE 3–6

GROUND WATER REMEDIAL TECHNOLOGY SCREENING
SITE 06 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

Screened On Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Extraction/ Treatment/ Discharge (Cont.)	Inorganic Treatment	Ion Exchange	Contaminants removed from aqueous phase by exchanging places with ions held by ion exchange material.	Effective for inorganics; ineffective for organics.
		Precipitation	Contaminants removed by decreasing solubility.	Effective for inorganics; ineffective for organics, which generally have solubilities less affected by pH adjustments.
		Membrane Microfiltration	Solid particles removed from liquids using pressure filter.	SITE program technology; applicable to ground water contaminated with suspended heavy metals; would not remove dissolved organics.
		Filtration	Suspended particles are removed from the ground water stream using conventional filtration methods.	Effective for removal of suspended solids contaminated with heavy metals; would not remove dissolved inorganics.
		Electrochemical	Utilizes the oxidation/reduction properties of ferrous ions for removing heavy metals from aqueous solutions.	Proven for treatment of heavy metals; ineffective for organics.
	Discharge	Ground Water	Treated water is recharged to the ground water via wells and/or infiltration galleries.	Potentially viable.
		Surface Water	Treated water is discharged directly or indirectly (via storm sewer) into surface water.	Potentially viable.
		Sanitary Sewer/ POTW	Treated water is discharged indirectly to surface water body via sanitary sewer and POTW.	Regulations may prohibit discharge of ground water to sewer system; preliminary evaluation indicates POTW will not be amenable to accepting treated ground water.

TABLE 3–7

SOIL PROCESS OPTION SCREENING
SITE 06 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

● Representative Process Option

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
No Action	None	Not Applicable	● May be effective if ARARs/TBCs are not exceeded and if the site poses no unacceptable risks.	No implementation is required.	No cost.
Institutional Control	Site Use Restrictions	Deed Restrictions	● Limits disturbance of existing contamination, unacceptable future site use, or introduction of additional contaminated materials.	Requires appropriate legal authority; enforcement may be hampered by base closure.	Low capital cost.
		Fencing	● Limits human exposure to site.	Easily implemented; maintenance may be hampered by base closure.	Low capital cost; low maintenance cost.

TABLE 3-8

GROUND WATER PROCESS OPTION SCREENING
SITE 06 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

● Representative Process Option

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
No Action	None	Not Applicable	● Not effective in prohibiting or monitoring contaminant migration.	No implementation required.	No cost.
Institutional Control	Ground Water Monitoring	Not Applicable	● Would provide means of monitoring contaminant migration but provides no treatment.	Easily implemented.	Low capital; moderate O&M.
	Ground Water Use Restrictions	Deed Restrictions	● Effective in limiting public ingestion of ground water contaminants by eliminating installation of potable wells in contaminated areas.	Requires legal authority.	Moderate capital.
Extraction/ Treatment/ Discharge	Extraction	Extraction Wells	Effective; best suited for steep hydraulic gradients and miscible contaminants.	Easily implemented.	Moderate capital; moderate O&M.
		Interceptor Trench	● Effective; best suited to shallow aquifers or floating contaminants; applicable to Site 06 due to shallow depth to bedrock.	Easily implemented; mechanically simple.	Moderate capital; moderate O&M.
	Inorganic Treatment	Ion Exchange	● Effective for inorganic removal; requires selection of resin suitable for contaminants of concern.	Fairly easily implemented;; operation is relatively simple.	Moderate capital; moderate O&M.
		Precipitation	● Effective for removal of dissolved inorganics; precipitate must be disposed of.	Readily implemented.	Low to moderate capital; moderate O&M.
		Electrochemical	Effective in producing metal hydroxide precipitates of such inorganic species as arsenic, cadmium, zinc and copper.	Newly developing technology; may not be widely available; more complicated than other inorganic treatment systems.	Moderate capital, moderate O&M.
	Discharge	Ground Water	Effective with permeable soils and relatively low flow rates; presence of contaminants in upgradient well complicates selection of injection location.	Requires construction of a recharge system; requires compliance with discharge criteria.	Moderate capital; low to moderate O&M.
		Surface Water	● Effective for discharge of treated ground water.	Requires installation of a discharge pipe; requires compliance with discharge criteria.	Moderate capital; low O&M.

TABLE 3–9

TECHNOLOGIES WHICH PASSED SCREENING
SOIL/GROUND WATER
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

Soil	Ground Water
No Action • No Action	No Action • No Action
Institutional Control • Deed Restrictions • Fencing	Institutional Control • Ground Water Monitoring • Deed Restrictions
	Extraction/Treatment/Discharge Extraction Wells • Interceptor Trench • Ion Exchange • Precipitation Electrochemical Discharge to Ground Water • Discharge to Surface Water Sanitary Sewer/POTW Discharge

– Process Technology Used to Formulate Remedial Alternatives

TABLE 3–10

ALTERNATIVES UNDERGOING DETAILED ANALYSIS
SOIL/GROUND WATER
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

Soil	Ground Water
Alternative S–1	Alternative GW–1
No Action	No Action
Alternative S–2	Alternative GW–2
Limited Action (Institutional Controls)	Limited Action (Institutional Controls)
A. Fencing/Deed Restrictions	A. Deed Restrictions/Ground Water Monitoring
	Alternative GW–3
	Extraction/Treatment/Discharge
	A. Interceptor Trench B. Precipitation C. Ion Exchange D. Discharge to Surface Water

TABLE 4-1
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-1 - NO ACTION
ALTERNATIVE S-2 - LIMITED ACTION
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Soils/Surfaces--				
	Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02)	To Be Considered	Sets forth an interim soil cleanup level for lead at 500 to 1000 ppm.	Will be considered at Site 06 with repect to soil lead contamination.
STATE				
Soils/Surfaces--				
	Lead Soil Cleanup Standards (Guidance)	To Be Considered	RIDEM and the Rhode Island Department of Health-Risk Assessment consider a safe lead level in soil (total) to be under 300 ppm.	To be considered with respect to lead soil contamination.

TABLE 4–2
COMPARISON AMONG SOIL ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	Least protective alternative; Provides protection of human health under the proposed future commercial/industrial site use scenario; However, no control of potential residential exposures to soil contamination is provided; Does not comply with state chemical–specific TBC for lead; Effective in the short–term and the long–term provided residential exposures do not occur; Does not meet remedial action objectives
Alternative S–2 – Limited Action	Provides protection of human health by limiting potential exposures to soil contaminants through site fencing and/or deed restrictions; Protective against future residential site use; Does not comply with state chemical–specific TBC for lead; Effective in the short–term and in the long–term; Meets remedial action objectives

TABLE 4-3
COMPARISON AMONG SOIL ALTERNATIVES
COMPLIANCE WITH ARARs/TBCs
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative S-1 – No Action	Does not meet state chemical-specific TBC for lead, but falls within the acceptable federal range for lead	Not applicable	Not applicable
Alternative S-2 – Limited Action	Does not meet state chemical-specific TBC for lead, but falls within the acceptable federal range for lead	Not applicable	Not applicable

TABLE 4–4
COMPARISON AMONG SOIL ALTERNATIVES
LONG–TERM EFFECTIVENESS AND PERMANENCE
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	Protective in long–term under proposed future commercial/industrial site use based on lack of identified unacceptable risks; No controls provided to prevent future residential exposures to soil contaminants; Requires five–year reviews
Alternative S–2 – Limited Action	Protective in long–term under proposed future commercial/industrial site use based on lack of identified unacceptable risks; Utilizes institutional controls to limit future residential exposures to the site; Fencing requires long–term maintenance; Deed restrictions on development would require long–term enforcement to ensure their protectiveness; Requires five–year reviews

TABLE 4-5
COMPARISON AMONG SOIL ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-1 – No Action	Provides no reduction of toxicity, mobility or volume through treatment
Alternativ S-2 – Limited Action	Provides no treatment of soil contamination and therefore no associated reduction of contaminant toxicity, mobility, or volume; Site access and deed restrictions would limit the potential contaminant exposure pathways associated with future residential site use

TABLE 4–6
COMPARISON AMONG SOIL ALTERNATIVES
SHORT–TERM EFFECTIVENESS
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	No remedial activities conducted; Therefore, no short–term risks result; Remedial response objectives not achieved
Alternative S–2 – Limited Action	Minimal short–term risks associated with fence construction; No increased off–site risks would result from the implementation activities; Short implementation time frame; Remedial response objectives would be achieved

TABLE 4–7
COMPARISON AMONG SOIL ALTERNATIVES
IMPLEMENTABILITY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	Requires no implementation other than five–year reviews; Would not limit the implementation of other remedial actions
Alternative S–2 – Limited Action	Fencing construction easily implemented; Deed restrictions would have to be incorporated in the base closure property transfer process; The presence of fencing could be incompatible with the future economic/industrial development of the site; Would not limit the implementation of other remedial actions

TABLE 4–8
COMPARISON AMONG SOIL ALTERNATIVES
COST
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST [1]	TOTAL PRESENT WORTH [2]
Alternative S–1 – No Action	––	––	––	Nominal [3]
Alt mative S–2 – Limited Action	$10,800	$300	$4,600	$18,500

[1] – Based on 5% discount rate.
[2] – Includes 20% contingency on all components.
[3] – The only cost associated with the implementation of Alternative S–1 would be that associated with conducting five–year reviews of the no action decision.

TABLE 4-9
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-1 - NO ACTION
ALTERNATIVE GW-2 - LIMITED ACTION
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.
STATE				
Ground Water--				
	RI Ground Water Protection Act (RIGL, 46-13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.

TABLE 4–10
FEDERAL AND STATE ACTION–SPECIFIC ARARs AND TBCs
ALTERNATIVE GW–2 – LIMITED ACTION
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE Monitoring	Rules and Regulations for Ground Water Quality	Applicable	Rules and regulations intended to protect and restore the quality of the State's ground water. Includes ground water program monitoring requirements and monitoring well construction and abandonment.	Ground water monitoring programs and well construction/abandonment methodologies will comply with these regulations.

TABLE 4-11
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.
Surface Water --				
	Clean Water Act (40 CFR 121) Ambient Water Quality Criteria (AWQC)	Applicable	Non-enforceable guidelines established for the protection of human health and/or aquatic organisms.	AWQC will be applicable to remedial alternatives which involve discharges to surface water.
	Clean Water Act (40 CFR 401.15) Effluent Discharge Limitations	Applicable	Regulates the discharge of contaminants from an industrial point source.	Regulations will be applicable to remedial alternatives which involve discharges to surface water.

TABLE 4-11(continued)
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
STATE				
Ground Water--				
	RI Ground Water Protection Act (RIGL, 46-13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.
Surface Water --				
	RI Water Pollution Control Law (RIGL 46-12 et seq.) RI Water Quality Standards	Applicable	Establishes water use classification and water quality criteria for all waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	Regulation will be applicable for remedial alternatives which involve discharges to surface water.

TABLE 4-12
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 06 - SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL				
Discharge	Clean Water Act (40 CFR 122-125) National Pollutant Discharge Elimination System (NPDES) Permit Requirements	Applicable	Permits contain applicable effluent standards (i.e., technology-based and/or water quality-based), monitoring requirements, and standards and special conditions for discharge.	Discharges of treated water to surface waters will meet these requirements.
On-site/ Off-site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off-Site Disposal	Applicable	Standards for manifesting, marking and recording off-site hazardous waste shipments for treatment/disposal.	If treatment system by-product requires off-site disposal/treatment as a hazardous waste, generator requirements will be followed.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	Applicable	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	Remedial actions which require storage of hazardous waste in containers will comply with these requirements.
	RCRA (40 CFR 263) Transporter Requirements for Off-Site Disposal	Applicable	Standards for transporters of hazardous waste materials.	If treatment system by-product requires off-site disposal/treatment as a hazardous waste, transporter requirements will be followed.
	RCRA (40 CFR 268) Land Disposal Restrictions	Applicable	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	If treatment system by-product requires off-site disposal as a hazardous waste, land disposal restrictions will be followed.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	Applicable	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	If treatment system by-product is determined to be hazardous, transport procedures will be followed.

TABLE 4–12(continued)
FEDERAL AND STATE ACTION–SPECIFIC ARARs AND TBCs
ALTERNATIVE GW–3 – EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW–3A THROUGH GW–3D
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE				
Discharge	RI Water Pollution Control Act			
	• RI Water Quality Regulations for Water Pollution Control (RIGL 46–12 et seq.) RI Water Quality Standards	Applicable	Establishes general requirements and effluent limits for discharge to area waters.	Discharges of treated water to area surface water will meet these requirements.
	• Regulations for the RI Pollutant Discharge Elimination Systems (RIGL 46–12 et seq.)	Applicable	Permits contain applicable effluent standards (i.e., technology–based and/or water quality–based), monitoring requirements, and standards and special conditions for discharge.	Discharges of treated water to area surface water will meet these requirements.
On–site/ Off–site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23–19.1 et seq.) • Hazardous Waste Management Rules and Regulations	Applicable	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal.	If treatment system by–product is determined to be hazardous, these rules will be followed.
	• Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	Applicable	Rules and regulations for the investigation and remediation of releases of hazardous materials.	Remedial systems will be designed and operated in accordance with these requirements.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right–to–Know Requirements	Applicable	Establishes rules for the public's right–to–know concerning hazardous waste storage and transportation.	These rules will be followed if treatment system by–product requires management as a hazardous waste.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	Applicable	Rules and regulations for solid waste management facilities.	These rules will be followed if treatment system by–product requires management as a solid waste.

TABLE 4-13
COMPARISON AMONG GROUND WATER ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW-1 – No Action	Least protective alternative; Does not limit future potable use of ground water and does not monitor ground water quality; Does not present any short-term impacts; Does not meet remedial response objectives
Alternative GW-2 – Limited Action	Provides protection of human health by limiting potential future exposures to inorganics in ground water through the institution of deed restrictions limiting potable ground water use; Does not provide compliance with drinking water standards through treatment; however, would prevent the development of a ground water ingestion exposure pathway; Uses institutional controls to meet remedial action objectives
Alternative GW-3 – Extraction/Treatment/ Discharge	Provides a reduction in potential future risks to human health associated with ground water ingestion through active treatment; Would comply with chemical-specific and action-specific ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term as long as the treatment system is operational
Option GW-3A – Ground Water Extraction via Interceptor Trench	Provides protection of the environment and human health by limiting potential ground water migration and by removing ground water for treatment; Would comply with applicable ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term
Option GW-3B – Precipitation Inorganic Treatment	Provides protection of the environment and human health through treatment of inorganic contaminants in ground water; Would comply with applicable ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term
Option GW-3C – Ion Exchange Inorganic Treatment	Provides protection of the environment and human health through treatment of inorganic contaminants in ground water; Would comply with applicable ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term
Option GW-3D – Discharge to Surface Water	Provides protection of the environment and human health when combined with ground water extraction and treatment; Would comply with applicable ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term

TABLE 4-14
COMPARISON AMONG GROUND WATER ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative GW-1 – No Action	Does not meet criteria	Not applicable	Not applicable
Alternative GW-2 – Limited Action	Does not meet criteria	Not applicable	Monitoring would comply with RIDEM's Rules and Regulations for Ground Water Quality
Alternative GW-3 – Extraction/Treatment/ Discharge	Treatment would meet criteria	Not applicable	Extraction/Treatment/Discharge systems would comply with action-specific criteria
Option GW-3A – Ground Water Extraction via Interceptor Trench	Meets criteria by capturing contaminants that exceed MCLs and PRGs	Not applicable	Would be implemented in compliance with RIDEM Remediation Regulations
Option GW-3B – Precipitation Inorganic Treatment	Meets criteria by treating inorganic contaminants that exceed MCLs and PRGs	Not applicable	Treatment system operation would comply with applicable criteria; Off-site disposal of sludge would require hazardous waste characterization and compliance with either hazardous or non-hazardous waste management regulations
Option GW-3C – Ion Exchange Inorganic Treatment	Meets criteria by treating inorganic contaminants that exceed MCLs and PRGs	Not applicable	Treatment system operation would comply with applicable criteria; Off-site disposal of backwash from the treatment system would require hazardous waste characterization and compliance with either hazardous or non-hazardous waste management regulations
Option GW-3D – Discharge to Surface Water	Water quality of the treatment process effluent would be required to meet ambient water quality criteria	Not applicable	Would comply with criteria applicable to surface water discharge

TABLE 4–15
COMPARISON AMONG GROUND WATER ALTERNATIVES
LONG–TERM EFFECTIVENESS AND PERMANENCE
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW–1 – No Action	Effective in the long–term provided ground water is not used as a drinking water supply; Provides no long–term monitoring of ground water quality; Requires five–year reviews
Alternative GW–2 – Limited Action	Effective in minimizing the long–term risks associated with the potential construction and use of an on–site well as a source of drinking water; Monitoring program provides a means of monitoring potential changes in ground water quality; Requires 5–year reviews
Alternative GW–3 – Extraction/Treatment/ Discharge	Treatment effective in treating contaminants which exceed ARARs or risk–based PRGs and in preventing off–site migration of contaminants during operation; Permanent contaminant reduction would not necessarily result if ground water treatment is discontinued in the future; Requires long–term maintenance
Option GW–3A – Ground Water Extraction via Interceptor Trench	Provides an effective and reliable means of extracting ground water; Well–proven in performance and can function with minimal maintenance
Option GW–3B – Precipitation Inorganic Treatment	Effective in the removal of inorganics from the wastestream; long–term risks associated with the residuals of ground water treatment would be relatively small; Sludge produced will require hazardous waste characterization and appropriate disposal; Long–term operation and maintenance of the treatment system is expected to pose no significant difficulties
Option GW–3C – Ion Exchange Inorganic Treatment	Effective in the removal of most organics from the wastestream; long–term risks associated with the residuals of ground water treatment would be relatively small; Residual backwash produced will require hazardous waste characterization and appropriate disposal; Long–term operation and maintenance of the treatment system is expected to pose no significant difficulties
Option GW–3D – Discharge to Surface Water	Long–term risks associated with discharge to surface water will be minimal, provided treatment system is operating properly; Long–term operation and maintenance of discharge piping is not expected to pose any major technical problems; Requires long–term monitoring of the quality of discharged water

TABLE 4–16
COMPARISON AMONG GROUND WATER ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW–1 – No Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternative GW–2 – Limited Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternative GW–3 – Extraction/Treatment/ Discharge	Provides a reduction in toxicity, mobility and volume through treatment
Option GW–3A – Ground Water Extraction via Interceptor Trench	Ground water extraction does not provide treatment but would be combined with a treatment option; Reduces the potential mobility of contaminated ground water
Option GW–3B – Precipitation Inorganic Treatment	Provides a reduction in the toxicity of identified inorganic contaminants through treatment; Volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated sludge residual
Option GW–3C – Ion Exchange Inorganic Treatment	Provides a reduction in the toxicity of identified inorganic contaminants through treatment; Volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated residual backwash
Option GW–3D – Discharge to Surface Water	Not expected to significantly affect the extraction or treatment system; therefore, it has little impact on the toxicity, mobility, or volume of contamination

TABLE 4-17
COMPARISON AMONG GROUND WATER ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW-1 – No Action	No remedial activities conducted; Therefore, no short-term risks result; Five-year reviews would provide the only means of ensuring compliance with remedial action objectives
Alternative GW-2 – Limited Action	Implementation of deed restrictions would result in no short-term risks; Implementation of the monitoring program would have minimal short-term adverse impacts based on the use of existing wells for ground water monitoring purposes; Would meet remedial response objectives related to minimizing potential human exposures to contaminated ground water by preventing on-site potable well installation
Alternative GW-3 – Extraction/Treatment/ Discharge	No significant risks to on-site workers or off-site risks are anticipated; Degree of short-term risk would be dependent upon the individual options employed; Remedial response objectives would be achieved during operation of the treatment system but may not be maintained if treatment is discontinued
Option GW-3A – Ground Water Extraction via Interceptor Trench	Presents minimal short-term risks to on-site workers and would not be expected to result in any increased off-site risks to human health or the environment; Easily implemented within a minimal time frame
Option GW-3B – Precipitation Inorganic Treatment	No significant short-term risks to workers are expected; Major operation and maintenance activities associated with chemical precipitation include maintenance of chemical supplies and sludge handling; No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation
Option GW-3C – Ion Exchange Inorganic Treatment	No significant short-term risks to workers are expected; Major operation and maintenance activities associated with ion exchange include maintenance of chemical supplies and backwash handling; No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation
Option GW-3D – Discharge to Surface Water	Short-term risks to workers associated with the construction of discharge piping would not be significant; Maintenance of the system will require maintenance of the piping and discharge monitoring; No added risks to the adjacent community or the environment are anticipated

TABLE 4–18
COMPARISON AMONG GROUND WATER ALTERNATIVES
IMPLEMENTABILITY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW–1 – No Action	Requires no implementation other than five–year reviews; Would not limit the implementation of other remedial actions
Alternative GW–2 – Limited Action	Deed restrictions would have to be implemented as part of the base closure property transfer process; Deed restrictions limiting future installation of on–site potable wells would not be expected to prevent future commercial/industrial use of the site; Implementation of deed restrictions or ground water monitoring would not limit the implementation of future remedial actions
Alternative GW–3 – Extraction/Treatment/ Discharge	Relatively easy to implement; Technical implementability would be dependent upon the individual alternative options selected; Some treatment technologies are more easily implemented than others; Services and materials should be readily available for the implementation of all options
Option GW–3A – Ground Water Extraction via Interceptor Trench	Implementation of a ground water extraction system is expected to be good; Materials and services are readily available; Minimal technical or administrative obstacles to implementation would be anticipated
Option GW–3B – Precipitation Inorganic Treatment	Easily implemented; Startup is not expected to result in unanticipated technical problems; Implementation is not expected to impact the implementation of any future remedial actions; Operational activities include maintenance of chemical suplies and sludge handling; Administrative feasibility is also expected to be good
Option GW–3C – Ion Exchange Inorganic Treatment	Implementation of an ion exchange treatment system is expected to be good; Treatment units are widely available and easily constructed; Implementation of an ion exchange system will not impact the implementation of future remedial actions; Operational activities include regeneration of the resin material and handling of residual backwash; Administrative feasilbility is also expected to be good
Option GW–3D – Discharge to Surface Water	Technical implementation of a discharge to surface water system is good; Continued monitoring of the discharged water quality will be required; Administrative feasibility of discharging treated ground water to surface water depends on the treatment system's ability to meet surface water discharge criteria

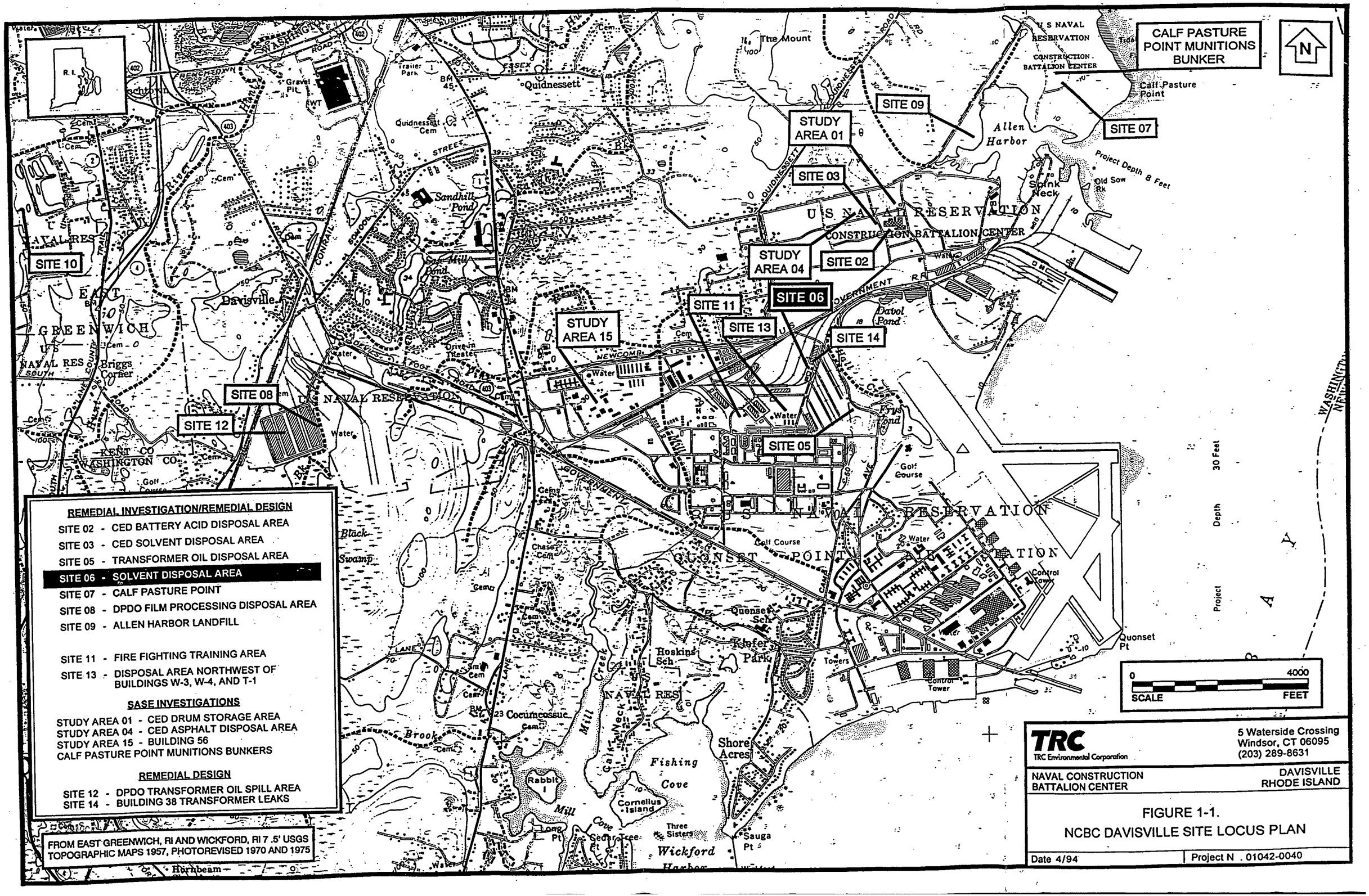
TABLE 4–19
COMPARISON AMONG GROUND WATER ALTERNATIVES
COST
SITE 06 – SOLVENT DISPOSAL AREA
NCBC – DAVISVILLE, RI

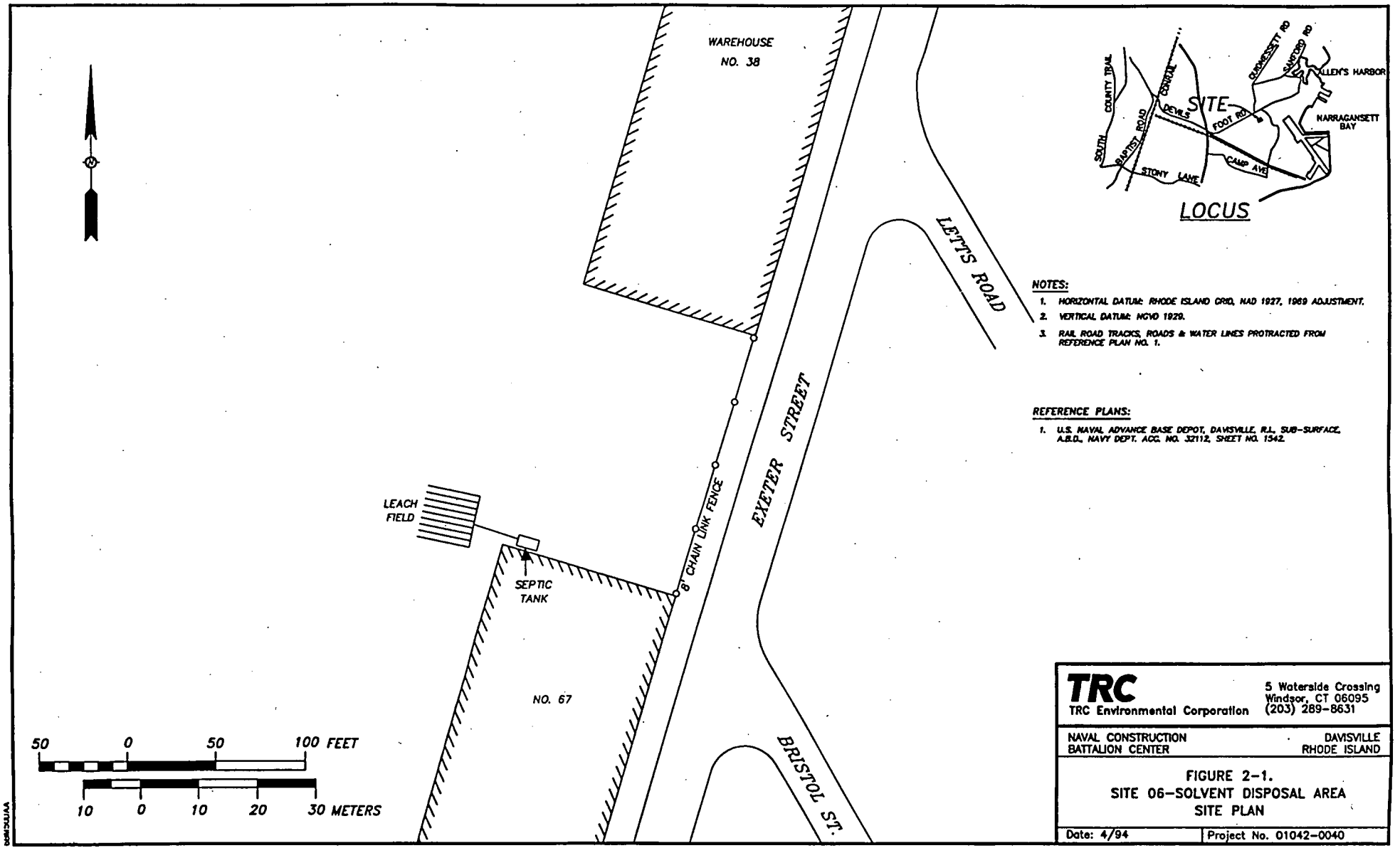
ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST (1)	TOTAL PRESENT WORTH (2)
Alt rnative GW–1 – No Action	--	--	--	Nominal (3)
Alt rnative GW–2 – Limited Action	--	$7,700	$120,000	$140,000
Alt rnative GW–3 – Extraction/Treatment/ Discharge	--	--	--	--
Option GW–3A – Ground Water Extraction via Interceptor Trench	$27,000	$4,800	$36,000	$76,000
Option GW–3B – Precipitation Inorganic Treatment	$150,000	$54,000	$420,000	$680,000
Option GW–3C – Ion Exchange Inorganic Treatment	$230,000	$13,000	$100,000	$400,000
Option GW–3D – Discharge to Surface Water	$8,000	$7,400	$57,000	$79,000

(1) – Based on 5% discount rate
(2) – Includes 20% contingency on all components
(3) – The only cost associated with the implementation of Alternative GW–1 would be that associated with conducting five–year reviews of the no action decision. Deed restrictions would be implemented under the base closure property transfer process.

TABLE 4-20
COST SENSITIVITY ANALYSIS
SITE 06 - SOLVENT DISPOSAL AREA

Item Varied (Minimum - Maximum)	Alternative	Minimum Cost	Maximum Cost
Discount Factor (3% - 10%)	Soil	**10%**	**3%**
	S-2	$16,000	$20,000
	Ground Water		
	GW-2	$87,000	$180,000
	GW-3A	$68,000	$82,000
	GW-3B	$581,000	$735,000
	GW-3C	$372,000	$410,000
	GW-3D	$64,000	$86,000
Remediation Period (5 yrs - 15 yrs)	Ground Water	**5 yrs**	**15 yrs**
	GW-3A	$58,000	$93,000
	GW-3B	$464,000	$855,000
	GW-3C	$343,000	$440,000
	GW-3D	$48,000	$102,000


CALF PASTURE POINT MUNITIONS BUNKER
N
SITE 09
SITE 07
STUDY AREA 01
SITE 03
STUDY AREA 04
SITE 02
SITE 06
SITE 11
SITE 13
SITE 14
STUDY AREA 15
SITE 10
SITE 08
SITE 12
SITE 05
U.S. NAVAL RESERVATION
CONSTRUCTION BATTALION CENTER
Allen Harbor
Calf Pasture Point
Project Depth 8 Feet
Davisville
Quidnessett
Quonset Point
Fishing Cove
Wickford Harbor
Shore Acres
Hoskins Sch
Quonset Sch
Kiefer Park
Cornelius Island
Rabbit I
Cocumcossuc
Mill Cove
Black Swamp
Sandhill Pond
Davol Pond
Golf Course
Control Tower
Quonset Pt
Sauga Pt
Three Sisters
Hornbeam
Cedar Tree
Gaspee Neck
Mill Creek
Spink Neck
Old Sow Rk
The Mount
Gravel Pit
Trailer Park
Drive-in Theater
Briggs Corner
EAST GREENWICH
KENT CO
WASHINGTON CO
R.I.
SCALE 0 4000 FEET
30 Feet Project Depth
REMEDIAL INVESTIGATION/REMEDIAL DESIGN
SITE 02 - CED BATTERY ACID DISPOSAL AREA
SITE 03 - CED SOLVENT DISPOSAL AREA
SITE 05 - TRANSFORMER OIL DISPOSAL AREA
SITE 06 - SOLVENT DISPOSAL AREA
SITE 07 - CALF PASTURE POINT
SITE 08 - DPDO FILM PROCESSING DISPOSAL AREA
SITE 09 - ALLEN HARBOR LANDFILL
SITE 11 - FIRE FIGHTING TRAINING AREA
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1
SASE INVESTIGATIONS
STUDY AREA 01 - CED DRUM STORAGE AREA
STUDY AREA 04 - CED ASPHALT DISPOSAL AREA
STUDY AREA 15 - BUILDING 56
CALF PASTURE POINT MUNITIONS BUNKERS
REMEDIAL DESIGN
SITE 12 - DPDO TRANSFORMER OIL SPILL AREA
SITE 14 - BUILDING 38 TRANSFORMER LEAKS
FROM EAST GREENWICH, RI AND WICKFORD, RI 7.5' USGS TOPOGRAPHIC MAPS 1957, PHOTOREVISED 1970 AND 1975
TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631
NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 1-1.
NCBC DAVISVILLE SITE LOCUS PLAN
Date 4/94
Project N . 01042-0040


WAREHOUSE
NO. 38
LETTS ROAD
EXETER STREET
BRISTOL ST.
8' CHAIN LINK FENCE
LEACH FIELD
SEPTIC TANK
NO. 67
50 0 50 100 FEET
10 0 10 20 30 METERS
SITE
LOCUS
SOUTH COUNTY TRAIL
BAPTIST ROAD
CONCAL
DEVILS FOOT RD
STONY LANE
CAMP AVE
CLIMOESSETT RD
SANFORD RD
ALLEN'S HARBOR
NARRAGANSETT BAY
NOTES:
1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. RAIL ROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
REFERENCE PLANS:
1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE, A.B.D., NAVY DEPT. ACC. NO. 32112, SHEET NO. 1542.
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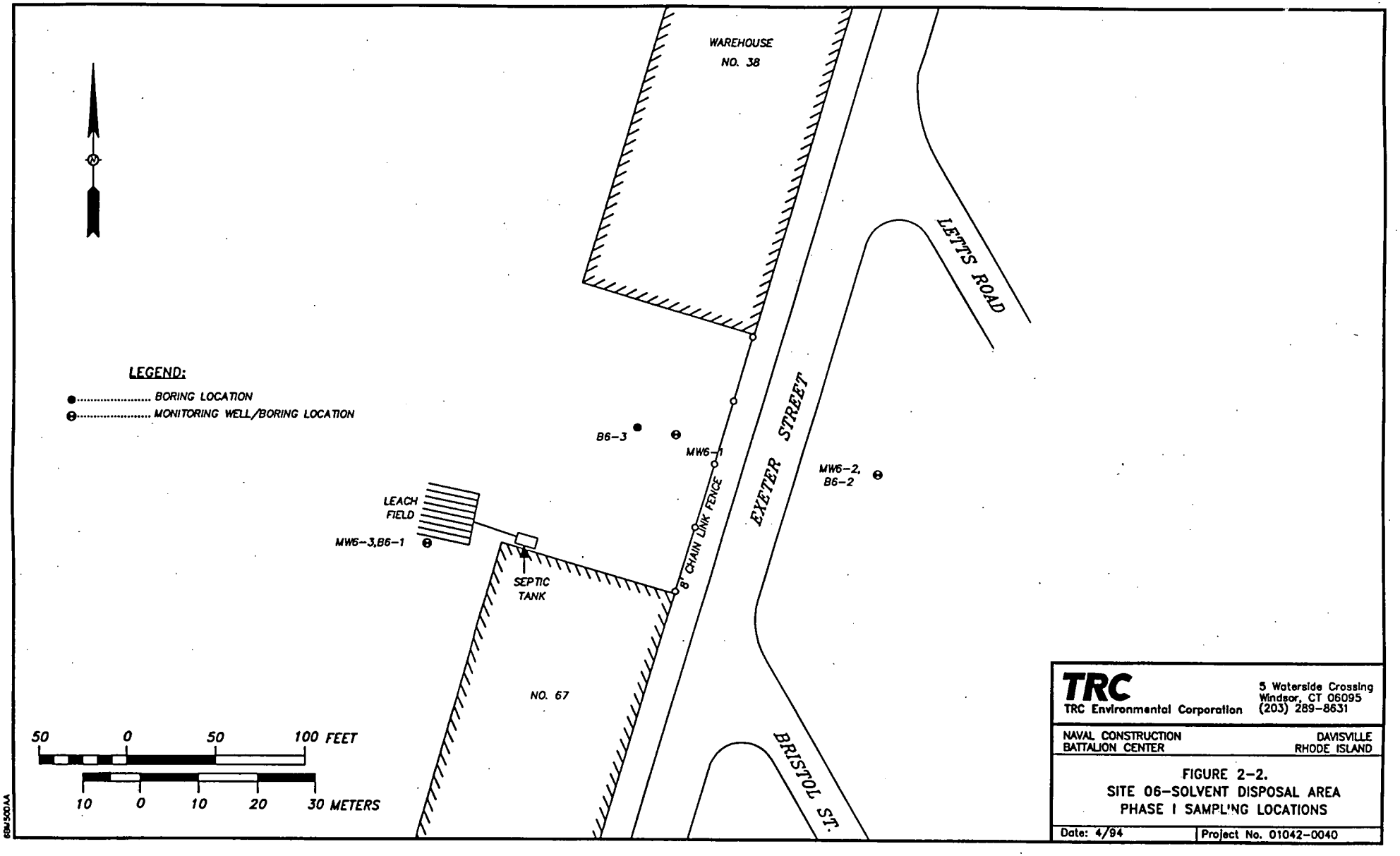
NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 2-1.
SITE 06-SOLVENT DISPOSAL AREA
SITE PLAN
Date: 4/94
Project No. 01042-0040


WAREHOUSE
NO. 38
LETTS ROAD
EXETER STREET
LEGEND:
BORING LOCATION
MONITORING WELL/BORING LOCATION
B6-3
MW6-1
MW6-2,
B6-2
LEACH
FIELD
MW6-3,B6-1
SEPTIC
TANK
8' CHAIN LINK FENCE
NO. 67
BRISTOL ST.
50 0 50 100 FEET
10 0 10 20 30 METERS
TRC
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Windsor, CT 06095
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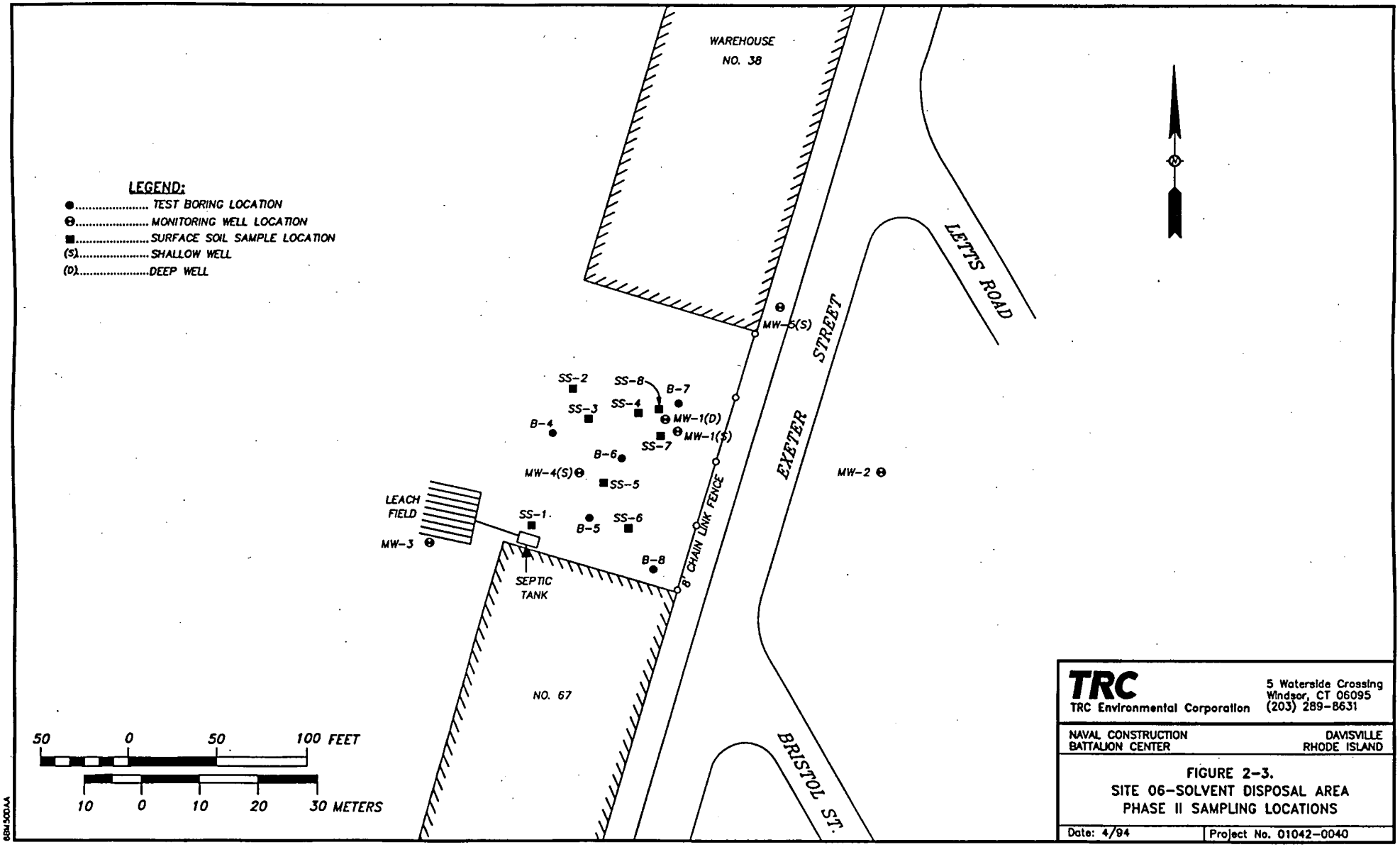
NAVAL CONSTRUCTION
BATTALION CENTER
DAVISVILLE
RHODE ISLAND
FIGURE 2-2.
SITE 06-SOLVENT DISPOSAL AREA
PHASE I SAMPLING LOCATIONS
Date: 4/94
Project No. 01042-0040


LEGEND:
TEST BORING LOCATION
MONITORING WELL LOCATION
SURFACE SOIL SAMPLE LOCATION
(S) SHALLOW WELL
(D) DEEP WELL
WAREHOUSE NO. 38
NO. 67
LETTS ROAD
EXETER STREET
BRISTOL ST.
MW-5(S)
SS-2
SS-8
B-7
SS-3
SS-4
MW-1(D)
MW-1(S)
B-4
SS-7
B-6
MW-4(S)
SS-5
MW-2
LEACH FIELD
SS-1
B-5
SS-6
MW-3
B-8
SEPTIC TANK
8' CHAIN LINK FENCE
50 0 50 100 FEET
10 0 10 20 30 METERS
TRC
TRC Environmental Corporation
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Windsor, CT 06095
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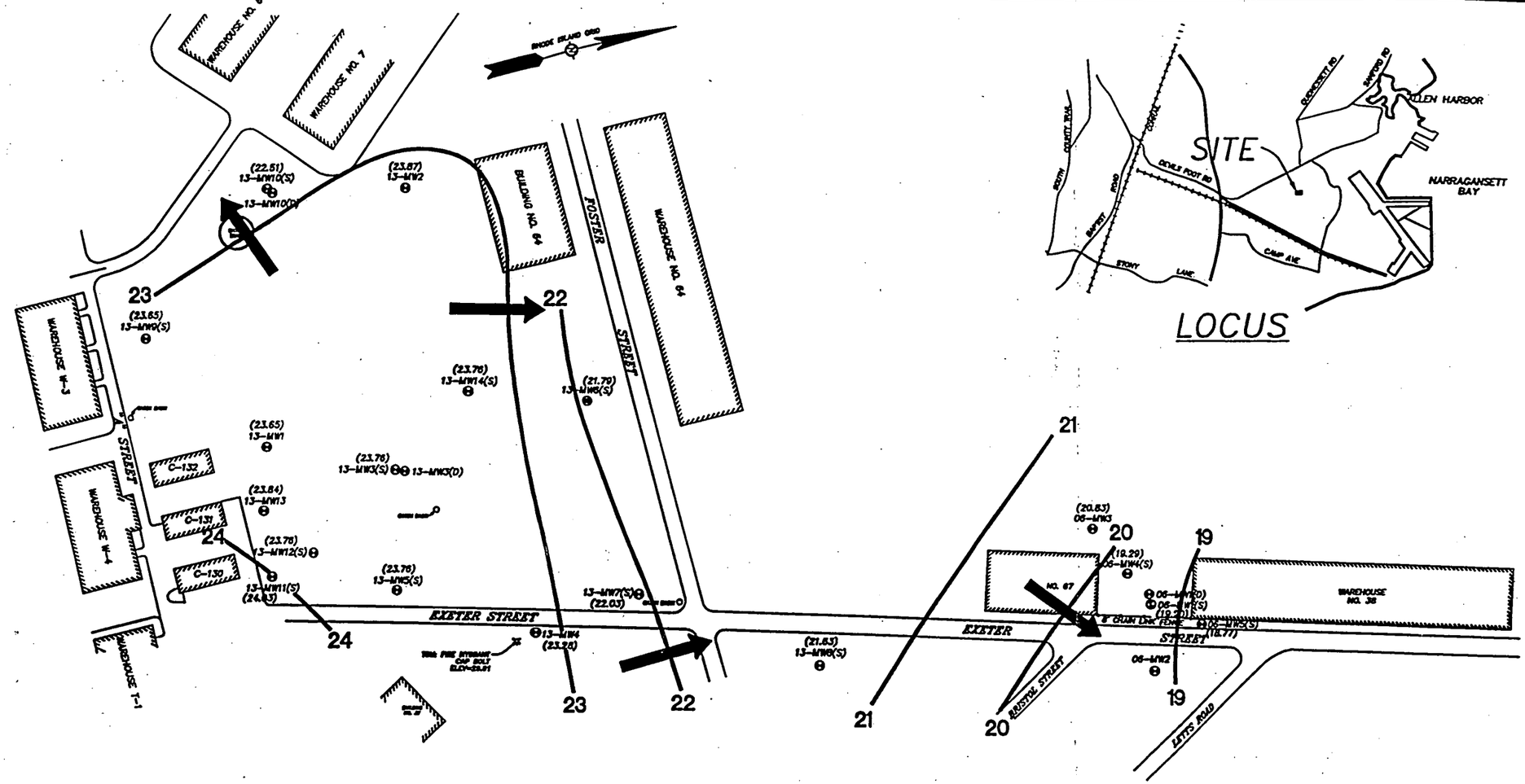
DAVISVILLE RHODE ISLAND
FIGURE 2-3.
SITE 06-SOLVENT DISPOSAL AREA
PHASE II SAMPLING LOCATIONS
Date: 4/94
Project No. 01042-0040



LEGEND:

- MONITORING WELL LOCATION
- (23.65) GROUND WATER ELEVATION (MSL)
- (S) SHALLOW WELL
- (D) DEEP WELL
- 23 GROUND WATER CONTOUR (MSL)
- GROUND WATER FLOW DIRECTION

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

60 0 60 120 180 240 FEET
20 0 20 40 60 METERS

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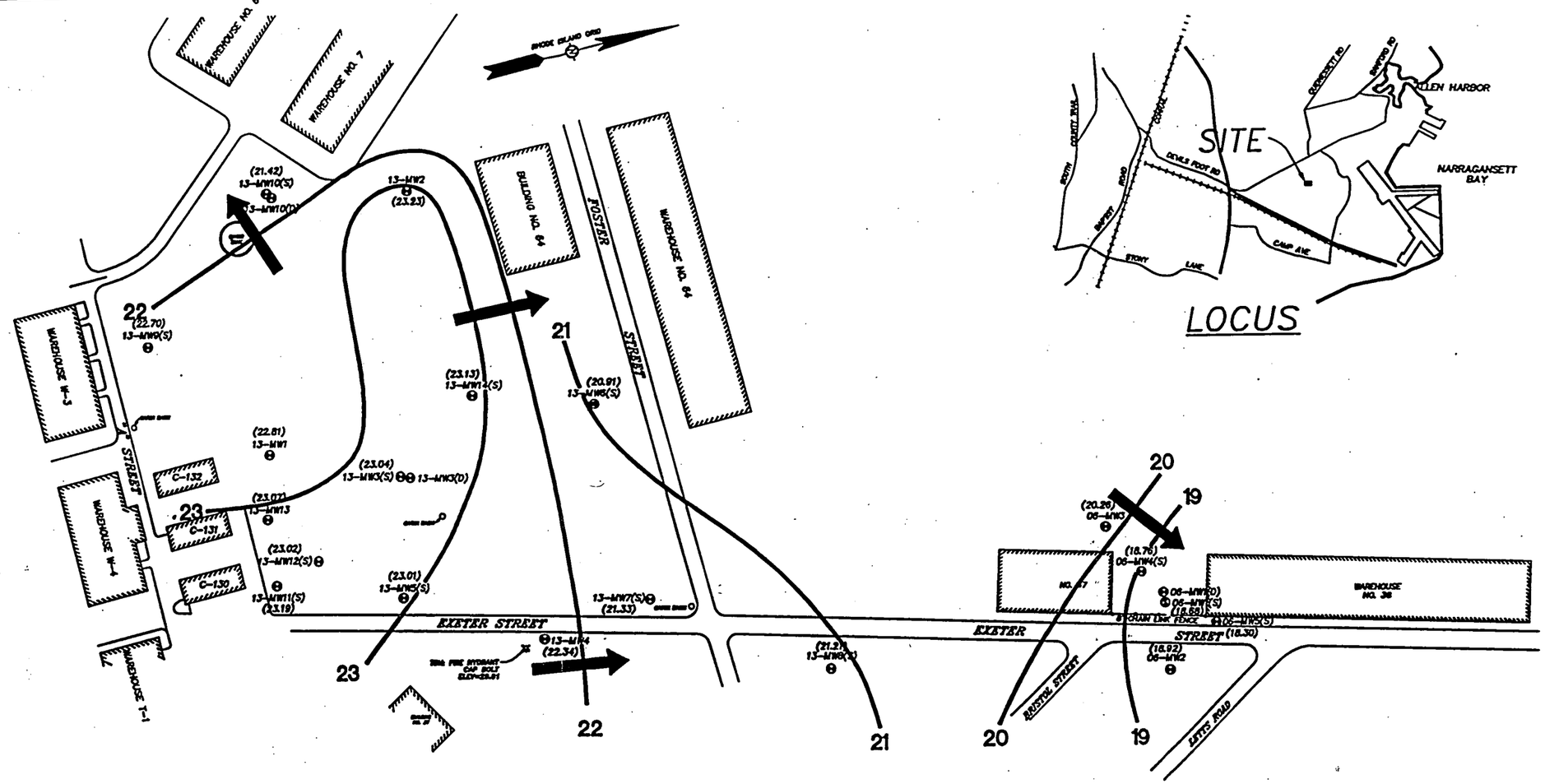
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 2-4.
SITE 06-SOLVENT DISPOSAL AREA
SITE 13-DISPOSAL AREA NORTHWEST
SHALLOW GROUND WATER LEVEL CONTOUR MAP
AUGUST 13, 1993

Date: 4/94 | Project No. 01042-0040



LEGEND:

- MONITORING WELL LOCATION
- (22.70) GROUND WATER ELEVATION (MSL)
- (S) SHALLOW WELL
- (D) DEEP WELL
- 22 GROUND WATER CONTOUR (MSL)
- GROUND WATER FLOW DIRECTION

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

60 0 60 120 180 240 FEET
20 0 20 40 60 METERS

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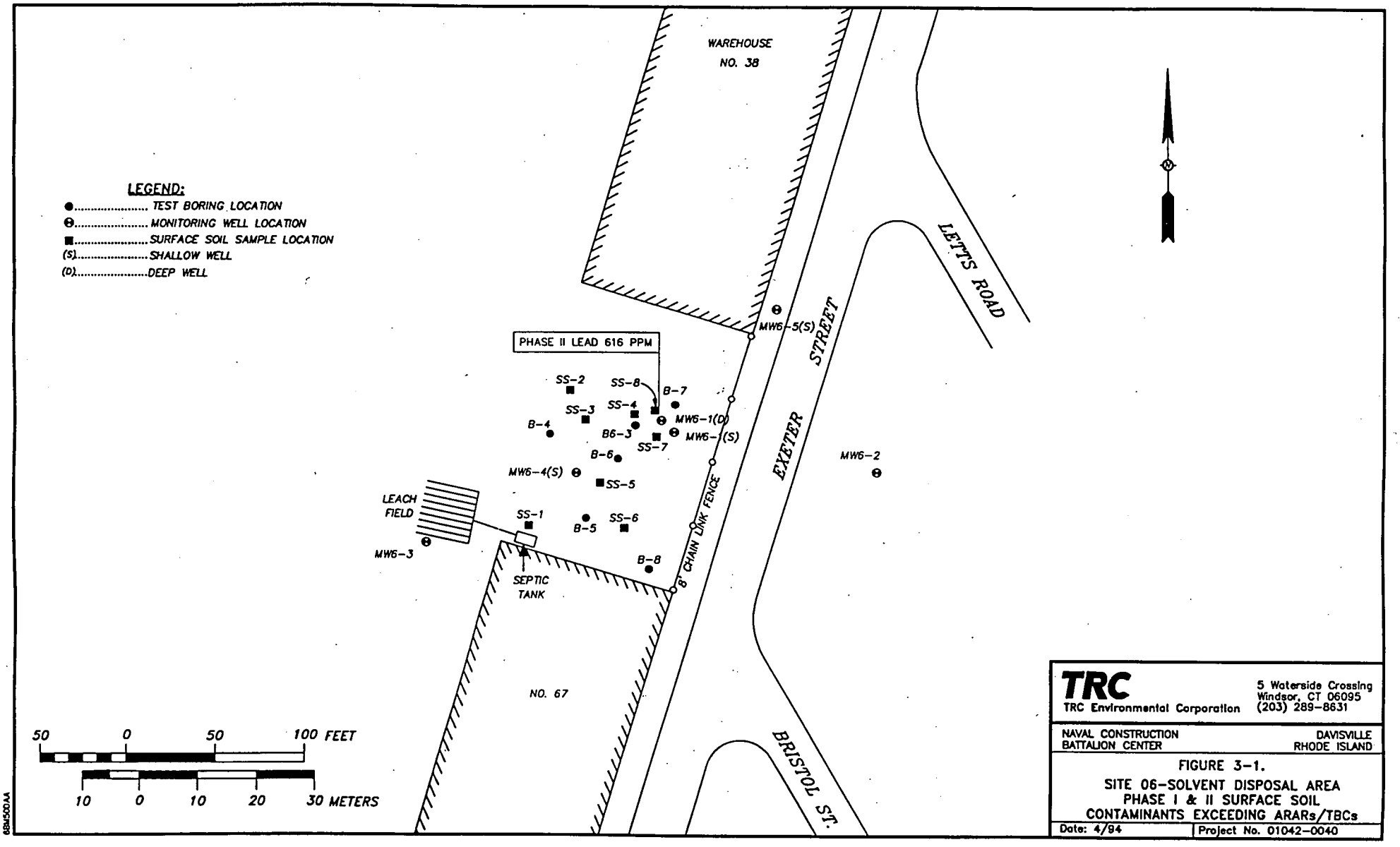
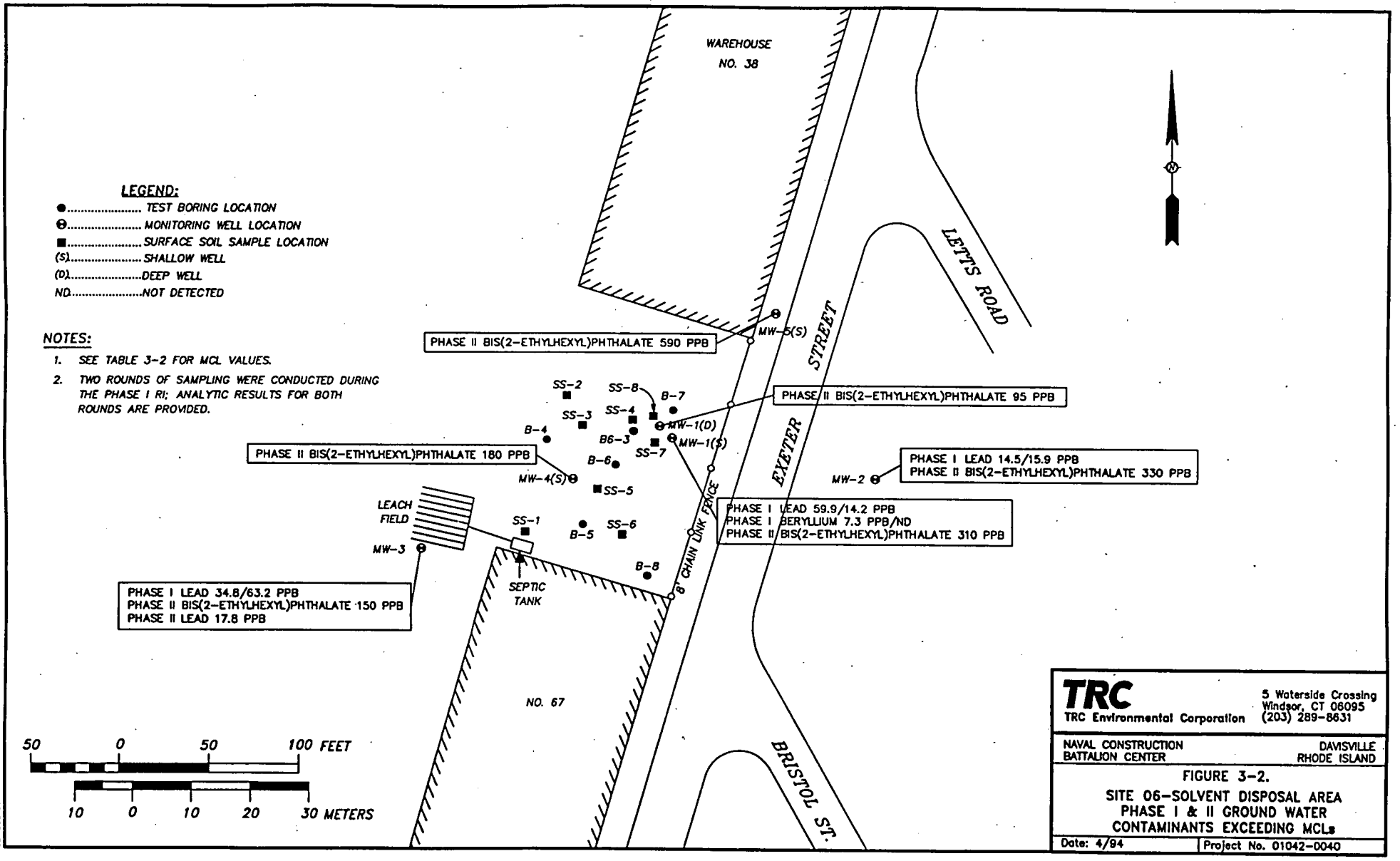
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 2-5.
SITE 06-SOLVENT DISPOSAL AREA
SITE 13-DISPOSAL AREA NORTHWEST
SHALLOW GROUND WATER LEVEL CONTOUR MAP
SEPTEMBER 17, 1993

Date: 4/94 | Project No. 01042-0040


LEGEND:
TEST BORING LOCATION
MONITORING WELL LOCATION
SURFACE SOIL SAMPLE LOCATION
(S) SHALLOW WELL
(D) DEEP WELL
WAREHOUSE
NO. 38
NO. 67
PHASE II LEAD 616 PPM
SS-2
SS-8
B-7
SS-3
SS-4
MW6-1(D)
B-4
B6-3
MW6-1(S)
SS-7
B-6
MW6-4(S)
SS-5
LEACH
FIELD
SS-1
B-5
SS-6
MW6-3
B-8
SEPTIC
TANK
8' CHAIN LINK FENCE
MW6-5(S)
EXETER
STREET
LETTS ROAD
MW6-2
BRISTOL ST.
N
50
0
50
100 FEET
10
0
10
20
30 METERS
TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631
NAVAL CONSTRUCTION
BATTALION CENTER
DAVISVILLE
RHODE ISLAND
FIGURE 3-1.
SITE 06-SOLVENT DISPOSAL AREA
PHASE I & II SURFACE SOIL
CONTAMINANTS EXCEEDING ARARs/TBCs
Date: 4/94
Project No. 01042-0040


LEGEND:
TEST BORING LOCATION
MONITORING WELL LOCATION
SURFACE SOIL SAMPLE LOCATION
(S) SHALLOW WELL
(D) DEEP WELL
ND NOT DETECTED
NOTES:
1. SEE TABLE 3-2 FOR MCL VALUES.
2. TWO ROUNDS OF SAMPLING WERE CONDUCTED DURING THE PHASE I RI; ANALYTIC RESULTS FOR BOTH ROUNDS ARE PROVIDED.
WAREHOUSE NO. 38
NO. 67
LETTS ROAD
EXETER STREET
BRISTOL ST.
8' CHAIN LINK FENCE
LEACH FIELD
SEPTIC TANK
MW-5(S)
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 590 PPB
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 95 PPB
MW-1(D)
MW-1(S)
SS-2
SS-8
B-7
SS-3
SS-4
B-4
B6-3
SS-7
B-6
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 180 PPB
MW-4(S)
SS-5
MW-2
PHASE I LEAD 14.5/15.9 PPB
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 330 PPB
PHASE I LEAD 59.9/14.2 PPB
PHASE I BERYLLIUM 7.3 PPB/ND
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 310 PPB
SS-1
B-5
SS-6
MW-3
B-8
PHASE I LEAD 34.8/63.2 PPB
PHASE II BIS(2-ETHYLHEXYL)PHTHALATE 150 PPB
PHASE II LEAD 17.8 PPB
50 0 50 100 FEET
10 0 10 20 30 METERS
TRC
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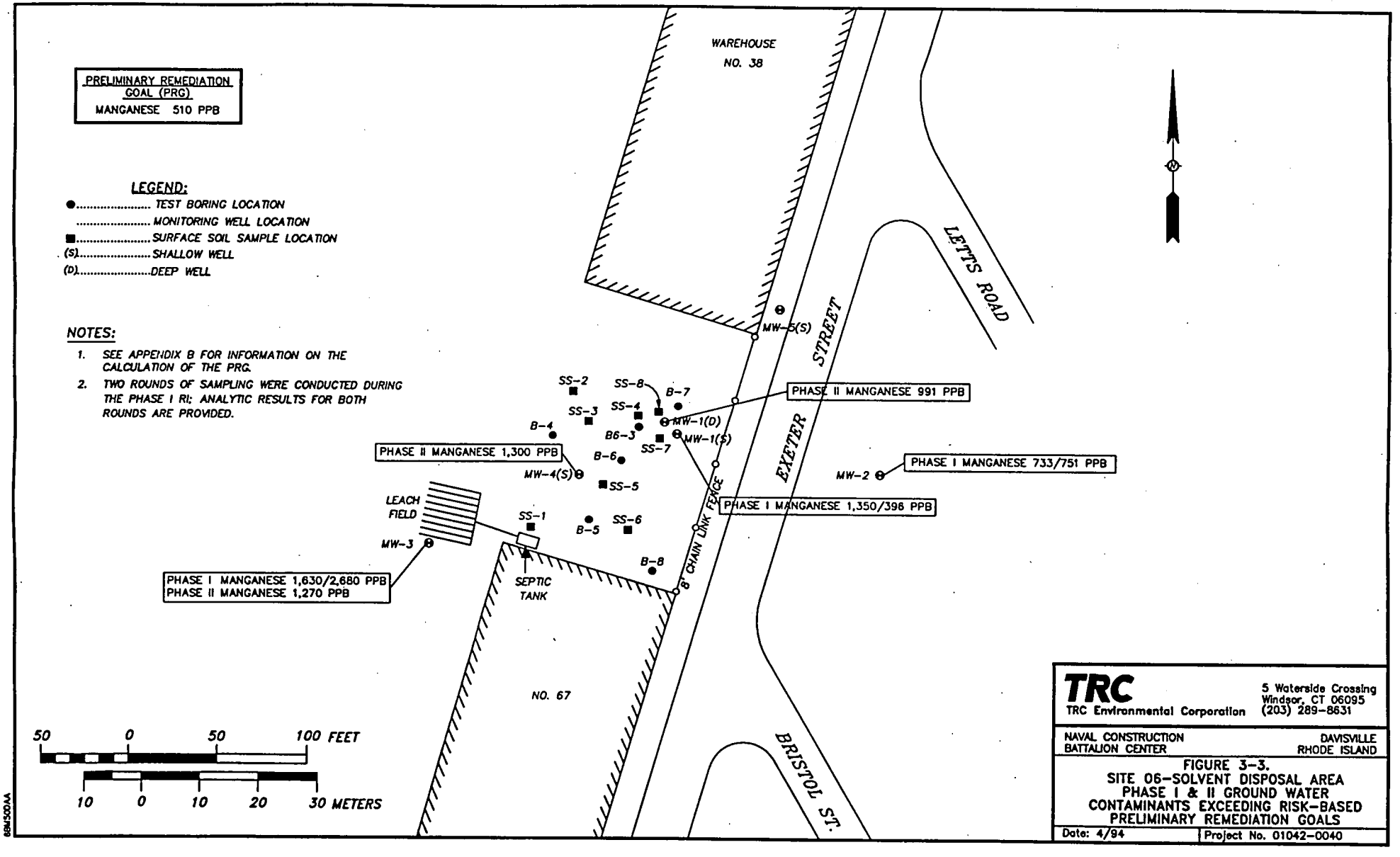
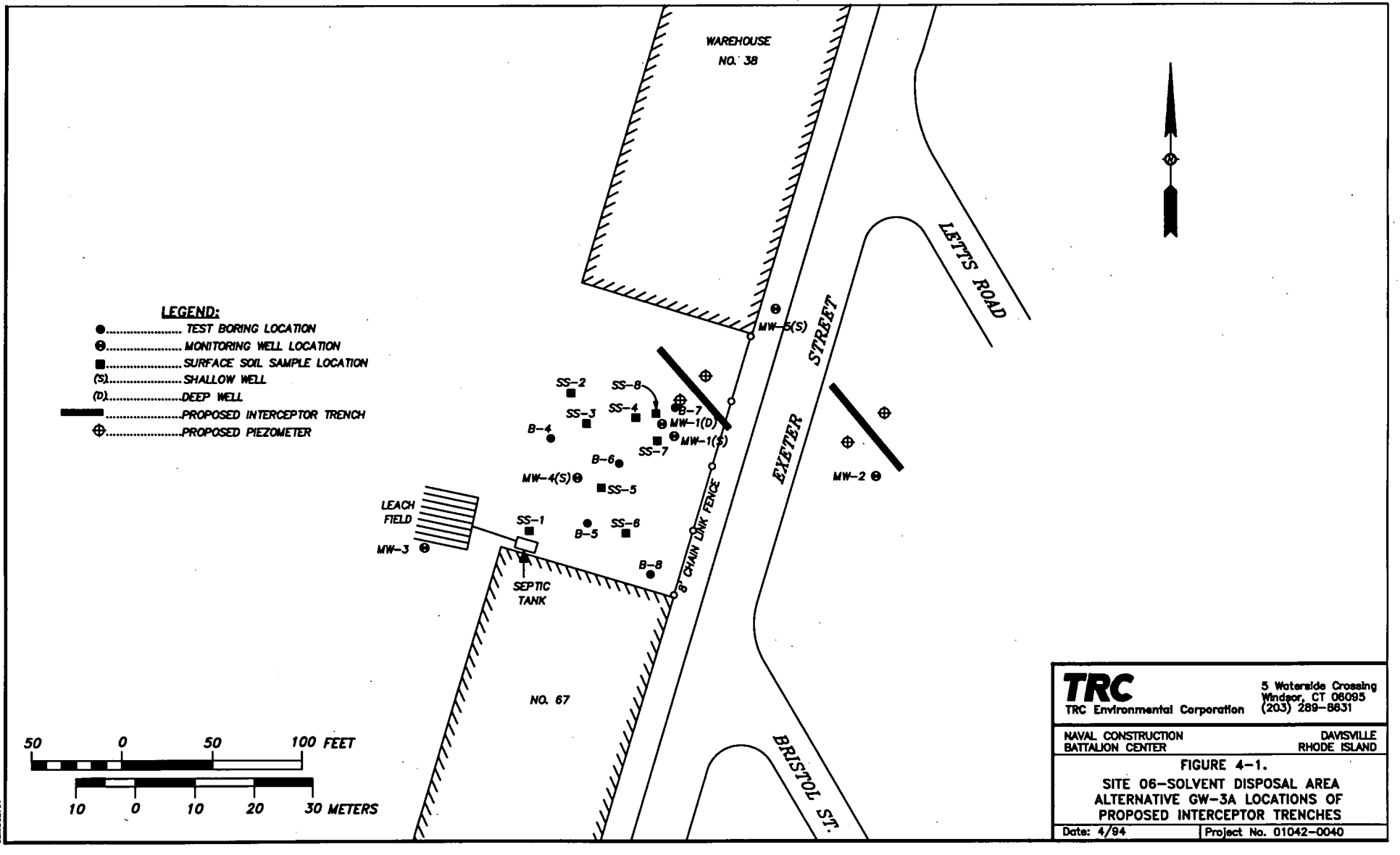
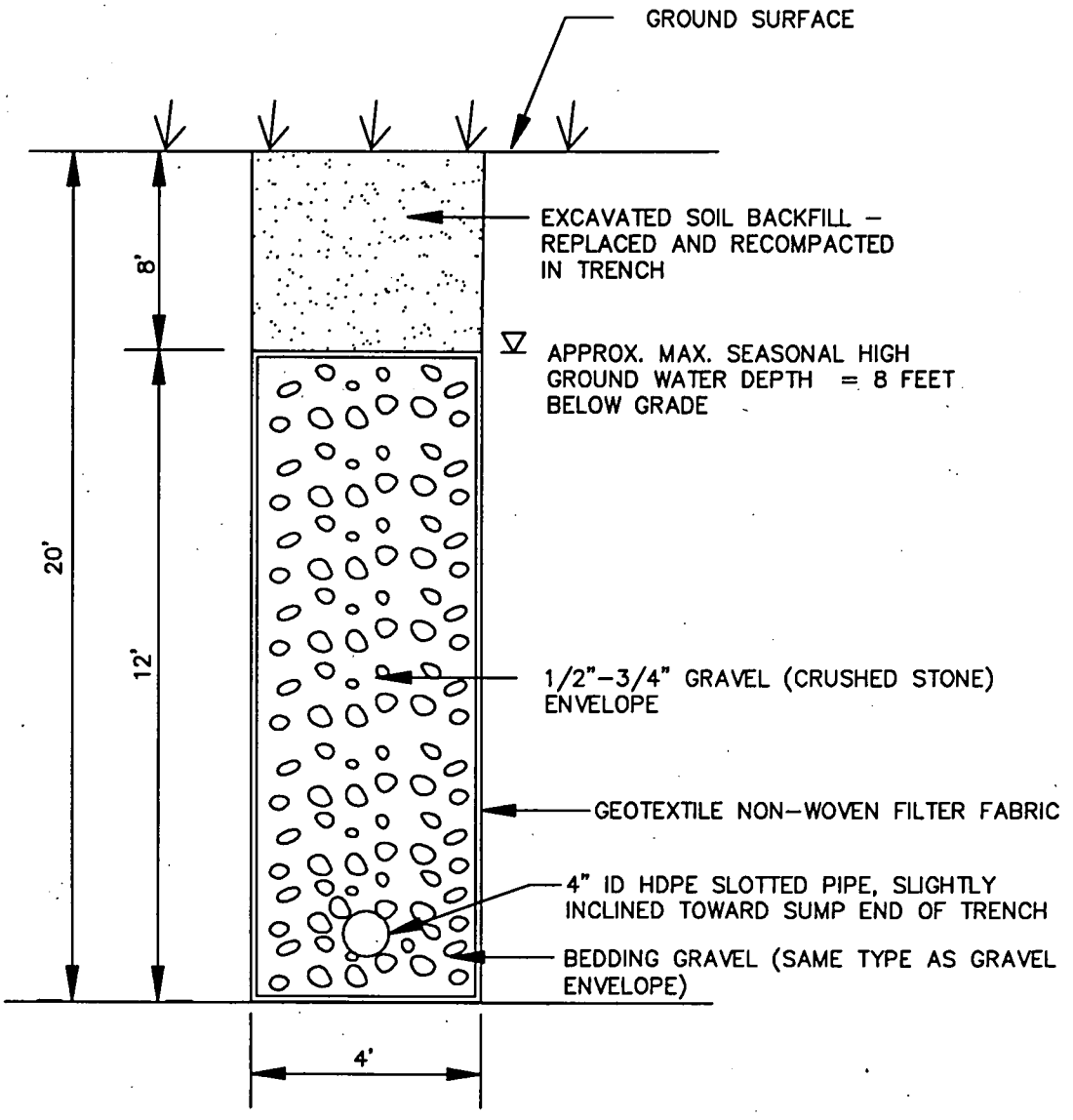
Windsor, CT 06095
(203) 289-8631
NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 3-2.
SITE 06-SOLVENT DISPOSAL AREA
PHASE I & II GROUND WATER
CONTAMINANTS EXCEEDING MCLs
Date: 4/94
Project No. 01042-0040


PRELIMINARY REMEDIATION GOAL (PRG)
MANGANESE 510 PPB
LEGEND:
TEST BORING LOCATION
MONITORING WELL LOCATION
SURFACE SOIL SAMPLE LOCATION
(S) SHALLOW WELL
(D) DEEP WELL
NOTES:
1. SEE APPENDIX B FOR INFORMATION ON THE CALCULATION OF THE PRG.
2. TWO ROUNDS OF SAMPLING WERE CONDUCTED DURING THE PHASE I RI; ANALYTIC RESULTS FOR BOTH ROUNDS ARE PROVIDED.
WAREHOUSE NO. 38
NO. 67
LETTS ROAD
EXETER STREET
BRISTOL ST.
8' CHAIN LINK FENCE
LEACH FIELD
SEPTIC TANK
MW-5(S)
MW-1(D)
MW-1(S)
MW-2
MW-3
MW-4(S)
SS-1
SS-2
SS-3
SS-4
SS-5
SS-6
SS-7
SS-8
B-4
B-5
B-6
B-7
B-8
B6-3
PHASE II MANGANESE 991 PPB
PHASE II MANGANESE 1,300 PPB
PHASE I MANGANESE 733/751 PPB
PHASE I MANGANESE 1,350/398 PPB
PHASE I MANGANESE 1,630/2,680 PPB
PHASE II MANGANESE 1,270 PPB
50 0 50 100 FEET
10 0 10 20 30 METERS
TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631
NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 3-3.
SITE 06-SOLVENT DISPOSAL AREA
PHASE I & II GROUND WATER
CONTAMINANTS EXCEEDING RISK-BASED
PRELIMINARY REMEDIATION GOALS
Date: 4/94
Project No. 01042-0040


WAREHOUSE
NO. 38
LETTS ROAD
EXETER STREET
BRISTOL ST.
NO. 67
LEGEND:
TEST BORING LOCATION
MONITORING WELL LOCATION
SURFACE SOIL SAMPLE LOCATION
(S) SHALLOW WELL
(D) DEEP WELL
PROPOSED INTERCEPTOR TRENCH
PROPOSED PIEZOMETER
MW-5(S)
SS-2
SS-8
SS-3
SS-4
B-7
MW-1(D)
MW-1(S)
B-4
SS-7
B-6
MW-4(S)
SS-5
LEACH FIELD
MW-3
SS-1
B-5
SS-6
B-8
SEPTIC TANK
8' CHAIN LINK FENCE
MW-2
50 0 50 100 FEET
10 0 10 20 30 METERS
TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631
NAVAL CONSTRUCTION BATTALION CENTER
DAVISVILLE RHODE ISLAND
FIGURE 4-1.
SITE 06-SOLVENT DISPOSAL AREA
ALTERNATIVE GW-3A LOCATIONS OF
PROPOSED INTERCEPTOR TRENCHES
Date: 4/94
Project No. 01042-0040



NOT TO SCALE

TRC
TRC Environmental Corporation

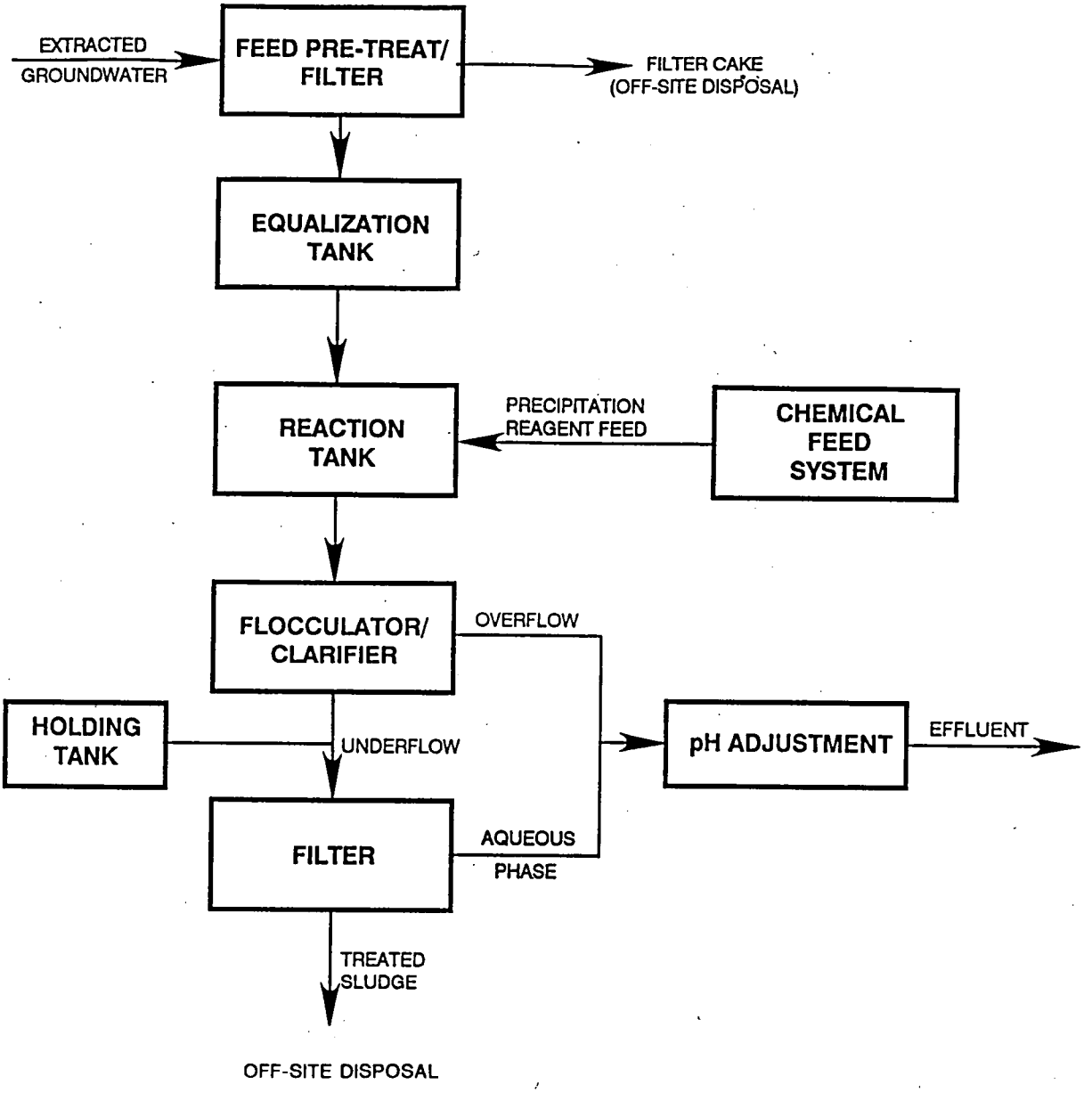
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631

NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 4–2.
SITE 6–SOLVENT DISPOSAL AREA
GROUND WATER INTERCEPTOR TRENCH
CROSS–SECTION

Date: 4/94 | Project No. 01042–0040

6TRENCH



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TRC Environmental Corporation

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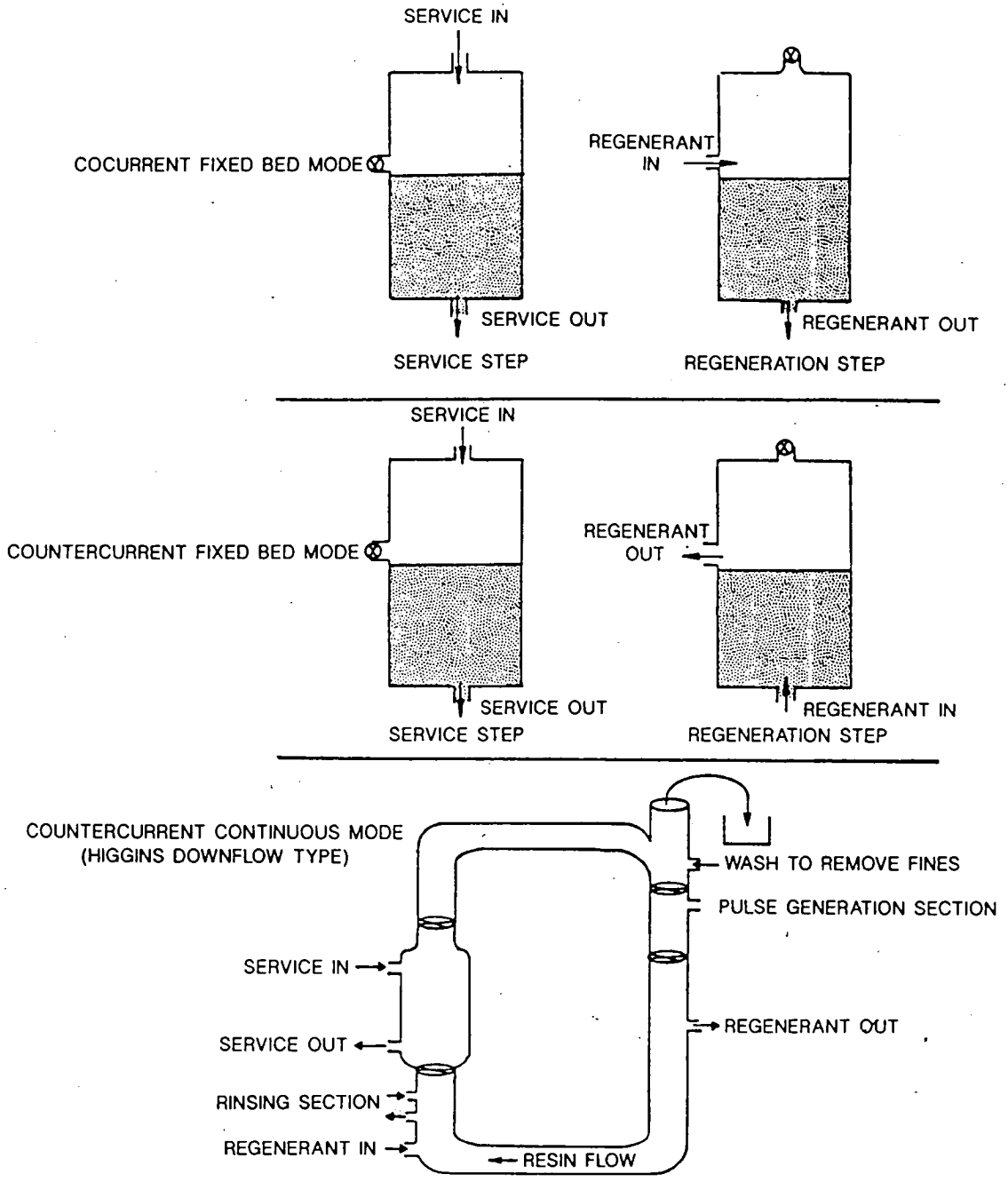
DAVISVILLE RHODE ISLAND

FIGURE 4-3.

SITE 06 - SOLVENT DISPOSAL AREA
CHEMICAL PRECIPITATION SCHEMATIC

Date: 4/94

Project No. 01042-0040



SOURCE: DeRENZO, D.J., 1978

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Windsor, CT 06095
(203) 289-8631

NAVAL CONSTRUCTION BATTALION CENTER

DAVISVILLE RHODE ISLAND

FIGURE 4-4.

SITE 06 - SOLVENT DISPOSAL AREA TYPICAL ION EXCHANGE SYSTEMS

Date: 4/94 | Project No. 01042-0040

APPENDIX A

APPENDIX A

IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

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APPENDIX A

IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

A.1 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA, 1986), and the NCP (1990) require that all remedial response actions attain or exceed applicable or relevant and appropriate requirements of Federal and more stringent promulgated requirements of State environmental statute(s). The NCP defines applicable requirements as "those cleanup standards, standards of control, other substantive environmental protection requirements or criteria, or limitations promulgated under federal environmental or state environmental facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site." Relevant and appropriate requirements are defined in the NCP as "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" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at the CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

To-Be-Considered materials (TBCs) are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances TBCs may be considered along with ARARs in determining the necessary level of cleanup for protection of health or the environment.

Current EPA CERCLA guidance calls for a preliminary identification of potential ARARs during the RI scoping phase to assist in initial identification of remedial alternatives. Early identification also facilitates communications with support agencies to evaluate ARARs, and may help planning of field activities. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as better understanding is gained of the site conditions, site contaminants, and remedial action alternatives. Findings of the Phase I RI aided

in the selection of ARARs as presented in Volume II of the Phase II RI/FS Work Plan (TRC, 1992). ARARs were further evaluated in the Initial Screening of Alternatives Report (TRC, May 1993). This section revisits the information provided in that report, updating it on the basis of the specific information related to Site 06, as addressed herein, as well as on the basis of evolving regulatory requirements.

ARARs may be categorized as: 1) chemical-specific requirements, which may define acceptable exposure levels and, therefore, be used in establishing preliminary remediation goals; 2) location-specific requirements, which may set restrictions on activities within specific locations such as coastal areas or wetlands; and 3) performance, design or other action-specific requirements, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes. The documents "CERCLA Compliance With Other Laws Manual" (USEPA, 1988), and "CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements" (USEPA, 1989), contain detailed information on identifying and complying with ARARs. In addition, Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991) provides guidance on the use of ARARs for the development of preliminary remediation goals (PRGs).

A.2 Approach

This evaluation focuses on the identification of potential chemical-specific ARARs/TBCs which will guide the development of PRGs at Site 06. Preliminary location-specific and action-specific ARARs/TBCs are also evaluated herein, but are further evaluated with respect to the individual remedial alternatives in the detailed alternative analysis portion of this report.

To determine the chemical-specific requirements which may be applicable to remediation at Site 06 (i.e., to identify preliminary remediation goals (PRGs) and chemical-specific ARARs which may be applicable to certain remedial actions), an evaluation of federal and State of Rhode Island chemical-specific ARARs was conducted. Those federal and state chemical-specific ARARs considered to potentially be applicable or relevant and appropriate to remedial actions at Site 06 have been compiled, as presented in Tables A-1 and A-2.

A.3 Potential Federal Chemical-Specific ARARs/TBCs

Potential federal chemical-specific ARARS and TBC criteria are presented in Table A-1. Chemical-specific ARARs/TBCs which may be applicable to the development of preliminary remediation goals for the various media at the site are addressed by media below. Following this discussion is a presentation of potential chemical-specific ARARs/TBCs which may be considered in the evaluation of specific remedial actions at the site.

A.3.1 Ground Water

Ground water at NCBC Davisville is not a current source of drinking water, and ground water at Site 06 is classified as GB. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991) provides guidance on the development of PRGs for ground water. Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), non-zero maximum contaminant level goals (MCLGs), and state drinking water standards are common ARARs and therefore PRGs for ground water that is a current or potential source of drinking water. Although the ground water at Site 06 is classified as GB, indicating that it would not be suitable for use as a drinking water supply without treatment, there currently is no regulatory mechanism which would prevent the installation of a potable well on-site. Therefore, MCLs, MCLGs and state drinking water standards are considered to be relevant and appropriate to Site 06. Where MCLs, MCLGs and state drinking water standards are unavailable for a particular ground water contaminant, USEPA Risk Reference Doses, Lifetime Health Advisories and Human Health Assessment Group Cancer Slope Factors will be used to develop risk-based PRGs.

A.3.2 Soils

The Toxic Substances Control Act provides PCB cleanup levels for solid surfaces and soils where spills occurred after May 4, 1987. These levels may be relevant and appropriate to the evaluation of any PCB contamination in Site 06 soils. In addition, the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02) will represent TBC criteria for lead in soils.

A.3.3 Chemical-Specific ARARs Potentially Applicable to Remedial Actions

Chemical-specific federal ARARs/TBCs which are applicable to the implementation of certain remedial actions include Ambient Water Quality Criteria (AWQC) and Effluent Discharge Limitations, both promulgated under the Clean Water Act, which represent potential chemical-specific ARARs for alternatives which involve discharges to surface waters.

The Toxicity Characteristic Leachate Parameter (TCLP) maximum concentrations (40 CFR 261.24) and the land disposal restrictions (40 CFR 268) will be applicable to any action which requires a hazardous waste determination and disposal option evaluation.

Sections of the Clean Air Act which establish maximum concentrations for particulates and fugitive dust emissions, emissions limitations for new sources, and emissions limitations for hazardous air pollutants, are considered potential chemical-specific ARARs for remedial alternatives which impact ambient air.

A.4 Potential Rhode Island Chemical-Specific ARARs/TBCs

A.4.1 Ground Water

Potential Rhode Island chemical-specific ARARs and TBC criteria are presented in Table A-2. As discussed in Section A.3.1, Rhode Island Public Drinking Water Regulations are not applicable to Site 06, based on its GB ground water classification, but are considered to be relevant and appropriate based on the lack of a regulatory mechanism to prohibit installation of a potable well on-site.

A.4.2 Soil

Rhode Island's Rules and Regulations for Solid Waste Management Facilities define solid wastes as including wastes which contain a concentration of 10 ppm or greater PCBs. The Rules and Regulations for Hazardous Waste Management define Type 6 - extremely hazardous waste as including wastes which contain a concentration of 50 ppm or greater PCBs. These regulations may be relevant and appropriate to the evaluation of soil PCB contaminant levels at Site 06. RIDEM and the Rhode Island Department of Health-Risk Assessment consider a safe lead level in soil (total) as under 300 ppm, a TBC in the identification of PRGs at Site 06.

A.4.3 Chemical-Specific ARARs Potentially Applicable to Remedial Actions

Chemical-specific ARARs/TBCs which may be applicable to the implementation of certain remedial actions include the Rhode Island Water Quality Standards, established under the RI Water Pollution Control Law (RIGL, Title 46, Chapter 12), which will be applicable to remedial actions which involve discharges to surface water. The RI Clean Air Act (RI Title 23, Chapter 23) establishes maximum ambient levels for criteria pollutants under the Air Pollution Control Regulation Standards. These levels constitute potential chemical-specific ARARs for remedial alternatives which emit pollutants into the air.

A.5 Potential Location-Specific ARARs/TBCs

A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they are in a specific location (U.S. EPA, 1988).

A.5.1 Potential Federal Location-Specific ARARs/TBCs

No federal location-specific ARARs and TBCs were identified as being potentially applicable to Site 06. The nearest wetlands are located approximately 500 feet northeast of Site 06. Therefore, wetlands/water resources regulations, including Executive Orders 11988 and 11990, Statement of Proceedings of Floodplain Management and Wetlands Protection, the Clean Water Act Section 404 Requirements for Discharge of Dredge or Fill Material and the Rivers and Harbors Act Prohibition of Filling a Navigable Water will not apply to remedial actions conducted on-site. Coastal area and harbor protection regulations are not applicable due to the site's distance from coastal areas.

The Fish and Wildlife Coordination Act of 1958 was enacted to protect fish and wildlife when federal actions result in the control or structural modification of a natural stream or water body. Since no water bodies are located on or immediately adjacent to the site, the Fish and Wildlife Coordination Act is not expected to be applicable to remedial actions conducted on-site. The Endangered Species Act of 1973, which restricts activities in areas inhabited by registered

endangered species, is not considered to be a potential ARAR for Site 06 based on the conclusion of an endangered species survey conducted in 1989 by RIDEM (RIDEM, 1989).

Based on the results of a cultural resources survey conducted at the NCBC facility, as described in Cultural Resource Assessment for Base Closure and Realignment, Redevelopment and Reuse at the Naval Construction Battalion Center, Davisville, Rhode Island, as prepared by Ecology and Environment, Inc. and dated November 1993, the National Historic Preservation Act of 1966 and the Archaeological and Historic Preservation Act of 1974 are not considered to be potential ARARs for remedial actions at Site 06. The cultural resource survey report concluded that the majority of surficial deposits at the facility have been severely impacted by extensive land moving activities conducted by the Navy, and did not recommend archaeological surveys or identify any historic properties at any areas in the immediate vicinity of Site 06.

To determine the potential applicability of the Farmland Protection Policy Act, the U.S. Department of Agriculture Important Farmlands Map for Kent County was reviewed. This map, developed on the basis of soil survey information, indicates that limited areas designated as Prime Farmland and Additional Farmland of Statewide Importance are located in the general vicinity of the NCBC Davisville facility but do not encompass or abut Site 06. Therefore, farmland protection regulations are not considered to be applicable to remedial actions at Site 06.

A.5.2 Potential State Location-Specific ARARs/TBCs

No state location-specific ARARs/TBCs were identified as being potentially applicable to Site 06. As noted in Section A.5.1, Site 06 does not encompass or abut any wetland areas. Therefore, the Rhode Island Wetlands Laws are not considered to be potential ARARs for Site 06. Also, since Site 06 is not located adjacent to the coast, Rhode Island Coastal Resources Management Law and Regulations are not applicable to the site.

A.6 Potential Action-Specific ARARs/TBCs

Based on the identification of contaminants in soil and ground water at Site 06, remediation activities may be required and numerous state and federal requirements could apply to the implementation of these activities. As discussed previously, potential action-specific

ARARs/TBCs cannot be well-defined until remedial alternatives are developed and response actions defined. Action-specific ARARs will be defined in more detail in the detailed analysis of alternatives (Section 4 of this report).

A.6.1 Potential Federal Action-Specific ARARs/TBCs

Numerous federally promulgated action-specific ARARs and TBC criteria could potentially affect the implementation of remedial measures. A preliminary evaluation of federal regulatory requirements potentially applicable to remedial activities at Site 06 is presented in Table A-3.

A.6.2 Potential State Action-Specific ARARs/TBCs

The State of Rhode Island has promulgated regulations similar to those of the federal government. A preliminary evaluation of potential state action-specific ARARs which may be applicable to remedial activities at Site 06 is presented in Table A-4.

References

RIDEM, 1989. Endangered Species Surveys at Camp Fogarty, West Davisville, and East Davisville.

TRC Environmental Corporation, 1992. Phase II RI/FS Work Plan, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division Naval Facilities Engineering Command, Philadelphia, PA. August, 1992.

TRC Environmental Corporation, 1993. Initial Screening of Alternatives, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division, Naval Facilities Engineering Command, Philadelphia, PA. Contract No. N62472-85-C-1026, April 1993.

USEPA, 1988. CERCLA Compliance with Other Laws Manual, Draft Guidance, Part I, OSWER Directive 9234.1-01, August 8, 1988.

USEPA, 1989. CERCLA Compliance with Other Law Manuals: Part II. Clean Air Act and Other Environmental Statues and State Requirements, Office of Solid Waste and Emergency Response, EPA/540/G-89/009, OSWER Directive 9234.1-02, August 1989.

USEPA, 1991. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim. EPA/540/R-92/003, December 1991.

TABLE A-1
FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.
	USEPA Human Health Assessment Group Cancer Slope Factors (CSFs)	To Be Considered	A slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.	USEPA CSFs are used to compute the individual incremental cancer risk resulting from exposure to certain compounds.

TABLE A–1 (continued)
FEDERAL CHEMICAL–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Surface Water --				
	Clean Water Act (40 CFR 121) Ambient Water Quality Criteria (AWQC)	To be determined	Non–enforceable guidelines established for the protection of human health and/or aquatic organisms.	AWQC will be applicable to remedial alternatives which involve discharges to surface water.
	Clean Water Act (40 CFR 401.15) Effluent Discharge Limitations	To be determined	Regulates the discharge of contaminants from an industrial point source.	Regulations will be applicable to remedial alternatives which involve discharges to surface water.
Soils/Surfaces--				
	Toxic Substances Control Act (40 CFR 761.125)	Relevant and Appropriate	Establishes PCB cleanup levels for soils and solid surfaces.	Applicable to spills of materials containing PCBs at concentrations of 50ppm or greater that occurred after May 4, 1987. These requirements may be relevant and appropriate to the evaluation of PCB levels in site soils.
	Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4–02)	To Be Considered	Sets forth an interim soil cleanup level for lead at 500 to 1000 ppm.	Will be considered at Site 06 with repect to soil lead contamination.
	Toxicity Characteristic (40 CFR 261.24)	To be determined	Establishes maximum concentrations of contaminants for the toxicity characteristic using the test method described in 40 CFR 261 Appendix II.	Applicable where wastes produced as a byproduct of a remedial action require handling as a hazardous waste on the basis of the Toxic Characteristic Leachate Parameter (TCLP) analysis.
	Land Disposal Restrictions (40 CFR 268)	To be determined	Establishes maximum concentrations of contaminants on the basis of which hazardous wastes are restricted from land disposal.	This regulation will be applicable to remedial alternatives which utilize land disposal of hazardous waste.

TABLE A–1 (continued)
FEDERAL CHEMICAL–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Air--				
	Clean Air Act (40 CFR 50) National Ambient Air Quality Standards (NAAQS)	To be determined	Establishes maximum levels for pollutants and particulates within air quality control districts.	Potential ARARS for alternatives involving remedial actions which impact ambient air (i.e. incinerators, soil venting, etc.).
	Clean Air Act (40 CFR 60) New Source Performance Standards (NSPS)	To be determined	Establishes emissions limitations for new sources.	Potential ARARS for alternatives involving treatment methods which emit pollutants.
	Clean Air Act (40 CFR 61) National Emissions Standard for Hazardous Air Pollutants	To be determined	Establishes emissions standards for hazardous air pollutants.	Potential ARARS for alternatives involving treatment methods which emit hazardous air pollutants.

TABLE A–2
STATE CHEMICAL–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Ground Water– –				
	RI Ground Water Protection Act (RIGL, 46–13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 06. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.
Surface Water – –				
	RI Water Pollution Control Law (RIGL 46–12 et seq.) RI Water Quality Standards	To be determined	Establishes water use classification and water quality criteria for all waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	Regulation will be applicable for remedial alternatives which involve discharges to surface water.
Soils/Surfaces– –				
	Lead Soil Cleanup Standards (Guidance)	To Be Considered	RIDEM and the Rhode Island Department of Health–Risk Assessment consider a safe lead level in soil (total) to be under 300 ppm.	To be considered with respect to lead soil contamination.
	RI Hazardous Waste Management Act of 1987 (RIGL 23–19.1 et seq.) Rules and Regulations for Hazardous Waste Management	Relevant and Appropriate or Applicable	Defines Type 6 – extremely hazardous waste as including wastes which contain PCBs at a concentration of 50 ppm or greater or showing 10 micrograms/ 100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
	Rules and Regulations for Solid Waste Management Facilities	Relevant and Appropriate or Applicable	Defines solid waste as including any soil, debris or other material with a concentration of PCBs of 10 ppm or greater or containing 2 micrograms/100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
Air– –				
	RI Clean Air Act (RIGL Title 23, Chapter 23) Air Pollution Control Regulation Standards	To be determined	Establishes maximum ambient levels for criteria pollutants.	Potential ARARs for remedial alternatives involving treatment methods which emit criteria pollutants.

TABLE A–3
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On–site/ Off–site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off–Site Disposal	To be determined	Standards for manifesting, marking and recording off–site hazardous waste shipments for treatment/disposal.	This regulation will be applicable to alternatives which utilize an off–site disposal/treatment method for hazardous wastes.
	RCRA (40 CFR 263) Transporter Requirements for Off–Site Disposal	To be determined	Standards for transporters of hazardous waste materials.	This regulation will be applicable to alternatives which utilize an off–site disposal/treatment method for hazardous wastes.
	RCRA (40 CFR 264 and 265) Requirements for Hazardous Waste Treatment Facility Design and Operating Standards for Treatment and Disposal Systems	To be determined	Outlines specifications and standards for design, operation, closure and monitoring of performance for hazardous waste storage, treatment and disposal facilities.	Potential ARARs for alternatives which utilize a surface impoundment, waste pile, landfill, land treatment, incineration or miscellaneous treatment units for on–site storage/disposal/treatment of hazardous wastes.
	RCRA (40 CFR 264.10–264.18) Subpart B – General Facility Standards	To be determined	General requirements regarding waste analysis, security, training, inspections, and location applicable to a facility which stores, treats or disposes of hazardous wastes (a TSDF facility).	This regulation may be applicable to a remedial action conducted at Site 06, if it meets the definition of a TSDF.
	RCRA (40 CFR 264.30–264.37) Subpart C – Preparedness and Prevention	To be determined	Requirements applicable to the design and operation, equipment, and communications associated with a TSDF facility, and to arrangements with local response departments.	This regulation may be applicable to a remedial action conducted at Site 06, if it meets the definition of a TSDF.
	RCRA (40 CFR 264.50–264.56) Subpart D – Contingency Plan and Emergency Procedures	To be determined	Emergency planning procedures applicable to a TSDF facility.	This regulation may be applicable to a remedial action conducted at Site 06, if it meets the definition of a TSDF.

TABLE A–3(continued)
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On–site/ Off–site Treatment/ Disposal (cont.)	RCRA (40 CFR 264) Subpart F Ground Water Protection	To be determined	Ground water monitoring/corrective action requirements; dictates adherence to MCLs and establishes points of compliance.	Potential ARARs for alternatives which involve placement of hazardous wastes within solid waste management units, including surface impoundments, waste piles, and land treatment units.
	RCRA (40 CFR 264) Subpart G Closure/Post Closure Requirements	To be determined	Establishes requirements for the closure and long–term management of a hazardous disposal facility.	Applicable to the closure of any hazardous waste management facility.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	To be determined	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	Potential ARARs for remedial actions which require storage of hazardous waste in containers.
	RCRA (40 CFR 264) Subpart L Waste Piles	To be determined	Regulates owners and operators of facilities that store or treat hazardous waste in piles.	Potential ARARs for remedial alternatives which utilize a waste pile for on–site storage/treatment of hazardous waste.
	RCRA (40 CFR 264) Subpart O Incinerator Restrictions	To be determined	Outlines specifications and standards for incinerating hazardous waste.	Potential ARARs for alternatives which utilize incineration for on–site treatment of hazardous wastes.
	RCRA (40 CFR 265) Subpart Q – Chemical, Physical and Biological Treatment	To be determined	General operating, waste analysis and trial test, inspection and closure requirements for facilities which treat hazardous waste by chemical, physical or biological methods in other than tanks, surface impoundments and land treatment facilities.	Remedial alternatives which utilize chemical, physical and biological treatment methods as described to treat hazardous wastes will meet these requirements.

TABLE A–3(continued)
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On–site/ Off–site Treatment/ Disposal (cont.)	RCRA (40 CFR 264.600–264.999) Subpart X – Miscellaneous Units	To be determined	Environmental performance standards, monitoring requirements and post–closure care requirements applicable to miscellaneous units (not otherwise defined in the RCRA regulations) used to treat, store or dispose of hazardous waste.	Potential ARARs for remedial actions involving hazardous waste treatment, storage or disposal in units not otherwise covered under RCRA regulations.
	RCRA (40 CFR 268) Land Disposal Restrictions	To be determined	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	This regulation will be applicable to alternatives which utilize land disposal of hazardous wastes.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	To be determined	Procedures for packaging, labelling, manifesting, and off–site transport of hazardous materials.	This regulation will be applicable to alternatives which include off–site transport of hazardous materials.
	Toxic Substances Control Act (15 USC. Sect. 2601) Subpart D – Storage and Disposal Requirements for PCBs	To be determined	Establishes requirements for the storage, landfilling, and incineration of PCBs.	This regulation may be applicable or relevant and appropriate to alternatives which involve handling of PCB–contaminated materials.
	Safe Drinking Water Act (40 CFR 144 and 146) Underground Injection Control Requirements	To be determined	Establishes the general requirements, technical criteria and standards for underground injection wells.	This regulation will be applicable to alternatives in which treated water is discharged back to the ground water.
Discharge	Clean Water Act (40 CFR 122–125) National Pollutant Discharge Elimination System (NPDES) Permit Requirements	To be determined	Permits contain applicable effluent standards (i.e., technology–based and/or water quality–based), monitoring requirements, and standards and special conditions for discharge.	Discharges of treated water to surface waters will meet these requirements.

TABLE A–3(continued)
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Discharge (cont.)	Clean Water Act (40 CFR 403) Discharge to Publicly– Owned Treatment Works (POTW)	To be determined	A national pretreatment program designed to protect municipal wastewater treatment plants and the environment from damage that may occur when hazardous, toxic or other non–domestic wastes are discharged into a sewer system.	This regulation is applicable to alternatives in which waters are discharged to a POTW.
Venting/ Discharges to Air	Clean Air Act (40 CFR 50) National Ambient Air Quality Standards (NAAQS)– Particulates	To be determined	Establishes maximum concentrations for particulates and fugitive dust emissions.	ARARs for alternatives involving treatment methods which impact ambient air (i.e. incineration, soil venting, etc.).
	Clean Air Act, Section 5 171 through 178, 42 USC §§ 7471–7478 (Requirements for Non–Attainment Areas)	To be determined	RI has adopted State Implementation Plan (SIP) requirements approved and enforcable by EPA which meet the New Source Review (NSR) requirement of the CAA. These provisions require that new or modified major sources of VOCs defined as a source which has the potential to emit 50 tpy install equipment to meet Lowest Available Emissions Rate (LAER), which is set on a case–by–case basis and is either the most stringent emissions limitation contained in any SIP for that category or source or the most stringent emissions limitation which is achieved for the source. NSR requirements apply to non–attainment pollutants, which are VOCs and NO_x in RI.	Monitoring will be conducted to determine if the requirements of this standard are applicable or relevant and appropriate based on the emissions levels and on the need to be protective of human health and the environment.

TABLE A–3(continued)
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air (cont.)	Clean Air Act, Section 5 160 through 169A – Prevention of Significant Deterioration Provisions	To be determined	RI has adopted SIP requirements approved and enforceable by EPA which meet the Prevention of Significant Deterioration (PSD) requirements of the CAA. These provisions require that new or modified major sources of VOCs, defined as a source which has the potential to emit 25 tons/year, install equipment to meet Best Available Control Technology (BACT). PSD requirements apply to attainment pollutants, which are SO2, CO, lead and particulates in Rhode Island.	Monitoring will be conducted to determine if the requirements of this standard are applicable or relevant and appropriate based on the emissions levels.
	Clean Air Act (40 CFR 61) National Emissions Standards for Hazardous Pollutants (NESHAPS)	To be determined	Establishes emissions limitations for hazardous air pollutants, and sets forth regulated sources of those pollutants.	Potential ARARs for alternatives using treatments (i.e., incineration, etc.) which result in emissions to the air.
	RCRA 40 CFR 265.375 Subpart P – Thermal Treatment	To be determined	Establishes requirements for air emissions from thermal treatment units.	Remedial actions which involve thermal treatment units, as defined in 40 CFR 265.370, will meet these standards.
	RCRA 40 CFR 264.1030 – 264.1036 Subpart AA – Air Emission Standards for Process Vents	To be determined	Establishes standards for air emissions from process vents associated with distillation, fractionation, thin film evaporation, column extraction or air steam stripping operations that treat RCRA substances and have total organic concentrations of 10 ppm or greater.	If these technologies are utilized and the threshold organic concentration is met, air emissions will comply with the standards.
	RCRA 40 CFR 264.1050 – 264.1065 Subpart BB – Air Emission Standards for Equipment Leaks	To be determined	Establishes standards for air emissions for equipment that contains or contacts RCRA wastes with organic concentrations of at least 10% by weight.	If such concentrated wastes are treated, the equipment used will meet these standards.
	EPA Technical Guidance Document: Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0.28)	To Be Considered	Guidance regarding the control of air emissions from air strippers used at Superfund sites for ground water treatment. Distinguishes between attainment and non–attainment areas for ozone.	These guidelines will be considered if air stripping is used as a ground water treatment alternative.

TABLE A–4
STATE ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On–site/ Off–site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23–19.1 et seq.) • Hazardous Waste Management Rules and Regulations	To be determined	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal.	These rules will be applicable for alternatives which involve the on– or off–site management of hazardous wastes.
	• Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	To be determined	Rules and regulations for the investigation and remediation of releases of hazardous materials.	These rules will be applicable to the design and operation of remedial systems.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right–to–Know Requirements	To be determined	Establishes rules for the public's right–to–know concerning hazardous waste storage and transportation.	These rules will be applicable for alternatives which involve the on– or off–site management of hazardous wastes.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	To be determined	Rules and regulations for solid waste management facilities.	ARARs for alternatives involving the on–site storage and disposal of solid wastes.
Discharge	RI Water Pollution Control Act • RI Water Quality Regulations for Water Pollution Control (RIGL 46–12 et seq.) RI Water Quality Standards	To be determined	Establishes general requirements and effluent limits for discharge to area waters.	This regulation will be applicable to alternatives in which treated water is discharged to area surface water or ground water.
	• Regulations for the RI Pollutant Discharge Elimination Systems (RIGL 46–12 et seq.)	To be determined	Permits contain applicable effluent standards (i.e., technology–based and/or water quality–based), monitoring requirements, and standards and special conditions for discharge.	This regulation will be applicable to alternatives in which treated water is discharged to area surface water or ground water.

TABLE A–4(continued)
STATE ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Discharge (cont.)	RI Water Pollution Control Act			
	• RI Pretreatment Regulations (RIGL 46–12 et seq.)	To be determined	Covers pollutants in wastewaters which can have detrimental effects on POTW processes. Sets specified limitations, pretreatment and monitoring requirements for discharges to POTWs based on federal regulations.	Remedial actions which include discharge to a POTW will meet all required discharge limitations.
	• RI Underground Injection Control Regulations (RIGL 46–12 et seq.)	To be determined	Establishes the general requirements, technical criteria and standards for underground injection wells.	This regulation will be applicable to alternatives in which treated water is discharged back to the ground water via injection.
	• RI Ground Water Protection Act (RIGL, Title 46, Chapter 13.1) Protection of Ground Water	To be determined	Establishes ground water classifications and maximum contaminant levels for each classification.	Potential ARARs for alternatives involving the treatment of contaminated ground water.
Venting/ Discharge to Air	RI Clean Air Act (RIGL, Title 23, Chapter 23) General Air Quality and Air Emissions Requirements	To be determined	Sets emissions limitations for particulates and visible air contaminants.	ARARs for alternatives involving remedial actions which impact ambient air.
	RI Clean Air Act (RIGL, Title 23, Chapter 23) General Air Quality and Air Emissions Requirements			
	• RI Air Pollution Control Regulations, RI Dept. of Health, Div. of Air Pollution Control, effective 8/2/67, most recently amended 5/20/91			
	– Regulation No. 1 – Visible Emissions	To be determined	No air contaminant emissions will be allowed for more than 3 minutes in any one hour which are greater than or equal to 20% opacity.	Air emissions from remedial actions will meet emission levels in regulation.

TABLE A–4(continued)
STATE ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 06 – SOLVENT DISPOSAL AREA
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharge to Air (cont.)	RI Clean Air Act (cont.) • RI Air Pollution Control Regulations, (cont.)			
	– Regulation No. 5 – Fugitive Dust	To be determined	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	On–site remedial actions will use good industrial practices to prevent particulate matter from becoming airborne.
	– Regulation No. 7 – Emissions Detrimental to Person or Property	To be determined	Prohibits emissions of contaminants which may be injurious to human, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	All emissions will meet this requirement or gas treatment will be required.
	– Regulation No. 9 – Approval to Construct, Install, Modify or Operate	To be determined	Establishes guidelines for the construction, installation, modification or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Technologies involving construction, installation, modification or operation of air emission units will meet these requirements.
	– Regulation No. 15 – Control of Organic Solvent Emissions	To be determined	Limits the amount of organic solvents emitted to the atmosphere.	If emissions exceed limits in this regulation, emission controls will be designed and implemented to meet these requirements.
	– Regulation No. 17 – Odors	To be determined	Prohibits the release of objectionable odors across property lines.	No remedial action or air emissions will emit objectionable odors beyond the facility boundary, as practicable.
	– Regulation No. 22 – Air Toxics	To be determined	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels with LAER, as set in the regulation.	If air emissions contain regulated substances, air emissions control equipment will be used as necessary to meet these standards.

APPENDIX B

APPENDIX B

CALCULATION OF PRELIMINARY RISK-BASED REMEDIATION GOALS

Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991a) provides guidance on the development of risk-based preliminary remediation goals (PRGs). One of the initial steps in development of PRGs is the identification of the most appropriate future land use for the site so that the appropriate exposure pathways, parameters and equations can be used to calculate PRGs. At Site 06, based on the Comprehensive Base Reuse Plan, the most appropriate future land use is for economic/industrial development. Therefore, exposures to surface soils and ground water, evaluated under the Human Health Risk Assessment for the future commercial/industrial use exposure scenario, will guide the development of PRGs.

According to the OSWER directive "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (USEPA, 1991b), action is generally warranted at a site when the cumulative carcinogenic risk is greater than 10^{-4} or the cumulative non-carcinogenic Hazard Index (HI) exceeds 1 based on reasonable maximum exposure (RME) assumptions. Therefore, the cumulative risks associated with a given medium under future commercial/industrial use were evaluated to determine if any medium poses a cumulative cancer risk greater than 10^{-4} or HI greater than 1. At Site 06, exposure to ground water results in a cumulative carcinogenic risk of 1×10^{-4} and the non-cancer RME HI is 6. Cumulative risks associated with exposure to surface soils were less than 10^{-4} (cancer risks) or less than 1 (non cancer risks). Therefore, the development of PRGs was evaluated with respect to ground water exposures only.

As described in the National Contingency Plan [40 CFR 300.430(e)(2)(i)(A)(2)], "The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available...". As summarized in Table B-1, those ground water constituents which contributed an individual RME cancer risk of greater than 1×10^{-6} to the overall cancer risk estimate, or an individual RME hazard quotient of greater than one to the total hazard index for noncarcinogenic risks, were identified and then evaluated to determine if there were any for which an ARAR/TBC was not available. For those constituents without an associated ARAR/TBC, a risk-based preliminary remediation goal (PRG) was calculated, based

on a future commercial/industrial use scenario. As shown in Table B-2, the calculations for ground water incorporate commercial/industrial worker exposures as an adult. Under this scenario, exposure is assumed to occur through ingestion of ground water. The exposure parameters for the ground water calculations are taken directly from the risk assessment portion of the Phase II RI.

References

USEPA, 1991a. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim. EPA/540/R-92/003, December 1991.

USEPA, 1991b. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30, April 1991.

Table B-1
Constituents Considered for the Development of Risk-Based
Preliminary Remediation Goals [a]
NCBC Davisville - Site 06

Constituent	Scenario	Medium	Cancer Risk or Hazard Quotient Elevated?	Ground Water MCL Available?	Selected for Development of Risk-Based PRGs?
Arsenic	Commercial	Ground Water	CR	Yes	No
Beryllium	Commercial	Ground Water	CR	Yes	No
Manganese	Commercial	Ground Water	HQ	No	**Yes**

[a] i.e., Constituents associated with individual cancer risks above 1E-06 or hazard quotients above 1 as estimated under the key exposure scenario for each medium (i.e., commercial/industrial for soil and for ground water)

Table B-2
Non-Cancer-Risk-Based Preliminary Remediation Goals (PRGs)
for Constituents in Ground Water
Assuming Future Commercial/Industrial Use
Site 06 – Solvent Disposal Area

Constituent	Oral Reference Dose (RfD) $(mg/kd*d)^{-1}$	Oral Relative Absorption Factor (RAF) (--)	Ground Water PRG [a] (mg/l)
Manganese	5.0E-03	1	5.1E-01 [b]

[a] Based on USEPA (1991) guidance and Phase II Human Health Risk Assessment
[b] PRG is within or less than concentrations detected upgradient for all sites (i.e., 0.034 mg/l at 03-MW03 to 2.2 mg/l at 10-MW05).

$PRG = [THI * AT * BW] / [(1/RfD) * IR_w * RAF_o * EF * ED]$

Where:

THI = Target hazard index:	1 --
AT = Averaging time:	9125 d
BW = Body weight:	70 kg
RfD = Reference dose:	CS Chemical-specific
IR_w = Water ingestion rate:	1 l/d
RAF_o = Oral relative absorption factor:	CS Chemical-specific
EF = Exposure frequency:	250 d/yr
ED = Exposure duration:	25 yr

APPENDIX C

APPENDIX C

EVALUATION OF LEACHING POTENTIAL BASED ON APPLICATION OF LEACHING MODEL

To evaluate the potential for surface and subsurface soil contaminants to leach into the ground water, an infiltration/leaching model was used. USEPA's document entitled Determining Soil Response Action Levels Based on Potential Contaminant Migration to Ground Water: A Compendium of Examples (EPA/540/2-89/057, October 1989) presents various methods which have been used to derive soil cleanup levels based on potential threats to ground water quality.

The Summers model and the "unnamed" model, as described in this USEPA document, were evaluated in terms of applicability to site conditions at Site 06 - Solvent Disposal Area. Both of these three-dimensional models assume that a percentage of rainfall will infiltrate and desorb contaminants from the soil based on equilibrium soil:water partitioning. It is assumed that this contaminated infiltration will mix completely with ground water below the site, resulting in an equilibrium ground water concentration with all contaminants from the infiltration in the final mixture. The Summers model is applicable to a large spill area and is based on a mass balance approach which is applied to the entire area and affected soil volume of the spill. Therefore, it involves a mass balance of the total volume and contaminant concentration of infiltration over the entire area of the site, the total volume and contaminant concentration of ground water flowing into the site area, and the total volume and contaminant concentration of ground water exiting the site.

The unnamed model is a variation of the Summers model in which the mass balance approach is applied to a column of the site, of unit area and of depth equal to the saturated portion of the aquifer. Since subsurface contamination at Site 06 is heterogeneous, characterized by small areas of elevated contamination, rather than consistently contaminated throughout the areal extent of the site, application of the unnamed model was determined to be more appropriate. The unnamed model also provides for the separate estimation of critical saturated and unsaturated soil contaminant levels.

Data Requirements

- Volumetric flow rate of recharge flowing downward through a unit area (based on the infiltration rate of precipitation) (cf/day)
- Volumetric flow rate of ground water in saturated zone in water column through unit width (cf/day)
- Concentration of contaminant in ground water recharge (μg/l)
- Hydraulic conductivity (ft/day)
- Hydraulic gradient (ft/ft)
- Concentration of contaminant adsorbed to the soil in the unsaturated zone (μg/kg)
- Concentration of contaminant in ground water in the saturated zone (μg/l)
- Total organic carbon concentration (mg/mg)

Method Description

In the unnamed model, soil cleanup levels (or maximum allowable soil contaminant levels) are calculated for saturated and unsaturated soils assuming equilibrium between dissolved and adsorbed phases for each contaminant using the following relationship:

$$S_{sat} = (K_d)(C_{sat}) \tag{1}$$

where: S_{sat} = concentration of contaminant adsorbed to the soil in the saturated zone (μg/kg)
K_d = distribution coefficient
C_{sat} = concentration of contaminant in ground water in saturated zone (μg/l)

The K_d is calculated as follows:

$$K_d = (0.63)(F_{oc})(K_{ow}) \tag{2}$$

where: 0.63 = Adjustment factor
F_{oc} = total organic carbon concentration in soil (mg/mg)
K_{ow} = octanol-water partition coefficient

In calculating K_d, it is assumed that the maximum desired contaminant concentration for ground water is equal to an established health-based criteria (i.e., MCLs). Using equation (1), the maximum soil contaminant concentration in the saturated zone may then be calculated.

Subsequent calculations to derive unsaturated soil maximum contaminant concentrations include the assumption that dissolved contamination in ground water recharge reaches equilibrium with the adsorbed phase on unsaturated soils, and that such recharge is fully diluted

into the entire water column upon reaching the water table. Thus the maximum unsaturated soil contaminant level is established using equation (1) and a dilution equation for calculating C_{sat}, the contaminant concentration in the ground water in the saturated zone which is based on the mass-balance approach, as indicated in Figure C-1.

$$C_{sat} = (C_{unsat})(e)/(e+Q) \tag{3}$$

where:
- C_{unsat} = contaminant concentration of ground water in recharge (μg/l)
- e = volumetric flow rate of recharge flowing downward through a unit area (cf/day)
- Q = volumetric flow rate of ground water in the saturated zone throughout the unit (cf/day)

The equilibrium assumption:

$$S_{unsat} = (K_d)(C_{unsat}) \tag{4}$$

and equation (1) combined with equation (3) yields the following relationship. The resultant equation is used to calculate the maximum contaminant concentration for soils in the unsaturated zone.

$$(S_{sat})/(K_d) = (S_{unsat})/(K_d)(e)/(e+Q)$$

and

$$S_{unsat} = (S_{sat})(e + Q)/e \tag{5}$$

where:
- S_{unsat} = concentration of contaminant adsorbed to the soil in the unsaturated zone (μg/kg)

and the ground water volumetric flow rate through the saturated zone (Q) is estimated from Darcy's Law:

$$Q = (K)\ (i)\ (A) \tag{6}$$

where:
- K = hydraulic conductivity (ft/day)
- i = hydraulic flow gradient (ft/ft)
- A = area of flow (unit width x saturated thickness of aquifer) (ft^2)

Site-Specific Application

The unnamed model was applied to Site 06 to determine the potential migration of soil contaminants into ground water. The evaluation was focused upon the soil contaminants which were identified as Contaminants of Concern (COCs) within the Phase II RI. Because the model assumes the maximum allowable ground water contaminant level is equal to the MCL, application of the model is generally limited to those constituents for which MCLs have been identified. For those COCs without final MCLs, proposed or tentative MCLs were used in the evaluation. However, a potential area of concern at Site 06 exists in the vicinity of B6-3 and B6-7, where 2-methylnaphthalene and naphthalene were detected. Since MCLs do not exist for naphthalene or 2-methylnaphthalene, risk-based ground water PRGs were developed for the contaminants, using the methodology presented in Appendix B, for use in place of MCLs in the unnamed model.

At Site 06 - Solvent Disposal Area, no Phase II RI soil samples were analyzed for total organic carbon. However, three samples from Site 13, located approximately 1,300 feet south-southwest of Site 06, were sampled for TOC. Given the proximity of the two sites and similar soil properties, the TOC values for Site 13 were applied to the Site 06 soils. Detected levels were 11,200 mg/kg, 648 mg/kg, and 674 mg/kg, with an average level of 4,174 mg/kg or 0.0047 mg/mg. Using this value and published octanol-water partition coefficient values, the maximum saturated soil contaminant level was calculated for the COCs for which an MCL was available and for 2-methylnaphthalene and naphthalene based on the risk-based PRG. The contaminants, octanol-water partition coefficients (K_{ow}) values used, calculated K_d values, assumed maximum ground water concentrations in the saturated zone (C_{sat} = MCL or PRG) and maximum saturated soil contaminant levels (S_{sat}) are presented in the first four columns of Table C-1. The depth of the saturated zone was determined by the depth to ground water for monitoring wells or the depth at which wet soils were first observed for soil borings, as reported in the Phase II RI.

To calculate the maximum acceptable unsaturated soil contaminant levels, the volumetric flow rate of ground water in the saturated zone through the unit area (Q) was calculated. The average linear velocity for the site was estimated to be 0.60 ft/day by averaging the velocity values presented in Table 2-2 of the Detailed Analysis of Alternatives for Site 06. The average

saturated thickness, estimated at 8.5 feet, was calculated by averaging the thickness of the interval from the water table surface to the top of the bedrock, as measured at the on-site monitoring wells. Therefore, for a unit width of soil,

$$Q = (0.60 \text{ ft/day})\ (8.5 \text{ ft})\ (1 \text{ ft}) = 5.1 \text{ cf/d}$$

To estimate e, the volumetric flow rate of recharge flowing downward through a unit area, the information provided in Section 1.3.2 of the Phase II RI regarding precipitation and infiltration was used. Based on an average annual precipitation of 42.3 inches and 36% infiltration, the annual infiltration is 1.27 ft/yr or 0.0035 ft/day. Therefore, for a unit area of surface,

$$e = (0.0035 \text{ ft/day})\ (1 \text{ ft})\ (1 \text{ ft}) = 0.0035 \text{ cf/day}$$

Then S_{unsat} can be calculated using equation (5), where:

$$S_{unsat} = (S_{sat})\ (e + Q)/e = (S_{sat})\ (0.0035 + 5.1)/0.0035 = (S_{sat})\ (1458)$$

The calculated S_{unsat} values are presented in column 7 of Table C-1. The maximum detected soil contaminant levels in the unsaturated zone and the location of the maximum detected concentration for each contaminant are presented in columns 8 and 9, respectively. No unsaturated soil samples exhibited contaminants at levels exceeding the calculated maximum allowable level.

TABLE C-1

Site 06 – Solvent Disposal Area
Comparsion of Soil Contaminant Levels to Modeled Soil Response Action Levels
Using the Unnamed Model (USEPA, EPA/540/2-89/057)

Column:	1	2	3	4	5	6	7	8	9
Constituent	K_{ow}	K_d	C_{sat} (ppm)	S_{sat} (ppm)	Q (cf/d)	e (cf/d)	S_{unsat} (ppm)	Max. Unsaturated Soil Concentration Detected (ppm)	Sample Location
Chloroform	89.1	0.617	0.1 T	0.0617	5.10	0.0035	90	0.002	B-06-02-00-S
Toluene	490	3.40	1 F	3.40	5.10	0.0035	4958	11	06-MW4-02
Ethylbenzene	1410	9.77	0.7 F	6.84	5.10	0.0035	9970	340	06-B07-02
Xylenes	1000	6.93	10 F	69.3	5.10	0.0035	101000	1900	06-B07-02
1,1,1-Trichloroethane	295	2.04	0.2 F	0.409	5.10	0.0035	600	0.001	B-06-01-00-S
Chrysene	2.45E+05	1698	0.0002 P	0.340	5.10	0.0035	496	0.60	06-SS02
Benzo(a)pyrene	9.55E+05	6618	0.0002 F	1.32	5.10	0.0035	1920	0.44	06-SS02
Benzo(a)anthracene	4.07E+05	2821	0.0001 P	0.28	5.10	0.0035	410	0.5	06-SS02
Benzo(b)fluoranthene	6.72E+06	46537	0.0002 P	9.31	5.10	0.0035	13575	0.64	06-SS02
Benzo(k)fluoranthene	6.92E+06	47944	0.0002 P	9.6	5.10	0.0035	14000	0.57	06-SS02
Bis(2-ethylhexyl)phthalate	1.00E+05	693	0.006 F	4.2	5.10	0.0035	6100	0.19	06-SS02
2-Methylnaphthalene	8510	59	4.1 R	241.8	5.10	0.0035	352600	8.1	06-B07-02
Naphthalene	871	6	4.1 R	24.7	5.10	0.0035	36000	0.63	B-06-03-02-S

$K_d = 0.63 \times 0.012 \times K_{ow}$ where 0.63=adjustment factor and 0.012=average total organic carbon concentration
C_{sat} = Maximum Contaminant Level or PRG; F = Final MCL; P = Proposed MCL; T = Tenative MCL; R = Risk-based PRG;
see Table C-2 for basis of calculation of PRGs for naphthalene and 2-methylnaphthalene.
$S_{sat} = C_{sat} \times K_d$
Q = Avg linear velocity * unit area
Avg linear velocity = 0.60 ft/d (from Table 4-8 of Phase II RI)
Unit Area = Avg saturated thickness to top of bedrock (8.5 ft) * unit width (1 ft) = 8.5 sq ft
Q = .60 x 8.5 = 5.1 cf/d
e = infiltration rate x unit area
Infiltration rate = 15.2 in/yr = 0.0035 ft/d (= recharge at 36% of average annual 42.3 in precipitation)
Unit area = 1 ft by 1 ft = 1 sq ft
e = 0.0035 x 1 = 0.0035 cf/d
$S_{unsat} = S_{sat} \times (e+Q)/e$

Table C-2
Non-Cancer-Risk-Based Preliminary Remediation Goals (PRGs)
for Use in Leaching Model Calculations
Assuming Future Commercial/Industrial Use
NCBC Davisville – Site 06 – Solvent Disposal Area

Constituent	Oral Reference Dose (RfD) $(mg/kd*d)^{-1}$	Oral Relative Absorption Factor (RAF) (--)	Ground Water PRG [a] (mg/l)
Methylnaphthalene, 2-	4.0E-02 [b]	1	4.1E+00
Naphthalene	4.0E-02 [b]	1	4.1E+00

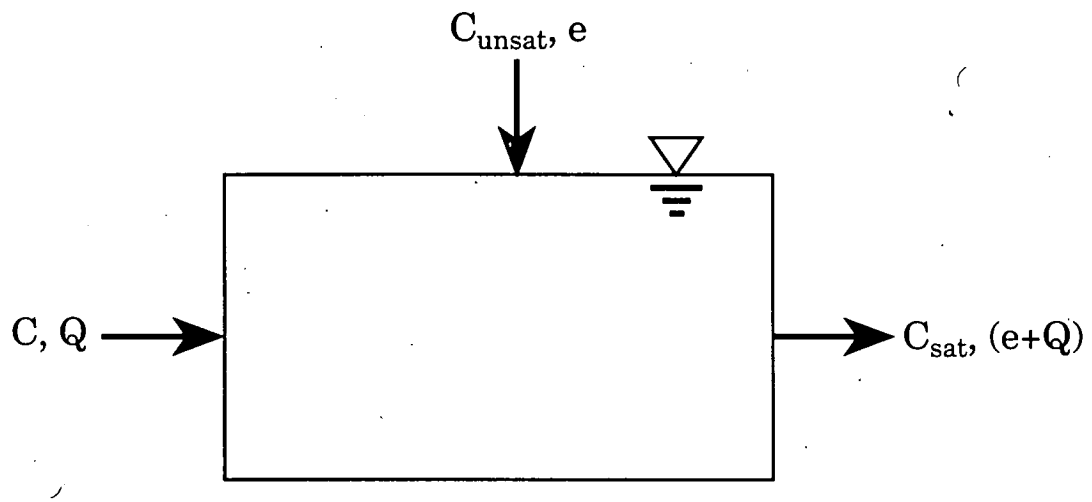
[a] Based on USEPA (1991) guidance and Phase II Human Health Risk Assessment
[b] RfD for naphthalene taken from HEAST (March 1992); this value was withdrawn by USEPA in November 1992 but was used in the Phase II HHRA per verbal guidance from EPA Region I

$PRG = [THI * AT * BW] / [(1/RfD) * IR_w * RAF_o * EF * ED]$

Where:

THI = Target hazard index:	1 --
AT = Averaging time:	9125 d
BW = Body weight:	70 kg
RfD = Reference dose:	CS Chemical-specific
IR_w = Water ingestion rate:	1 l/d
RAF_o = Oral relative absorption factor:	CS Chemical-specific
EF = Exposure frequency:	250 d/yr
ED = Exposure duration:	25 yr

FIGURE C-1
MASS BALANCE DERIVATION OF THE INFILTRATION EQUATION



$$(C_{unsat})\,(e) + (C)\,(Q) = (C_{sat})\,(e + Q)$$

$$C_{sat} = [(C_{unsat})\,(e) + (C)\,(Q)] \,/\, (e + Q)$$

Since C = 0, then:

$$C_{sat} = (C_{unsat})\,(e) \,/\, (e + Q)$$

C_{sat}	=	concentration of contaminant in ground water in saturated zone (µg/l)
C	=	initial concentration of contaminant in ground water (assumed zero)
C_{unsat}	=	contaminant concentration of ground water in recharge (µg/l)
e	=	volumetric flow rate of infiltration (cf/day)
Q	=	volumetric flow rate of ground water in the saturated zone throughout the unit (cf/day)

APPENDIX D

APPENDIX D

TECHNOLOGY AND PROCESS OPTION SCREENING

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APPENDIX D

TECHNOLOGY AND PROCESS OPTION SCREENING

Based on the general response actions developed for Site 06, remedial technologies which could potentially meet the remedial action objectives and cleanup criteria are identified and screened. This process is a two-step process in which technologies are initially screened on the basis of technical implementability. For the technologies which pass the initial screening, the process options associated with each technology are screened based on effectiveness, implementability and cost. Representative process options are then chosen based on this screening for inclusion in the comprehensive remedial alternatives developed for the site.

Technology Screening

The intent of the technology screening is to reduce the universe of potentially applicable technology types and process options based on technical implementability. Two factors which may be considered in the evaluation of the technical implementability of a technology are the type of contaminants present at a site and site-specific conditions which may limit the implementability of a technology. Examples of the application of these factors include the screening of a technology because it does not treat the contaminants of concern, or the screening of a technology which cannot be applied to a site due to site-specific subsurface conditions. The technologies or technology process options which do not pass the screening process on the basis of technical implementability are not retained for further consideration.

A combined technology screening was performed for all of the sites addressed within the Initial Screening of Alternatives Report. For the ISA report, Site 06 ground water was not included in the remedial action development process, because the data collected from the Phase I RI did not sufficiently define the nature and extent of ground water contamination. Thus, the development of remedial action objectives was postponed until the completion of the Phase II RI. The technology screening presented herein revisits the technology screening, considering the results of the Phase II RI. The Site 06 technology screening is conducted for soil in Table 3-5 of the report and for ground water in Table 3-6.

The technology screening tables each include brief descriptions of the individual technologies or process options. More detailed descriptions of the technologies are provided in the text which follows this introduction.

The technology screening tables also include comments on the general applicability of the technologies and limiting characteristics which may prevent their application at Site 06. The technology or process option title block is shaded gray only for those technologies which have been screened from further analysis.

For Site 06 soil, the potential remedial technologies presented in Table 3-5 were identified based on the remedial action objectives and consistent with the Superfund program, as outlined in the National Contingency Plan [NCP, 40 CFR 300.430(a)(1)]. The technologies which were identified include no action and site use restrictions. Active remediation of Site 06 surface soils was not considered because the surface soils do not pose a principal threat to human health or the environment, as described in Section 3.2.1 of the report. None of the identified technologies chosen were screened from further consideration based on technical implementability.

The potential remedial technologies identified for ground water at Site 06 include no action, ground water monitoring, ground water use restrictions, extraction, off-site treatment, inorganic treatment, and discharge. In ground water, only inorganic contaminants exceeded water quality standards. Therefore, when considering treatment technologies, only those process options which address inorganic contaminants were included in the screening process. One technology, off-site treatment, was screened from further consideration. Off-site treatment was screened based on difficulties associated with the technical implementability of off-site ground water treatment at a POTW or at a RCRA facility. Ground water process options screened from further consideration based on technical implementability include provision of an alternative water supply, well point extraction system, membrane microfiltration, filtration and discharge of treated ground water to the POTW. Due to the lack of potable ground water receptors, provision of an alternate water supply is not technically implementable. Due to the silty formation at Site 06, well points would not be effective means of extracting ground water. Membrane microfiltration and filtration were eliminated because analytical results for filtered and unfiltered Phase II RI ground water samples indicated that detected inorganics are likely to be dissolved and would not be removed by filtration mechanisms. Discharge of treated ground

water to a POTW was eliminated because of preliminary indications that the POTW would not be amenable to accepting such discharges.

Process Option Screening

Upon identification of those technologies which are technically implementable, the process options are further evaluated to allow the selection of representative process option(s) for each technology type. In the process option screening, the process options are evaluated on the basis of effectiveness, implementability, and cost. Factors considered in the effectiveness evaluation include the effectiveness of the process in handling the estimated areas or volumes of media, its ability in meeting remediation goals, potential impacts to human health and the environment during construction and implementation, and how proven and reliable the process is. Both technical and administrative feasibility are considered in the implementability evaluation, while relative capital and O&M costs are broadly compared in the cost evaluations.

The process option evaluation for soil is presented in Table 3-7 of the report and the evaluation for ground water is presented in Table 3-8. The selected representative process options are indicated with a bullet in these tables.

Due to the limited number of process options evaluated for soil, all of the process options were retained for further consideration, as indicated in Table 3-7.

For ground water, one process option for extraction was selected for further consideration. The use of extraction wells was considered, but based on the low monitoring well extraction rates observed during the RI, sustainable extraction rates would be minimal. Based on the shallow depth to ground water, shallow depth to bedrock, and the potential for an increased extraction rate offered by an interceptor trench, the interceptor trench was selected for further consideration.

For inorganic treatment, precipitation, and ion exchange treatment were selected as representative process options to be used for remedial alternative development. Filtration processes (both filtration and microfiltration) were screened in the technology screening because they may not be successful in achieving inorganic PRGs alone, since inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved

rather than suspended (filtered and unfiltered results were comparable). However, filtration will be considered as a potential pretreatment process for either precipitation or ion exchange, since the silty nature of the ground water at Site 06 could interfere with the effectiveness of the precipitation or ion exchange processes. Filtering would remove the suspended solids from the ground water to increase the effectiveness of the precipitation and ion exchange treatment systems. Ion exchange is a commonly used inorganic treatment technology but the resin must be tailored to the contaminants requiring treatment. Precipitation is a commonly used treatment technology for which significant treatability data exists. Therefore, precipitation and ion exchange treatments were selected as representative inorganic treatment process options.

For ground water discharge, discharge to surface water was selected as a representative discharge option. Due to the presence of inorganics in the upgradient well at levels exceeding MCLs and risk-based PRGs, discharge to ground water was not selected based on the uncertainty associated with locating an appropriate discharge location. Discharge to surface water was also considered to be more administratively implementable and more economically feasible than discharging to a POTW.

TECHNOLOGY AND PROCESS OPTION SCREENING

SOIL REMEDIAL TECHNOLOGIES

Site Use Restrictions

Site use restrictions are intended to prevent or reduce exposure to on-site contamination. They include actions such as fencing, signage, and restrictive covenants on the property deed to prevent development of the site or use of the ground water of the site. Site use restrictions may also be imposed to reduce required maintenance and to protect the integrity of a remedial alternative. Conditions in the area of the site should be evaluated in the five-year reviews to assess the continuing or future need for site use restrictions. Two types of access restrictions typically used at hazardous waste sites include deed restrictions and fencing.

Deed Restrictions

Deed restrictions are intended to prevent or limit site use and development. Restrictive covenants, written into the property deed, notify any potential purchaser of the site property that the land use must be restricted in order to ensure the integrity of any waste remediation systems, if they exist. Based on the closure of the NCBC facility, deed restrictions could be incorporated into property transfer documents, as required. The effectiveness of deed restrictions depends on state and local laws, continued enforcement, and maintenance.

Fencing

Fencing is used to physically limit access to the site. The most common type of fence used to limit access is a chain-link fence about eight feet high. Signs may be posted to make clear to potential trespassers that there may be a health threat associated with direct exposure to the site. Fencing may also help reduce the required maintenance and protect the integrity of a remediation system.

GROUND WATER REMEDIAL TECHNOLOGIES

Institutional Control

Institutional controls are intended to minimize exposures to contaminated ground water. They include actions such as ground water monitoring, ground water use restrictions and provision of alternate water supplies. If a five-year review is required for a remedial action involving institutional controls, site conditions such as ground water monitoring results, if available, or changes in ground water usage should be reviewed to determine the need for continuing or future site use restrictions.

Ground Water Monitoring

Ground water monitoring provides a means to assess changes in ground water quality and contaminant migration patterns.

Ground Water Use Restrictions

Ground water use restrictions are intended to prevent or reduce exposure to ground water contamination. The use of ground water below or adjacent to the site is usually restricted. Ground water use restrictions may encompass potable use as well as non-potable use of the ground water. At Site 06, potable use would not be anticipated due to the industrial nature of the area, the GB ground water classification, and the easy access to municipal water supplies. However, non-potable use could be conceivable in association with potential future industrial site use.

Alternate Water Supply

Alternate water supply represents another type of institutional control in restricting ground water usage. Basically, ground water that is contaminated is no longer utilized as a potable water source, and an alternate source is provided. Since ground water is not used for potable water supply in the vicinity of Site 06, this process option is screened from further consideration.

Extraction

Extraction technology provides a means to collect contaminated ground water at a site. Various means of extraction include extraction wells, well points, or interceptor trenches.

Extraction Wells

Extraction wells represent a conventional technology which is frequently used in the removal of contaminated ground water. Stainless steel or PVC well casings and screens are installed within the contaminated ground water, and submersible pumps are typically used to extract water from the well. An array of wells with overlapping radii of influence can be designed to capture an entire plume or to halt contaminant migration. At Site 06, limited extraction rates were sustainable within on-site monitoring wells during the RI.

Well Points

This ground water extraction technology involves the removal of ground water through a group of closely spaced wells connected by a header pipe. The wells are installed by driving a perforated pipe with a pointed cap into the area to be dewatered. Well point systems are best suited for shallow aquifers where extraction is not needed below twenty feet. The suction lifting pump technique commonly employed with well points is effective up to this depth. However, well points are ineffective when high percentages of silt or clay are present in site soils. Due to the silty nature of soils at Site 06, this technology has been screened from further evaluation.

Interceptor Trench

Interceptor trenches may be employed as a means of collecting ground water through the use of a perforated pipe placed below the natural ground water table. Ground water enters the perforated pipe and flows by gravity to the lowest point in the pipe, where it is pumped to the surface for treatment and/or discharge. This technology is typically limited to areas where the depth to ground water is not so

deep that trench construction becomes prohibitively expensive or complicated (bracing, etc.). This technology offers the advantage of a horizontally oriented intake structure which allows collection of ground water within the area of interest. Additionally, trenches are relatively simple to construct and are passive structures with little maintenance required. Based on the shallow depth to ground water at Site 06, this technology is retained for further consideration.

Off-Site Treatment

Off-site treatment utilizes an off-site facility to treat extracted ground water. The contaminated ground water must be transported or conveyed to the treatment facility. Costs associated with conveyance or transportation can be extremely expensive if the distance from the site to the off-site treatment facility is far. Two types of off-site treatment facilities include publicly owned treatment works (POTW) and RCRA treatment facilities.

Off-Site Treatment at a POTW

This technology involves the discharge of aqueous wastes, which can constitute the majority of waste treated during a remedial cleanup effort, from a site to a Publicly Owned Treatment Works (POTW) for off-site treatment. These aqueous wastes can include ground water, leachate, surface water runoff, or other aqueous wastes. A number of criteria must be met when utilizing a POTW. These restrictions, as they apply to CERCLA sites, are detailed in the U.S. EPA's CERCLA Site Discharges to POTWs: Guidance Manual (U.S. EPA, 1990a). Typically, the wastes are piped to the POTW via an existing sanitary sewer or by constructing a dedicated sewer line. No sanitary sewers are present in the immediate vicinity of Site 06. An additional concern of POTWs in accepting a discharge from a CERCLA site is the issue of whether the POTW is then considered a hazardous waste treatment facility. Therefore, the administrative acceptability of discharging water to a POTW may be limited. Based on these considerations, off-site treatment at a POTW will be screened from further consideration.

Off-Site Treatment at a RCRA Facility

Discharge to a RCRA facility also represents a potential off-site treatment technology for remediating contaminated ground water and other aqueous wastes. The extracted ground water is collected and transported off-site to a licensed RCRA facility for treatment. High extraction rates and the distance to the nearest RCRA treatment facility can greatly limit the cost-effectiveness of this alternative. This technology is screened from further consideration based on the lack of a locally available RCRA treatment facility.

Inorganic Treatment

Inorganic treatment typically involves physical or chemical treatment processes, as discussed below.

Ion Exchange

Ion exchange is a process whereby the toxic ions are removed from the aqueous phase by being exchanged with relatively harmless ions held by the ion exchange material. Ion exchange is a well-established technology for removal of heavy metals and hazardous anions from dilute solutions. Ion exchange can be expected to perform well for these applications when fed wastes of variable composition, provided the system's effluent is continually monitored to determine when the resin bed exhaustion has occurred. However, the reliability of ion exchange is markedly affected by the presence of suspended solids.

Ion exchange systems are commercially available from a number of vendors. The units are relatively compact and are not energy intensive. Although exchange columns can be operated manually or automatically, manual operation is better suited for hazardous waste site applications because of the diversity of wastes encountered. In addition, use of several exchange columns at a site can provide considerable flexibility. Ion exchange, with filtration pretreatment to remove suspended solids, will be retained for further consideration.

Precipitation

Precipitation is a physicochemical process whereby some or all of a substance in solution is transformed into a solid phase. It is based on alteration of the chemical equilibrium relationships affecting the solubility of inorganic species. Removal of metals as hydroxides or sulfides is the most common precipitation application in wastewater treatment. Generally, lime or sodium sulfide is added to the wastewater in a rapid mixing tank along with flocculating agents. The wastewater flows to a flocculating chamber in which adequate mixing and retention time is provided for agglomeration of precipitate particles. Agglomerated particles are separated from the liquid phase by settling in a sedimentation chamber, and/or by other physical processes such as filtration. Precipitation, with filtration pretreatment, will be retained for further evaluation.

Membrane Microfiltration

Membrane microfiltration involves the use of an automatic pressure filter in which the filter material has tiny openings (0.10 microns or 1 ten-millionth of a meter) which allow for the filtration of particles normally not separated from the wastestream using standard filtration processes. Membrane microfiltration is most applicable to hazardous waste suspensions, ground water contaminated with heavy metals, landfill leachate and process wastewaters containing uranium (U.S. EPA, 1991). Filtration processes (both filtration and microfiltration) may not be successful in meeting inorganic remediation goals since inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved rather than suspended (filtered and unfiltered results were comparable). For this reason, membrane microfiltration is screened from further consideration.

Filtration

Filtration is a type of physical separation of a solid material based on particle size. As commonly employed in ground water treatment, filtration involves the separation of suspended solids, primarily silt, from the influent stream. Filters generally work on the same principal as a domestic vacuum cleaner whereby particles are intercepted in a fabric. Fabric size, particle size, and density differences each play a role in the proper selection of a filtration device. Inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved rather than suspended (filtered and unfiltered results were comparable). Therefore, filtration would not be effective as a "stand-alone" treatment, but will be considered as a pretreatment process to improve the efficiency of the treatment technology.

Electrochemical

Electrochemical treatment provides treatment of inorganic contaminants. Contaminated water passes through an electrochemical cell where ferrous ions, hydroxide ions and hydrogen are produced. The ferrous ions act as reducing agents for oxidized heavy metals and also react with the hydroxide ions, forming iron hydroxides and metal hydroxides. The metal hydroxides are removed by adsorption onto the iron hydroxide precipitate that is formed (Hazardous Waste Consultant, 1991). Electrochemical treatment will be retained for further consideration since it is an innovative technology and has been proven effective for inorganic treatment during test operations.

Discharge

Following treatment, extracted ground water must be discharged back to the environment. Several options exist for the discharge of ground water, as described below.

Discharge to Ground Water

Treated ground water can be discharged to ground water using recharge basins, infiltration galleries or reinjection wells. The technology selected for recharge is dependent on site-specific considerations such as available space, extent of contamination, and hydrogeology. Ground water recharge systems can provide an added element of hydraulic control to ground water extraction systems. Typically recharge systems can be subject to clogging or other operational problems and must be closely monitored. Compliance with ground water discharge regulations must also be maintained. Since ground water in the vicinity is classified GB, discharge to ground water will be retained for further consideration. However, the presence of inorganics in the Site 06 upgradient well at levels exceeding ARARs and risk-based PRGs may complicate the placement of a ground water recharge system.

Discharge to Surface Water

Treated ground water can also be discharged to a surface water body. The nearest surface water body to Site 06 would be Hall Creek, located approximately 600 feet northeast of the site. Hall Creek discharges into Frys Pond. Implementation of this alternative would require compliance with NPDES discharge requirements. Discharge to surface water will be retained for further consideration.

Discharge to Sanitary Sewer/POTW

If available nearby, discharge of treated or untreated ground water to a sanitary sewer for subsequent treatment at a Publicly Owned Treatment Works (POTW) is a possible alternative. No sanitary sewers are present in the vicinity of Site 06. Many POTWs have regulations prohibiting discharges of ground water to the treatment system and special approval for such a discharge may be required. The POTW may also require pretreatment of the wastestream prior to acceptance. An additional concern of POTWs in accepting a discharge from a CERCLA site is the issue of whether the POTW is then considered a hazardous waste treatment facility. The administrative acceptability of discharging water to a POTW may therefore be

limited. Based on these considerations, this option will be screened from further evaluation.

APPENDIX E

APPENDIX E

REMEDIAL COST ESTIMATES

Cost estimates are provided for the following alternatives:

SOIL ALTERNATIVES

Alternative S-2, Deed Restrictions and Fencing

GROUND WATER ALTERNATIVES

Alternative GW-2 , Long-Term Monitoring

Alternative GW-3A, Extraction of Ground Water via Interceptor Trench

Alternative GW-3B, Chemical Precipitation

Alternative GW-3C, Ion Exchange

Alternative GW-3D, Discharge to Surface Water

ALTERNATIVE S–2
DEED RESTRICTIONS AND FENCING
SITE 06 – SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST – DIRECT										
Fencing										
– Chain Link , 9 gauge wire, aluminized steel, 6' high	650 l. ft.		$13.75	1994	2	1.000	$13.75	$8,937.50		
– Double Swing Gate 6' high, 4' opening	1	each	$252.00	1994	2	1.000	$252.00	$252.00		
– Warning Signs	6	each	$45.50	1994	2	1.000	$45.50	$273.00		
Total Fencing Cost										$9,462.50
Direct Capital Cost Subtotal										$9,462.50
CAPITAL COSTS – INDIRECT										
Engineering and Design (10%)					1			$946.25		
Legal and Administrative (4%)					1			$378.50		
Indirect Capital Cost Total										$1,324.75
TOTAL CAPITAL COSTS										$10,787.25
OPERATION AND MAINTENANCE COSTS										
Site Fence Maintenance	1	each	$300.00	1994	5	1.000	$300.00	$300.00	30	$4,611.60
ANNUAL O & M COST								$300.00		
TOTAL NET PRESENT VALUE OF O & M										$4,611.60
SUBTOTAL COST										$15,398.85
CONTINGENCY (20%)										$3,079.77
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S–2										$18,478.62

(1) – Calculated based on 5% interest rate.

ALTERNATIVE GW–2
LONG–TERM GROUND WATER MONITORING
SITE 06 – SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
TOTAL CAPITAL COSTS										$0.00
OPERATION AND MAINTENANCE COSTS										
Ground Water Monitoring (including trip blanks, field blanks and duplicate samples)										
– Annual Sampling	7	samples	$300.00	1994	5	1.000	$300.00	$2,100.00	30	$32,281.20
– Analysis: TAL + cyanide	8	samples	$320.00	1994	3	1.000	$320.00	$2,560.00	30	$39,352.32
– Report Preparation	1	each	$3,000.00	1994	5	1.000	$3,000.00	$3,000.00	30	$46,116.00
ANNUAL O&M (1994 $)								$7,660.00		
TOTAL NET PRESENT VALUE OF O & M										$117,749.52
SUBTOTAL COST										$117,749.52
CONTINGENCY (20%)										$23,549.90
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW–2										$141,299.42

(1) – Calculated based on 5% interest rate.

ALTERNATIVE GW–3, OPTION A
EXTRACTION OF GROUND WATER VIA INTERCEPTOR TRENCH
SITE 06 – SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST – DIRECT										
Ground Water Extraction Trench										
–Excavation and Backfill	360	cu. yd.	$3.59	1994	2	1.000	$3.59	$1,292.40		
–1/2" Crushed Stone	220	cu. yd.	$30.00	1994	2	1.000	$30.00	$6,600.00		
–Geotextile Filter Fabric	430	sq. yd.	$1.41	1994	2	1.000	$1.41	$606.30		
–4" O.D. Slotted HDPE	120	l. ft.	$6.95	1994	2	1.000	$6.95	$834.00		
–Submersible Pumps	2	each	$196.00	1994	2	1.000	$196.00	$392.00		
–Pre–Cast Concrete Manhole	2	each	$2,584.00	1994	2	1.000	$2,584.00	$5,168.00		
Pipe Trench from Manhole to Treatment Area										
– 1 1/4" O.D. Non–Slotted HDPE Pipe	200	l. ft.	$4.60	1994	2	1.000	$4.60	$920.00		
–Excavation and Backfill	50	cu. yd.	$3.59	1994	2	1.000	$3.59	$179.50		
–Bedding Sand	25	cu. yd.	$16.20	1994	2	1.000	$16.20	$405.00		
Total Ground Water Extraction Trench										$16,397.20
Pizeometer Installation										
– 4 20–ft Piezometers – 2"	4	each	$1,760.00	1992	6	1.077	$1,895.52	$7,582.08		
Total Piezometer Installation										$7,582.08
Total Direct Capital Cost Subtotal										$23,979.28
CAPITAL COST – INDIRECT										
Engineering and Design (10 %)					1			$2,397.93		
Legal and Administrative (4%)					1			$959.17		
Total Indirect Capital Cost										$3,357.10
TOTAL CAPITAL COSTS										$27,336.38
OPERATION AND MAINTENANCE COSTS										
Piezometer Monitoring	48	hours	$100.00	1994	5	1.000	$100.00	$4,800.00	10	$35,652.96
ANNUAL O&M (1994$)								$4,800.00		
TOTAL NET PRESENT VALUE OF O&M										$35,652.96
SUBTOTAL										$62,989.34
CONTINGENCY (20%)										$12,597.87
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW–3, OPTION A										[illegible]587.21

(1) – Calculated based on 5% interest rate.

ALTERNATIVE GW–3, OPTION B
CHEMICAL PRECIPITATION
SITE 06 – SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST – DIRECT										
Precipitation Treatment System										
– Neutralization/Precipitation/ Filtration/Filter Press Unit	1	each	$72,000.00	1987	9	1.219	$87,768.00	$87,768.00		
– Electrical Connections	1	LS.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
– Equalization Tank	1	LS.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
Total Ground Water Treatment System Cost										$127,768.00
Direct Capital Cost Subtotal										$127,768.00
CAPITAL COST – INDIRECT										
Engineering and Design (15%)					1			$19,165.20		
Legal and Administrative (5%)					1			$6,388.40		
Total Indirect Capital Cost										$25,553.60
TOTAL CAPITAL COSTS										$153,321.60
OPERATION AND MAINTENANCE COSTS										
– Precipitation O&M	5,256	1000 gal	$8.00	1985	18	1.281	$10.25	$53,863.49	10	$415,933.85
ANNUAL O&M (1994 $)								$53,863.49		
TOTAL NET PRESENT VALUE OF O&M										$415,933.85
SUBTOTAL										$569,255.45
CONTINGENCY (20%)										$113,851.09
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW–3, OPTION B										$683,106.55

(1) – Calculated based on 5% interest rate.

ALTERNATIVE GW-3, OPTION C
ION EXCHANGE
SITE 06 - SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Ground Water Treatment System										
-Ion Exchange Unit (with pre-filtration)	1	each	$122,300.00	1987	7	1.219	$149,083.70	$149,083.70		
-Electrical Connection	1	L.S.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
-Piping and Controls	1	L.S.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
-Transfer Pumps	2	each	$580.00	1992	2	1.000	$580.00	$1,160.00		
Total Direct Cost										$190,243.70
CAPITAL COST - INDIRECT										
Engineering and Design (15 %)								$28,536.56		
Legal and Administrative (5%)								$9,512.19		
Total Indirect Capital Cost										$38,048.74
TOTAL CAPITAL COSTS										$228,292.44
OPERATION AND MAINTENANCE COSTS										
Ion Exchange O&M										
-Ion Exchange O&M	1	year	$10,940.00	1987	7	1.219	$13,335.86	$13,335.86	10	$102,979.51
ANNUAL O&M (1994 $)								$13,335.86		
TOTAL NET PRESENT VALUE OF O&M										$102,979.51
SUBTOTAL										$331,271.95
CONTINGENCY (20%)										$66,254.39
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-3, OPTION C										$397,526.34

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW–3, OPTION D
DISCHARGE TO SURFACE WATER
SITE 06 – SOLVENT DISPOSAL AREA

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST – DIRECT										
Piping From Treatment System To Surface Water										
– Trench Excavation & Backfill	600 l. ft.		$5.73	1994	2	1.000	$5.73	$3,438.00		
– 2" Diam. PVC in Trench	600 l. ft.		$4.60	1994	2	1.000	$4.60	$2,760.00		
– Pipe Bedding (sand)	600 l. ft.		$1.32	1994	2	1.000	$1.32	$792.00		
Total Piping Cost										$6,990.00
Direct Capital Cost Subtotal										$6,990.00
CAPITAL COST – INDIRECT										
Engineering and Design (10%)					1			$699.00		
Legal and Administrative (4%)					1			$279.60		
Total Indirect Capital Cost										$978.60
TOTAL CAPITAL COSTS										$7,968.60
OPERATION AND MAINTENANCE COSTS										
Discharge Sampling & Analysis										
– Monthly Sampling	12 samples		$300.00	1994	5	1.000	$300.00	$3,600.00	10	$27,799.20
– TAL + cyanide	12 samples		$320.00	1994	13	1.000	$320.00	$3,840.00	10	$29,652.48
ANNUAL O&M (1994 $)								$7,440.00		
TOTAL NET PRESENT VALUE OF O&M										$57,451.68
SUBTOTAL										$65,420.28
CONTINGENCY (20%)										$13,084.06
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW–3, OPTION D										$78,504.34

(1) – Calculated based on 5% interest rate.

COST REFERENCES

1) Remedial Action Costing Procedures Manual; JRB Associates; October 1987.

2) Means Site Work & Landscape Cost Data; 1994.

3) Complete Environmental Testing, Inc.; 1994.

4) Remedial Action at Waste Disposal Sites; October 1985. EPA/625/6-85/006.

5) TRC Environmental Corporation; 1994.

6) Empire Soils Investigations, Inc., Division of Huntingdon; January 1992.

7) Technical Resource Document; Treatment Technologies for Metals/Cyanide Containing Wastes, Alliance Technologies Corp.; December 1987.

APPENDIX F

APPENDIX F

GROUND WATER MODELING SUMMARY

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APPENDIX F

GROUND WATER MODELING SUMMARY

1.0 INTRODUCTION/OBJECTIVES

Under Alternative GW-3A - Ground Water Extraction via Interceptor Trench, a system of one or more ground water interceptor trenches was proposed for the capture and extraction of impacted Site 06 ground water from the unconsolidated overburden for treatment and disposal. The Phase I and Phase II RI field investigations revealed that at Site 06 the depth to bedrock is shallow (15 to 20 feet) and the silt content of the unconsolidated overburden aquifer appears to yield low hydraulic conductivity values (K-values) and pumping rates. Due to these circumstances, interceptor trenches were judged to be a more effective means than extraction wells in providing effective capture of the Site 06 ground water and preventing off-site migration of the ground water contaminants. In order to produce a preliminary interceptor trench design for the purposes of option analysis, evaluation, and costing, a ground water flow model was used to: 1) simulate the ground water flow regime at Site 06, and 2) configure an interceptor trench system to provide control and capture of the estimated areal extent of site ground water with contaminant concentrations exceeding ARARs and/or risk-based PRGs. ARARs and/or risk-based PRGs were exceeded in the Phase I and/or Phase II samples from all of the Site 06 shallow and deep monitoring wells except shallow monitoring well 06-MW05S, located at the hydraulically downgradient (northeastern) margin of the site. Therefore, the area of Site 06 requiring ground water capture, extraction and treatment was assumed to include the entire site except the area immediately surrounding 06-MW05S. In addition, within the estimated area of ground water impacts, it was assumed that the entire saturated interval between the shallow water table and the bedrock underlying Site 06 would require capture and extraction. A description of the modeling procedures, including the model assumptions and the input initial and boundary conditions, is presented in the following sections. Model data sheets are provided following this summary and the associated figures.

2.0 INITIAL MODEL SETUP

FLOWPATH™ Version 3.0 (Waterloo Hydrogeologic Software, 1992), a two-dimensional numerical ground water flow and particle pathlines simulation model, was used to simulate the Site 06 ground water flow regime and to design the proposed ground water interception trench system. The area encompassed by the FLOWPATH™ model grid is shown in Figure F-1. The grid was configured with the principal axes oriented to parallel the direction of shallow ground water flow at Site 06 (southwest to northeast). The model grid is comprised of 36 rows and 28 columns; the variable nodal spacing ranges from 10 to 20 feet. The grid measures 520 feet by 580 feet, for a total simulation area of 301,600 square feet (6.9 acres). The nodal spacing was considered to be optimal to provide coverage of the large modeled area while also allowing flexibility in the development and optimization of the interceptor trench configuration.

A one-layer simulation was used to simulate the Site 06 unconsolidated overburden aquifer. The aquifer was modeled as unconfined, where a portion of the water stored in the aquifer is released by dewatering of the aquifer, and the transmissivity is a product of the hydraulic conductivity (K-value) and the saturated thickness (the hydraulic head minus the elevation of the aquifer bottom at bedrock). The initial input nodal K-value was 7.0 ft/d; this value represents the median K-value determined from the slug tests conducted at monitoring wells 06-MW01D, 06-MW04S and 06-MW05S during the Phase II RI field investigation (Table 4-6, Phase II RI, TRC, 1993). The input aquifer porosity was 0.15 (15 percent); this value represents the average typical value for silty sands determined from 55 field sites (EPRI, 1985). The aquifer bottom was input as 3.1 feet above mean sea level (ft msl), the average bedrock elevation value determined from the boring logs for monitoring wells 06-MW01D, 06-MW04S and 06-MW05S and the "06-MW03D" core boring at 06-MW03S.

A large area was modeled to account for the spatial distribution and potential influence area of the interception trench system; a substantial distance between the system components and the model boundaries must be maintained to limit the influence of boundary effects. The model boundaries were extended outward as far as considered practical when taking into account the areal range of Site 06 water level data points available. As the modeled area of the unconsolidated overburden aquifer is not bounded on any side by an impermeable boundary, constant-head boundaries were placed at the edges of the modeled area to establish flow through

the model. The potential constant head boundary effects are considered to be minimal and conservative.

3.0 MODEL CALIBRATION

The ground water flow model was calibrated to steady-state (non-stressed) conditions existing at Site 06 on August 13, 1993. After each model run was conducted, the nodal K-value and/or constant head boundary head values were adjusted as necessary until the model was calibrated to the non-pumping conditions at Site 06 on August 13, 1993. Figure F-2 shows the results of the steady-state calibration for the unconsolidated overburden aquifer at the site. The nodal K-values were kept at the initial input value of 7.0 ft/d.

4.0 REMEDIAL SIMULATIONS

After completing the model calibration, remedial simulations were run to establish the optimal configuration of an interceptor trench system for capturing the unconsolidated overburden ground water flow from areas that were found in the Phase I and Phase II RI field investigations to exhibit contamination above ARARs and/or risk-based PRGs. It was assumed that a trench or trenches would be located in the area of the presumed downgradient edge of the ground water plume, just south of monitoring well 06-MW05S.

Preliminary Remedial Simulations - Extraction Wells

Prior to simulating the interceptor trench system, a preliminary evaluation was made whereby a system of ground water extraction wells was simulated to assist in the determination of the optimum locations and extraction rates for the trenches. The resulting ground water hydraulic head distributions and corresponding model-calculated ground water particle pathlines were inspected to ensure that adequate capture was accomplished across the estimated area of ground water to be extracted and treated. Because monitoring well 06-MW02 is separated from the rest of the site by Exeter Street, it was determined that two separate areas of extraction, one on each side of Exeter Street, would be required in order to capture the ground water from the entire estimated areal extent of Site 06 with ground water contaminant levels in excess of ARARs and/or risk-based PRGs. Based on the low yields (approximately 0.5 gallon per minute) of the Site 06 monitoring wells during their development, it was determined that a system of four extraction wells, located in the northeastern portion of the site and each extracting at a rate of 0.5 gpm, would provide adequate control and capture of the impacted site ground water.

Final Remedial Simulations - Interceptor Trenches

After completing the preliminary extraction well simulations, numerous interceptor trench remedial simulations were run to determine the optimum combination of number, locations, lengths and extraction rates of trenches to provide hydraulic control and capture equivalent to that produced by the simulated extraction wells. The resulting ground water hydraulic head distributions and corresponding model-calculated ground water particle pathlines were inspected to ensure that adequate capture was accomplished across the estimated area of ground water to

be extracted and treated. The capture zones were limited to those portions of the flow regime where the ground water particles were shown migrating toward and into the trenches for extraction. Based on the results of the preliminary extraction well simulations, it was assumed that each trench would be capable of capturing and extracting the site ground water at a rate of one gpm. The position and length of the trenches were adjusted until capture of the ground water requiring extraction and treatment was shown. In addition, the trench system configuration was adjusted so that neither of the trenches would cross under Exeter Street nor lie too close to Warehouse No. 38.

5.0 RESULTS OF INTERCEPTOR TRENCH REMEDIAL SIMULATIONS

The evaluation of the interceptor trench simulations determined that two separate 60-foot-long interceptor trenches, one on each side of Exeter Street and each extracting ground water at a rate of one gpm, would be required in order to capture the ground water from the entire estimated areal extent of Site 06 with ground water contaminant levels in excess of ARARs and/or risk-based PRGs. Figure F-3 shows the locations of the two trenches, as well as the hydraulic head distribution resulting from the two gpm total extraction at the trenches. Figure F-4 presents the model-calculated ground water particle pathlines, and shows the extent of capture that the trenches would establish as modeled. Figure 4-1 also shows the locations of the two trenches. The trenches would be located in the northeastern portion of the site, and would be elongated northwest-southeast, or perpendicular to the principal direction of site ground water flow, to the northeast.

6.0 RECOMMENDED INTERCEPTOR TRENCH SYSTEM DESIGN

Interceptor Trenches

The proposed Site 06 ground water interceptor trenches should be designed to intercept the entire saturated thickness at their locations. Based on the Phase II RI monitoring well logs for 06-MW01D, "06-MW03D", 06-MW04S and 06-MW05S, it is estimated that the average depth to bedrock in the proposed trench areas is 20 feet below grade. Each trench would therefore be approximately 60 feet long, 20 feet deep and 3 to 4 feet wide, and would be equipped on one end with a precast manhole sump into which the intercepted ground water would flow to be lifted by means of a submersible pump to the surface for treatment. A typical interceptor trench cross-section is provided as Figure 4-2. Within each trench, the drain itself would consist of a 60-foot length of 4-inch O.D. perforated HDPE pipe placed at a slight incline toward the sump end of the trench, to direct drainage flow toward the sump. The placement depth of the drain pipe and sump would depend on the shallowest depth to bedrock at each trench location, expected to be approximately 15 to 20 feet below grade.

At each trench after excavation, a nonwoven geotextile fabric filter should be installed around the trench perimeter to surround the gravel envelope for the pipe drain and inhibit the entrance of fines into the trench. The gravel envelope, consisting of one-half- to three-quarter-inch diameter crushed stone, would then be installed to surround the drainage pipe. At least one foot of compacted gravel should underlie the drainage pipe to establish a gravel bed for the pipe. After installing the drain pipe, additional gravel should be installed and compacted up to a depth of eight feet below grade (the approximate maximum seasonal high ground water level); the fabric filter should then be wrapped over the top of the gravel envelope. The remainder of the trench should then be backfilled with excavated soil, compacted and brought to original grade. The trench sump should be fitted with a one-quarter-horsepower sump pump to lift the intercepted ground water to the surface for treatment.

Piezometers

In order to monitor the effectiveness of the interceptor trenches in providing capture of the site ground water, a system of ground water piezometers should be installed surrounding each trench. It is proposed that a total of four piezometers, one hydraulically upgradient

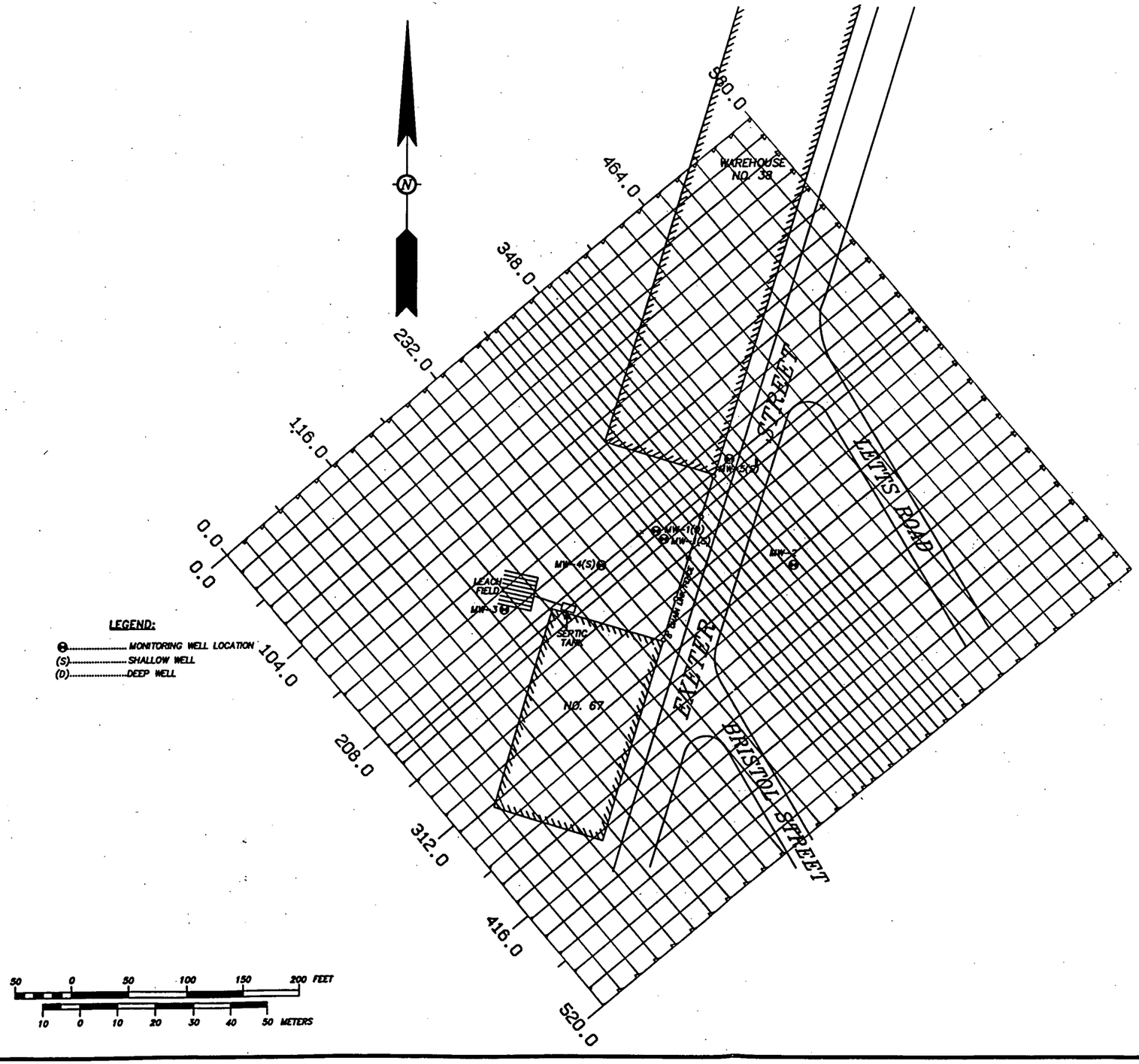
(southwest) and one downgradient (northeast) of each trench, be installed after the trench installation. Figure 4-1 shows the locations of the piezometers relative to the trench locations. The piezometers would be located approximately 10 feet from the sides of each trench, and would be installed midway along the trench length. Each piezometer would be installed to screen the aquifer from the water table to bedrock, with a total depth of approximately 15 to 20 feet below grade. Each piezometer would be constructed of two-inch I.D. Schedule 40 PVC, with approximately the bottom 15 feet screened with 0.010-inch slotted screen.

REFERENCES - APPENDIX F

Electric Power Research Institute (EPRI), 1985. A review of field-scale physical solute transport processes in saturated and unsaturated porous media. EPRI EA-4190, Electric Power Research Institute, Palo Alto, California.

TRC Environmental Corporation (TRC), 1993. Phase II Remedial Investigation Report, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division, Naval Facilities Engineering Command, Philadelphia, Pennsylvania. Contract No. N62472-86-C-1282, November 1993.

Waterloo Hydrogeologic Software, 1992. FLOWPATH™ Version 3.0 Steady-State Two-Dimensional Horizontal Aquifer Simulation Model. Waterloo Hydrogeologic Software, Waterloo, Ontario, Canada.

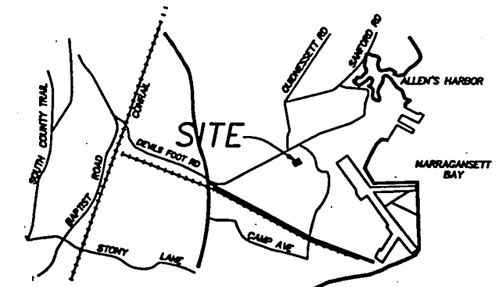


LEGEND:

- ⊖ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL

50 0 50 100 150 200 FEET

10 0 10 20 30 40 50 METERS



LOCUS

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. RAIL ROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1.

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE, A.B.D., NAVY DEPT. ACC. NO. 32112, SHEET NO. 1542.

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5 Waterside Crossing
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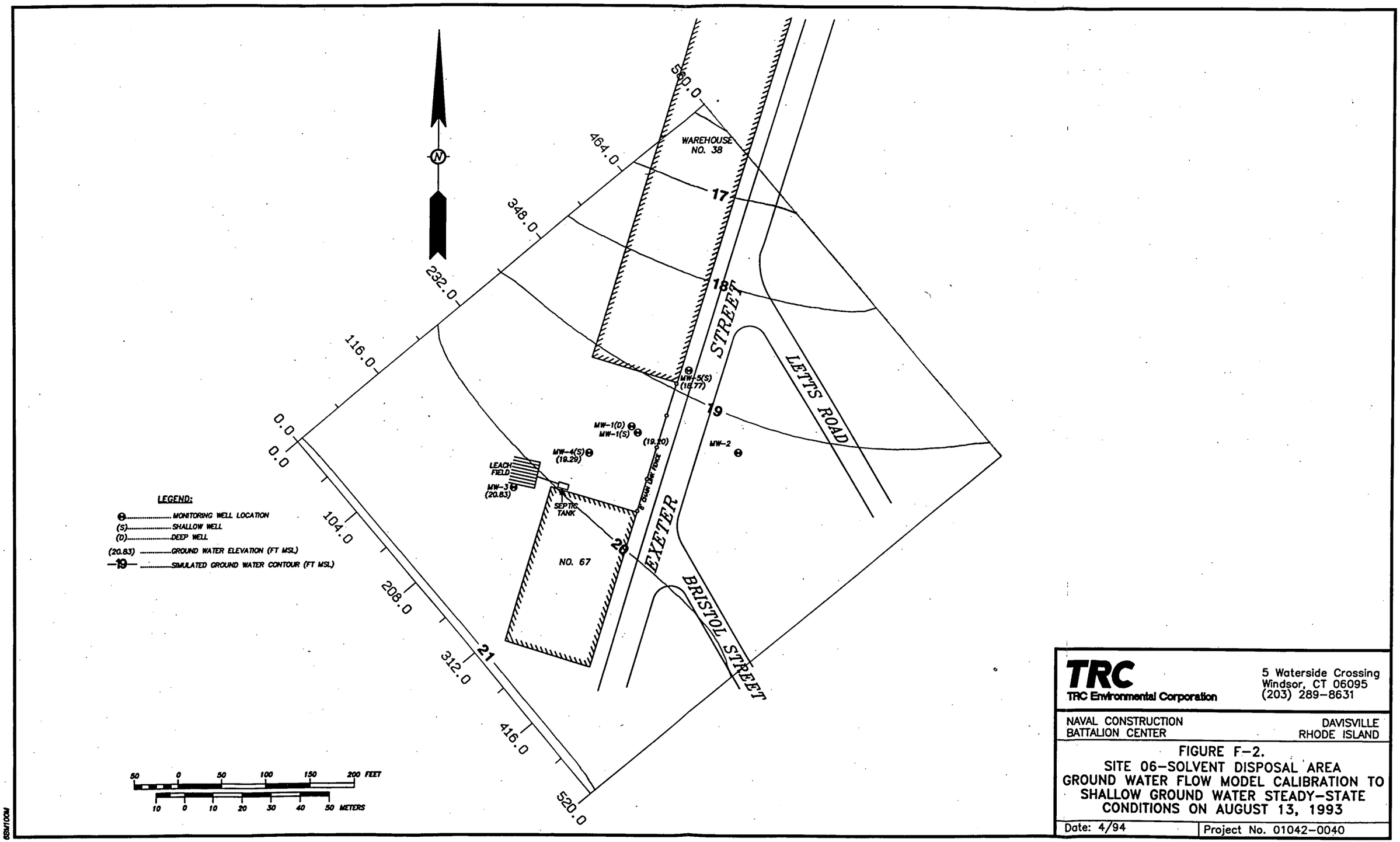
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-1.
SITE 06-SOLVENT DISPOSAL AREA
FLOWPATH GROUND WATER FLOW MODEL GRID

Date: 4/94 | Project No. 01042-0040

6SM100M



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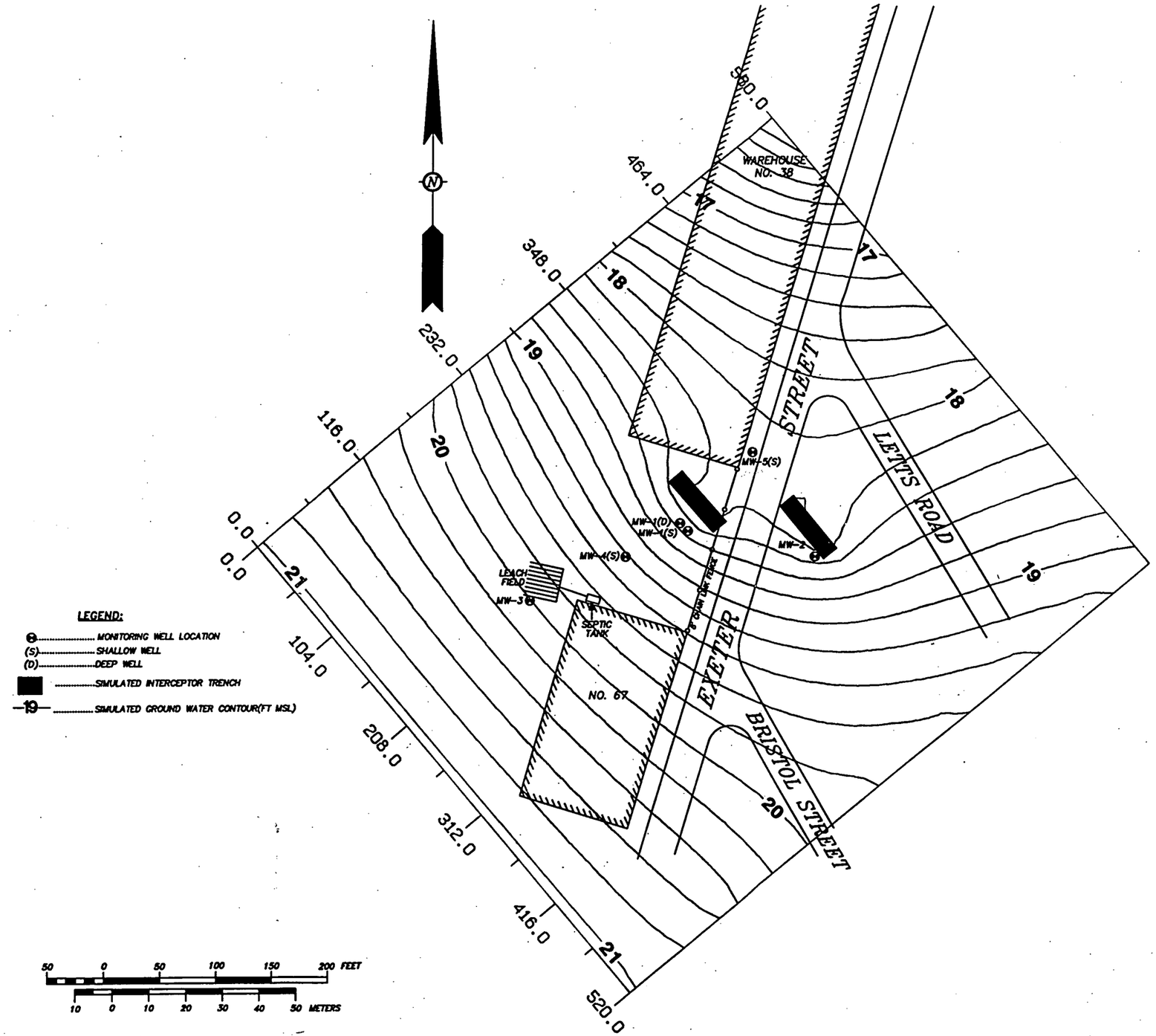
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-2.
SITE 06-SOLVENT DISPOSAL AREA
GROUND WATER FLOW MODEL CALIBRATION TO SHALLOW GROUND WATER STEADY-STATE CONDITIONS ON AUGUST 13, 1993

Date: 4/94 | Project No. 01042-0040

BSM/100M



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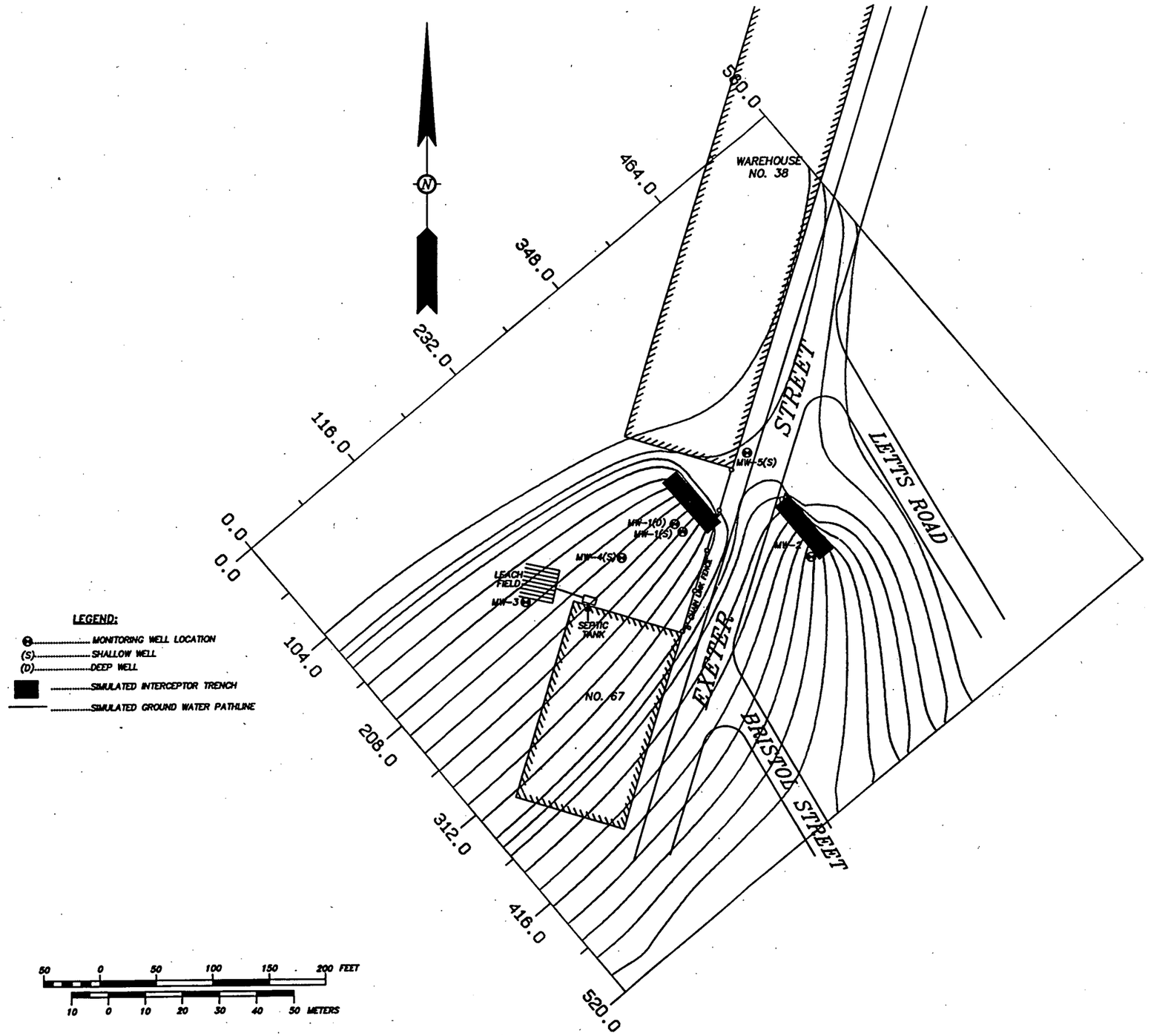
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-3.
SITE 06-SOLVENT DISPOSAL AREA
SIMULATION RESULTS, PROPOSED
GROUND WATER INTERCEPTOR TRENCHES
SHALLOW GROUND WATER LEVEL CONTOURS

Date: 4/94 | Project No. 01042-0040

6SM100M



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NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-4.
SITE 06-SOLVENT DISPOSAL AREA
SIMULATION RESULTS, PROPOSED
GROUND WATER INTERCEPTOR TRENCHES
INTERCEPTOR TRENCH CAPTURE ZONES

Date: 4/94 | Project No. 01042-0040

M001M059

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*************************************************************
*                    E C H O P R I N T                      *
*                                                           *
*                     F L O W P A T H                       *
*                       version 3.0                         *
*                                                           *
*  FLOWPATH was written by Thomas Franz and Nilson Guiguer  *
*                                                           *
*************************************************************
*                                                           *
*                   Copyright 1989, 1990                    *
*                            by                             *
*               Waterloo Hydrogeologic Software             *
*                    113-106 Seagram Drive                  *
*                      Waterloo, Ontario                    *
*                       N2L 3B8, Canada                     *
*                                                           *
*                      ph (519) 746-1798                    *
*                                                           *
*************************************************************
```

FLOWPATH logbook for data set : SITE06CA

Unit System : English units [ft/gal/d]

***** GRID PARAMETERS *****

Number of x-grid lines : 28

Number of y-grid lines : 36

Grid coordinates (x-grid lines) [ft] :

1	0.00000E+00
2	2.00000E+01
3	4.00000E+01
4	6.00000E+01
5	8.00000E+01
6	1.00000E+02
7	1.20000E+02
8	1.40000E+02
9	1.60000E+02
10	1.80000E+02
11	2.00000E+02
12	2.20000E+02
13	2.29690E+02
14	2.40000E+02
15	2.60000E+02
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17	3.00000E+02

18	3.20000E+02
19	3.40000E+02
20	3.60000E+02
21	3.80000E+02
22	4.00000E+02
23	4.20000E+02
24	4.40000E+02
25	4.60000E+02
26	4.80000E+02
27	5.00000E+02
28	5.20000E+02

Grid coordinates (y-grid lines) [ft] :

1	0.00000E+00
2	2.00000E+01
3	4.00000E+01
4	6.00000E+01
5	8.00000E+01
6	1.00000E+02
7	1.20000E+02
8	1.40000E+02
9	1.60000E+02
10	1.80000E+02
11	2.00000E+02
12	2.20000E+02
13	2.40000E+02
14	2.60000E+02
15	2.80000E+02
16	2.90000E+02
17	3.00000E+02
18	3.09248E+02
19	3.20000E+02
20	3.29779E+02
21	3.40000E+02
22	3.50310E+02
23	3.60000E+02
24	3.69558E+02
25	3.80000E+02
26	3.90088E+02
27	4.00000E+02
28	4.20000E+02
29	4.40000E+02
30	4.60000E+02
31	4.80000E+02
32	5.00000E+02
33	5.20000E+02
34	5.40000E+02
35	5.60000E+02
36	5.80000E+02

***** WELL PARAMETERS *****

Number of wells : 6

No.	i	j	X	Y	well discharge

			[ft]	[ft]	[gpd]
1	13	16	2.29690E+02	2.90000E+02	0.00000E+00
2	14	16	2.39956E+02	2.90000E+02	0.00000E+00
3	12	25	2.19425E+02	3.79823E+02	0.00000E+00
4	11	8	2.00177E+02	1.39867E+02	0.00000E+00
5	12	13	2.19425E+02	2.39956E+02	0.00000E+00
6	18	24	3.19513E+02	3.69558E+02	0.00000E+00

***** CONSTRAINED HEAD NODES *****

Number of constant head nodes : 114

No.	i	j	X [ft]	Y [ft]	const. head [ft]
1	1	1	0.00000E+00	0.00000E+00	2.10500E+01
2	2	1	2.05310E+01	0.00000E+00	2.10500E+01
3	3	1	3.97788E+01	0.00000E+00	2.10500E+01
4	4	1	6.03097E+01	0.00000E+00	2.10500E+01
5	5	1	7.95575E+01	0.00000E+00	2.10500E+01
6	6	1	1.00088E+02	0.00000E+00	2.10500E+01
7	7	1	1.20619E+02	0.00000E+00	2.10500E+01
8	8	1	1.39867E+02	0.00000E+00	2.10500E+01
9	9	1	1.60398E+02	0.00000E+00	2.10500E+01
10	10	1	1.79646E+02	0.00000E+00	2.10500E+01
11	11	1	2.00177E+02	0.00000E+00	2.10500E+01
12	12	1	2.19425E+02	0.00000E+00	2.10500E+01
13	13	1	2.29690E+02	0.00000E+00	2.10500E+01
14	14	1	2.39956E+02	0.00000E+00	2.10500E+01
15	15	1	2.60487E+02	0.00000E+00	2.10500E+01
16	16	1	2.79735E+02	0.00000E+00	2.10500E+01
17	17	1	3.00265E+02	0.00000E+00	2.10500E+01
18	18	1	3.19513E+02	0.00000E+00	2.10500E+01
19	19	1	3.40044E+02	0.00000E+00	2.10500E+01
20	20	1	3.60575E+02	0.00000E+00	2.10500E+01
21	21	1	3.79823E+02	0.00000E+00	2.10500E+01
22	22	1	4.00354E+02	0.00000E+00	2.10500E+01
23	23	1	4.19602E+02	0.00000E+00	2.10500E+01
24	24	1	4.40133E+02	0.00000E+00	2.10500E+01
25	25	1	4.59381E+02	0.00000E+00	2.10500E+01
26	26	1	4.79912E+02	0.00000E+00	2.10500E+01
27	27	1	5.00442E+02	0.00000E+00	2.10500E+01
28	28	1	5.19690E+02	0.00000E+00	2.10500E+01
29	28	2	5.19690E+02	2.05310E+01	2.09000E+01
30	28	3	5.19690E+02	3.97788E+01	2.09000E+01
31	28	4	5.19690E+02	6.03097E+01	2.08000E+01
32	28	5	5.19690E+02	7.95575E+01	2.07000E+01
33	28	6	5.19690E+02	1.00088E+02	2.06000E+01
34	28	7	5.19690E+02	1.20619E+02	2.04000E+01
35	28	8	5.19690E+02	1.39867E+02	2.03000E+01
36	28	9	5.19690E+02	1.60398E+02	2.02000E+01
37	28	10	5.19690E+02	1.79646E+02	2.01000E+01
38	28	11	5.19690E+02	2.00177E+02	2.00000E+01
39	28	12	5.19690E+02	2.19425E+02	1.99000E+01
40	28	13	5.19690E+02	2.39956E+02	1.99000E+01
41	28	14	5.19690E+02	2.60487E+02	1.99000E+01

42	28	15	5.19690E+02	2.79735E+02	1.98000E+01
43	28	16	5.19690E+02	2.90000E+02	1.98000E+01
44	28	17	5.19690E+02	3.00265E+02	1.98000E+01
45	28	19	5.19690E+02	3.19513E+02	1.98000E+01
46	28	21	5.19690E+02	3.40044E+02	1.97000E+01
47	28	23	5.19690E+02	3.60575E+02	1.97000E+01
48	28	25	5.19690E+02	3.79823E+02	1.96000E+01
49	28	27	5.19690E+02	4.00354E+02	1.96000E+01
50	28	28	5.19690E+02	4.19602E+02	1.95000E+01
51	28	29	5.19690E+02	4.40133E+02	1.95000E+01
52	28	30	5.19690E+02	4.59381E+02	1.94000E+01
53	28	31	5.19690E+02	4.79912E+02	1.94000E+01
54	28	32	5.19690E+02	5.00442E+02	1.93000E+01
55	28	33	5.19690E+02	5.19690E+02	1.93000E+01
56	28	34	5.19690E+02	5.40221E+02	1.92000E+01
57	28	35	5.19690E+02	5.59469E+02	1.92000E+01
58	28	36	5.19690E+02	5.80000E+02	1.91000E+01
59	27	36	5.00442E+02	5.80000E+02	1.90000E+01
60	26	36	4.79912E+02	5.80000E+02	1.89000E+01
61	25	36	4.59381E+02	5.80000E+02	1.88000E+01
62	24	36	4.40133E+02	5.80000E+02	1.87000E+01
63	23	36	4.19602E+02	5.80000E+02	1.86000E+01
64	22	36	4.00354E+02	5.80000E+02	1.85000E+01
65	21	36	3.79823E+02	5.80000E+02	1.84000E+01
66	20	36	3.60575E+02	5.80000E+02	1.83000E+01
67	19	36	3.40044E+02	5.80000E+02	1.82000E+01
68	1	2	0.00000E+00	2.05310E+01	2.09000E+01
69	1	3	0.00000E+00	3.97788E+01	2.08000E+01
70	1	4	0.00000E+00	6.03097E+01	2.07000E+01
71	1	5	0.00000E+00	7.95575E+01	2.06000E+01
72	1	6	0.00000E+00	1.00088E+02	2.05000E+01
73	1	7	0.00000E+00	1.20619E+02	2.04000E+01
74	1	8	0.00000E+00	1.39867E+02	2.03000E+01
75	1	9	0.00000E+00	1.60398E+02	2.02000E+01
76	1	10	0.00000E+00	1.79646E+02	2.01000E+01
77	1	11	0.00000E+00	2.00177E+02	2.00000E+01
78	1	12	0.00000E+00	2.19425E+02	1.98000E+01
79	1	13	0.00000E+00	2.39956E+02	1.96000E+01
80	1	14	0.00000E+00	2.60487E+02	1.94000E+01
81	1	15	0.00000E+00	2.79735E+02	1.92000E+01
82	1	16	0.00000E+00	2.90000E+02	1.90000E+01
83	1	17	0.00000E+00	3.00265E+02	1.89000E+01
84	1	19	0.00000E+00	3.19513E+02	1.87000E+01
85	1	21	0.00000E+00	3.40044E+02	1.85000E+01
86	1	23	0.00000E+00	3.60575E+02	1.83000E+01
87	1	25	0.00000E+00	3.79823E+02	1.81000E+01
88	1	27	0.00000E+00	4.00354E+02	1.78000E+01
89	1	28	0.00000E+00	4.19602E+02	1.76000E+01
90	1	29	0.00000E+00	4.40133E+02	1.74000E+01
91	1	30	0.00000E+00	4.59381E+02	1.72000E+01
92	1	31	0.00000E+00	4.79912E+02	1.70000E+01
93	1	32	0.00000E+00	5.00442E+02	1.68000E+01
94	1	33	0.00000E+00	5.19690E+02	1.66000E+01
95	1	34	0.00000E+00	5.40221E+02	1.64000E+01
96	1	35	0.00000E+00	5.59469E+02	1.61000E+01
97	1	36	0.00000E+00	5.80000E+02	1.58000E+01
98	2	36	2.05310E+01	5.80000E+02	1.59000E+01
99	3	36	3.97788E+01	5.80000E+02	1.60000E+01
100	4	36	6.03097E+01	5.80000E+02	1.62000E+01
101	5	36	7.95575E+01	5.80000E+02	1.64000E+01

102	6	36	1.00088E+02	5.80000E+02	1.66000E+01
103	7	36	1.20619E+02	5.80000E+02	1.68000E+01
104	8	36	1.39867E+02	5.80000E+02	1.69000E+01
105	9	36	1.60398E+02	5.80000E+02	1.70000E+01
106	10	36	1.79646E+02	5.80000E+02	1.72000E+01
107	11	36	2.00177E+02	5.80000E+02	1.73000E+01
108	12	36	2.19425E+02	5.80000E+02	1.74000E+01
109	13	36	2.29690E+02	5.80000E+02	1.75000E+01
110	14	36	2.39956E+02	5.80000E+02	1.76000E+01
111	15	36	2.60487E+02	5.80000E+02	1.77000E+01
112	16	36	2.79735E+02	5.80000E+02	1.78000E+01
113	17	36	3.00265E+02	5.80000E+02	1.80000E+01
114	18	36	3.19513E+02	5.80000E+02	1.81000E+01

***** SPECIFIED FLUX NODES *****

Number of flux nodes : 0

***** SURFACE WATER BODIES *****

Number of surface water body nodes : 0

**** AQUIFER PROPERTIES *****

Number of different material properties : 1

No.	Kxx [ft/d]	Kyy [ft/d]	Porosity [-]	
1	7.00000E+00	7.00000E+00	1.50000E-01	(default)

********** DISTRIBUTION OF AQUIFER MATERIAL PROPERTIES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1

5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28

***** AQUIFER TYPE *****

Unconfined aquifer

***** AQUIFER BOTTOM ELEVATIONS *****

Number of different aquifer bottom elevations : 1

No.	aquifer bottom elevation [ft]
1	3.10000E+00 (default)

********** DISTRIBUTION OF AQUIFER BOTTOM ELEVATIONS **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1

***** AREAL RECHARGE *****

Number of different infiltration/evapotranspiration rates : 1

No.	infiltration [L/T]	evapotranspiration [L/T]	effective recharge [L/T]	
1	0.00000E+00	0.00000E+00	0.00000E+00	(default)

********** DISTRIBUTION OF AREAL IN/OUT-FLUXES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1

31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28

***** PATHLINE & PARTICLE TRACKING DATA *****

Number of forward particles : 0

Number of reverse particles : 0

Particles released at wells :

Well-No.	Particles released
1	0
2	0
3	0
4	0
5	0
6	0

********** HYDRAULIC HEAD DISTRIBUTION **********

	1	2	3	4	5	6
	1.5800E+01	1.5900E+01	1.6000E+01	1.6200E+01	1.6400E+01	1.6600E+01
35	1.6100E+01	1.6195E+01	1.6306E+01	1.6457E+01	1.6620E+01	1.6785E+01
34	1.6400E+01	1.6465E+01	1.6567E+01	1.6694E+01	1.6833E+01	1.6975E+01
33	1.6600E+01	1.6693E+01	1.6797E+01	1.6914E+01	1.7038E+01	1.7165E+01
32	1.6800E+01	1.6904E+01	1.7010E+01	1.7122E+01	1.7236E+01	1.7352E+01
31	1.7000E+01	1.7108E+01	1.7215E+01	1.7322E+01	1.7429E+01	1.7537E+01
30	1.7200E+01	1.7309E+01	1.7414E+01	1.7517E+01	1.7619E+01	1.7719E+01
29	1.7400E+01	1.7509E+01	1.7613E+01	1.7711E+01	1.7806E+01	1.7899E+01
28	1.7600E+01	1.7712E+01	1.7812E+01	1.7904E+01	1.7992E+01	1.8077E+01
27	1.7800E+01	1.7923E+01	1.8014E+01	1.8097E+01	1.8177E+01	1.8254E+01
26	1.7967E+01	1.8038E+01	1.8116E+01	1.8193E+01	1.8268E+01	1.8341E+01
25	1.8100E+01	1.8151E+01	1.8220E+01	1.8290E+01	1.8360E+01	1.8429E+01
24	1.8216E+01	1.8263E+01	1.8325E+01	1.8390E+01	1.8455E+01	1.8519E+01
23	1.8300E+01	1.8360E+01	1.8420E+01	1.8480E+01	1.8541E+01	1.8601E+01
22	1.8410E+01	1.8459E+01	1.8515E+01	1.8571E+01	1.8627E+01	1.8683E+01
21	1.8500E+01	1.8561E+01	1.8615E+01	1.8667E+01	1.8719E+01	1.8770E+01
20	1.8615E+01	1.8663E+01	1.8713E+01	1.8761E+01	1.8809E+01	1.8855E+01
19	1.8700E+01	1.8759E+01	1.8807E+01	1.8851E+01	1.8894E+01	1.8936E+01
18	1.8820E+01	1.8868E+01	1.8911E+01	1.8950E+01	1.8987E+01	1.9025E+01
17	1.8900E+01	1.8962E+01	1.9000E+01	1.9034E+01	1.9066E+01	1.9100E+01
16	1.9000E+01	1.9068E+01	1.9098E+01	1.9124E+01	1.9151E+01	1.9180E+01
15	1.9200E+01	1.9182E+01	1.9195E+01	1.9214E+01	1.9236E+01	1.9260E+01
14	1.9400E+01	1.9387E+01	1.9384E+01	1.9390E+01	1.9401E+01	1.9416E+01
13	1.9600E+01	1.9578E+01	1.9564E+01	1.9558E+01	1.9560E+01	1.9567E+01
12	1.9800E+01	1.9760E+01	1.9732E+01	1.9717E+01	1.9712E+01	1.9713E+01
	2.0000E+01	1.9926E+01	1.9887E+01	1.9866E+01	1.9856E+01	1.9853E+01
	2.0100E+01	2.0055E+01	2.0024E+01	2.0003E+01	1.9991E+01	1.9986E+01
9	2.0200E+01	2.0171E+01	2.0148E+01	2.0131E+01	2.0120E+01	2.0114E+01
8	2.0300E+01	2.0281E+01	2.0265E+01	2.0252E+01	2.0243E+01	2.0238E+01
7	2.0400E+01	2.0388E+01	2.0378E+01	2.0369E+01	2.0362E+01	2.0358E+01
6	2.0500E+01	2.0494E+01	2.0488E+01	2.0483E+01	2.0479E+01	2.0476E+01
5	2.0600E+01	2.0599E+01	2.0598E+01	2.0596E+01	2.0594E+01	2.0592E+01
4	2.0700E+01	2.0705E+01	2.0707E+01	2.0708E+01	2.0708E+01	2.0707E+01
3	2.0800E+01	2.0812E+01	2.0818E+01	2.0821E+01	2.0822E+01	2.0822E+01
2	2.0900E+01	2.0924E+01	2.0932E+01	2.0935E+01	2.0936E+01	2.0936E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	1	2	3	4	5	6
	7	8	9	10	11	12
36	1.6800E+01	1.6900E+01	1.7000E+01	1.7200E+01	1.7300E+01	1.7400E+01
35	1.6942E+01	1.7069E+01	1.7192E+01	1.7333E+01	1.7453E+01	1.7573E+01
34	1.7112E+01	1.7239E+01	1.7361E+01	1.7485E+01	1.7604E+01	1.7720E+01
33	1.7289E+01	1.7409E+01	1.7525E+01	1.7640E+01	1.7752E+01	1.7863E+01
32	1.7466E+01	1.7578E+01	1.7687E+01	1.7795E+01	1.7900E+01	1.8003E+01
31	1.7642E+01	1.7746E+01	1.7848E+01	1.7948E+01	1.8046E+01	1.8142E+01
30	1.7817E+01	1.7913E+01	1.8007E+01	1.8100E+01	1.8190E+01	1.8279E+01
29	1.7989E+01	1.8078E+01	1.8165E+01	1.8250E+01	1.8334E+01	1.8415E+01
28	1.8160E+01	1.8242E+01	1.8321E+01	1.8399E+01	1.8476E+01	1.8551E+01
27	1.8329E+01	1.8403E+01	1.8475E+01	1.8546E+01	1.8616E+01	1.8684E+01
[illegible]	1.8412E+01	1.8482E+01	1.8551E+01	1.8619E+01	1.8685E+01	1.8751E+01
25	1.8496E+01	1.8562E+01	1.8627E+01	1.8691E+01	1.8754E+01	1.8816E+01
24	1.8582E+01	1.8644E+01	1.8705E+01	1.8765E+01	1.8825E+01	1.8884E+01
23	1.8660E+01	1.8718E+01	1.8776E+01	1.8833E+01	1.8889E+01	1.8945E+01

22	1.8738E+01	1.8793E+01	1.8847E+01	1.8900E+01	1.8953E+01	1.9006E+01
21	1.8821E+01	1.8871E+01	1.8922E+01	1.8972E+01	1.9021E+01	1.9071E+01
20	1.8902E+01	1.8949E+01	1.8995E+01	1.9042E+01	1.9088E+01	1.9134E+01
19	1.8979E+01	1.9022E+01	1.9065E+01	1.9108E+01	1.9151E+01	1.9194E+01
18	1.9063E+01	1.9101E+01	1.9141E+01	1.9180E+01	1.9220E+01	1.9260E+01
17	1.9134E+01	1.9169E+01	1.9205E+01	1.9242E+01	1.9279E+01	1.9316E+01
16	1.9210E+01	1.9242E+01	1.9275E+01	1.9308E+01	1.9342E+01	1.9376E+01
15	1.9286E+01	1.9314E+01	1.9343E+01	1.9374E+01	1.9405E+01	1.9436E+01
14	1.9435E+01	1.9456E+01	1.9479E+01	1.9504E+01	1.9529E+01	1.9556E+01
13	1.9579E+01	1.9594E+01	1.9612E+01	1.9631E+01	1.9652E+01	1.9674E+01
12	1.9719E+01	1.9729E+01	1.9742E+01	1.9757E+01	1.9774E+01	1.9792E+01
11	1.9855E+01	1.9861E+01	1.9870E+01	1.9881E+01	1.9894E+01	1.9909E+01
10	1.9986E+01	1.9989E+01	1.9995E+01	2.0003E+01	2.0014E+01	2.0025E+01
9	2.0112E+01	2.0114E+01	2.0118E+01	2.0124E+01	2.0132E+01	2.0141E+01
8	2.0236E+01	2.0236E+01	2.0239E+01	2.0243E+01	2.0249E+01	2.0256E+01
7	2.0356E+01	2.0356E+01	2.0358E+01	2.0361E+01	2.0365E+01	2.0370E+01
6	2.0474E+01	2.0474E+01	2.0475E+01	2.0477E+01	2.0481E+01	2.0485E+01
5	2.0591E+01	2.0591E+01	2.0592E+01	2.0593E+01	2.0596E+01	2.0598E+01
4	2.0707E+01	2.0707E+01	2.0707E+01	2.0708E+01	2.0710E+01	2.0712E+01
3	2.0822E+01	2.0822E+01	2.0822E+01	2.0823E+01	2.0824E+01	2.0825E+01
2	2.0936E+01	2.0936E+01	2.0936E+01	2.0937E+01	2.0937E+01	2.0938E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	7	8	9	10	11	12
	13	14	15	16	17	18
36	1.7500E+01	1.7600E+01	1.7700E+01	1.7800E+01	1.8000E+01	1.8100E+01
35	1.7639E+01	1.7709E+01	1.7826E+01	1.7943E+01	1.8078E+01	1.8188E+01
34	1.7778E+01	1.7839E+01	1.7953E+01	1.8064E+01	1.8178E+01	1.8284E+01
33	1.7915E+01	1.7971E+01	1.8078E+01	1.8182E+01	1.8285E+01	1.8384E+01
32	1.8052E+01	1.8104E+01	1.8202E+01	1.8299E+01	1.8394E+01	1.8486E+01
31	1.8187E+01	1.8235E+01	1.8327E+01	1.8416E+01	1.8503E+01	1.8588E+01
30	1.8321E+01	1.8366E+01	1.8450E+01	1.8532E+01	1.8613E+01	1.8692E+01
29	1.8454E+01	1.8495E+01	1.8572E+01	1.8648E+01	1.8722E+01	1.8794E+01
28	1.8586E+01	1.8624E+01	1.8694E+01	1.8763E+01	1.8830E+01	1.8897E+01
27	1.8717E+01	1.8750E+01	1.8814E+01	1.8877E+01	1.8938E+01	1.8998E+01
26	1.8781E+01	1.8813E+01	1.8874E+01	1.8933E+01	1.8991E+01	1.9049E+01
25	1.8846E+01	1.8876E+01	1.8933E+01	1.8989E+01	1.9044E+01	1.9099E+01
24	1.8911E+01	1.8940E+01	1.8994E+01	1.9047E+01	1.9099E+01	1.9151E+01
23	1.8971E+01	1.8998E+01	1.9049E+01	1.9100E+01	1.9149E+01	1.9199E+01
22	1.9031E+01	1.9056E+01	1.9105E+01	1.9152E+01	1.9200E+01	1.9246E+01
21	1.9094E+01	1.9118E+01	1.9163E+01	1.9208E+01	1.9253E+01	1.9297E+01
20	1.9156E+01	1.9178E+01	1.9221E+01	1.9264E+01	1.9306E+01	1.9347E+01
19	1.9214E+01	1.9236E+01	1.9276E+01	1.9316E+01	1.9356E+01	1.9395E+01
18	1.9279E+01	1.9298E+01	1.9336E+01	1.9374E+01	1.9411E+01	1.9448E+01
17	1.9333E+01	1.9352E+01	1.9388E+01	1.9423E+01	1.9458E+01	1.9493E+01
16	1.9393E+01	1.9410E+01	1.9443E+01	1.9477E+01	1.9510E+01	1.9542E+01
15	1.9451E+01	1.9468E+01	1.9499E+01	1.9530E+01	1.9561E+01	1.9591E+01
14	1.9569E+01	1.9583E+01	1.9610E+01	1.9637E+01	1.9664E+01	1.9690E+01
13	1.9685E+01	1.9697E+01	1.9720E+01	1.9744E+01	1.9767E+01	1.9790E+01
12	1.9801E+01	1.9811E+01	1.9831E+01	1.9851E+01	1.9870E+01	1.9890E+01
11	1.9916E+01	1.9925E+01	1.9941E+01	1.9958E+01	1.9975E+01	1.9991E+01
10	2.0031E+01	2.0038E+01	2.0051E+01	2.0066E+01	2.0080E+01	2.0094E+01
9	2.0145E+01	2.0151E+01	2.0162E+01	2.0174E+01	2.0186E+01	2.0198E+01
8	2.0259E+01	2.0264E+01	2.0273E+01	2.0283E+01	2.0293E+01	2.0302E+01
7	2.0373E+01	2.0377E+01	2.0384E+01	2.0392E+01	2.0400E+01	2.0408E+01
6	2.0487E+01	2.0490E+01	2.0495E+01	2.0502E+01	2.0508E+01	2.0515E+01
5	2.0600E+01	2.0602E+01	2.0607E+01	2.0611E+01	2.0616E+01	2.0621E+01
4	2.0713E+01	2.0715E+01	2.0718E+01	2.0721E+01	2.0725E+01	2.0729E+01

3	2.0826E+01	2.0827E+01	2.0829E+01	2.0831E+01	2.0834E+01	2.0836E+01
2	2.0938E+01	2.0938E+01	2.0940E+01	2.0941E+01	2.0942E+01	2.0943E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	13	14	15	16	17	18

	19	20	21	22	23	24
36	1.8200E+01	1.8300E+01	1.8400E+01	1.8500E+01	1.8600E+01	1.8700E+01
35	1.8291E+01	1.8389E+01	1.8487E+01	1.8583E+01	1.8680E+01	1.8776E+01
34	1.8383E+01	1.8479E+01	1.8573E+01	1.8666E+01	1.8758E+01	1.8850E+01
33	1.8478E+01	1.8570E+01	1.8660E+01	1.8748E+01	1.8836E+01	1.8923E+01
32	1.8575E+01	1.8661E+01	1.8746E+01	1.8830E+01	1.8913E+01	1.8995E+01
31	1.8672E+01	1.8753E+01	1.8833E+01	1.8911E+01	1.8989E+01	1.9067E+01
30	1.8769E+01	1.8844E+01	1.8919E+01	1.8992E+01	1.9065E+01	1.9137E+01
29	1.8866E+01	1.8936E+01	1.9005E+01	1.9073E+01	1.9140E+01	1.9208E+01
28	1.8962E+01	1.9026E+01	1.9090E+01	1.9153E+01	1.9215E+01	1.9277E+01
27	1.9058E+01	1.9117E+01	1.9175E+01	1.9232E+01	1.9289E+01	1.9346E+01
26	1.9105E+01	1.9161E+01	1.9217E+01	1.9271E+01	1.9326E+01	1.9380E+01
25	1.9153E+01	1.9206E+01	1.9259E+01	1.9311E+01	1.9363E+01	1.9414E+01
24	1.9202E+01	1.9253E+01	1.9303E+01	1.9352E+01	1.9401E+01	1.9450E+01
23	1.9247E+01	1.9295E+01	1.9342E+01	1.9389E+01	1.9436E+01	1.9482E+01
22	1.9292E+01	1.9338E+01	1.9383E+01	1.9427E+01	1.9471E+01	1.9515E+01
21	1.9341E+01	1.9383E+01	1.9426E+01	1.9468E+01	1.9509E+01	1.9550E+01
20	1.9388E+01	1.9428E+01	1.9468E+01	1.9507E+01	1.9546E+01	1.9584E+01
19	1.9434E+01	1.9472E+01	1.9509E+01	1.9546E+01	1.9582E+01	1.9617E+01
18	1.9484E+01	1.9519E+01	1.9554E+01	1.9588E+01	1.9621E+01	1.9654E+01
17	1.9527E+01	1.9560E+01	1.9593E+01	1.9625E+01	1.9655E+01	1.9685E+01
16	1.9574E+01	1.9605E+01	1.9635E+01	1.9665E+01	1.9693E+01	1.9719E+01
15	1.9621E+01	1.9650E+01	1.9678E+01	1.9705E+01	1.9730E+01	1.9754E+01
	1.9716E+01	1.9741E+01	1.9765E+01	1.9787E+01	1.9807E+01	1.9825E+01
	1.9812E+01	1.9833E+01	1.9853E+01	1.9871E+01	1.9886E+01	1.9898E+01
12	1.9909E+01	1.9926E+01	1.9943E+01	1.9957E+01	1.9969E+01	1.9976E+01
11	2.0007E+01	2.0022E+01	2.0035E+01	2.0047E+01	2.0055E+01	2.0060E+01
10	2.0107E+01	2.0120E+01	2.0131E+01	2.0140E+01	2.0146E+01	2.0149E+01
9	2.0209E+01	2.0219E+01	2.0228E+01	2.0236E+01	2.0241E+01	2.0243E+01
8	2.0312E+01	2.0320E+01	2.0328E+01	2.0334E+01	2.0339E+01	2.0341E+01
7	2.0416E+01	2.0423E+01	2.0429E+01	2.0435E+01	2.0439E+01	2.0442E+01
6	2.0521E+01	2.0527E+01	2.0532E+01	2.0537E+01	2.0542E+01	2.0546E+01
5	2.0626E+01	2.0631E+01	2.0636E+01	2.0640E+01	2.0644E+01	2.0649E+01
4	2.0732E+01	2.0736E+01	2.0740E+01	2.0743E+01	2.0747E+01	2.0751E+01
3	2.0838E+01	2.0841E+01	2.0843E+01	2.0846E+01	2.0848E+01	2.0851E+01
2	2.0944E+01	2.0946E+01	2.0947E+01	2.0948E+01	2.0949E+01	2.0951E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	19	20	21	22	23	24

	25	26	27	28
36	1.8800E+01	1.8900E+01	1.9000E+01	1.9100E+01
35	1.8872E+01	1.8970E+01	1.9074E+01	1.9200E+01
34	1.8942E+01	1.9034E+01	1.9125E+01	1.9200E+01
33	1.9011E+01	1.9099E+01	1.9191E+01	1.9300E+01
32	1.9078E+01	1.9159E+01	1.9238E+01	1.9300E+01
31	1.9144E+01	1.9222E+01	1.9302E+01	1.9400E+01
30	1.9209E+01	1.9281E+01	1.9349E+01	1.9400E+01
	1.9275E+01	1.9342E+01	1.9412E+01	1.9500E+01
	1.9339E+01	1.9400E+01	1.9458E+01	1.9500E+01
27	1.9403E+01	1.9460E+01	1.9520E+01	1.9600E+01
26	1.9434E+01	1.9488E+01	1.9542E+01	1.9588E+01

25	1.9466E+01	1.9517E+01	1.9567E+01	1.9600E+01
24	1.9499E+01	1.9548E+01	1.9597E+01	1.9641E+01
23	1.9529E+01	1.9576E+01	1.9625E+01	1.9700E+01
22	1.9559E+01	1.9603E+01	1.9648E+01	1.9690E+01
21	1.9591E+01	1.9632E+01	1.9673E+01	1.9700E+01
20	1.9623E+01	1.9661E+01	1.9702E+01	1.9741E+01
19	1.9653E+01	1.9689E+01	1.9730E+01	1.9800E+01
18	1.9685E+01	1.9717E+01	1.9752E+01	1.9790E+01
17	1.9714E+01	1.9742E+01	1.9770E+01	1.9800E+01
16	1.9744E+01	1.9768E+01	1.9788E+01	1.9800E+01
15	1.9776E+01	1.9795E+01	1.9809E+01	1.9800E+01
14	1.9840E+01	1.9853E+01	1.9868E+01	1.9900E+01
13	1.9907E+01	1.9910E+01	1.9908E+01	1.9900E+01
12	1.9979E+01	1.9973E+01	1.9953E+01	1.9900E+01
11	2.0059E+01	2.0051E+01	2.0032E+01	2.0000E+01
10	2.0147E+01	2.0138E+01	2.0122E+01	2.0100E+01
9	2.0241E+01	2.0233E+01	2.0219E+01	2.0200E+01
8	2.0340E+01	2.0334E+01	2.0322E+01	2.0300E+01
7	2.0443E+01	2.0441E+01	2.0433E+01	2.0400E+01
6	2.0550E+01	2.0555E+01	2.0566E+01	2.0600E+01
5	2.0655E+01	2.0663E+01	2.0677E+01	2.0700E+01
4	2.0756E+01	2.0765E+01	2.0778E+01	2.0800E+01
3	2.0855E+01	2.0861E+01	2.0871E+01	2.0900E+01
2	2.0952E+01	2.0952E+01	2.0943E+01	2.0900E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01
	25	26	27	28

********** End of logbook **********

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*************************************************************
*                      E C H O P R I N T                    *
*                                                           *
*                       F L O W P A T H                     *
*                         version 3.0                       *
*                                                           *
*  FLOWPATH was written by Thomas Franz and Nilson Guiguer  *
*                                                           *
*************************************************************
*                                                           *
*                    Copyright 1989, 1990                   *
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*                Waterloo Hydrogeologic Software            *
*                     113-106 Seagram Drive                 *
*                       Waterloo, Ontario                   *
*                        N2L 3B8, Canada                    *
*                                                           *
*                       ph (519) 746-1798                   *
*                                                           *
*************************************************************
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FLOWPATH logbook for data set : SITE06IT

Unit System : English units [ft/gal/d]

***** GRID PARAMETERS *****

Number of x-grid lines : 28

Number of y-grid lines : 36

Grid coordinates (x-grid lines) [ft] :

1	0.00000E+00
2	2.00000E+01
3	4.00000E+01
4	6.00000E+01
5	8.00000E+01
6	1.00000E+02
7	1.20000E+02
8	1.40000E+02
9	1.60000E+02
10	1.80000E+02
11	2.00000E+02
12	2.20000E+02
13	2.29690E+02
14	2.40000E+02
15	2.60000E+02
16	2.80000E+02
17	3.00000E+02

18	3.20000E+02
19	3.40000E+02
20	3.60000E+02
21	3.80000E+02
22	4.00000E+02
23	4.20000E+02
24	4.40000E+02
25	4.60000E+02
26	4.80000E+02
27	5.00000E+02
28	5.20000E+02

Grid coordinates (y-grid lines) [ft] :

1	0.00000E+00
2	2.00000E+01
3	4.00000E+01
4	6.00000E+01
5	8.00000E+01
6	1.00000E+02
7	1.20000E+02
8	1.40000E+02
9	1.60000E+02
10	1.80000E+02
11	2.00000E+02
12	2.20000E+02
13	2.40000E+02
14	2.60000E+02
15	2.80000E+02
16	2.90000E+02
17	3.00000E+02
18	3.09248E+02
19	3.20000E+02
20	3.29779E+02
21	3.40000E+02
22	3.50310E+02
23	3.60000E+02
24	3.69558E+02
25	3.80000E+02
26	3.90088E+02
27	4.00000E+02
28	4.20000E+02
29	4.40000E+02
30	4.60000E+02
31	4.80000E+02
32	5.00000E+02
33	5.20000E+02
34	5.40000E+02
35	5.60000E+02
36	5.80000E+02

***** WELL PARAMETERS *****

Number of wells : 8

No.	i	j	X	Y	well discharge

			[ft]	[ft]	[gpd]
1	13	16	2.29690E+02	2.90000E+02	0.00000E+00
2	14	16	2.39956E+02	2.90000E+02	0.00000E+00
3	12	25	2.19425E+02	3.79823E+02	0.00000E+00
4	14	19	2.39956E+02	3.19513E+02	-1.44000E+03
5	12	13	2.19425E+02	2.39956E+02	0.00000E+00
6	11	8	2.00177E+02	1.39867E+02	0.00000E+00
7	16	25	2.79735E+02	3.79823E+02	-1.44000E+03
8	18	24	3.19513E+02	3.69558E+02	0.00000E+00

***** CONSTRAINED HEAD NODES *****

Number of constant head nodes : 114

No.	i	j	X [ft]	Y [ft]	const. head [ft]
1	1	1	0.00000E+00	0.00000E+00	2.10500E+01
2	2	1	2.05310E+01	0.00000E+00	2.10500E+01
3	3	1	3.97788E+01	0.00000E+00	2.10500E+01
4	4	1	6.03097E+01	0.00000E+00	2.10500E+01
5	5	1	7.95575E+01	0.00000E+00	2.10500E+01
6	6	1	1.00088E+02	0.00000E+00	2.10500E+01
7	7	1	1.20619E+02	0.00000E+00	2.10500E+01
8	8	1	1.39867E+02	0.00000E+00	2.10500E+01
9	9	1	1.60398E+02	0.00000E+00	2.10500E+01
10	10	1	1.79646E+02	0.00000E+00	2.10500E+01
11	11	1	2.00177E+02	0.00000E+00	2.10500E+01
12	12	1	2.19425E+02	0.00000E+00	2.10500E+01
13	13	1	2.29690E+02	0.00000E+00	2.10500E+01
14	14	1	2.39956E+02	0.00000E+00	2.10500E+01
15	15	1	2.60487E+02	0.00000E+00	2.10500E+01
16	16	1	2.79735E+02	0.00000E+00	2.10500E+01
17	17	1	3.00265E+02	0.00000E+00	2.10500E+01
18	18	1	3.19513E+02	0.00000E+00	2.10500E+01
19	19	1	3.40044E+02	0.00000E+00	2.10500E+01
20	20	1	3.60575E+02	0.00000E+00	2.10500E+01
21	21	1	3.79823E+02	0.00000E+00	2.10500E+01
22	22	1	4.00354E+02	0.00000E+00	2.10500E+01
23	23	1	4.19602E+02	0.00000E+00	2.10500E+01
24	24	1	4.40133E+02	0.00000E+00	2.10500E+01
25	25	1	4.59381E+02	0.00000E+00	2.10500E+01
26	26	1	4.79912E+02	0.00000E+00	2.10500E+01
27	27	1	5.00442E+02	0.00000E+00	2.10500E+01
28	28	1	5.19690E+02	0.00000E+00	2.10500E+01
29	28	2	5.19690E+02	2.05310E+01	2.09000E+01
30	28	3	5.19690E+02	3.97788E+01	2.09000E+01
31	28	4	5.19690E+02	6.03097E+01	2.08000E+01
32	28	5	5.19690E+02	7.95575E+01	2.07000E+01
33	28	6	5.19690E+02	1.00088E+02	2.06000E+01
34	28	7	5.19690E+02	1.20619E+02	2.04000E+01
35	28	8	5.19690E+02	1.39867E+02	2.03000E+01
36	28	9	5.19690E+02	1.60398E+02	2.02000E+01
37	28	10	5.19690E+02	1.79646E+02	2.01000E+01
38	28	11	5.19690E+02	2.00177E+02	2.00000E+01
39	28	12	5.19690E+02	2.19425E+02	1.99000E+01

40	28	13	5.19690E+02	2.39956E+02	1.99000E+01
41	28	14	5.19690E+02	2.60487E+02	1.99000E+01
42	28	15	5.19690E+02	2.79735E+02	1.98000E+01
43	28	16	5.19690E+02	2.90000E+02	1.98000E+01
44	28	17	5.19690E+02	3.00265E+02	1.98000E+01
45	28	19	5.19690E+02	3.19513E+02	1.98000E+01
46	28	21	5.19690E+02	3.40044E+02	1.97000E+01
47	28	23	5.19690E+02	3.60575E+02	1.97000E+01
48	28	25	5.19690E+02	3.79823E+02	1.96000E+01
49	28	27	5.19690E+02	4.00354E+02	1.96000E+01
50	28	28	5.19690E+02	4.19602E+02	1.95000E+01
51	28	29	5.19690E+02	4.40133E+02	1.95000E+01
52	28	30	5.19690E+02	4.59381E+02	1.94000E+01
53	28	31	5.19690E+02	4.79912E+02	1.94000E+01
54	28	32	5.19690E+02	5.00442E+02	1.93000E+01
55	28	33	5.19690E+02	5.19690E+02	1.93000E+01
56	28	34	5.19690E+02	5.40221E+02	1.92000E+01
57	28	35	5.19690E+02	5.59469E+02	1.92000E+01
58	28	36	5.19690E+02	5.80000E+02	1.91000E+01
59	27	36	5.00442E+02	5.80000E+02	1.90000E+01
60	26	36	4.79912E+02	5.80000E+02	1.89000E+01
61	25	36	4.59381E+02	5.80000E+02	1.88000E+01
62	24	36	4.40133E+02	5.80000E+02	1.87000E+01
63	23	36	4.19602E+02	5.80000E+02	1.86000E+01
64	22	36	4.00354E+02	5.80000E+02	1.85000E+01
65	21	36	3.79823E+02	5.80000E+02	1.84000E+01
66	20	36	3.60575E+02	5.80000E+02	1.83000E+01
67	19	36	3.40044E+02	5.80000E+02	1.82000E+01
68	1	2	0.00000E+00	2.05310E+01	2.09000E+01
69	1	3	0.00000E+00	3.97788E+01	2.08000E+01
70	1	4	0.00000E+00	6.03097E+01	2.07000E+01
71	1	5	0.00000E+00	7.95575E+01	2.06000E+01
72	1	6	0.00000E+00	1.00088E+02	2.05000E+01
73	1	7	0.00000E+00	1.20619E+02	2.04000E+01
74	1	8	0.00000E+00	1.39867E+02	2.03000E+01
75	1	9	0.00000E+00	1.60398E+02	2.02000E+01
76	1	10	0.00000E+00	1.79646E+02	2.01000E+01
77	1	11	0.00000E+00	2.00177E+02	2.00000E+01
78	1	12	0.00000E+00	2.19425E+02	1.98000E+01
79	1	13	0.00000E+00	2.39956E+02	1.96000E+01
80	1	14	0.00000E+00	2.60487E+02	1.94000E+01
81	1	15	0.00000E+00	2.79735E+02	1.92000E+01
82	1	16	0.00000E+00	2.90000E+02	1.90000E+01
83	1	17	0.00000E+00	3.00265E+02	1.89000E+01
84	1	19	0.00000E+00	3.19513E+02	1.87000E+01
85	1	21	0.00000E+00	3.40044E+02	1.85000E+01
86	1	23	0.00000E+00	3.60575E+02	1.83000E+01
87	1	25	0.00000E+00	3.79823E+02	1.81000E+01
88	1	27	0.00000E+00	4.00354E+02	1.78000E+01
89	1	28	0.00000E+00	4.19602E+02	1.76000E+01
90	1	29	0.00000E+00	4.40133E+02	1.74000E+01
91	1	30	0.00000E+00	4.59381E+02	1.72000E+01
92	1	31	0.00000E+00	4.79912E+02	1.70000E+01
93	1	32	0.00000E+00	5.00442E+02	1.68000E+01
94	1	33	0.00000E+00	5.19690E+02	1.66000E+01
95	1	34	0.00000E+00	5.40221E+02	1.64000E+01
96	1	35	0.00000E+00	5.59469E+02	1.61000E+01
97	1	36	0.00000E+00	5.80000E+02	1.58000E+01
98	2	36	2.05310E+01	5.80000E+02	1.59000E+01
99	3	36	3.97788E+01	5.80000E+02	1.60000E+01

100	4	36	6.03097E+01	5.80000E+02	1.62000E+01
101	5	36	7.95575E+01	5.80000E+02	1.64000E+01
102	6	36	1.00088E+02	5.80000E+02	1.66000E+01
103	7	36	1.20619E+02	5.80000E+02	1.68000E+01
104	8	36	1.39867E+02	5.80000E+02	1.69000E+01
105	9	36	1.60398E+02	5.80000E+02	1.70000E+01
106	10	36	1.79646E+02	5.80000E+02	1.72000E+01
107	11	36	2.00177E+02	5.80000E+02	1.73000E+01
108	12	36	2.19425E+02	5.80000E+02	1.74000E+01
109	13	36	2.29690E+02	5.80000E+02	1.75000E+01
110	14	36	2.39956E+02	5.80000E+02	1.76000E+01
111	15	36	2.60487E+02	5.80000E+02	1.77000E+01
112	16	36	2.79735E+02	5.80000E+02	1.78000E+01
113	17	36	3.00265E+02	5.80000E+02	1.80000E+01
114	18	36	3.19513E+02	5.80000E+02	1.81000E+01

***** SPECIFIED FLUX NODES *****

Number of flux nodes : 0

***** SURFACE WATER BODIES *****

Number of surface water body nodes : 0

***** AQUIFER PROPERTIES *****

Number of different material properties : 5

No.	Kxx [ft/d]	Kyy [ft/d]	Porosity [-]	
1	7.00000E+00	7.00000E+00	1.50000E-01	(default)
2	3.00000E+02	3.00000E+02	2.50000E-01	
3	3.00000E+02	3.00000E+02	2.50000E-01	
4	7.00000E+00	7.00000E+00	1.50000E-01	
5	7.00000E+00	7.00000E+00	1.50000E-01	

********** DISTRIBUTION OF AQUIFER MATERIAL PROPERTIES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	3	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1

***** AQUIFER TYPE *****

Unconfined aquifer

***** AQUIFER BOTTOM ELEVATIONS *****

Number of different aquifer bottom elevations : 1

No.	aquifer bottom elevation [ft]
1	3.10000E+00 (default)

********** DISTRIBUTION OF AQUIFER BOTTOM ELEVATIONS **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28

***** AREAL RECHARGE *****

Number of different infiltration/evapotranspiration rates : 1

No.	infiltration [L/T]	evapotranspiration [L/T]	effective recharge [L/T]	
1	0.00000E+00	0.00000E+00	0.00000E+00	(default)

********** DISTRIBUTION OF AREAL IN/OUT-FLUXES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	18	19	20	21	22	23	24	25	26	27	28

	18	19	20	21	22	23	24	25	26	27	28
36	1	1	1	1	1	1	1	1	1	1	1
35	1	1	1	1	1	1	1	1	1	1	1
34	1	1	1	1	1	1	1	1	1	1	1
33	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1

***** PATHLINE & PARTICLE TRACKING DATA *****

Number of forward particles : 30

No.	x-release	y-release
1	3.19513E+02	1.28319E+00
2	3.40044E+02	1.28319E+00
3	3.60575E+02	1.28319E+00
4	5.18407E+02	2.39956E+02
5	5.18407E+02	3.09248E+02
6	1.20619E+02	1.28319E+00
7	1.39867E+02	1.28319E+00
8	1.60398E+02	1.28319E+00
9	1.79646E+02	1.28319E+00
10	2.00177E+02	1.28319E+00

11	2.19425E+02	1.28319E+00
12	2.39956E+02	1.28319E+00
13	2.60487E+02	1.28319E+00
14	2.79735E+02	1.28319E+00
15	3.00265E+02	1.28319E+00
16	5.00442E+02	1.28319E+00
17	5.18407E+02	3.60575E+02
18	3.79823E+02	1.28319E+00
19	4.00354E+02	1.28319E+00
20	4.19602E+02	1.28319E+00
21	4.40133E+02	1.28319E+00
22	4.59381E+02	1.28319E+00
23	4.79912E+02	1.28319E+00
24	3.50310E+02	1.28319E+00
25	5.18407E+02	3.19513E+02
26	5.18407E+02	2.79735E+02
27	5.18407E+02	3.50310E+02
28	1.00088E+02	1.28319E+00
29	1.29602E+02	1.28319E+00
30	5.18407E+02	3.90088E+02

Number of reverse particles : 0

Particles released at wells :

Well-No.	Particles released
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0

********** HYDRAULIC HEAD DISTRIBUTION **********

	1	2	3	4	5	6
36	1.5800E+01	1.5900E+01	1.6000E+01	1.6200E+01	1.6400E+01	1.6600E+01
35	1.6100E+01	1.6187E+01	1.6292E+01	1.6436E+01	1.6593E+01	1.6752E+01
34	1.6400E+01	1.6451E+01	1.6539E+01	1.6653E+01	1.6779E+01	1.6908E+01
33	1.6600E+01	1.6672E+01	1.6756E+01	1.6853E+01	1.6958E+01	1.7065E+01
32	1.6800E+01	1.6877E+01	1.6957E+01	1.7042E+01	1.7131E+01	1.7221E+01
31	1.7000E+01	1.7075E+01	1.7150E+01	1.7225E+01	1.7300E+01	1.7376E+01
30	1.7200E+01	1.7271E+01	1.7338E+01	1.7404E+01	1.7467E+01	1.7529E+01
29	1.7400E+01	1.7466E+01	1.7526E+01	1.7582E+01	1.7633E+01	1.7682E+01
28	1.7600E+01	1.7664E+01	1.7716E+01	1.7761E+01	1.7800E+01	1.7835E+01
27	1.7800E+01	1.7870E+01	1.7911E+01	1.7942E+01	1.7969E+01	1.7990E+01
	1.7956E+01	1.7982E+01	1.8010E+01	1.8034E+01	1.8053E+01	1.8068E+01
	1.8100E+01	1.8095E+01	1.8110E+01	1.8127E+01	1.8139E+01	1.8147E+01
24	1.8205E+01	1.8204E+01	1.8213E+01	1.8223E+01	1.8229E+01	1.8231E+01
23	1.8300E+01	1.8302E+01	1.8307E+01	1.8311E+01	1.8312E+01	1.8308E+01

22	1.8398E+01	1.8399E+01	1.8401E+01	1.8401E+01	1.8397E+01	1.8387E+01
21	1.8500E+01	1.8502E+01	1.8501E+01	1.8497E+01	1.8488E+01	1.8472E+01
20	1.8603E+01	1.8604E+01	1.8601E+01	1.8592E+01	1.8578E+01	1.8558E+01
19	1.8700E+01	1.8702E+01	1.8696E+01	1.8684E+01	1.8666E+01	1.8642E+01
18	1.8809E+01	1.8812E+01	1.8802E+01	1.8785E+01	1.8763E+01	1.8736E+01
17	1.8900E+01	1.8908E+01	1.8894E+01	1.8873E+01	1.8848E+01	1.8818E+01
16	1.9000E+01	1.9016E+01	1.8995E+01	1.8968E+01	1.8939E+01	1.8907E+01
15	1.9200E+01	1.9133E+01	1.9096E+01	1.9064E+01	1.9031E+01	1.8997E+01
14	1.9400E+01	1.9342E+01	1.9293E+01	1.9252E+01	1.9213E+01	1.9176E+01
13	1.9600E+01	1.9537E+01	1.9482E+01	1.9434E+01	1.9392E+01	1.9354E+01
12	1.9800E+01	1.9723E+01	1.9660E+01	1.9608E+01	1.9564E+01	1.9526E+01
11	2.0000E+01	1.9894E+01	1.9824E+01	1.9771E+01	1.9728E+01	1.9692E+01
10	2.0100E+01	2.0028E+01	1.9969E+01	1.9921E+01	1.9882E+01	1.9850E+01
9	2.0200E+01	2.0148E+01	2.0102E+01	2.0062E+01	2.0028E+01	2.0000E+01
8	2.0300E+01	2.0262E+01	2.0227E+01	2.0195E+01	2.0167E+01	2.0143E+01
7	2.0400E+01	2.0373E+01	2.0346E+01	2.0322E+01	2.0300E+01	2.0282E+01
6	2.0500E+01	2.0482E+01	2.0463E+01	2.0446E+01	2.0430E+01	2.0415E+01
5	2.0600E+01	2.0590E+01	2.0579E+01	2.0567E+01	2.0556E+01	2.0546E+01
4	2.0700E+01	2.0698E+01	2.0693E+01	2.0687E+01	2.0681E+01	2.0674E+01
3	2.0800E+01	2.0807E+01	2.0809E+01	2.0807E+01	2.0804E+01	2.0800E+01
2	2.0900E+01	2.0921E+01	2.0927E+01	2.0928E+01	2.0927E+01	2.0926E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	1	2	3	4	5	6
	7	8	9	10	11	12
36	1.6800E+01	1.6900E+01	1.7000E+01	1.7200E+01	1.7300E+01	1.7400E+01
35	1.6902E+01	1.7023E+01	1.7140E+01	1.7276E+01	1.7391E+01	1.7508E+01
34	1.7033E+01	1.7147E+01	1.7258E+01	1.7372E+01	1.7481E+01	1.7590E+01
33	1.7171E+01	1.7272E+01	1.7371E+01	1.7470E+01	1.7568E+01	1.7666E+01
32	1.7310E+01	1.7397E+01	1.7483E+01	1.7568E+01	1.7653E+01	1.7739E+01
31	1.7450E+01	1.7522E+01	1.7594E+01	1.7665E+01	1.7736E+01	1.7808E+01
30	1.7589E+01	1.7647E+01	1.7703E+01	1.7759E+01	1.7815E+01	1.7873E+01
29	1.7727E+01	1.7770E+01	1.7811E+01	1.7852E+01	1.7892E+01	1.7933E+01
28	1.7866E+01	1.7894E+01	1.7919E+01	1.7943E+01	1.7966E+01	1.7990E+01
27	1.8007E+01	1.8019E+01	1.8027E+01	1.8033E+01	1.8038E+01	1.8044E+01
26	1.8077E+01	1.8081E+01	1.8081E+01	1.8077E+01	1.8073E+01	1.8072E+01
25	1.8150E+01	1.8145E+01	1.8135E+01	1.8121E+01	1.8107E+01	1.8098E+01
24	1.8225E+01	1.8213E+01	1.8192E+01	1.8166E+01	1.8141E+01	1.8125E+01
23	1.8296E+01	1.8276E+01	1.8245E+01	1.8207E+01	1.8169E+01	1.8148E+01
22	1.8369E+01	1.8341E+01	1.8300E+01	1.8247E+01	1.8193E+01	1.8166E+01
21	1.8449E+01	1.8413E+01	1.8361E+01	1.8289E+01	1.8210E+01	1.8177E+01
20	1.8530E+01	1.8488E+01	1.8426E+01	1.8331E+01	1.8215E+01	1.8179E+01
19	1.8610E+01	1.8564E+01	1.8496E+01	1.8376E+01	1.8208E+01	1.8180E+01
18	1.8701E+01	1.8653E+01	1.8585E+01	1.8481E+01	1.8320E+01	1.8281E+01
17	1.8781E+01	1.8734E+01	1.8670E+01	1.8582E+01	1.8474E+01	1.8439E+01
16	1.8869E+01	1.8823E+01	1.8766E+01	1.8695E+01	1.8623E+01	1.8597E+01
15	1.8959E+01	1.8915E+01	1.8865E+01	1.8808E+01	1.8758E+01	1.8740E+01
14	1.9140E+01	1.9101E+01	1.9063E+01	1.9026E+01	1.8998E+01	1.8992E+01
13	1.9319E+01	1.9286E+01	1.9256E+01	1.9230E+01	1.9214E+01	1.9213E+01
12	1.9494E+01	1.9465E+01	1.9440E+01	1.9422E+01	1.9412E+01	1.9413E+01
11	1.9662E+01	1.9636E+01	1.9616E+01	1.9602E+01	1.9595E+01	1.9597E+01
10	1.9823E+01	1.9801E+01	1.9784E+01	1.9773E+01	1.9768E+01	1.9769E+01
9	1.9976E+01	1.9958E+01	1.9944E+01	1.9935E+01	1.9931E+01	1.9932E+01
8	2.0124E+01	2.0108E+01	2.0097E+01	2.0089E+01	2.0086E+01	2.0087E+01
7	2.0266E+01	2.0253E+01	2.0244E+01	2.0238E+01	2.0235E+01	2.0236E+01
6	2.0403E+01	2.0393E+01	2.0386E+01	2.0381E+01	2.0379E+01	2.0380E+01
5	2.0537E+01	2.0530E+01	2.0524E+01	2.0521E+01	2.0519E+01	2.0520E+01
4	2.0668E+01	2.0663E+01	2.0659E+01	2.0656E+01	2.0655E+01	2.0656E+01

3	2.0797E+01	2.0793E+01	2.0791E+01	2.0789E+01	2.0789E+01	2.0789E+01
2	2.0924E+01	2.0922E+01	2.0921E+01	2.0920E+01	2.0920E+01	2.0920E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	7	8	9	10	11	12
	13	14	15	16	17	18
36	1.7500E+01	1.7600E+01	1.7700E+01	1.7800E+01	1.8000E+01	1.8100E+01
35	1.7572E+01	1.7641E+01	1.7758E+01	1.7874E+01	1.8011E+01	1.8124E+01
34	1.7645E+01	1.7703E+01	1.7814E+01	1.7926E+01	1.8043E+01	1.8155E+01
33	1.7715E+01	1.7767E+01	1.7868E+01	1.7972E+01	1.8080E+01	1.8188E+01
32	1.7782E+01	1.7827E+01	1.7919E+01	1.8014E+01	1.8114E+01	1.8219E+01
31	1.7844E+01	1.7884E+01	1.7963E+01	1.8049E+01	1.8143E+01	1.8246E+01
30	1.7902E+01	1.7934E+01	1.8000E+01	1.8075E+01	1.8162E+01	1.8263E+01
29	1.7954E+01	1.7978E+01	1.8027E+01	1.8087E+01	1.8166E+01	1.8267E+01
28	1.8002E+01	1.8015E+01	1.8042E+01	1.8079E+01	1.8147E+01	1.8248E+01
27	1.8046E+01	1.8047E+01	1.8044E+01	1.8039E+01	1.8092E+01	1.8187E+01
26	1.8070E+01	1.8065E+01	1.8046E+01	1.7997E+01	1.8048E+01	1.8121E+01
25	1.8094E+01	1.8087E+01	1.8053E+01	1.7963E+01	1.8023E+01	1.8065E+01
24	1.8120E+01	1.8114E+01	1.8099E+01	1.8041E+01	1.8095E+01	1.8173E+01
23	1.8143E+01	1.8141E+01	1.8149E+01	1.8151E+01	1.8214E+01	1.8317E+01
22	1.8161E+01	1.8164E+01	1.8202E+01	1.8246E+01	1.8325E+01	1.8437E+01
21	1.8171E+01	1.8176E+01	1.8255E+01	1.8338E+01	1.8433E+01	1.8548E+01
20	1.8166E+01	1.8163E+01	1.8305E+01	1.8426E+01	1.8533E+01	1.8648E+01
19	1.8160E+01	1.8134E+01	1.8357E+01	1.8511E+01	1.8626E+01	1.8739E+01
18	1.8272E+01	1.8278E+01	1.8475E+01	1.8614E+01	1.8727E+01	1.8835E+01
17	1.8439E+01	1.8458E+01	1.8589E+01	1.8708E+01	1.8814E+01	1.8916E+01
16	1.8601E+01	1.8621E+01	1.8712E+01	1.8811E+01	1.8907E+01	1.9002E+01
15	1.8746E+01	1.8764E+01	1.8832E+01	1.8915E+01	1.9000E+01	1.9087E+01
14	1.8998E+01	1.9011E+01	1.9056E+01	1.9115E+01	1.9182E+01	1.9253E+01
13	1.9218E+01	1.9229E+01	1.9261E+01	1.9305E+01	1.9358E+01	1.9415E+01
12	1.9417E+01	1.9426E+01	1.9450E+01	1.9484E+01	1.9525E+01	1.9571E+01
11	1.9601E+01	1.9607E+01	1.9627E+01	1.9653E+01	1.9686E+01	1.9723E+01
10	1.9773E+01	1.9778E+01	1.9793E+01	1.9814E+01	1.9840E+01	1.9870E+01
9	1.9935E+01	1.9939E+01	1.9951E+01	1.9968E+01	1.9989E+01	2.0012E+01
8	2.0090E+01	2.0093E+01	2.0103E+01	2.0116E+01	2.0132E+01	2.0151E+01
7	2.0238E+01	2.0241E+01	2.0248E+01	2.0259E+01	2.0272E+01	2.0287E+01
6	2.0381E+01	2.0383E+01	2.0389E+01	2.0397E+01	2.0407E+01	2.0419E+01
5	2.0521E+01	2.0522E+01	2.0526E+01	2.0533E+01	2.0540E+01	2.0549E+01
4	2.0656E+01	2.0657E+01	2.0661E+01	2.0665E+01	2.0670E+01	2.0677E+01
3	2.0789E+01	2.0790E+01	2.0792E+01	2.0795E+01	2.0798E+01	2.0803E+01
2	2.0921E+01	2.0921E+01	2.0922E+01	2.0923E+01	2.0925E+01	2.0927E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	13	14	15	16	17	18
	19	20	21	22	23	24
36	1.8200E+01	1.8300E+01	1.8400E+01	1.8500E+01	1.8600E+01	1.8700E+01
35	1.8231E+01	1.8335E+01	1.8439E+01	1.8542E+01	1.8645E+01	1.8749E+01
34	1.8264E+01	1.8371E+01	1.8478E+01	1.8584E+01	1.8690E+01	1.8796E+01
33	1.8297E+01	1.8406E+01	1.8515E+01	1.8625E+01	1.8734E+01	1.8843E+01
32	1.8328E+01	1.8440E+01	1.8552E+01	1.8665E+01	1.8777E+01	1.8888E+01
31	1.8356E+01	1.8470E+01	1.8587E+01	1.8704E+01	1.8820E+01	1.8934E+01
30	1.8377E+01	1.8498E+01	1.8621E+01	1.8744E+01	1.8864E+01	1.8980E+01
29	1.8389E+01	1.8521E+01	1.8655E+01	1.8784E+01	1.8909E+01	1.9028E+01
28	1.8389E+01	1.8542E+01	1.8690E+01	1.8828E+01	1.8957E+01	1.9079E+01
27	1.8375E+01	1.8565E+01	1.8732E+01	1.8879E+01	1.9012E+01	1.9134E+01
26	1.8366E+01	1.8584E+01	1.8760E+01	1.8909E+01	1.9042E+01	1.9163E+01

25	1.8361E+01	1.8614E+01	1.8793E+01	1.8943E+01	1.9075E+01	1.9195E+01
24	1.8440E+01	1.8662E+01	1.8836E+01	1.8982E+01	1.9111E+01	1.9229E+01
23	1.8522E+01	1.8716E+01	1.8880E+01	1.9021E+01	1.9147E+01	1.9261E+01
22	1.8607E+01	1.8777E+01	1.8929E+01	1.9064E+01	1.9185E+01	1.9296E+01
21	1.8695E+01	1.8846E+01	1.8986E+01	1.9112E+01	1.9228E+01	1.9334E+01
20	1.8780E+01	1.8916E+01	1.9044E+01	1.9163E+01	1.9272E+01	1.9373E+01
19	1.8860E+01	1.8983E+01	1.9102E+01	1.9213E+01	1.9316E+01	1.9411E+01
18	1.8946E+01	1.9058E+01	1.9166E+01	1.9269E+01	1.9365E+01	1.9455E+01
17	1.9019E+01	1.9122E+01	1.9223E+01	1.9318E+01	1.9408E+01	1.9493E+01
16	1.9097E+01	1.9191E+01	1.9284E+01	1.9372E+01	1.9456E+01	1.9535E+01
15	1.9174E+01	1.9260E+01	1.9345E+01	1.9427E+01	1.9504E+01	1.9577E+01
14	1.9325E+01	1.9398E+01	1.9469E+01	1.9538E+01	1.9604E+01	1.9665E+01
13	1.9474E+01	1.9534E+01	1.9594E+01	1.9651E+01	1.9706E+01	1.9756E+01
12	1.9620E+01	1.9669E+01	1.9718E+01	1.9766E+01	1.9811E+01	1.9851E+01
11	1.9762E+01	1.9803E+01	1.9843E+01	1.9882E+01	1.9919E+01	1.9951E+01
10	1.9902E+01	1.9935E+01	1.9968E+01	2.0000E+01	2.0029E+01	2.0055E+01
9	2.0038E+01	2.0065E+01	2.0092E+01	2.0118E+01	2.0142E+01	2.0164E+01
8	2.0172E+01	2.0194E+01	2.0216E+01	2.0237E+01	2.0257E+01	2.0275E+01
7	2.0303E+01	2.0321E+01	2.0338E+01	2.0356E+01	2.0373E+01	2.0389E+01
6	2.0432E+01	2.0446E+01	2.0460E+01	2.0475E+01	2.0489E+01	2.0503E+01
5	2.0559E+01	2.0570E+01	2.0581E+01	2.0592E+01	2.0604E+01	2.0616E+01
4	2.0684E+01	2.0692E+01	2.0700E+01	2.0709E+01	2.0718E+01	2.0727E+01
3	2.0807E+01	2.0812E+01	2.0818E+01	2.0823E+01	2.0830E+01	2.0836E+01
2	2.0929E+01	2.0932E+01	2.0934E+01	2.0937E+01	2.0940E+01	2.0943E+01
1	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01

	19	20	21	22	23	24

	25	26	27	28
36	1.8800E+01	1.8900E+01	1.9000E+01	1.9100E+01
35	1.8852E+01	1.8957E+01	1.9068E+01	1.9200E+01
34	1.8902E+01	1.9008E+01	1.9112E+01	1.9200E+01
33	1.8951E+01	1.9060E+01	1.9171E+01	1.9300E+01
32	1.8999E+01	1.9107E+01	1.9213E+01	1.9300E+01
31	1.9046E+01	1.9158E+01	1.9271E+01	1.9400E+01
30	1.9094E+01	1.9205E+01	1.9312E+01	1.9400E+01
29	1.9144E+01	1.9256E+01	1.9370E+01	1.9500E+01
28	1.9195E+01	1.9306E+01	1.9411E+01	1.9500E+01
27	1.9249E+01	1.9359E+01	1.9469E+01	1.9600E+01
26	1.9277E+01	1.9385E+01	1.9489E+01	1.9578E+01
25	1.9307E+01	1.9413E+01	1.9513E+01	1.9600E+01
24	1.9338E+01	1.9442E+01	1.9542E+01	1.9630E+01
23	1.9368E+01	1.9470E+01	1.9571E+01	1.9700E+01
22	1.9399E+01	1.9498E+01	1.9594E+01	1.9679E+01
21	1.9434E+01	1.9529E+01	1.9620E+01	1.9700E+01
20	1.9468E+01	1.9560E+01	1.9649E+01	1.9731E+01
19	1.9502E+01	1.9589E+01	1.9678E+01	1.9800E+01
18	1.9540E+01	1.9621E+01	1.9702E+01	1.9780E+01
17	1.9572E+01	1.9648E+01	1.9722E+01	1.9800E+01
16	1.9608E+01	1.9678E+01	1.9743E+01	1.9800E+01
15	1.9645E+01	1.9709E+01	1.9766E+01	1.9800E+01
14	1.9722E+01	1.9775E+01	1.9829E+01	1.9900E+01
13	1.9801E+01	1.9840E+01	1.9873E+01	1.9900E+01
12	1.9885E+01	1.9911E+01	1.9922E+01	1.9900E+01
11	1.9978E+01	1.9996E+01	2.0005E+01	2.0000E+01
10	2.0077E+01	2.0092E+01	2.0099E+01	2.0100E+01
9	2.0181E+01	2.0194E+01	2.0200E+01	2.0200E+01
8	2.0291E+01	2.0301E+01	2.0305E+01	2.0300E+01
7	2.0403E+01	2.0415E+01	2.0419E+01	2.0400E+01

6	2.0518E+01	2.0534E+01	2.0556E+01	2.0600E+01
5	2.0630E+01	2.0647E+01	2.0669E+01	2.0700E+01
4	2.0739E+01	2.0753E+01	2.0772E+01	2.0800E+01
3	2.0844E+01	2.0853E+01	2.0867E+01	2.0900E+01
[illegible]	2.0946E+01	2.0948E+01	2.0941E+01	2.0900E+01
[illegible]	2.1050E+01	2.1050E+01	2.1050E+01	2.1050E+01
	25	26	27	28

********** End of logbook **********

Detailed Analysis of Alternatives
Naval Construction Battalion Center

Volume III
Site 13 - Disposal Area Northwest of Buildings W-3, W-4 and T-1

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1.0 INTRODUCTION

Volume III addresses the Detailed Analysis of Alternatives for Site 13 - Disposal Area Northwest of Buildings W-3, W-4, and T-1 (Disposal Area Northwest). The location of Site 13 relative to the Davisville facility is provided in Figure 1-1. The following sections provide background information and a description of the site, followed by a summary of remedial response objectives and cleanup criteria, general response actions, identification and screening of technologies and process options, a refinement of remedial alternatives previously developed in the ISA, a preliminary screening of remedial alternatives, and a detailed analysis of the remedial alternatives. It builds upon the evaluation conducted in the ISA (TRC, 1993a) and incorporates the results of the Phase II RI in the evaluation of potential remedial technologies for Site 13.

2.0 SITE CHARACTERIZATION

2.1 Site Location and Description

Site 13 is approximately six acres in size and consists of a large grassy field bounded on three sides by paved roads. Several small devegetated areas are evident within the site area. The area is located northwest of Buildings W-3, W-4, and T-1. There are eight catch basins located in this area. Two storm sewer drain pipes join near the center of the site, entering from two locations along "A" Street and exiting at the northeast corner of the site at the intersection of Exeter Street and Foster Street. A site map is provided in Figure 2-1.

The Comprehensive Reuse Plan for NCBC Davisville specifies the area in which Site 13 is located is to be used for economic/industrial development.

2.2 Site History Overview

From 1945 to 1955, the NCBC Davisville Construction and Equipment Department was located in Buildings W-3, W-4, and T-1. Overhaul and repair activities were conducted in these buildings, vehicles were stored in fields to the north and west, and drums of oils, thinners and solvents were stored adjacent to the buildings. Approximately 300 gallons of waste oils per month were reportedly spread on the fields northwest of the three buildings (Hart, 1984a).

2.3 Site Geology, Hydrogeology and Hydrology

2.3.1 Site Geology

The subsurface soil investigation activities performed under the Phase I and Phase II RIs provided information on the site geology. These activities included the excavation of one test pit and the drilling and sampling of borings across the site. The Phase I and Phase II RI investigation locations are shown on Figures 2-2 and 2-3, respectively.

In the "Interim Soil Survey Report for North Kingstown, Rhode Island" (USDA, 1973), the Site 13 surface soils are mapped as Quonset gravelly sandy loam. The surface soil sample descriptions indicate that the surface soils on this site consist predominantly of native fine to coarse sand with variable silt and gravel content. The descriptions of the surface soil samples were consistent with the mapped surface soils at Site 13.

According to the USGS surficial geologic map of the Wickford, Rhode Island quadrangle (Schafer, 1961), overlying the bedrock at Site 13 are surficial overburden deposits of Pleistocene glacial water-laid ice-contact sediments, consisting of sand, gravel and silt. The soil boring results indicate that the overburden deposits on this site consist of native fine to medium sand with variable silt, coarse sand and gravel content, silt with variable sand and gravel content, and sand and silt layers. At several locations, the presence of fine-grained and fibrous peat as well as organic silts was observed. No fill was encountered at this site. The descriptions of the soil boring samples were consistent with the mapped surficial overburden materials at Site 13. Overburden thicknesses ranged from 25.5 feet to 27.3 feet.

Competent bedrock was encountered at the Site 13 shallow and deep monitoring well locations at elevations ranging from 0.7 feet above mean sea level (msl) to 9.1 feet msl. The bedrock surface at Site 13 appears to have a low in the central area of the site and slopes upward to the northeast and southwest. A 1.6-foot layer of weathered bedrock was encountered just above competent bedrock near the center of the site, and a 11.5-foot layer of weathered bedrock was encountered just above competent bedrock at another monitoring well in the southwest corner of the site.

One seismic refraction survey line was completed at Site 13; this investigation indicated that the competent bedrock at Site 13 is located approximately 12 feet below ground surface, and appears to exhibit a relatively flat topography. Apparent competent bedrock elevations from the seismic refraction survey at Site 13 ranged from 16.0 feet msl to 21.1 feet msl.

According to the USGS bedrock geologic map of the Wickford, Rhode Island quadrangle (Williams, 1964), Site 13 is underlain at depth by bedrock belonging to the Pennsylvanian Rhode Island Formation. Nx rock cores were collected of competent bedrock at three monitoring well borings. The rock cores indicate that the bedrock at 13-MW7S and 13-MW10D consists of massive and competent, medium to dark grey, fine- to medium-grained meta-sandstone gneiss, interbedded with dark grey shale. The 13-MW7S core contains abundant shale partings, while the 13-MW10D core contains some iron oxide-stained natural fractures. The core from 13-MW3D consists of massive and competent, light to medium grey, fine- to medium-grained meta-sandstone gneiss. The core contains scattered quartz veins, some vein-healed natural fractures and several iron oxide-stained natural fractures.

2.3.2 Site Hydrogeology

Contour maps of the shallow ground water elevations as measured in Site 13 monitoring wells on August 13 and September 17, 1993, are presented as Figures 2-4 and 2-5, respectively. The shallow ground water contour maps indicate that the site shallow ground water flow patterns are complex; an approximately northwest-trending zone of higher shallow ground water elevation forms a shallow ground water divide extending from the southeast portion of the site to the northwest portion.

The shallow ground water elevations measured within the divide area vary only slightly (i.e., less than 0.5 foot), and the areal configuration of the divide may vary with changes in water level and precipitation recharge. The divide may reflect the location of Site 13 midway between Mill and Hall Creeks. Along the southwestern flank of the divide, shallow ground water flows generally to the southwest, toward Site 11 and Mill Creek. Along the northern and northeastern flanks of the divide, shallow ground water flows generally north-northeastward toward Site 06 and Hall Creek. The shallow ground water in the northeast corner of the site may sometimes flow toward the north-northwest, as indicated by the September 17, 1993 shallow ground water level contour map (Figure 2-5).

Vertical hydraulic gradients were calculated from the two sets of paired monitoring wells as presented in Table 2-1. A positive hydraulic gradient indicates a potential for upward flow and a negative gradient indicates a potential for downward flow of ground water.

For the two measuring events, the calculated vertical gradients ranged from -8.83×10^{-3} ft/ft to 6.92×10^{-4} ft/ft. Positive vertical gradients (upward) were measured at one well pair during both events, while negative vertical gradients (downward) were measured at the other well pair during both events. The positive and negative vertical hydraulic gradients observed at Site 13 are low in magnitude; this indicates that vertical transport would appear to have little impact on contaminant migration at the site.

Horizontal hydraulic gradients were also calculated from the water level measurements at the site. Representative average horizontal gradients for both the shallow and deep ground water were determined for several areas on the site, and are provided in Table 2-2. Excluding the areas within the shallow ground water divide with zero and near-zero gradients, average horizontal gradients for shallow ground water ranged from 5.12×10^{-4} ft/ft to the southwest to

1.15×10^{-2} ft/ft to the northeast. Average deep ground water horizontal gradients ranged from 2.68×10^{-3} ft/ft to 3.35×10^{-3} ft/ft to the southwest.

The calculated average horizontal hydraulic gradients, along with hydraulic conductivity and estimated effective porosity values, were used to calculate average linear ground water flow velocity values at the site. The average linear velocity values, calculated on the basis of the shallow and deep hydraulic conductivities of 2.2 and 21.1 ft/d, respectively (derived from Phase II RI slug tests), and an assumed effective porosity of 20% for the silty sands, are presented in Table 2-3. Excluding the areas within the shallow ground water divide with zero and near-zero gradients, average linear velocities of the shallow ground water ranged from 0.01 ft/d to 0.13 ft/d. Average deep linear velocities ranged from 0.28 ft/d to 0.35 ft/d between the two water level measurements.

2.3.3 Site Hydrology

The topography of Site 13 is relatively flat and consists of large grassy fields with several small devegetated areas. Site soils consist of coarse grained sand with varying amounts of gravel and silt, thus suggesting the soils are well drained. Runoff is expected to be minimal due to the flat surface, light vegetation, and well drained soils. There are three storm water catch basins across the site into which most of the surface water runoff flows. Surface water from Site 13 eventually flows into Hall Creek before draining into Frys Pond.

2.4 Ecological Setting

RIDEM has classified ground water in the vicinity of Site 13 as Class GB. Ground water classified GB encompasses those resources designated as not suitable for public or private drinking water use without treatment due to known or presumed degradation. GB-classified ground water is primarily located at highly urbanized areas or in the vicinity of disposal sites for solid waste, hazardous waste, or sewage sludge.

No surface water bodies exist within or adjacent to Site 13. However, surface water runoff from the Site 13 area flows to storm drains that eventually discharge into Hall Creek. Site 13 and Hall Creek are both part of the Hall Creek Watershed. The ecological assessment activities conducted as part of the Phase II RI for NCBC Davisville included an assessment of

the Hall Creek Watershed, focusing on the portion of the watershed between Davol Pond and Frys Pond. An assessment of terrestrial risks considered site surface soil data.

Based on the observations made during the ecological risk assessment, Hall Creek Watershed appears to support a diverse avian fauna, exhibits signs of small mammals, and supports fish species in abundance (enough to provide a food source for piscivorous birds in the tidal reaches of the watershed). Observed were several frogs, painted turtles, and small unidentified fish in the freshwater sections of the Hall Creek Watershed. Thirteen species of birds in the freshwater reach of the Hall Creek Watershed and 21 species around Frys Pond were observed during the ecological risk assessment activities.

The benthos of Hall Creek appear to support a diverse insect and non-insect fauna in the freshwater sections. The numerical dominance is shared between an insect family, *Chironomidae*, and non-insect organisms. Diversity and abundance decrease in the brackish water portions of the watershed. Observed in the brackish water portions were *Paleomonetes, Nassarius, Fundulus*, post-larval fish, polychaetes, and shells of *Mya arenaria*. The deeper sediments in Frys Pond appear to be anoxic, supporting no living organisms.

The State of Rhode Island (RIDEM, 1989) conducted an endangered species survey of East Davisville, also referred to as the Main Center, of which Site 13 is part. It describes the area as having fringing saline and brackish marsh which does not provide suitable habitat for rare species, and upland areas which are slowly reverting to natural communities of shrubs.

2.5 Site Investigation Overview

2.5.1 Initial Assessment Study and Confirmation Study

Site 13 was identified in the IAS as a possible receptor of hazardous wastes. However, the IAS concluded that the risk posed by Site 13 to human health and the environment was minimal and that no further investigation was necessary. At the request of RIDEM, the site was included in the Verification Step of the Confirmation Study.

The Verification Step field program consisted of OVA screening, a geophysical survey, collection of a single composite surface soil sample, and one ground water sample. Both samples were analyzed for petroleum-based hydrocarbons and scanned for purgeable organics.

During a second field mobilization, a second grab surface soil sample was collected for analysis, and also analyzed for petroleum-based hydrocarbons and scanned for purgeable organics.

2.5.2 Phase I RI

The Phase I RI included a soil gas survey, collection and analysis of 13 surface soil samples (including three sediment samples from on-site catch basins) and five subsurface soil samples, drilling of six soil borings and associated subsurface soil sample collection, and the installation and sampling of three monitoring wells as well as sampling of an existing monitoring well. The Phase I RI sample locations are shown on Figure 2-2. All surface soil samples were analyzed for TCL VOCs, ten samples were analyzed for TCL pesticides/PCBs, and six samples were analyzed for TCL SVOCs and TAL metals. All subsurface soil samples, and ground water samples were analyzed for full TCL/TAL analyses, while the three sediment samples were submitted for analysis of TCL volatiles, TCL pesticides/PCBs, and total petroleum hydrocarbons. Also, two subsurface samples were submitted for TCLP extraction and analysis.

2.5.3 Phase II RI

The scope of the Phase II RI was developed on the basis of the Phase I results and included activities to further delineate the horizontal and vertical extent of contamination associated with former disposal activities at Site 13. The investigations also provided a basis for the evaluation of contaminant fate and transport mechanisms, human health risks, and ecological risks.

The field investigation activities were conducted at Site 13 from December 1992 to September 1993. Field activities included the completion of a seismic refraction survey, surface soil sampling, test pit sampling, soil boring sampling, ground water sampling, and catch basin/storm sewer sampling.

A total of forty-seven soil samples were collected during the Phase II site investigation. Thirty-four surface soil samples were collected from sixteen surface soil locations, twelve test boring locations (0- to 2-feet), and six monitoring well locations (0- to 2-feet). Twelve test borings and twelve monitoring well borings were completed across the site and fifteen subsurface soil samples were taken from the borings. After the completion of the monitoring well borings,

ten shallow wells and two deep wells were installed. In addition, three bedrock cores were collected during the drilling activities. One test pit excavation was conducted beneath the conduit pipe that connects to the storm drain. Three sediment samples were collected from the catch basins on-site. The Phase II RI sample locations are shown on Figure 2-3.

The surface soil and subsurface soil samples were analyzed for full TCL and TAL parameters. Two surface soil samples and one subsurface soil sample were collected for TCLP extraction and analysis. Also, the three sediment samples taken from the catch basins were analyzed for full TCL/TAL parameters, plus total organic carbon analysis.

Ground water samples were collected from fourteen shallow wells and two deep wells during the Phase II RI ground water sampling event. Ground water samples were analyzed in the field for the water quality parameters of pH, specific conductance, Eh, temperature, and turbidity, and in the laboratory for full TCL and TAL parameters. In addition, three ground water samples were analyzed for filtered metals, BOD, COD, and TSS.

Eighteen background surface soil samples were collected across NCBC Davisville during the Phase II RI to provide a range of background soil quality for NCBC Davisville soils. All eighteen samples were analyzed for full TCL and TAL compounds. Only inorganic, semi-volatile, and pesticide/PCB background results are pertinent to Site 13. The applicable background soil quality results are summarized in Table 2-3 and are considered in the evaluation of containment levels presented below.

2.6 Nature and Extent of Contamination

The nature and extent of contamination based on the RI investigations are presented by chemical class below. Where appropriate, Confirmation Study results are also referenced.

2.6.1 Volatile Organic Compounds (VOCs)

Surface Soils

The first composite surface soil sample from the Verification Step of the Confirmation Study contained 193 ppm of petroleum hydrocarbons and 36 ppm of total volatile organics, although most of the volatile fraction was acetone, a potential remnant of the decontamination

procedure. Very low levels of organic contaminants were found in the second round surface soil sample.

Acetone, chloroform, and 1,1,1-trichloroethane were each detected in at least one of the Phase I RI surface soil samples. Acetone was detected in three surface soil samples at concentrations ranging from 17 ppb to 19 ppb. Chloroform was detected in five of the surface soil samples at estimated concentrations ranging from 1 ppb to 2 ppb. 1,1,1-Trichloroethane was detected in soil boring sample B-13-06-00 at a concentration of 7 ppb.

Volatile organic compounds detected in the Phase II RI surface soil samples included acetone, toluene, and total xylenes. Acetone was detected in three of the surface soil samples at concentrations ranging from 15 ppb to 24 ppb. The infrequent detection and low concentrations of acetone in the Site 13 surface soil results may indicate that its presence is due to laboratory-induced contamination.

Toluene was detected in surface soil samples 13-B15-01 and 13-MW9-01 at an estimated concentration of 2 ppb in each sample. Total xylenes were also detected in one surface soil sample at an estimated concentration of 2 ppb. Both samples were collected in the southwest portion of the site along "A" Street.

Subsurface Soils

The only VOC detected in the subsurface soils during the Phase I RI was acetone. Acetone was detected in three of the subsurface soil samples at concentrations ranging from 20 to 29 ppb.

The Phase II RI subsurface soil analyses indicated that acetone, 2-butanone, and toluene were detected in the subsurface soil samples. Acetone was detected in five of the soil samples at estimated concentrations ranging from 20 ppb to 100 ppb. 2-Butanone was detected in one of the subsurface soil samples, 11-B07-02 (2- to 4-feet), at an estimated concentration of 8 ppb. Toluene was detected in subsurface soil samples 13-B9-02 and 13-B12-02 at estimated concentrations of 2 ppb and 6 ppb, respectively. The samples were each collected from the 2- to 4-foot interval at borings located in the eastern portion of the site. Toluene was also detected in the test pit sample at an estimated concentration of 1 ppb.

Ground Water

Results of the Phase I RI ground water sampling rounds indicated that 1,2-dichloroethane and total xylenes were present in the Site 13 ground water. 1,2-Dichloroethane was detected in monitoring well 13-MW1S at an estimated concentration of 2 ppb during both sampling rounds. Total xylenes were detected in monitoring well 13-MW3S at an estimated concentration of 1 ppb during the second round of sampling.

Results of the Phase II RI ground water sampling indicate that 1,2-dichloroethane, 2-butanone, trichloroethene, and total xylenes are present in the Site 13 ground water. 1,2-Dichloroethane was detected at an estimated concentration of 1 ppb in monitoring well 13-MW1S. The presence of 1,2-dichloroethane in monitoring well 13-MW1S verifies the results of the Phase I RI ground water sampling at this location. 2-Butanone was detected in monitoring well 13-MW5S at an estimated concentration of 6 ppb. Trichloroethene was detected in monitoring well 13-MW4S at an estimated concentration of 1 ppb, while total xylenes were detected in monitoring well 13-MW3D at an estimated concentration of 1 ppb.

Catch Basin

No volatile organic compounds were detected in Phase I or Phase II RI sediment samples.

2.6.2 Semivolatile Organic Compounds (SVOCs)

Surface Soils

Bis(2-ethylhexyl)phthalate and benzoic acid were the only SVOCs present in the Phase I RI surface soil samples. Bis(2-ethylhexyl)phthalate was detected in two surface soil samples at estimated concentrations of 55 ppb and 190 ppb, respectively. Benzoic acid was detected in three surface soil samples at estimated concentrations ranging from 71 ppb to 590 ppb.

PAH compounds and phthalate esters were detected in Phase II RI subsurface soil samples. PAH compounds were detected in nineteen of the thirty-four samples during the Phase II RI at total PAH concentrations ranging from 42 ppb to 2,847 ppb. PAHs were detected in samples located throughout the site. The highest concentrations of PAHs, each greater than 1,000 ppb, were detected in surface soil samples 13-SS17 (1,489 ppb), 13-SS22 (2,677 ppb), and 13-SS25 (2,847 ppb). Carcinogenic PAHs totalled 1,110 ppb in surface soil sample 13-SS17, 1,960 ppb in sample 13-SS22, and 1,610 ppb in sample 13-SS25.

Other semivolatile organic compounds detected in the Site 13 surface soils include bis(2-ethylhexyl)phthalate, butyl benzyl phthalate, di-n-butyl phthalate, diethyl phthalate, pentachlorophenol, and 2,4-dinitrotoluene. These compounds were detected infrequently across the site and generally at low concentrations. As indicated in Table 2-3, butyl benzyl phthalate and bis(2-ethylhexyl)phthalate were detected at levels which were less than the NCBC background range.

Subsurface Soils

During the Phase I RI, SVOCs detected in the subsurface soils included bis(2-ethylhexyl)phthalate, benzoic acid, and PAH compounds. Bis(2-ethylhexyl)phthalate was detected in one subsurface soil sample at an estimated concentration of 330 ppb. Benzoic acid was detected in two subsurface soil samples, each at estimated concentrations of 110 ppb. PAH compounds were detected in three of the subsurface soil samples at total PAH concentrations ranging from 43 ppb to 582 ppb.

PAHs and bis(2-ethylhexyl)phthalate were among the SVOCs detected in Phase II RI subsurface soil samples. PAH compounds were detected in two of the subsurface soil samples (13-B16-02 and 13-MW7-02) at total PAH concentrations ranging from 58 ppb to 84 ppb. Both samples were collected from the 2- to 4-foot interval. PAHs were present in the test pit sample at a total concentration of 488 ppb. 2-Methylnaphthalene was detected in sample 13-B16-02 at a concentration of 58 ppb.

Bis(2-ethylhexyl)phthalate was detected in four of the subsurface soil samples and the one test pit sample at estimated concentrations ranging from 38 ppb to 360 ppb. Of the SVOCs detected in subsurface soil, only 2-methylnaphthalene was detected at a level exceeding the NCBC background range.

Ground Water

Naphthalene, 2-methylnaphthalene, and bis(2-ethylhexyl)phthalate were each present in at least one ground water sample collected during the two Phase I sampling rounds. Naphthalene was detected in monitoring well 13-MW3S at an estimated concentration of 2 ppb during the first sampling round, but its presence was not confirmed during the second sampling round. 2-Methylnaphthalene also was detected in monitoring well 13-MW3S at estimated concentrations of 5 ppb and 3 ppb during the two sampling rounds. Bis(2-ethylhexyl)phthalate

was detected at a concentration of 45 ppb in 13-MW1S during the second ground water sampling round only.

Phenol, pentachlorophenol, naphthalene, 2-methylnaphthalene, diethyl phthalate, di-n-butyl phthalate, and bis(2-ethylhexyl)phthalate were each present in at least one of the Phase II RI ground water samples. Phenol was detected in monitoring wells 13-MW5S and 13-MW13S at estimated concentrations of 2 ppb and 3 ppb, respectively. Pentachlorophenol was detected in monitoring well 13-MW12S at an estimated concentration of 2 ppb. Naphthalene and 2-methylnaphthalene were detected in monitoring wells 13-MW3S, 13-MW3D, and 13-MW12S. Naphthalene was also detected in monitoring well 13-MW13S. The concentrations of the naphthalene and 2-methylnaphthalene in the above wells ranged from 1 ppb to 4 ppb. Phthalate esters were detected in ten of the Site 13 monitoring wells. Diethyl phthalate was detected in monitoring well 13-MW6S at an estimated concentration of 1 ppb. Di-n-butyl phthalate was detected in seven of the wells at estimated concentrations ranging from 1 ppb to 2 ppb. Bis(2-ethylhexyl)phthalate was detected in three of the monitoring wells at concentrations ranging from 19 ppb to 63 ppb. The detection of this phthalate is believed to be due to leaching from equipment used during the low flow ground water sampling, as discussed in the Phase II RI Technical Report (TRC, 1993b).

Catch Basin

The Phase I RI catch basin sediment samples were not analyzed for SVOCs.

Results of the semivolatile organic analyses of the three catch basin sediment samples collected during the Phase II RI indicate that PAH compounds are present in each of the three samples. The highest concentrations of PAH compounds were detected in catch basin sample 13-SD01, located upstream of the site. Total PAH concentrations in this sample totalled 3,843 ppb. Samples 13-SD02, collected from a catch basin in the center of the site, and 13-SD03, collected from a downstream catch basin, contained total PAH concentrations of 1,156 ppb and 1,068 ppb, respectively. Asphalt fragments were contained within each of the sediment samples collected. While an attempt was made to remove non-representative asphalt particles, the detection of PAHs in each of the samples may be attributable to their presence in the sample.

2.6.3 Pesticides/PCBs

Surface Soil

Only PCB compounds were present in the Phase I RI surface soil samples. PCBs were detected in three of the surface soil samples. Sample SS13-9, located in the eastern portion of the site, exhibited a 1.2% level of PCBs during its original analysis. However, due to laboratory QA/QC problems, the sample and a duplicate were recollected and reanalyzed, exhibiting 970 ppm and 720 ppm PCBs, respectively. An average concentration of 4,563 ppm will be considered to be representative of this sample location. The other two samples (SS13-8 and B13-6) were located adjacent to each other, approximately 80 feet to the north of sample SS13-9 and exhibited 5.0 ppm and 1.3 ppm PCBs, respectively.

Both pesticides and PCBs were detected in the Phase II RI surface soil samples. Pesticides were detected at low concentrations in thirty-one of the surface soil samples collected at the site.

PCBs were detected at twenty-five of the surface soil sample locations at concentrations ranging from 4.4 ppb to 2,000 ppb, respectively. The highest concentrations of PCBs were detected in surface soil samples 13-SS11 (1,190 ppb), 13-SS12 (1,970 ppb), and 13-B7-01 (2,000 ppb), each of which were located in the southeastern portion of the site along Exeter Street.

Subsurface Soil

No pesticide or PCB compounds were present in the Phase I RI subsurface soil samples.

Pesticides and PCBs were present in the Phase II RI subsurface soil samples at low concentrations. Pesticides were detected in eight of the subsurface soil samples collected across the site. Of the twenty-one pesticide compounds analyzed for, twelve of the compounds were each detected in at least one of the samples. Of the eight subsurface soil samples which contained detectable levels of pesticides, only 13-B11-02 in the southeastern corner of the site contained a total pesticide concentration of greater than 10 ppb.

PCBs were detected in four subsurface soil samples at concentrations ranging from 5.7 ppb to 57 ppb. PCBs were detected in subsurface soil samples 13-B8-02, 13-B11-02, 13-B16-02, and 13-MW10-02. All four samples were collected from the 2- to 4-foot interval.

Ground Water

No pesticide/PCB compounds were present during either of the Phase I RI ground water sampling rounds.

Six pesticide compounds were each detected in at least one of the monitoring well samples collected during the Phase II RI. Alpha-BHC was detected in monitoring well 13-MW11S and duplicate sample 13-MW16S at estimated concentrations of 0.0043 ppb and 0.0042 ppb, respectively. Alpha chlordane was also detected in duplicate sample 13-MW16S at a concentration of 0.0074 ppb, but was not detected in the original sample. Heptachlor epoxide was detected in five of the Site 13 wells at concentrations ranging from 0.0017 ppb to 0.028 ppb. Dieldrin was detected in monitoring well 13-MW13S at an estimated concentration of 0.0017 ppb. 4,4'-DDD was detected in six of the wells at concentrations ranging from 0.0069 ppb to 0.021 ppb. Eldrin ketone was detected in three monitoring wells at concentrations ranging from 0.0025 ppb to 0.0077 ppb. No PCB compounds were detected in the Phase II RI ground water samples.

Catch Basin

One pesticide compound and two PCB Aroclors were present in the Phase I RI catch basin sediment samples. 4,4'-DDD was detected in catch basin sediment sample S-13-13-04, collected from a catch basin in the northeastern portion of the site, at a concentration of 1,200 ppb. PCBs were detected in all three catch basin samples at concentrations ranging from 3,100 ppb to 7,800 ppb.

Three pesticide compounds were each detected at low concentrations in at least one of the Phase II RI sediment samples. The highest total pesticide levels (22 ppb) were in the upgradient sample, 13-SD01. One PCB compound, Aroclor-1260, was detected in sediment samples 13-SD01, 13-SD02, and 13-SD03 at concentrations of 1,600 ppb, 860 ppb and 11,000 ppb, respectively.

2.6.4 Inorganic Analytes

Surface Soils

Among the inorganic compounds common to each of the Phase I RI surface soil samples were arsenic, chromium, copper, and lead. The levels of lead detected in each of the surface soil samples ranged from 6.3 ppm to 64.1 ppm.

The inorganics detected in Phase II RI surface soil samples were compared with background sample results from surface soil samples collected throughout the NCBC Davisville

facility. A comparison of the observed Phase II RI surface soil concentration ranges at Site 13 to the NCBC background samples is presented in Table 2-3.

Sixteen inorganic analytes were detected in Site 13 surface soils at concentrations above the NCBC background concentration ranges. These inorganics included aluminum, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, and zinc. Twenty of the surface soil samples collected during the Phase II RI contained at least one of these inorganic compounds at a concentration above the NCBC background range. The highest levels of inorganics were detected in surface soil samples 13-SS11, 13-SS17, 13-SS20, 13-B7-01, and 13-MW5-01. Four of these five samples are located in the southeastern portion of the site.

Subsurface Soils

Results of the subsurface soil sample analyses conducted during the Phase I RI were similar to the surface soil sample results. Lead was detected in each of the samples at concentrations ranging from 2.5 ppm to 63.2 ppm.

Fourteen inorganic analytes were detected in the Phase II RI subsurface soil samples at concentrations above the NCBC background ranges. These analytes included antimony, barium, beryllium, cadmium, calcium, cobalt, copper, iron, lead, magnesium, manganese, nickel, sodium, and cyanide. The highest level of inorganics was detected at monitoring well boring sample 13-MW8-02, collected from the 2- to 4-foot interval. The inorganic concentrations detected in the subsurface soils were primarily lower than those concentrations detected in the surface soil samples at Site 13.

Ground Water

Antimony, arsenic, beryllium, cadmium, chromium, lead, and nickel were among the inorganic analytes present in at least one of the Phase I RI ground water samples.

The Phase II ground water sampling and analyses indicated that low levels of inorganic analytes are present in the Site 11 ground water. The inorganic analytes detected in the ground water include aluminum, antimony, arsenic, barium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, potassium, silver, sodium, vanadium, and zinc. Comparison of the Phase I and Phase II analytical data reveals a significant reduction in analyte

concentrations, which may be attributable to the low flow sampling methodology employed during the Phase II ground water sampling program.

Inorganic analysis was also conducted on three filtered ground water samples collected at Site 13. Comparison of the filtered and non-filtered analytical sample results indicate that the inorganic concentrations in the filtered samples are primarily equivalent to or slightly less than the concentrations of the non-filtered samples.

Catch Basin

Phase I RI catch basin sediment samples were not analyzed for inorganics. The only TAL inorganic analytes not detected in the Phase II RI catch basin sediment samples were antimony, mercury, selenium, and thallium. When comparing those inorganics detected in the Site 13 catch basin sediment samples to background sample results from surface soil samples collected throughout the NCBC Davisville facility, fifteen inorganic analytes were detected above the background range. These inorganics include barium, beryllium, cadmium, calcium, chromium, cobalt, copper, lead, magnesium, nickel, silver, sodium, vanadium, zinc, and cyanide.

2.6.5 TCLP Analyses

During the Phase I RI, only inorganics were detected in the two TCLP samples. Arsenic, beryllium, copper, lead, zinc, barium, iron, manganese, aluminum, cobalt, magnesium, and calcium were present in at least one TCLP sample.

No contaminants were detected in the Phase II RI TCLP samples.

2.7 Summary of Contaminant Fate and Transport

A contaminant fate and transport analysis was initially conducted as a part of the Phase I RI and incorporated in the Initial Screening of Alternatives (TRC, 1993a). Subsequently, information obtained during the Phase II RI was incorporated into the contaminant fate and transport analysis and a revised discussion was presented in the Draft Phase II RI Technical Report (TRC, 1993b).

Potential routes of migration, contaminant persistence and observed contaminant migration were considered in evaluating the fate and transport of the site contaminants identified during the RI investigation.

In general, of the environmental media investigated at Site 13, surface soil, catch basin, and ground water contaminants have the greatest potential for off-site migration. Typically, contaminants in surface soils can migrate or be carried off-site by surface runoff (resulting from precipitation), by being sorbed to windblown dust, and by site visitors via adherence to vehicle tires, shoes, etc. Based on current site use, dust generation and surface runoff at Site 13 are expected to be moderate, given the flat, sparsely vegetated cover. Contaminants can also migrate from the surface soils through leaching (by the infiltration of precipitation) and subsequent transport by ground water, by volatilization to ambient air, or by uptake by plants or animals. Subsurface contaminants can migrate through leaching and ground water transport. Ground water transport at Site 13 would be to the southwest, towards Site 11, or to the north-northeast, towards Site 06. No significant differences were observed between shallow and deep ground water quality at the site. Migration of contaminants off-site would also be affected by the storm water drainage system on-site. The catch basins collect the precipitation runoff and eventually discharge to Hall Creek. Contaminated sediments in the catch basins could be carried by storm waters towards the discharge points.

The following sections examine the presence of Contaminants of Concern (COCs), as identified during the Human Health Risk Assessment process (TRC, 1993b), across the site in combination with the potential migration pathways to provide an understanding of contaminant persistence and potential for migration at the site. The discussions below are presented with respect to individual contaminants or contaminant groups based on environmental fate data such as water solubility, vapor pressure, Henry's Law constants, organic carbon-water partition coefficients (K_{oc}), octanol-water partition coefficients (K_{ow}), and half-life in water.

Volatile Organic Compounds

In general, VOCs were detected infrequently and at low concentrations in soils at Site 13. Three VOCs detected in surface or subsurface soil samples, acetone, chloroform, and toluene, were identified as COCs.

The principal mechanism for the natural removal of VOCs is through volatilization, based on vapor pressures (@ approximately 25°C) ranging from 28 mmHg (toluene) to 270 mmHg (acetone) and Henry's Law Constants ranging from 4.3×10^{-5} atm-m^3/mol (acetone) to 3.4×10^{-3} atm-m^3/mol (chloroform).

The role of biodegradation in the natural attenuation of these compounds is compound-specific. Similarly, the role of adsorption is compound-specific (i.e., a greater log K_{oc} indicates a tendency to be retained by soils). The volatile COCs are fairly soluble in water with solubilities of 520 mg/l (toluene) to being miscible (acetone). The tendency of these constituents to partition from organic media into water varies, with log K_{ow}s ranging from 2.69 (for toluene) to -0.24 (for acetone which is highly water soluble). The volatile COCs in surface and subsurface soil are not expected to persist in these media. The primary migration pathways from soil for these constituents are expected to be volatilization and leaching through soil into water.

None of the soil COCs were detected in ground water. Although not detected in soil, 1,2-dichloroethane and xylene were also selected as COCs in ground water. While the solubility of 1,2-dichloroethane is similar to those VOCs detected in soil, xylene is insoluble in water.

Semi-Volatile Organic Compounds

Thirteen SVOCs were identified as COCs in surface soil at Site 13. In subsurface soil, ten of these SVOCs were selected as COCs. The SVOC COCs include nine PAHs, three phthalates and benzoic acid. One PAH and two phthalates were identified as COCs in surface soil but not subsurface soil. In general, the PAHs and phthalates were detected at the highest frequencies and concentrations. It should be noted that phthalates are common laboratory contaminants and are widespread in the environment (ATSDR, 1987; ATSDR, 1989).

SVOCs, particularly PAHs, are persistent in the environment due to their complex chemical nature. While some of the lighter PAHs (with fewer aromatic rings) are subject to biodegradation or volatilization, chemical persistence generally increases with increasing number of aromatic rings. SVOCs are generally characterized by high boiling point, low vapor pressure, and low solubility (except for lower molecular weight PAHs, phenols).

PAHs generally exhibit a very low solubility (i.e., as low as 1×10^{-4} mg/l), with higher solubilities for the smaller PAHs (e.g., 26 for 2-methylnaphthalene). The solubility of the

phthalate COCs ranges from 0.4 mg/l for bis(2-ethylhexyl)phthalate to 400 mg/l for di-n-butyl phthalate.

SVOCs, in general, have moderate to high log K_{oc} and log K_{ow} values indicating a relative affinity for organic materials in solid (e.g., soil) and liquid (e.g., octanol) phases. The log K_{oc}s and log K_{ow}s of PAHs and phthalates are generally greater than 3 with many greater than 5.

Of the 13 semivolatile COCs in soil, three were identified as COCs in ground water including one PAH and two phthalates. Two additional COCs, naphthalene and phenol, were identified in ground water. In general, the SVOCs identified as COCs in ground water are more soluble (and therefore more likely to migrate into ground water) than the SVOCs identified as COCs in soil only.

With the exception of the more soluble SVOCs identified as COCs in ground water, migration of SVOCs from soil to ground water is not likely to be a primary route of concern. Off-site transport of the less soluble SVOCs detected in surface soil may be possible through dust generation at the soil surface and through soil transport in surface water runoff. SVOCs in soil are more likely to persist than VOCs, but are less likely to persist than pesticides/PCBs or inorganics.

Contaminants can migrate off-site through surface water runoff via the catch basins. High levels of PAHs were detected in the catch basin sediment samples which could indicate the transport of SVOCs off-site through the catch basins. However, the highest level of SVOCs detected in the catch basin samples was in the upgradient sample, 13-SD01, which indicates that the contamination may not have originated from Site 13. The detection of PAHs in the sediment samples may be attributable to the presence of asphalt fragments in the samples.

Pesticides and PCBs

Thirteen pesticides and two PCBs (PCB-1254 and PCB-1260) were identified as COCs in surface and/or subsurface soil at Site 13. Pesticides and PCBs have a strong affinity for organic materials in soils which tends to reduce their mobility in this medium. In addition, many pesticides and PCBs are persistent in the environment (i.e., have large half-lives). Of these 15 pesticide/PCB COCs in soil, three were identified as COCs in ground water (4,4'-DDD, endrin ketone and heptachlor epoxide). The much smaller number of pesticide/PCB COCs in ground water indicates that the migration of these constituents from soil into ground

water is limited. The primary migration pathways for pesticides and PCBs in soil include transport of soil particulates in surface water runoff and via wind erosion.

Low levels of pesticides were detected in the catch basin sediment samples, indicating potential migration of pesticides from surface soil into the catch basins may have occurred. Elevated levels of PCBs were detected in the catch basin sediment samples and the highest levels of PCBs were detected in the downstream catch basin, indicating that PCBs may also be migrating off-site through the catch basins.

Inorganic Analytes

Many metals have a strong affinity for soils (particularly clay particles and organic matter in soils) which reduces their mobility. Under extremes of pH, some metals can be rendered mobile. The presence of the inorganic analytes at Site 13, particularly the naturally occurring elements, was examined in the context of facility background concentrations, as presented in Table 2-3. Site background samples were collected as composite samples from background locations at Sites 02, 07, 09, 10 and wooded areas east of Sites 06, 11 and 13 during the Phase II RI. The inorganic COCs in surface soil which appear elevated above site background in one or more samples include arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, manganese, mercury, nickel, and zinc. The inorganic COCs which appear elevated above site background in subsurface soil include barium, beryllium, chromium, cobalt, copper, cyanide, lead, manganese, and nickel.

The inorganics COCs in ground water include aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, copper, cobalt, lead, manganese, nickel, silver, vanadium, and zinc. The presence of a number of these inorganics in surface and subsurface soils indicates migration from soil to ground water may have occurred. However, it is important to note that a comparison of Phase I and Phase II results indicates a considerable decrease in the concentration of inorganics in Phase II. This decrease is believed to be due to the sampling methodology utilized in Phase II which incorporated a low flow sampling rate, which decreased the turbidity of the ground water samples. Thus, the Phase II ground water data are thought to be more reflective of the actual concentrations of inorganics than the Phase I data.

Surface soil COCs detected in the catch basin samples include arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, cyanide, lead, nickel, and zinc. The highest concentrations

of arsenic, barium, chromium, and cyanide were detected in the upgradient catch basin, indicating that the contamination may have migrated from off-site. The highest concentrations of the remaining elements were detected in the catch basin in the middle of the site. The presence and elevated levels of these elements in 13-SD02 indicates migration from surface soil to sediment may have occurred.

TCLP Analyses

No soil samples submitted for TCLP analysis exhibited contaminants above the regulatory action levels as identified on the TCLP list (40 CFR 261.24).

2.8 Summary of Human Health Risk Assessment

The Human Health Risk Assessment conducted for Site 13 (TRC, 1993b) evaluated the contaminants of potential concern, assessed potential exposure pathways and chemical toxicity, and characterized potential risks to human health posed by the site. Both Phase I RI and Phase II RI data were used to characterize the human health risks. Exposure doses were developed based on the geometric mean of chemical concentrations (mean) as well as on the basis of the maximum detected chemical concentration (Reasonable Maximum Exposure or RME). Potential human health exposure scenarios evaluated include the following:

- Scenario 1 (Future Construction Worker) - Exposure of adult workers to subsurface soils (via dermal contact, ingestion and inhalation) for a one-year period, assuming construction of commercial or residential buildings; and

- Scenario 2 (Future Commercial/Industrial Worker) - Exposure of adult employees to surface soils (via dermal contact and ingestion) and to ground water through ingestion under future use of the site.

Human health risks were presented with regard to potential cancerous or non-cancerous (systemic) effects from the contaminants of concern. Cancer risks are presented in scientific notation, where a lifetime risk of 1×10^{-4} represents a lifetime risk of one in ten thousand. The calculated cancer risk is compared to the acceptable cancer risk range (1×10^{-4} to 1×10^{-6}) for evaluating the need for remediation, as stated in 40 CFR Part 300. A cancer risk of 1×10^{-6} is considered as the point of departure for determining risk-based remediation goals. Non-carcinogenic risks are represented by a summation of hazard quotients, which is referred to as

the hazard index (HI). HI values exceeding unity (1) indicate the potential for non-cancer health effects. Therefore, the cancer risk and HI ratios that constitute a potential concern are those greater than 1×10^{-6} and 1, respectively.

Cancer and non-cancer risk estimates for Site 13 are summarized in Table 2-4. Cancer and non-cancer risk estimates were less than the potential levels of concern for subsurface soil exposures under Scenario 1 (construction scenario). Surface soil exposures under Scenario 2 (commercial/industrial scenario) indicated a cumulative potential cancer risk range of 2×10^{-6} (mean) to 1×10^{-3} (RME), and the non-cancer hazard index value was below 1. Exposure to Aroclor-1260, cadmium, and carcinogenic PAHs accounts for the majority of the estimated cancer risks.

Ground water exposures under Scenario 2 (commercial/industrial scenario) indicated a potential cancer risk range of 5×10^{-5} (mean) to 4×10^{-4} (RME) and a non-cancer hazard index value range of 3 (mean) to 10 (RME). Exposure to arsenic and beryllium accounts for the majority of estimated cancer risks, while manganese accounted for the majority of the non-cancer risks.

2.9 Summary of Ecological Risk Assessment

Ecological risks were assessed based on an evaluation of potential receptors identified through the ecological characterization of the Hall Creek Watershed, and the detected levels and bioavailability of contaminants in environmental media. Terrestrial risks were characterized based on site-specific biological observations and surface soil data. Aquatic risk was assessed for the watershed. A "weight of evidence" approach was used in which information generated from exposure and ecological effects assessments, field observations and a toxicity quotient (TQ) evaluation are used to provide an overall weight of evidence concerning the nature of risks. As with the human health HI ratios, when the calculated TQ value exceeds unity (one), a potential for environmental risks exists.

Risks to benthic invertebrates were assessed based on sediment quality criteria derived from equilibrium partitioning on a station-by-station basis; an estimate of metal bioavailability based on a ratio of Simultaneously Extracted Metal (SEM) to Acid Volatile Sulfide (AVS); a comparison to NOAA ER-L and ER-M values; and direct observations on the freshwater benthos

in the watershed. Risks to water column organisms were estimated based on a comparison to ambient water quality criteria. An exposure model was used to estimate risks to mink from exposure to PCBs in the sediments. Risks to small mammals and birds were estimated on the basis of calculated TQ values.

The ecological assessment concluded that Site 13 and the developed areas of the Hall Creek Watershed pose little likelihood of ecological risk due to exposure to metals in the Hall Creek Watershed because:

- sediment metals are generally within naturally occurring levels;
- SEM and AVS data generally indicate that metals in the sediment of the brook have low bioavailability, except at watershed sample station 13, which was a course-grained environment where AVS was below detection; and,
- sediment metals concentrations were generally below or near their respective ER-Ls.

There is some potential for risk due to exposure to PCBs, based on the mink exposure model. However, this potential is qualified somewhat by the fact that sediment PCB concentrations generally fall below NOAA ER-M levels, the toxicity quotient based on comparison to sediment quality criteria is less than 1, and the results of the tern foraging model indicate little risk to terns foraging in the Frys Pond area (Frys Pond is the downstream sink for materials from Hall Creek).

There is also some potential for risk due to DDT, DDE, and DDD within the Hall Creek Watershed. This conclusion is based on the comparison to NOAA criteria (ER-Ms for DDT, DDE, and/or DDD were exceeded at all stations) and the comparison to station-specific sediment quality criteria (toxicity quotients within the 10 to 100 range were calculated for pesticides at stations in Hall Creek and Frys Pond).

However, the potential for risk suggested by some of the above analyses does not appear to be reflected in the functional value of Hall Creek wetland, based on the analysis for pollutant reduction (i.e., sediment stabilization, sediment/toxicant retention, nutrient removal/transformation) functions. In addition, the benthic and wildlife observations in Hall Creek Watershed indicate a diverse and functioning ecosystem.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND DEVELOPMENT OF ALTERNATIVES

Based on the available site information, potential remedial actions can be identified. Initially, remedial action objectives are developed in order to set goals for protecting human health and the environment early in the alternative development process. General response actions are then developed to address the objectives. Remedial technologies and process options associated with the general response actions are identified and screened to eliminate those that are not technically implementable and to identify those that offer the optimum combination of effectiveness, implementability and cost.

3.1 Development of Preliminary Remediation Goals (PRGs)

Prior to the development of remedial action objectives, preliminary remediation goals (PRGs) are developed and evaluated with respect to site contaminant levels. Existing contaminant levels are compared to Applicable or Relevant and Appropriate Requirements (ARARs), To-Be-Considered guidance (TBCs), and risk-based PRGs to identify the extent of contamination requiring remediation. Also included in the evaluation is the role of environmental risks and the application of models to predict the potential for migration of soil contaminants to the ground water.

3.1.1 Comparison of Contaminants to ARARs/TBCs

Soil, ground water, and sediment must be considered in the development of potential remedial actions at Site 13. The soil and ground water contaminants are evaluated separately against appropriate chemical-specific ARARs/TBCs below. No chemical-specific ARARs/TBCs were identified as being applicable to sediments. A more detailed identification and evaluation of potential chemical-specific ARARs/TBCs is presented in Appendix A.

Soil Contamination

In evaluating soil contaminant levels, available state and federal standards and guidance levels were used as ARARs/TBCs. Only a limited number of standards are applicable to soil contamination. The only identified standards and guidance levels were those applicable to PCB and lead contamination. Therefore, these levels were used as the basis for this evaluation.

As presented in Table 3-1, TSCA includes a PCB Spill Cleanup Policy (Subpart G, 40 CFR 761.120 through 761.135) which establishes a PCB cleanup level of 10 ppm for soils to a minimum depth of 10 inches in nonrestricted access areas. This level is applicable to spills of materials containing PCBs at concentrations of 50 ppm or greater which occurred after May 4, 1987. While not applicable to Site 13, this cleanup level is to be considered in the remedial evaluation of PCB-contaminated surface soils at the site. The State of Rhode Island Department of Environmental Management (RIDEM) Rules and Regulations for Solid Waste Management Facilities define solid waste as including any soil, debris, or other material with a concentration of 10 ppm or greater PCBs, while the Rules and Regulations for Hazardous Waste Management define Type 6 - extremely hazardous waste as including waste which contains 50 ppm or greater PCBs. These definitions are also considered with respect to soil contamination at Site 13.

With respect to lead contamination, the USEPA has developed an Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02) which sets forth an interim lead soil cleanup level of 500 to 1,000 ppm, based on residential exposures. RIDEM considers a safe lead level in soil to be under 300 ppm. These guidance values will be considered in the evaluation of surface soil contamination at the site.

Table 3-1 provides a comparison of maximum detected surface soil contaminant levels to associated guidance levels. No samples from either the Phase I RI or the Phase II RI had lead concentrations which exceeded the state or federal guidance levels. PCBs were detected in Phase I RI surface soil sample SS13-09 at a concentration of 4,563 ppm, exceeding both the definition for solid waste (wastes containing a concentration of 10 ppm or greater PCBs) included in RIDEM's Rules and Regulations for Solid Waste Management Facilities and the definition for hazardous waste (Type 6 - extremely hazardous waste includes wastes containing a concentration of 50 ppm or greater PCBs) included in RIDEM's Rules and Regulations of Hazardous Waste Management. This sample also exceeds the 10 ppm cleanup level specified under TSCA. No other surface soil samples had PCB levels exceeding guidance levels. The location of the surface soil sample which contained PCBs at a level exceeding the regulatory guidance level is presented on Figure 3-1.

While the action levels listed in Table 3-1 may not be applicable to catch basin sediments, they do allow for a relative evaluation of sediment contaminant levels. One Phase II RI

sediment sample, 13-SD03, exhibited a PCB concentration of 11 ppm, exceeding the 10 ppm definition of solid waste and TSCA cleanup level. Sediment sample 13-SD02 contained lead at a level of 482 ppm which exceeds the RIDEM guidance level of 300 ppm. No other Phase I or Phase II RI sediment samples exceeded PCB or lead standards or guidance levels.

Ground Water Contamination

For ground water which is a potential source of drinking water, MCLs, MCLGs, state drinking water requirements or other health-based levels generally are appropriate for consideration as PRGs. Also considered in the evaluation are the Rhode Island Ground Water Quality Standards as amended by RIDEM in July 1993 for Class GAA and Class GA ground waters. For those detected contaminants for which RIDEM Ground Water Quality Standards have been established, the standards mirror the federal MCLs.

The maximum concentrations of ground water contaminants that exceed MCLs for the Phase I and Phase II RIs are presented by well location on Figure 3-2. Table 3-2 presents a comparison of maximum detected ground water contaminant levels to associated federal and state standards and guidelines.

Of the contaminants detected in the Phase I RI ground water samples, one semivolatile, bis(2-ethylhexyl)phthalate, and six inorganics, antimony, beryllium, cadmium, chromium, lead, and nickel, were detected at concentrations which exceeded federal and state standards. However, only three contaminants detected in the ground water during the Phase II RI, pentachlorophenol, bis(2-ethylhexyl)phthalate, and antimony, exceeded federal and state standards. The large disparity between the Phase I and Phase II inorganic results may be attributable to the low flow sampling methodology which was used during the Phase II RI to minimize the presence of suspended solids in the samples. Therefore, the Phase I RI results may not be indicative of actual ground water quality at Site 13.

3.1.2 Human Health Risk-Based Considerations

As described in the National Contingency Plan [40 CFR 300.43(e)(2)(i)(A)(2)], "The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available...". The 10^{-6} starting point indicates U.S. EPA's preference for setting cleanup levels at the more protective end of the acceptable 10^{-4} to 10^{-6} risk

range for Superfund remedial actions. Site-specific and remedy-specific factors are then taken into consideration in the determination of where within the 10^{-4} to 10^{-6} risk range the cleanup standard for a given contaminant will be established. For the purposes of this evaluation, preliminary remediation goals (PRGs) which correspond to a 10^{-6} risk are calculated. Site-specific and remedy-specific factors which may affect the determination of the final cleanup level will be addressed in subsequent portions of this document.

Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (RAGS, Volume I, Part B, USEPA, 1991a) provides additional guidance on the development of preliminary remediation goals (PRGs). One of the initial steps in development of PRGs is the identification of the most appropriate future land use for the site so that the appropriate exposure pathways, parameters and equations can be used to calculate PRGs. At Site 13, based on the Comprehensive Base Reuse Plan, the most appropriate future land use is as an economic/industrial development area. Therefore, the risk assessment scenario (Scenario 2) which evaluated risks to commercial/industrial workers based on exposures to surface soils and ground water will be used in the development of PRGs.

As a further guide to determining the media and chemicals of potential concern at a site, the OSWER directive "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (USEPA, 1991b) states that "where the cumulative site risk to an individual based on reasonable maximum exposure for both current and future land use is less than 10^{-4}, and the non-carcinogenic hazard quotient is less than 1, action generally is not warranted unless there are adverse environmental impacts." At Site 13, the cumulative carcinogenic risk to an individual based on reasonable maximum exposure to surface soils under the future commercial/industrial site use scenario exceeds 10^{-4} although the cumulative hazard index (HI) value does not exceed unity (1). Therefore, risk-based PRGs are calculated for carcinogens in Site 13 surface soils.

For ground water, the cumulative carcinogenic risk to an individual based on reasonable maximum exposure to ground water under the future commercial/industrial site use scenario is 4×10^{-4} and the non-cancer hazard index (HI) is 10. Therefore, risk-based PRGs are also calculated for carcinogenic and non-carcinogenic ground water contaminants.

PRGs are developed for contaminants which present individual cancer risks of greater than 10^{-6} and for which no ARARs/TBCs have been identified. The surface soil contaminants which contribute an individual cancer risk of greater than 1×10^{-6} under the reasonable maximum exposure scenario for future economic/industrial development scenario and for which ARAR/TBCs have not been identified include beryllium, benzo(b)fluoranthene, and benzo(k)fluoranthene. The maximum detected concentrations of these contaminants in surface soils, the associated reasonable maximum exposure cancer risks and the surface soil preliminary remediation goals calculated for these contaminants based on a 1×10^{-6} cancer risk level are presented in Table 3-3. Additional information used in the development of risk-based PRGs is presented in Appendix B.

The locations of the surface soil samples where detected contaminant levels exceeded risk-based PRGs are presented on Figure 3-3. Only beryllium was detected at a level exceeding the risk-based PRG of 1.3 ppm. Surface soil sample 13-B7-01 had a detected beryllium concentration of 2.1 ppm. No other samples had contaminant concentrations exceeding the risk-based PRGs developed for Site 13.

In ground water, only manganese exhibited a hazard index ratio greater than unity. A non-carcinogenic PRG of 510 ppb was calculated for manganese, as presented in Table 3-4. Detected manganese levels are indicated for each well location in Figure 3-4. At Site 13, manganese exceeded the PRG level in all of the ground water samples collected during the Phase I RI, with a maximum concentration of 2,170 ppb detected at 13-MW4S. Twelve of the sixteen monitoring wells sampled during the Phase II RI had manganese concentrations greater than the PRG, with a maximum concentration of 3,810 ppb at 13-MW6S. It should be noted that manganese may not be a site-related contaminant based on the apparent presence of manganese in ground water throughout the facility, as evidenced by its significant contribution to non-cancer risks at each of the Davisville sites where ground water ingestion was evaluated (i.e. Sites 02, 03, 06, 07, 09, 10, 11 and 13) and by the fact that the PRG is within the range of manganese concentrations detected in upgradient wells (34 ppb to 2,200 ppb) at these sites.

3.1.3 Environmental Risk-Based Considerations

As discussed in the ecological risk assessment (TRC, 1993b), a potential for environmental risk due to exposure to pesticides/PCBs in the Hall Creek Watershed has been identified based on a weight of evidence approach to risk evaluation. Since Hall Creek Watershed is comprised of a large area, including Sites 02, 03, 05, 06, and 13, an evaluation of the potential impacts of Site 13 alone is important in determining preliminary remediation goals associated with the site. Therefore, a comparison of catch basin sediment contaminant levels to NOAA ER-L (Effects Range-Low) and ER-M (Effects Range-High) values (Long and Morgan, 1990) is presented in Table 3-5. ER-L and ER-M values represent the lower 10th percentile (ER-L) and median (ER-M) concentrations at which effects have been observed or predicted, based on Long and Morgan's evaluation. While not intended to be used as criteria by which to judge whether sediments are contaminated, ER-L and ER-M values provide initial screening criteria and may be used to assess contaminant levels in a qualitative way. Comparison of contaminant levels to ER-L and ER-M values was assessed as just one consideration in the overall evaluation of ecological risk to the Hall Creek Watershed. For instance, lead was detected in Hall Creek sediments at levels exceeding ER-M values but, in the overall weight of evidence approach to evaluating environmental risks, lead was not considered to pose a significant ecological risk. Therefore, the comparison provided in Table 3-5 is useful in providing an indication of the relative contamination of sediments associated with Site 13 but must be considered with respect to other available evidence of potential risk. As indicated in Table 3-5, concentrations of total PCBs exceeded the ER-M value of 400 ppb in each of the Phase I and Phase II RI catch basin sediment samples. Other contaminants detected at levels exceeding ER-M values include 4,4'-DDE (in one Phase II sediment sample), 4,4'-DDD (in one Phase I sediment sample), lead (in two of three Phase II sediment samples), and zinc (in three of three Phase II sediment samples).

The ecologically based ER-M levels will be used in combination with the federal and state guidance levels (discussed in Section 3.1.1) as a basis for evaluating pesticide/PCB contamination in the catch basin sediment samples at Site 13.

Potential environmental risks to Mill Creek Watershed must also be considered with respect to Site 13 since a portion of the Site 13 ground water appears to flow towards Mill

Creek. Site 11 at NCBC Davisville is also located within the Mill Creek Watershed. However, the ecological risk assessment concluded that the developed areas of NCBC in the Mill Creek Watershed do not pose an ecological risk to aquatic or terrestrial communities in the Mill Creek Watershed. Considering the relatively low contaminant levels detected in ground water at Site 13, the distance from Site 13 to Mill Creek (approximately 2,500 feet) and the lack of existing significant ecological risks within the watershed, ground water quality at Site 13 is not considered to pose a significant potential ecological risk to the Mill Creek Watershed.

3.1.4 Contaminant Migration Considerations

Another consideration in the development of remedial response objectives is the potential for contaminant migration, especially as it applies to soil contamination. Since exposures to subsurface soils are not included in the expected future use exposure scenario (commercial/industrial use) for the site, potential leaching of subsurface contaminants to the ground water is the greatest concern with respect to the existing subsurface soil contaminants. To evaluate the potential for contaminant leaching to be a major factor in contaminant migration, the "Unnamed Model" described in Determining Soil Response Action Levels Based on Potential Contaminant Migration to Ground Water: A Compendium of Examples (USEPA, 1989a) was applied to existing site data.

The unnamed model is a variation of the Summers Model, also described in the above-referenced document. The Summers Model is basically a mass balance in which the concentration of contaminant leached from a contaminated area multiplied by the volumetric rate of infiltration over the area of contamination plus the upgradient (incoming) ground water contaminant concentration (assumed to be equal to zero) multiplied by the volumetric rate of ground water flow entering the site will equal the ground water contaminant concentration exiting the site multiplied by the volumetric rate of ground water flow exiting the site (which is equal to the volumetric rate of infiltration plus the volumetric rate of ground water flow into the site). The Summers Model is applied to the entire area of the site, assuming that the entire site area is equally contaminated.

The unnamed model uses the same approach but applies it to a unit area of the site. Therefore, the rate of infiltration is applied to a 1-square-foot area in determining the volumetric

rate of infiltration and the ground water flow velocity is applied to an area which is a unit dimension wide (1 foot) but equal to the saturated thickness of the aquifer in terms of height. This approach is more applicable to the characteristics of Site 13 where specific areas of the site may exhibit higher levels of contamination which are not characteristic of the site as a whole.

In both models, the maximum allowable ground water contaminant concentration leaving the site (or the unit area) is assumed to equal the Maximum Contaminant Level. The volumetric flow rate of infiltration is estimated based on known precipitation and infiltration values and the volumetric flow rate of ground water entering the site is estimated based on information obtained during the Phase I and II RIs. Using published octanol-water partition coefficients (K_{ow}) and organic carbon soil concentrations measured during the RI, the maximum allowable concentration of a contaminant in the ground water (equal to the MCL) can be related to the maximum allowable contaminant concentration in the soil in the saturated zone. The maximum concentration of a contaminant adsorbed to the soil in the unsaturated zone can then be back-calculated using the mass-balance approach described above.

The calculations conducted for Site 13 are described in detail in Appendix C. The results of the unnamed model calculations for Site 13, as presented in Appendix C and summarized in Table 3-6, indicate that PCBs detected in unsaturated surface soil samples exceed the estimated maximum allowable contaminant concentration in unsaturated soils which is protective of ground water quality (based on use of the MCL as the maximum allowable ground water concentration). The PCB concentration detected at Phase I RI surface soil sample S-13-09-00-S was 4,653 ppm which exceeds the 1,500 ppm estimated maximum allowable contaminant concentration. Although the leaching model indicates the potential for PCBs to leach from the soils, no PCBs were detected in Site 13 ground water samples. No other contaminants detected in unsaturated surface or subsurface soil exceed the estimated maximum allowable contaminant concentrations.

No soil samples were collected from the saturated zone during either the Phase I RI or Phase II RI for TCL/TAL analysis. Therefore, comparisons to the estimated maximum allowable saturated contaminant concentrations could not be made.

Another consideration in the potential migration of contaminants from site soils is the information provided by the Toxicity Characteristic Leaching Procedure (TCLP) analyses conducted during both the Phase I and Phase II RIs on two surface and three subsurface soil

samples. Of the five samples collected and analyzed for TCLP (Phase I RI samples B-13-04-02-S and B-13-05-02-S and Phase II RI samples 13-B12-02, 13-MW11-01, and 13-MW14-01), no detected constituent exceeded maximum allowable TCLP levels. Therefore, available TCLP analyses support the unnamed model results in indicating that minimal leaching of contaminants from unsaturated subsurface soils could be expected, especially considering that the leaching conditions at Site 13 would be expected to be less severe than those employed in the TCLP analysis.

3.1.5 PRG Summary

Based on this analysis, remediation of surface soils must be considered on the basis of exceedances of state and federal guidance levels for PCBs, based on the potential risks posed by surface soils to human health under future commercial/industrial site use, and based on the potential for PCBs to leach from the soils to the ground water. ARAR/TBC levels may be used as PRGs for surface soils along with risk-based PRGs. The potential contribution of surface soil contaminants to run-off-generated catch basin sediments and ultimately the Hall Creek Watershed must also be considered.

Subsurface soils pose no significant human health risks since the anticipated future use of the site does not involve exposures to subsurface soils. Modeling of the potential for contaminant migration from the subsurface soils did not identify any subsurface soil contaminants which are of potential concern with respect to contaminant leaching.

With respect to ground water quality, although potable use of ground water at Site 13 would not be anticipated based on its GB ground water classification, the lack of a regulatory mechanism to prohibit installation of a potable well on site requires consideration of MCLs, MCLGs and state drinking water standards. Also applicable are risk-based PRGs for those contaminants which pose risks which exceed the point of departure (10^{-6} or an HI = 1) and for which ARARs/TBCs have not been identified. At Site 13, semivolatile organics and inorganics were detected in ground water samples at levels exceeding state and federal drinking water standards. Specific contaminants detected at levels exceeding drinking water standards include pentachlorophenol, bis(2-ethylhexyl)phthalate, antimony, beryllium, cadmium, chromium lead and nickel. Pentachlorophenol was detected in only one well (13-MW12S) at a level (2 ppb)

barely exceeding the MCL (1 ppb). Bis(2-ethylhexyl)phthalate was detected in both Phase I RI and Phase II RI ground water samples at levels exceeding the MCL; however, it was detected in only one Phase I RI monitoring well (13-MW4S) during only one sampling round and its presence in three Phase II RI monitoring wells (13-MW3D, 13-MW10D and 13-MW11S) may be attributable to the low flow sampling methodology used during the Phase II RI. With respect to inorganics, while six inorganic analytes were detected in ground water samples at levels exceeding MCLs during the Phase I RI, the use of the low flow sampling methodology resulted in only one inorganic analyte, antimony, being detected at a level exceeding the MCL in only one well, 13-MW10S, during the Phase II RI. With respect to manganese, which poses an unacceptable non-carcinogenic risk based on ground water ingestion, while the PRG is exceeded at the majority of Site 13 monitoring wells, the PRG (510 ppb) is within the range of manganese concentrations detected in upgradient wells at all NCBC Davisville sites (34 ppb to 2,200 ppb). The identification of manganese as a potential source of risk at each Davisville site for which ground water ingestion risks were calculated indicates that manganese is present through the NCBC Davisville facility and is not a site-specific contaminant. Therefore, while federal and state drinking water standards and PRGs will be used to identify potential contaminants of concern in ground water, the extent of ground water contamination which exceeds drinking water standards is very limited and the application of the risk-based PRG to Site 13 may not be appropriate based on its presence throughout the facility.

For catch basin sediments, PCBs are present at levels exceeding soil TBCs. PCBs and other contaminants, including 4,4'-DDE, 4,4'-DDD, lead and zinc, are also present at levels exceeding ER-M values. Based on the potential ecological risk associated with PCBs, DDT, DDE and DDD within the Hall Creek Watershed, as identified in the Ecological Risk Assessment, the TBC and ER-M values will be considered as being representative PRGs for PCBs and pesticides in catch basin sediments. However, it should be noted that ER-M values for pesticides were exceeded in the NCBC facility background samples. Therefore, the contribution of pesticides to the Hall Creek Watershed from Site 13 would be difficult to differentiate from the potential contributions of other areas of the facility.

3.2 Remedial Action Objectives

The remedial action objectives developed to guide the implementation of a remedial response at Site 13 are presented by environmental medium below.

3.2.1 Soils

A comparison of TSCA's PCB Spill Cleanup Policy and RIDEM's solid waste and hazardous waste definitions with PCB contaminant levels indicates that one surface soil sample location (SS13-09) exhibits PCB contamination at levels exceeding these standards. Similarly, only one surface soil sample (13-B7-01) exhibited a beryllium concentration at a level exceeding risk-based PRGs.

Pesticides and PCBs are present in catch basin sediment samples and may be contributing to potential ecological risks identified in the Hall Creek Watershed. Therefore, the potential contribution of surface soil contaminants to catch basin sediments must be considered. While PCBs were detected in eight surface soil samples (Phase I RI samples SS13-08, SS13-09, and B-13-06-00 and Phase II RI samples SS13-11, SS13-12, SS13-19, SS13-24 and 13-B7-01) at levels exceeding the ER-M of 400 ppb, all of these sample locations were located a minimum of 100 feet from catch basin locations. Also, the presence of PCBs in the upgradient catch basin indicates the potential for an off-site source. While pesticides were detected in five surface soil samples (Phase II RI samples SS13-11, SS13-19, SS13-20, 13-B7-01 and 13-B15-01) at levels exceeding the ER-M values, these samples were also located a minimum of 100 feet from catch basin locations, with the exception of SS13-20. At SS13-20, located immediately adjacent to the southernmost catch basin, gamma chlordane was present in the surface soil at a level exceeding the ER-M; however, the sediment sample collected from the southernmost catch basin (13-SD01) did not exhibit detectable levels of gamma chlordane. The presence of pesticides in NCBC facility background samples indicates a potential widespread source of pesticides to the Hall Creek Watershed.

The results of the unnamed model, as discussed in Section 3.1.4, indicate the potential for PCBs to leach into ground water at Site 13. Therefore, the potential for PCB to leach from soil into ground water needs to be considered.

Therefore, based on the analysis presented above, the remedial action objectives for Site 13 soils are as follows:

- Minimize the potential for commercial/industrial exposures to surface soil contaminants at levels which exceed ARARs/TBCs, as presented in Table 3-1 or which exceed risk-based PRGs, as presented in Table 3-3;

- Minimize the potential migration of surface soil contaminants into the storm drainage system due to surface water runoff; and

- Minimize the potential migration of PCBs from surface soil into ground water.

3.2.2 Ground Water

While ground water is classified GB and would not provide a suitable potable water source, no regulatory means of preventing installation of a potable well and subsequent exposures exist. Based on the detection of organic and inorganic contaminants at levels exceeding ARARs/TBCs and PRGs, the remedial action objective for ground water is as follows:

- Prevent exposure, due to ground water ingestion, to contaminants which are present at levels exceeding acceptable ARARs/TBCs as indicated in Table 3-2, or which exceed risk-based preliminary remediation goals as indicated in Table 3-3.

3.2.3 Sediment

Potential environmental risks associated with sediment contamination have been identified for Hall Creek Watershed. Sediments in the catch basins at Site 13 have the potential to migrate from the site to the watershed, via sediment transport (pesticide and PCB contaminants are not expected to significantly impact surface water quality due to their tendency to sorb to organic materials in the sediment). However, the presence of PCB and pesticide contamination in the upgradient catch basin indicates that off-site sources may also be contributing to the contamination of Site 13 catch basin sediments. As noted in Section 3.2.1, the presence of pesticides in NCBC facility background samples indicates that other portions of the facility may also be contributing to the presence of pesticides within the Hall Creek Watershed. Therefore, while catch basin sediments may be contributing to PCB or pesticide contamination within the watershed, there are no data on which to base a definite determination of Site 13's impact on

catch basin sediments or the impact of catch basin sediment contamination on potential ecological receptors within the watershed. Therefore, the remedial action objectives for sediment at Site 13, based on available data, are as follows:

- Minimize the generation of contaminated sediments due to potential erosion of surface soil contaminants into the storm drainage system; and
- Minimize potential environmental impacts due to the presence of contaminated sediments within the storm drainage system.

3.2.4 Other Considerations

A test pit was excavated during the Phase II RI and a subsurface soil sample collected to investigate whether backfill material around the storm drainage piping which passes through the site may be acting as a conduit for the migration of site-related contamination. The material surrounding the pipe was described as an orange- to rust-colored fine sand, with little coarse sand and gravel. The sample collected at a depth of 3.5 feet exhibited toluene at an estimated level of 1 ppb, bis(2-ethylhexyl)phthalate at a level of 360 ppb and various PAHs at a total concentration of 488 ppb. 4,4'-DDT was the only pesticide detected in the sample, at an estimated concentration of 2.4 ppb, and various inorganics were also detected in the sample. No PCBs were detected in the sample. As indicated in Table 2-3, detected semivolatile contaminant levels were within NCBC facility background ranges. Barium, cadmium, lead and manganese were the only inorganics detected at levels exceeding the NCBC facility background ranges. Based on the detected contaminant levels and the relative lack of significant soil contamination at the site, as evidenced by the previous evaluations, the storm drainage pipe backfill material does not seem to be acting as a significant conduit for potential contaminant migration and will not be considered further with respect to remedial action objective development.

3.3 General Response Actions

General response actions are those remedial actions which will satisfy the remedial action objectives. The first step in determining appropriate general response actions for Site 13 is an initial determination of the areas or volumes to which the general response actions may be

applied. In determining these volumes/areas of media, consideration has been given to site conditions, the nature and extent of contamination, acceptable exposure levels and potential exposure routes.

3.3.1 Soils

As indicated in Section 3.2, the remedial action objectives for soil at Site 13 are to minimize potential commercial/industrial exposures to contaminated surface soils, minimize potential migration of surface soil contaminants into the storm drainage system due to surface water runoff, and minimize potential leaching of PCBs into the ground water. In general, existing soil quality does not pose a significant concern under the proposed commercial/industrial site use. However, a small area of surface soil contamination exists where PCB cleanup levels and risk-based PRGs are exceeded.

Two remedial scenarios have been developed for Site 13. The first scenario involves remediation of soils which exceed action levels and the risk-based PRG. This scenario would require the remediation of soils in an area of approximately 11,800 square feet, as identified in Figure 3-5. The extent of this area has been defined by assuming the contamination extends half the distance to the next surface soil sample location. Additional sampling would be required to firmly establish the extent of contamination. Assuming remediation of the upper two feet is required, the total volume of soil requiring remediation under this scenario would be approximately 900 cubic yards.

The second scenario involves remediation of soils which exceed action levels only. Since the risks posed by the one sample which exceeds the PRG for beryllium are within the acceptable risk range for remedial actions at Superfund sites, and considering the apparent limited extent of the beryllium-contaminated soils, a risk management decision could be made in which the beryllium-contaminated soil would not be remediated. This second scenario would require the remediation of only the area surrounding the one soil sample which exhibited elevated PCB levels. This area is estimated to cover approximately 5,200 square feet, as identified in Figure 3-5. If remediated to a depth of two feet, the total volume of soil which would require remediation under this scenario would be approximately 400 cubic yards.

A listing of general response actions identified for site soils is as follows:

- No Action
- Institutional Control
- Containment
- Treatment/Disposal

3.3.2 Ground Water

In order to provide a preliminary estimate of the volume of ground water requiring remediation, the extent of ground water contamination at levels exceeding ground water ARARs/TBCs and risk-based cleanup standards must be evaluated. As discussed in Section 3.1.1 and 3.1.2, organic and inorganic constituents present in ground water samples at Site 13 exceed MCLs or risk-based PRGs. The area of ground water where MCLs or risk-based PRGs were exceeded was estimated to encompass approximately 15 acres (the entire area of investigation). Using an estimated saturated thickness of 13 feet, and assuming a conservative effective porosity of 20%, the volume of ground water containing organics or inorganics at levels exceeding MCLs or risk-based PRGs is on the order of 12.5 million gallons. However, there is a high degree of uncertainty associated with this estimate due to the presence of manganese at levels exceeding PRGs throughout the site area, including the most upgradient well location (13-MW11S).

A listing of general response actions developed for ground water at Site 13 is provided below.

- No Action
- Institutional Control
- Extraction/Treatment/Discharge

3.3.3 Sediment

To meet the remedial action objective for sediments which calls for minimizing the potential generation of contaminated sediments due to soil erosion, implementation of soil general response actions would be required. To address the sediments themselves, a preliminary estimate of the volume of contaminated sediment present within the catch basins was developed. There are a total of eight catch basins on-site. During the RI sampling activities, a average of approximately four inches of sediment was observed in the catch basins sampled. Based on an

average three-foot diameter catch basin, the total volume of contaminated sediments is estimated to be less than one cubic yard.

To minimize the potential environmental impacts associated with the existing contaminated sediments within the catch basins at Area 13, the following general response actions were identified.

- No Action
- Institutional Control
- Removal
- Treatment/Disposal

3.4 Identification and Screening of Technologies and Process Options

The general response actions are developed further through the identification and screening of remedial technologies which could potentially meet the remedial action objectives and PRGs. Following a screening of the remedial technologies on the basis of technical implementability, the process options associated with each technology are screened based on effectiveness, implementability and cost. Representative process options are chosen for inclusion in the remedial alternatives developed for the sites.

While technology and process option screenings were conducted in the Initial Screening of Alternatives Report (TRC, 1993a), the screening process is re-evaluated herein based on the results of the Phase II RI and the impact of those results on the remedial action objectives for the site.

3.4.1 Technology Screening

The technology screening performed for Site 13 is presented for soil in Table 3-7, for ground water in Table 3-8 and for sediment in Table 3-9. The table includes brief descriptions of the individual technologies or process options, and comments on their technical implementability. Technologies which are screened from further consideration are shaded in the technology screening tables. More detailed descriptions of the screening process and the technologies considered are provided in Appendix D.

3.4.2 Process Option Screening

Upon identification of those technologies which are technically implementable, the process options are further evaluated to allow the selection of representative process options to be used in the development of remedial alternatives. The process options are evaluated on the basis of effectiveness, implementability, and cost. The process option screening is presented for soil, ground water and sediments in Tables 3-10, 3-11 and 3-12, respectively. The selected representative process options are indicated with a bullet in the process option screening tables. Table 3-13 summarizes the technologies and process options which passed the technology screening, with selected representative process options indicated with a bullet. More details on the representative process option selection process are provided in Appendix D.

3.5 Remedial Alternative Development

The selected technologies and process options identified in Section 3.4.2 are combined as appropriate in this section to form remedial alternatives. The developed range of alternatives is intended to provide a streamlined evaluation of possible remedial actions. The alternatives presented herein have been developed in accordance with the expectations of the Superfund program, as outlined within the NCP. Rather than combining alternatives for the various media, the alternatives developed for each media will be evaluated separately to allow greater flexibility in determining the overall remedial action for the site. The remedial alternatives developed for soil, ground water, and sediments at Site 13 are presented in Table 3-14.

Within the Initial Screening of Alternatives (ISA) Report (TRC, 1993a), remedial alternatives were developed for Sites 05, 06 and 13 combined. For Site 13, only soil remediation was evaluated within the ISA and an initial screening of the soil remedial alternatives developed solely on the basis of Phase I RI data was conducted. The remediation scenario involving remediation of soils which exceed ARARs/TBCs and which exceed PRGs was eliminated from further evaluation due to uncertainties associated with the presence of inorganic contaminants which were driving the PRGs. However, based on the NCBC facility background sampling conducted as part of the Phase II RI as well as the re-evaluation of PRGs, the beryllium level in the one sample identified herein which exceeds the PRG also exceeds the background concentration range. Therefore, this scenario will be retained for further evaluation

within the Detailed Analysis of Alternatives. Due to the lack of sufficient data to clearly support the delineation of ground water contamination at Site 13 following the Phase I RI, no ground water remedial alternatives were developed; similarly, no sediment remedial alternatives were developed. Therefore, the ground water and sediment alternatives presented within this report have been developed on the basis of Phase I and Phase II RI data combined. All developed alternatives will undergo a detailed analysis herein.

4.0 DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

Each of the remedial alternatives developed for the site, as presented in Section 3.5, are further defined and then undergo a detailed analysis. Following the detailed analysis of individual alternatives, a comparative analysis is conducted between alternatives.

4.1 Evaluation Criteria

The NCP defines nine evaluation criteria to be considered in the detailed analysis of alternatives. The evaluation criteria are divided into three groups: threshold criteria, which relate to statutory requirements that each alternative must satisfy; balancing criteria, which are the technical criteria that are considered during the detailed analysis; and modifying criteria, which are formally assessed after the public comment period. The nine criteria include the following:

Threshold Criteria

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirements (ARARs);

Balancing Criteria

- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume through treatment;
- Short-term effectiveness;
- Implementability;
- Cost;

Modifying Criteria

- Community acceptance; and
- State acceptance.

When evaluating alternatives in terms of overall protection of human health and the environment, consideration is given to the manner in which site-related risks are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. Long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs are given major consideration in determining the overall protection offered by each alternative.

The alternatives are assessed to determined whether they attain applicable or relevant and appropriate requirements (ARARs) under federal environmental laws and state environmental or facility siting laws. The identification of ARARs is a site-specific process which is dependent on the specific hazardous substances, pollutants, and contaminants at a site, the physical characteristics of a site and the remedial actions under consideration at a site. Therefore, it is an iterative process which requires re-examination throughout the RI/FS process, until a Record of Decision (ROD) is issued. A preliminary ARARs analysis is presented in Appendix A of this document. In the following alternative analyses, the individual remedial alternatives will be evaluated in detail to determine their compliance with ARARs/TBCs which are applicable to the specific media being addressed by the remedial action, and the potential impacts of ARARs/TBCs on the alternative's implementation.

An alternative that does not meet an ARAR may be selected as a remedial action under several circumstances, including the following:

- If the alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement;
- If compliance with the requirement will result in greater risk to human health and the environment than other alternatives;
- If compliance with the requirement is technically impracticable from an engineering perspective;
- If the alternative will attain an equivalent standard of performance through the use of another method or approach; or
- If the ARAR is a state requirement that the state has not consistently applied in similar circumstances.

Each alternative is also evaluated for long-term effectiveness and permanence, in which the magnitude of residual risk remaining from untreated waste or treatment residuals and the adequacy and reliability of containment systems and institutional controls is evaluated. The degree to which alternatives employ recycling or treatment to reduce toxicity, mobility or volume is assessed, including how treatment is used to address the principal threats at the site. The short-term effectiveness evaluation takes into consideration the short-term risks that might

be posed to on-site workers, the surrounding community, or the environment during implementation, as well as the time until protection is achieved. The analysis of implementability considers the technical feasibility and administrative feasibility of implementation, as well as the availability of required materials and services. The cost analysis evaluates capital (direct and indirect) costs and annual operation and maintenance (O&M). The net present value of capital and O&M costs is presented for each alternative.

In selecting a remedial action, the following criteria must be considered. Each selected remedial action shall meet the threshold criteria, and thereby be protective of human health and the environment. Provided the remedy meets the threshold criteria, it shall also be cost-effective. The overall effectiveness of an alternative is determined by evaluating long-term effectiveness and permanence, reduction of toxicity, mobility or volume through treatment, and short-term effectiveness. The alternative is then evaluated with regard to cost to ensure that it is cost-effective. Each remedial action shall also utilize permanent solutions and alternative treatment technologies to the maximum extent practicable. This requirement is fulfilled by selecting the alternative that satisfies the threshold criteria and provides the best balance of trade-offs among alternatives in terms of the five balancing criteria, with an emphasis on long-term effectiveness and reduction of toxicity, mobility and toxicity through treatment.

4.2 Soil Alternative Individual Descriptions and Evaluations

4.2.1 Alternative S-1 - No Action Alternative Description

The NCP requires consideration of the no-action alternative; at a minimum it provides a baseline for comparison with other alternatives. This alternative would involve no remedial response activities with respect to soils at Site 13. No removal or treatment of contaminated media or control of source areas would be conducted and no minimization of potential risks associated with direct contact with on-site contaminants or erosion of contaminants would be achieved. Because remaining contamination would not allow for unlimited future use of the site, five-year reviews of the no action decision would be required.

An evaluation of the no action alternative with respect to the evaluation criteria is presented below.

An evaluation of the no action alternative with respect to federal and state chemical-specific and location-specific ARARs/TBCs is presented in Tables 4-1 and 4-2, respectively. Since there are no actions involved in this alternative, action-specific ARARs/TBCs do not apply.

4.2.2 Alternative S-1 - No Action Alternative Evaluation

Overall Protection of Human Health and the Environment - The no action alternative offers no protection of human health and the environment, because it does not address potential risks through the elimination, reduction, or control of exposures to soil contamination. It does not limit future use of the site, and therefore does not limit the potential for future exposures due to changes in site use. It provides no protection against erosion of surficial contamination or leaching of contamination or leaching of contaminants from the soil. This alternative is not effective in the long-term or short-term and does not meet remedial action objectives. Alternative S-1 complies with location-specific ARARs but does not meet chemical-specific ARARs/TBCs.

Compliance with ARARs - Since this alternative does not address PCBs in soils, state and federal chemical-specific ARARs/TBCs, as presented in Table 4-1, will not be met. Federal location-specific ARARs would be met by the no action alternative since this alternative involves no actions which could impact potential archaeologically sensitive areas. Since there are no actions involved in this alternative, action-specific ARARs/TBCs do not apply.

Long-Term Effectiveness and Permanence - The no action alternative offers no long-term effectiveness or permanence in addressing soil contamination at the site. The existing potential risks to human health and the environment would remain, with no controls provided to manage exposures to contaminants under potential future site use scenarios. Due to the residual risk which would be associated with the no action alternative, five-year reviews of the no action decision would be required under the NCP.

Reduction of Toxicity, Mobility, or Volume through Treatment - The no action alternative does not include any treatment methods other than naturally occurring degradation or attenuation processes. Therefore, the alternative offers no significant reductions in the toxicity, mobility, or volume of contamination through treatment.

Short-Term Effectiveness - The no action alternative does not result in any increased short-term risks due to the lack of activities associated with its implementation. It does not offer any short-term reduction in potential risks to human health or the environment. Potential migration pathways would not be addressed, thereby continuing to allow potential contaminant migration due to surface water runoff into storm drains. Remedial action objectives would not be achieved.

Implementability - The no action alternative would require no implementation other than a five-year review of the no action decision. Its implementation would not limit the future implementation of additional remedial actions.

Cost - The cost associated with the no action alternative would be the nominal cost associated with conducting the five-year reviews.

4.2.3 Alternative S-2 - Limited Action Alternative Description

Alternative S-2 was developed as a limited action option which provides no active source control but limits potential risks to human health through the construction of a perimeter site fence and/or implementation of deed restrictions. A chain-link fence would be placed around the perimeter of the site to limit site access. Warning signs would be placed on the fence to warn any trespassers of the potential hazards associated with existing site conditions. Deed restrictions would restrict future use and development of the site, thereby further limiting potential exposures to on-site contamination. Since exposures to surface soils currently pose an unacceptable reasonable maximum exposure risk under a future commercial/industrial use scenario, deed restrictions would prevent both future residential and commercial/industrial site use.

An evaluation of Alternative S-2 with respect to federal and state chemical-specific and location-specific ARARs/TBCs is presented in Tables 4-1 and 4-2. No action-specific ARARs/TBCs were identified as being applicable to this alternative.

4.2.4 Alternative S-2 - Limited Action Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative S-2 provides a limited degree of protection of human health by limiting potential exposures to the site. It provides no additional protection of the environment.

Through fencing, the action would limit potential exposures due to direct contact with the contaminated areas. Deed restrictions would limit future site use and development, thereby providing protection against potential contaminant exposure pathways.

While fencing would be designed and constructed to comply with ARARs/TBCs, this alternative would not comply with chemical-specific ARARs/TBCs concerning PCBs in soils. It would not treat principal threats as defined in current EPA guidance (USEPA, 1990b). It is effective in the short-term but would not prove as effective in the long-term as other more sophisticated source control actions.

Compliance with ARARs - Alternative S-2 does not address PCBs in soils and therefore, does not meet chemical-specific ARARs/TBCs. Implementation of the fencing component of this alternative would be conducted in accordance with applicable location-specific ARARs, as noted in Table 4-2. No action-specific ARARs/TBCs were identified as being applicable to this alternative.

Long-Term Effectiveness and Permanence - Alternative S-2 relies on the limitation of access to the site to reduce risk from direct contact. Though fencing limits access, it may not be totally effective. Deed restrictions on access/development would require long-term enforcement to ensure their protectiveness. The alternative would not be effective in the long-term in limiting soil erosion or leaching of contaminants. Since contaminants would remain on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative S-2 would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-2 provides no treatment of soil contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume. Treatment of principal threats, defined by current EPA guidance (USEPA 1990b) as soil contaminated with greater than 500 ppm PCBs in industrial areas, is not provided. Site access and deed restrictions would limit the potential contaminant exposure pathways associated with current or future site use.

Short-Term Effectiveness - Minimal short-term risks would result from the implementation of Alternative S-2. Routine construction activities would be required to install the perimeter fence. Any exposures to contaminated material during these activities could be limited through the use of personnel protective equipment. No increased off-site risks would result from the implementation activities. Implementation is estimated to require one month. Remedial response objectives regarding the minimization of risks to human health would be achieved but the minimization of potential environmental impacts would not be achieved.

Implementability - The construction of a fence would generally be easy to implement, since associated equipment and materials are readily available. Deed restrictions would have to be incorporated into the property transfer process following base closure. However, implementation of site deed and access restrictions could contradict the Comprehensive Reuse Plan, which specifies that Site 13 be set aside for economic/industrial development. Implementation of Alternative S-2 would not be expected to limit the implementation of future remedial actions.

Cost - Costs associated with the implementation of Alternative S-2 would be those associated with fence placement and the establishment of land use restrictions. The cost of implementation for Alternative S-2 is estimated to include $45,000 in direct capital costs, $6,300 in indirect capital costs and $500 in annual operation and maintenance costs ($7,700 net present value). The present worth value of this alternative, including contingency, is estimated at $71,000. A detailed cost estimate is presented in Appendix E.

4.2.5 Alternative S-3 - Containment Alternative Description

Alternative S-3 was developed to meet the NCP's requirement for consideration of an alternative which utilizes containment with little or no treatment. This alternative provides no active remediation but limits potential risks to human health and the environment through the implementation of institutional controls, such as deed restrictions, and containment features. The implementation of deed restrictions would limit future site use and potential disruption of the cap. The main component of Alternative S-3 is the construction of a containment system over the site, as indicated in Figure 4-1. The containment component will minimize direct exposures to surficial contaminants, provide some restriction of the infiltration of precipitation into

underlying media and minimize potential erosion of surficial contaminants into the storm drainage system. The two containment options considered for Site 13 include a revegetative layer and a single-barrier cap; these are discussed in more detail with respect to the evaluation criteria in Sections 4.2.7 to 4.2.10. The discussions presented in this section and Section 4.2.6 are intended to provide a general basis for comparison of this alternative with other alternatives.

An evaluation of Alternative S-3 with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-3 through 4-5.

4.2.6 Alternative S-3 - Containment Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative S-3 provides protection of human health and the environment through the minimization of potential exposures to the soil contaminants and by minimizing the potential migration of soil contaminants due to erosion and/or leaching. Alternative S-3 would result in some increased short-term risks during implementation but would be effective in the long-term. It would comply with chemical-specific, action-specific and location-specific ARARs/TBCs.

Compliance with ARARs - Alternative S-3 would prevent exposures to PCBs at levels exceeding chemical-specific ARARs through its containment features. Containment construction activities at the site would be conducted in accordance with location-specific ARARs listed in Table 4-4, and cap design would consider current EPA guidance (USEPA 1990b), as listed in Table 4-5.

Long-Term Effectiveness and Permanence - Alternative S-3 would reduce the potential risks associated with direct contact with site-related contaminants but some residual risk would remain since the contaminated soils are not treated or removed. The containment options are expected to be relatively reliable in the long-term although periodic maintenance may be required. Since contaminants would remain on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative S-3 would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-3 provides no treatment or destruction of site contamination. Reductions in contaminant mobility due to erosion of surficial contaminants and/or due to infiltration of precipitation through the soils and leaching of contaminants to the ground water would be achieved to various degrees depending

on the selected containment option. Treatment of principal threats, defined by current EPA guidance (USEPA, 1990b) as soil contaminated with greater than 500 ppm PCBs in industrial areas, is not provided under this alternative.

Short-Term Effectiveness - Due to the site disturbance required to implement Alternative S-3, some increased short-term risks to workers could result. Any exposures to contaminated material during these activities could be limited through the use of personnel protective equipment. Remedial action objectives associated with minimizing potential risk to human health resulting from exposure to surface soil contaminants and minimizing potential environmental impacts by reducing off-site migration of surface soil contaminants would be met by this alternative. The implementation period of Alternative S-3 varies from three months to a year, depending on the containment option.

Implementability - Implementation of this alternative would require a significant construction effort but could be achieved. Implementation of Alternative S-3 would depend on the availability of containment materials. The containment features of this alternative could be impacted if implementation of future remedial actions was required.

Cost - The main costs associated with this alternative are those associated with construction and long-term maintenance of the various containment designs. Total present worth costs are estimated to range from $510,000 to $1,700,000, depending on the capping option selected, as detailed in Sections 4.2.8 and 4.2.10.

4.2.7 Alternative S-3A - Revegetation Containment Option Description

One containment option which could be implemented involves revegetating the entire site. Currently, the site is sparsely vegetated, which could allow for the erosion of surficial soil contamination. Revegetation would limit direct contact with contaminated soil and minimize runoff of contaminated soil. For this evaluation, it has been assumed that revegetation would consist of the placement of a one-foot thick layer of topsoil over the site to allow for the establishment and support of a dense vegetative layer. The topsoil layer would be seeded, mulched, and fertilized. Design details are shown in Figure 4-2. This design is consistent with long-term management controls described in current EPA guidance (USEPA, 1990b) for soils contaminated with low levels of PCBs (e.g., 5 to 20 ppm). The presence of the soil would limit

direct contact with soil contaminants and the vegetation would limit erosion. Alternative S-3A would not address the potential of PCBs leaching from highly-contaminated soils into the ground water unless combined with a soil removal action.

An evaluation of Alternative S-3A with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-3 through 4-5.

4.2.8 Alternative S-3A - Revegetation Containment Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-3A provides protection of human health and the environment through the minimization of potential exposures to soil contaminants and by minimizing the potential migration of soil contaminants due to erosion. Alternative S-3A does not address the potential leaching of PCB contaminants from highly-contaminated soils, however. Alternative S-3A would limit direct contact with PCBs and therefore could meet chemical-specific ARARs. The revegetation option would comply with location-specific and action-specific ARARs/TBCs. Alternative S-3A would result in some increased short-term risks during implementation but would be relatively effective in the long-term, provided continued maintenance of the vegetative layer.

Compliance with ARARs - Although PCBs are not removed or treated, revegetation would limit direct contact with PCBs and therefore, Alternative S-3A could meet federal and state chemical-specific ARARs, as indicated in Table 4-3. Since Alternative S-3A would not have any subsurface disturbance within the potential archaeologically significant area, location-specific ARARs/TBCs would be met, as identified in Table 4-4. Current EPA guidance would be considered in the development of a revegetation plan for Site 13, as indicated in Table 4-5.

Long-Term Effectiveness and Permanence - Some residual risk remains since the contaminated soil is not treated or removed, but covered by the vegetative layer. The vegetative layer will provide more protection against direct exposures, surface soil contaminant migration and infiltration than existing site conditions. However, the potential for leaching of PCBs from highly-contaminated soils would remain. With proper maintenance, a vegetative layer would offer relatively reliable protection against the risks associated with direct contact with contaminants and surface migration of contaminants. Since soil contaminants would remain on-

site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative S-3A would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-3A provides no treatment or destruction of site contamination. Treatment of principal threats is not provided. However, reductions in contaminant mobility associated with surficial erosion would be achieved through the revegetation of the entire Site 13 area.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative S-3A include the possibility of exposures to contaminants during placement of the vegetative layer over the site, although personnel protective equipment could be utilized to minimize these risks. Potential migration of contamination during construction due to run-off could be minimized through the use of drainage control measures. Off-site impacts of construction would be expected to be minimal. Remedial response objectives would be partially addressed by Alternative S-3A by limiting direct contact with contaminated soil and minimizing runoff of contaminated soil; the potential leaching of PCBs from highly-contaminated soils would not be addressed however. The time frame required for this alternative to meet remedial response objectives is estimated to be approximately three months.

Implementability - Alternative S-3A would be easy to implement. The construction of a vegetative layer employs commonly used and widely accepted equipment, materials, and techniques. Implementation of a vegetative layer should not pose a significant barrier to the implementation of other remedial actions.

Cost - The main costs associated with this alternative are those associated with construction and long-term maintenance of the vegetative layer. The cost of implementation for Alternative S-3A is estimated to include $360,000 in direct capital costs, $50,000 in indirect capital costs and $1,200 in annual operation and maintenance costs ($18,000 net present value). The present worth value of this alternative, including contingency, is estimated at $510,000. A detailed cost estimate is presented in Appendix E.

4.2.9 Alternative S-3B - Single-Barrier Cap Containment Option Description

This alternative involves the capping of Site 13 with a single-barrier cap. Based on the leaching model presented in Section 3.2.4, leaching of PCBs from unsaturated soils may pose

a potential soil contaminant migration pathway to the ground water. Therefore, the cap proposed for this containment alternative option provides added protection against infiltration.

An evaluation of Alternative S-3B with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-3 through 4-5.

The single-barrier cap proposed for Site 13 is described below (from visible top surface to top of contaminated soil):

- Vegetative and protective layer - 12 inches of topsoil
- Geonet drainage layer
- Synthetic geomembrane
- 6" bedding layer

The final cap surface would be constructed with a minimum five percent slope to prevent ponding on top of the cap and limit erosion. Details associated with the proposed cap are provided in Figure 4-2. This design is consistent with long-term management controls described in current EPA guidance (USEPA, 1990b) for soils contaminated with higher levels of PCBs (e.g., 100 ppm).

The vegetative/protective layer, the surficial layer of the cap, provides stability and erosion control. It also provides protection for the drainage layer and for the synthetic liner. The single-barrier cap's vegetative layer would be planted with shallow-rooted grasses to minimize erosion.

The drainage layer minimizes the time any infiltration contacts the geomembrane and thus reduces the potential for water to reach the underlying soils. Water that migrates through the vegetative/protective layer would drain laterally through the drainage layer due to the slope of the cap. The drainage layer could consist of a sand or granular material layer or a geosynthetic drainage layer (geonet). For this evaluation, the use of a geonet has been assumed. A geonet is a structure made of two sets of plastic strands arranged together to form a "net". The arrangement of these strands allows for fluids to be easily conveyed along the plane of the net. Filter fabric material could be used between the vegetative/protective layer and the geonet to prevent intrusion of soil into and subsequent clogging of the geonet.

The geomembrane lies beneath the drainage layer and provides an impermeable layer which prevents water from migrating deeper into the underlying soils. Water that reaches the

geomembrane drains to the side of the cap due to the cap's slope and the presence of the drainage layer.

The bedding layer provides a bed upon which the geomembrane can be installed with minimal potential for puncturing of the geomembrane. The bedding layer consists of a 6-inch thick layer of soil located over the existing surface soils and below the geomembrane.

4.2.10 Alternative S-3B - Single-Barrier Cap Containment Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-3B provides overall protection of human health and the environment through the minimization of potential exposures to soil contaminants, by minimizing the potential migration of soil contaminants due to erosion, and by minimizing the potential leaching of PCBs from the soil. The single-barrier cap would comply with chemical-specific, action-specific and location-specific ARARs/TBCs. This alternative could result in some increased short-term risks during implementation but would be effective in the long-term.

Compliance with ARARs - By preventing exposures to contaminants in the future, Alternative S-3B would meet federal and state chemical-specific ARARs, as indicated in Table 4-3. The single-barrier cap would have to be constructed in accordance with location-specific ARARs/TBCs listed in Table 4-4. Current EPA guidance would be considered in the final design of the cap, as indicated in Table 4-5.

Long-Term Effectiveness and Permanence - Alternative S-3B would significantly reduce the potential risks associated with direct contact with surface soil contamination, but some residual risk would remain since the contaminated soil is not treated or removed. The single-barrier cap would be effective in the long-term minimization of surface water infiltration and subsequent leaching of contamination from the soil. With proper maintenance, a single-barrier cap would offer reliable, long-term protection against direct contact with or surficial erosion of contaminants. Since soil contaminants would remain on-site above levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative S-3B would be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-3B provides no treatment or destruction of site contamination and does not provide treatment of

principal threats. However, reductions in contaminant mobility due to erosion of surficial contaminants and due to infiltration of precipitation and contaminant leaching would be achieved through the construction of the single-barrier cap.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative S-3B include the possibility of exposures to soil contaminants during the construction of the cap, although personnel protective equipment could be utilized to minimize these risks. Potential migration of contamination during construction due to run-off would be minimized through the use of drainage control measures. Off-site impacts of construction would be expected to be minimal. The time frame required for this alternative to meet remedial response objectives is estimated to be approximately one year.

Implementability - Several factors affect the implementability of Alternative S-3B. The construction of the single-barrier cap requires the use of a synthetic liner. Installation of a synthetic liner requires a specialty contractor to ensure proper installation. Special care is also required in the placement of the drainage and vegetative layers over the synthetic liner to ensure the membrane is not punctured. Overall, the single-barrier cap should be implementable.

Cost - The main costs associated with this alternative are those associated with construction and long-term maintenance of the cap. The cost of implementation for Alternative S-3B is estimated to include $1,200,000 in direct capital costs, $160,000 in indirect capital costs and $5,900 in annual operation and maintenance costs ($91,000 net present value). The present worth value of this alternative, including contingency, is estimated at $1,700,000. Detailed cost estimates are presented in Appendix E.

4.2.11 Alternative S-4 -Treatment/Disposal Alternative Description

Alternative S-4 provides active source control through the disposal or treatment of contaminated soils. As mentioned previously in Section 3.3.1, two remedial scenarios have been developed for Site 13 soils. The first scenario (Scenario 1) involves remediation of soil contaminants which exceed ARARs/TBCs (e.g. PCBs) and the risk-based PRG (e.g. beryllium). This scenario would require the remediation of approximately 900 cubic yards of soil. The second scenario (Scenario 2) involves the remediation of soils which exceed ARARs/TBCs only (e.g. PCBs). Since the risks posed by the one sample which exceeds the PRG for beryllium are

within the acceptable risk range for remedial actions at Superfund sites, the second scenario would require a risk management decision in which the limited extent of the beryllium-contaminated soils would not be remediated. The second scenario would require the remediation of approximately 400 cubic yards of PCB-contaminated soils.

One off-site disposal and three treatment options were evaluated under this alternative, as described in Sections 4.2.13 through 4.2.20.

An evaluation of Alternative S-4 with respect to federal and state chemical-specific, location-specific, and action specific ARARs/TBCs is presented in Tables 4-6 through 4-8.

4.2.12 Alternative S-4 - Treatment/Disposal Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative S-4 provides protection of human health and the environment through disposal or treatment of contaminants. The alternative would meet chemical-specific, location-specific and action-specific ARARs. Alternative S-4 would be effective in the long-term although increases in the short-term risks could be anticipated during implementation activities.

Compliance with ARARs - Alternative S-4 removes or treats soil contaminants and thereby meets federal and state chemical-specific ARARs/TBCs, as listed in Table 4-6. The alternative would need to comply with location-specific ARARs, as listed in Table 4-7, and with action-specific ARARs, including federal and state ARARs applicable to hazardous waste characterization and PCB-contaminated material handling, as listed in Table 4-8.

Long-Term Effectiveness and Permanence - Off-site disposal or treatment of contaminated soils would be effective in preventing direct contact with soils and migration of PCBs into ground water. Sampling would be required in order to verify the effectiveness of the removal or treatment options. Since residual soil contaminants would not exceed levels that allow for unlimited use and unrestricted exposure, five-year reviews of Alternative S-4 would not be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-4 would utilize either disposal or treatment to reduce the toxicity and mobility of existing contaminated soils.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative S-4 include the possibility of exposures to contaminants during the removal or treatment of contaminated soils, although personnel protective equipment could be utilized to minimize these risks. Potential migration of contamination during construction due to run-off would be minimized through the use of drainage control measures. Off-site impacts of construction would be expected to be minimal. The time frame required for this alternative to meet remedial response objectives is estimated to vary from approximately one month to one year.

Implementability - Implementation of Alternative S-4 would be relatively easy, with the possible exception of the treatment options. The technical implementability would be dependent upon the individual alternative options selected, with some treatment technologies more easily implemented than others. Services and materials should be readily available for the implementation of the disposal option.

Cost - The cost of this alternative is dependent on the individual options utilized in the final alternative. Based on the individual option evaluations presented in the following sections, the total cost of Alternative S-4 is estimated to range from $85,000 to $2,200,000.

4.2.13 Alternative S-4A - Excavation and Disposal Option Description

Alternative S-4A involves the excavation and off-site transportation of contaminated soils for disposal at a suitable landfill. Under Scenario 1 (defined previously in Section 4.2.11), approximately 900 cubic yards of soil including 400 cubic yards of PCB-contaminated soil and 500 cubic yards of beryllium-contaminated soil would require off-site disposal. Under Scenario 2, only the 400 cubic yards of PCB-contaminated soils would be excavated. It is important to note that, of the samples collected and analyzed for TCLP analyses at Site 13, no detected constituent exceeded maximum allowable TCLP levels. Therefore, it is assumed that the beryllium-contaminated soil would not require disposal as a hazardous waste. Due to the high concentration of PCBs detected in one surface soil sample, it is assumed that the PCB-contaminated soils would require disposal at a Toxic Substance Control Act (TSCA)-permitted landfill. Since it is not anticipated that the excavated PCB-contaminated soils would be characteristically hazardous, they would not be subject to land disposal restrictions.

Confirmatory TCLP analysis of the excavated soils would be required. Disposal of contaminated soil at an off-site landfill would eliminate the need for long-term management of soils on-site.

An evaluation of Alternative S-4 with respect to federal and state chemical-specific, location-specific, and action specific ARARs/TBCs is presented in Tables 4-6 through 4-8.

4.2.14 Alternative S-4A - Excavation and Disposal Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-4A provides protection of human health and the environment through the removal and off-site disposal of soil contaminants. The alternative would meet chemical-specific and action-specific ARARs. Alternative S-4A also would need to comply with location-specific ARARs concerning the disturbance of potentially significant archaeological areas at Site 13. Alternative S-4A could result in some increased short-term risks due to the disruption of surface soils during excavation and removal activities. However, these short-term risks could be minimized through the use of appropriate health and safety equipment. No off-site impacts are anticipated in the short-term. Alternative S-4A would be effective in the long-term since the contaminants are permanently removed from the site.

Compliance with ARARs - Alternative S-4A removes contaminated soil from the site and thereby meets federal and state chemical-specific ARARs/TBCs, as listed in Table 4-6. Since Alternative S-4A may impact potential archaeologically significant areas through the excavation of soils, this alternative would have to be conducted in accordance with location-specific ARARs, as listed in Table 4-7. Alternative S-4A would have to comply with action-specific ARARs, including federal and state ARARs applicable to off-site transportation and land disposal of the contaminated soils, as listed in Table 4-8.

Long-Term Effectiveness and Permanence - Off-site disposal of contaminated soils would be effective in preventing future direct contact with the soils and migration of PCBs into the ground water. This alternative requires no long-term maintenance. Sampling would be required in order to verify the effectiveness of the removal action. The long-term operating and maintenance procedures at the receiving landfill will affect the ultimate long-term effectiveness of the alternative. Five-year reviews of Alternative S-4A would not be required since soil

contaminants would not remain on-site above levels that allow for unlimited use and unrestricted exposure.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative S-4A provides no treatment of contaminated soils; however the off-site disposal of soils would reduce the mobility of the soil contaminants.

Short-Term Effectiveness - Alternative S-4A could result in increases in short-term risks due to the disruption of contaminated soils during the excavation and removal activities. However, personnel protective equipment could be utilized to minimize these risks. Remedial action objectives could be achieved within a relatively short time frame.

Implementability - Implementation of Alternative S-4A would be relatively easy from a technical point of view. Services are readily available for the excavation of contaminated soils. Implementability of off-site landfill disposal is directly related to the availability of a suitable landfill of adequate capacity to accept the type of material generated from Site 13. The minimal quantity of PCB-contaminated soils at Site 13 is not expected to present a capacity problem for the receiving landfill. The PCB-contaminated soils would need to be disposed of at an approved TSCA-permitted landfill. The implementation of Alternative S-4A would not affect the implementation of future remedial actions, if needed.

Cost - Costs associated with the implementation of Alternative S-4A would be those associated with the excavation, off-site transportation, and disposal of contaminated soils. For Scenario 1, the cost of implementation is estimated to include $250,000 in direct capital costs and $35,000 in indirect capital costs. The present worth value of this alternative, including contingency, is estimated at $350,000. For Scenario 2, the cost of implementation is estimated to include $150,000 in direct capital costs and $22,000 in indirect capital costs. The present worth value of this alternative, including contingency, is estimated at $210,000. Detailed cost estimates are presented in Appendix E.

4.2.15 Alternative S-4B - Excavation and Off-Site Incineration Option Description

The off-site incineration alternative was developed as an option which utilizes treatment to reduce the toxicity, mobility, or volume of contaminated soils as a principal element. Alternative S-4B consists of the excavation, transportation, and incineration of PCB-contaminated

soils at an off-site incinerator. Only Scenario 2, which involves the incineration of PCB-contaminated soils, is evaluated under this alternative.

An evaluation of Alternative S-4B with respect to federal and state chemical-specific, location-specific, and action specific ARARs/TBCs is presented in Tables 4-6 through 4-8.

4.2.16 Alternative S-4B - Excavation and Off-Site Incineration Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-4B provides a reduction in the mobility, volume, and toxicity of contaminants through off-site incineration. Organic contaminants, including PCBs, would be destroyed in the incineration process. Any inorganics present in the soil would either volatilize in the incineration process and be removed in the air treatment system or remain in the ash residue. The alternative would meet chemical-specific ARARs by destroying the PCB-contaminated soils through incineration. Alternative S-4B would need to comply with location-specific ARARs concerning the disturbance of potentially significant archaeological areas at Site 13. Remedial activities associated with Alternative S-4B would need to comply with action-specific ARARS/TBCs. This alternative would result in some increased short-term risks but would be effective in the long-term.

Compliance with ARARs - Alternative S-4B would meet chemical-specific ARARs by destroying the PCB-contaminated soils through incineration. Chemical-specific ARARs/TBCs for Alternative S-4B are listed in Table 4-6. Excavation activities would need to comply with location-specific ARARs concerning the disturbance of potentially significant archaeological areas at Site 13, as listed in Table 4-6. Remedial activities, including excavation, off-site transportation and incineration, associated with Alternative S-4B would need to comply with action-specific ARARS/TBCs such as TSCA and RIDEM storage and handling requirements, as listed in Table 4-8.

Long-Term Effectiveness and Permanence - The long-term effectiveness and permanence of Alternative S-4B would be good. PCBs are readily destroyed by incineration.

Reduction in Toxicity, Mobility or Volume Through Treatment - Alternative S-4B provides a reduction in the toxicity of PCB-contaminants through excavation, off-site transportation, and incineration. Incineration would provide treatment of the principal threat posed by the elevated PCB contaminant levels.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative S-4B include the possibility of exposures to contaminants during excavation and removal activities, although personnel protective equipment could be utilized to minimize these risks. Off-site impacts of excavation, removal, and off-site transportation activities would be expected to be minimal. The time frame required for this alternative to meet remedial response objectives is estimated to be approximately 6 months.

Implementability - Alternative S-4B would be implementable although it requires compliance with regulatory requirements. The administrative implementability would be dependent on the identification of a receiving facility which meets federal and state requirements applicable to the operation of incinerators, including regulations applicable to the destruction of PCBs.

Cost - Costs associated with the implementation of Alternative S-4B would be those associated with the excavation, off-site transportation, and incineration of contaminated soils. The cost of implementation for Alternative S-4B is estimated to include $1,600,000 in direct capital costs and $220,000 in indirect capital costs. The present worth value of this alternative, including contingency, is estimated at $2,200,000. A detailed cost estimate is presented in Appendix E.

4.2.17 Alternative S-4C - Excavation and On-Site Solvent Extraction Option Description

Alternative S-4C provides for the decontamination of soils through excavation and on-site solvent extraction. Solvent extraction technology physically separates organic contaminants from an inorganic matrix, thereby reducing the volume of wastes which require further treatment. The solvent extraction process consists of multiple extraction cycles followed by solvent recovery, oil polishing, solids drying, and water stripping. Residues from the solvent extraction process may require additional treatment. Only Scenario 2, which involves the treatment of PCB-contaminated soils, is evaluated under this alternative.

Solvent extraction is a developing technology which has exhibited success in removing PCBs from contaminated soils through the use of a solvent. It has also been applied to the treatment of contaminants such as PAHs, pesticides and dioxin. One such technology application, Resources Conservation Company's Basic Extractive Sludge Treatment (B.E.S.T.™)

Solvent Extraction Technology, has been demonstrated as part of the Superfund Innovative Technology Evaluation (SITE) program. In the B.E.S.T.™ process, aliphatic amines (e.g., triethylamine or TEA), which exhibit inverse miscibility, can simultaneously solvate oils and water at temperatures below 15 degrees C. Applied to soils, oils and PCB contaminants are extracted from the soil. When the temperature is raised, the water separates from the oil and solvent, leaving a concentrated PCB-contaminated solvent. A schematic of the B.E.S.T.™ treatment system is provided in Figure 4-3. The SITE demonstration reported PCB level reductions of greater than 99% (USEPA, 1993a) in sediment samples. Residual TEA may remain in the soils/sediments following treatment. Reported residual TEA levels in the SITE demonstration ranged from 45.1 ppm to 103 ppm. Other solvent extraction processes utilize critical fluid extraction, in which the solvent properties of certain gases are increased when they are heated and compressed to their "critical point". When the PCBs have been extracted by the gases, the pressure is reduced, allowing the solvent to vaporize (USEPA, 1990b). The high-concentration PCB residual solvent from either process is typically transported to an incinerator for final destruction.

An evaluation of Alternative S-4C with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-6 through 4-8.

4.2.18 Alternative S-4C - Excavation and On-Site Solvent Extraction Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-4B provides a reduction in the mobility, volume, and toxicity of contaminants through on-site solvent extraction. PCB contaminants would be removed from soils through the solvent extraction process. The alternative would meet chemical-specific ARARs by removing PCBs from the contaminated soils. Alternative S-4C would need to comply with location-specific ARARs concerning the excavation of on-site soils which could disturb potentially significant archaeological areas at Site 13. Remedial activities associated with Alternative S-4C would need to comply with action-specific ARARS/TBCs. This alternative would result in some increased short-term risks but would be effective in the long-term.

Compliance with ARARs - Alternative S-4C would meet chemical-specific ARARs by removing PCBs from soils through solvent extraction. Chemical-specific ARARs/TBCs for

Alternative S-4C are listed in Table 4-6. Excavation activities would need to comply with location-specific ARARs concerning the disturbance of potentially significant archaeological areas at Site 13, as listed in Table 4-7. Remedial activities, including excavation and solvent extraction, associated with Alternative S-4C would need to comply with action-specific ARARS/TBCs such as TSCA and RIDEM storage, handling and treatment requirements, as listed in Table 4-8.

Long-Term Effectiveness and Permanence - The long-term effectiveness of Alternative S-4C is expected to be good but would depend upon the treatment system's ability to remove the PCB contaminants and the ultimate destruction of the concentrated solvent in an incinerator. Some solvent residual may remain in the soils following treatment. Overall, Alternative S-4B is expected to be effective in the long-term by permanently destroying the contaminants of concern.

Reduction in Toxicity, Mobility or Volume Through Treatment - Alternative S-4C provides a reduction in the volume of contaminants through on-site solvent extraction. Incineration of the residual solvent reduces the toxicity of the contaminants. This alternative would address the principal threats associated with the PCB-contaminated soils through treatment.

Short-Term Effectiveness - Potential short-term risks associated with the implementation of Alternative S-4C include the possibility of exposures to contaminants during excavation and solvent extraction activities, although personnel protective equipment could be utilized to minimize these risks. Depending on the solvent extraction process used, solvent flammability, explosivity, or volatility could present additional increased short-term risks. Off-site impacts are expected to be minimal. The time frame required for this alternative to meet remedial response objectives is estimated to be approximately 6 months.

Implementability - Alternative S-4C would be implementable although it represents an emerging technology and therefore only a limited number of vendors may be available to provide effective services. The commercial-scale B.E.S.T.™ System, which will be capable of treating 186 tons of contaminated soil per day, is oversized for use in treating the estimated 400 cy of PCB-contaminated soil. However, other solvent extraction systems have reportedly been applied to sites with relatively small contaminant volumes (VISITT, 1993).

Cost - Costs associated with the implementation of Alternative S-4C would be those associated with the excavation and solvent extraction of contaminated soils. Costs are not well-defined at this point in technology development. VISITT reports costs as ranging from $100 to $900 per ton. Using the unit treatment cost reported for the site demonstration of the B.E.S.T.™ technology, the cost of implementation for Alternative S-4C is estimated to include $62,000 in direct capital costs and $8,700 in indirect capital costs. The present worth value of this alternative, including contingency, is estimated at $85,000. A detailed cost estimate is presented in Appendix E.

4.2.19 Alternative S-4D - In-Situ Fungal Degradation Option Description

Alternative S-4D involves the use of fungal enzymes to degrade soil contaminants via an oxidation reduction process. End products of the fungal degradation process are simple compounds, primarily carbon dioxide and water, leaving free radicals such as chlorine to evolve or combine in very low concentrations. Fungal degradation can be applied in-situ for shallow contaminants in soil down to a depth of eighteen inches. Fungal enzymes are produced on a solid substrate which is introduced to the contaminated media as a living organism. The fungal substrates are grown in controlled conditions involving a batch process of substrate preparation, substrate inoculation, and growth phase. The end product is a 10% moist, solid substrate mass which is transported to the contaminated site and introduced into soils by roto-tilling or other blending machinery. Fungi continue to grow in the soil mixture until growth substrates are fully consumed, producing cell free enzymes which degrade the hazardous compounds. Treatment periods have been reported to range from 4 weeks to 1 year, depending upon concentration and soil conditions. Other applications require the excavation of contaminated soils and treatment within a contained treatment area. (VISITT, 1993)

Fungal degradation is an innovative technology which has been applied to few sites on a full-scale basis. Other applications being evaluated include use of fungal degradation to treat PAHs, fuel residuals, and pesticides.

4.2.20 Alternative S-4D - In-Situ Fungal Degradation Option Evaluation

Overall Protection of Human Health and the Environment - Alternative S-4D provides a reduction in the toxicity of contaminants through on-site fungal degradation. PCBs in soils would be expected to be effectively treated through the fungal degradation process, although treatability studies would be required; therefore, the alternative would be expected to meet chemical-specific ARARs. Alternative S-4C would need to comply with location-specific ARARs since the mixture of fungal enzymes with on-site soils could disturb potentially significant archaeological areas. Remedial activities associated with Alternative S-4D would comply with action-specific ARARS/TBCs. This alternative would result in minimal increased short-term risks and would be effective in the long-term.

Compliance with ARARs - Alternative S-4D would meet chemical-specific ARARs by treating PCBs in soils. Chemical-specific ARARs/TBCs for Alternative S-4D are listed in Table 4-6. Application of fungal enzymes would need to comply with location-specific ARARs concerning the disturbance of potentially significant archaeological areas at Site 13, as listed in Table 4-7. Alternative S-4D would need to comply with action-specific ARARS/TBCs such as RIDEM waste management and site remediation regulations, as listed in Table 4-8.

Long-Term Effectiveness and Permanence - The long-term effectiveness of Alternative S-4D would depend upon the site factors such as climatic conditions, soil characteristics (e.g. permeability, temperature, and pH), and the presence of competing microbes. Overall, Alternative S-4D is expected to be effective in the long-term by permanently destroying the contaminants of concern.

Reduction in Toxicity, Mobility or Volume Through Treatment - Alternative S-4D provides a reduction in the mobility, volume, and toxicity of contaminants through on-site fungal degradation.

Short-Term Effectiveness - Alternative S-4C would result in minimal risks to workers since limited contact with soil contaminants would occur. Off-site impacts are expected to be minimal since Alternative S-4C is an on-site treatment alternative. The time frame required for this alternative to meet remedial response objectives is estimated to be approximately one year, although it could be less, depending on site-specific conditions.

Implementability - Alternative S-4D would be implementable although it represents an emerging technology and therefore only a limited number of vendors may be available to provide effective services. Full-scale applications have been limited to date.

Cost - Costs associated with the implementation of Alternative S-4D would be those associated with the in-situ fungal degradation of contaminated soils, which are not well-defined at this stage in the development of the technology. VISITT reports costs as ranging for $60 to $300 per cubic yard. Assuming the maximum unit cost of $300 per cubic yard, the cost of implementation for Alternative S-4D is estimated to include $120,000 in direct capital costs and $25,000 in indirect capital costs. The present worth value of this alternative, including contingency, is estimated at $180,000. A detailed cost estimate is presented in Appendix E.

4.3 Soil Alternative Comparative Evaluation

A comparative analysis is conducted to evaluate the significant differences between the alternatives based on the threshold and balancing criteria. Tabular comparisons of the alternatives based on the seven evaluation criteria are presented in Tables 4-9 through 4-15, respectively.

4.3.1 Overall Protection of Human Health and the Environment

A comparative analysis of the remedial alternatives with respect to overall protection of human health and the environment is presented in Table 4-9.

Alternative S-4 provides the greatest degree of long-term protection of human health and the environment through disposal or treatment of soil contaminants. However, Alternative S-4, does not address other low-level surficial contaminants which could potentially erode and be carried into the storm drainage system. Four options considered under the disposal/treatment alternative (Alternative S-4) include soil excavation and off-site disposal (S-4A), soil excavation and off-site incineration (S-4B), soil excavation and on-site solvent extraction (S-4C), and in-situ fungal degradation (S-4D). While Option S-4A would provide protection of human health and the environment through removal of soil contaminants and off-site disposal, Option S-4B would permanently destroy soil contaminants through the incineration process. Options S-4C and S-4D would also provide treatment of the PCB soil contaminants although the effectiveness of these

treatment technologies is not as well proven as incineration. Therefore, Alternatives S-4C and S-4D would require treatability studies. All four of the Alternative S-4 options would comply with chemical-specific and action-specific ARARs/TBCs, and would need to comply with location-specific ARARs concerning potential archaeologically significant areas. All four options considered under Alternative S-4 would result in some increased short-term risks to workers during implementation. In addition, all of the options of Alternative S-4 would be effective in the long-term. Alternative S-4 could be combined with the containment alternative (S-3) to provide overall protection of human health and the environment.

Alternative S-3 provides a greater degree of long-term protection of human health and the environment than Alternatives S-1 and S-2 by minimizing potential exposures to soil contaminants and by minimizing the potential migration of soil contaminants due to erosion and/or leaching. Two options considered under the containment Alternative (S-3) include revegetation (S-3A) and a single-barrier cap (S-3B). While both options minimize exposures to surficial contamination and the migration of soil contaminants due to erosion, the single-barrier cap is more effective in minimizing the potential for leaching of PCBs from soils. However, Alternative S-3A could be combined with a treatment/disposal alternative to provide overall protection of human health and the environment. Alternatives S-3A and S-3B would result in some increased short-term risk during their implementation. Both options would be effective in the long-term, although each would require long-term maintenance.

Alternative S-2 provides a limited degree of protection of human health by limiting potential exposures to site contaminants through site fencing and deed restrictions. Alternative S-2 provides no additional protection of the environment. Alternative S-2 does not comply with chemical-specific ARARs/TBCs. Alternative S-2 is effective in the short-term, but does not provide the long-term effectiveness offered by Alternative S-3 and S-4.

The no action alternative is not considered to be protective of human health or the environment since it provides no control for potential exposures to soil contamination or protection against erosion of surficial contamination or leaching of contaminants from the soil. It would not be effective in the long- or short-term and does not comply with chemical-specific ARARs.

4.3.2 Compliance with ARARs

A comparative analysis of the remedial alternatives with respect to their compliance with ARARs is presented in Table 4-10.

Alternative S-4 provides the best overall compliance with chemical-specific, location-specific, and action-specific criteria. By removing or treating soil contaminants, Alternative S-4 would meet chemical-specific ARARs/TBCs. Implementation of removal or treatment activities would comply with criteria applicable to potential archaeologically significant areas. The four options considered under the disposal/treatment alternative would also comply with action-specific ARARs/TBCs. Options S-4A and S-4B would comply with requirements regarding hazardous waste characterization and off-site transportation of the contaminated soils. In addition, Option S-4A would comply with TSCA storage and disposal requirements as well as RIDEM waste management requirements. Option S-4B would comply with TSCA storage and incineration requirements as well as RIDEM waste management regulations. Option S-4C would comply with requirements concerning hazardous waste characterization, off-site disposal and treatment of the concentrated solvent. Option S-4D would need to comply with RIDEM site remediation regulations.

Alternative S-3 provides better compliance with chemical-specific, location-specific, and action-specific ARARs/TBCs than Alternatives S-2 and S-1. By preventing exposures to soil contaminants in the future, Alternative S-3 would meet chemical-specific ARARs/TBCs. Implementation of construction activities would comply with criteria applicable to potential archaeologically significant areas. In addition, current EPA guidance on PCB remediation (USEPA 1990b) would be considered in the implementation of both options (Option S-3A Revegetation and Option S-3B-Single-Barrier Cap) of Alternative S-3.

Alternative S-2 provides some degree of compliance with state and federal ARARs. Alternative S-2 does not address PCBs in site soils and therefore does not meet chemical-specific ARARs/TBCs. Implementation of fencing would comply with criteria applicable to potential archaeologically significant areas. Implementation of the fencing component would comply with action-specific ARARs/TBCs.

Alternative S-1 does not address PCBs in site soils and therefore does not meet chemical-specific ARARs. Alternative S-1 involves no actions which impact potential archaeologically

significant areas and therefore, meets location-specific criteria. Since no actions are conducted under Alternative S-1, other than five-year reviews, action-specific ARARs/TBCs are not applicable.

4.3.3 Long-Term Effectiveness and Permanence

A comparative analysis of the remedial alternatives with respect to long-term effectiveness and permanence is presented in Table 4-11.

Alternative S-4 involves the off-site disposal or on-site or off-site treatment of contaminated soils. Alternative S-4 provides a greater degree of long-term effectiveness and permanence than the other alternatives by permanently treating the PCB contamination or by removing it from the site. However, Alternative S-4 does not provide protection against the potential erosion of low-level surficial contaminants from other areas of the site into the storm water drainage system. The treatment/disposal options are expected to be relatively reliable in the long-term although verification sampling would be required to verify the effectiveness of the removal or treatment options. Disposal Option S-4A is effective in the long-term in removing the PCB-contaminated soils, but is not as effective as Options S-4B, S-4C, and S-4D in terms of treating the PCB contaminants. Option S-4B represents the most proven technology in treating soil contaminants (e.g. PCBs) while Options S-4C and S-4D represent emerging technologies.

Alternative S-3 is effective in reducing the potential risks associated with erosion. leaching or direct contact with soil-related contaminants through containment. Some residual risk would remain since the contaminated soils are not treated or removed. Option S-3B provides more protection against infiltration and subsequent leaching than Option S-3A. Both options provide more protection against direct exposures, surface soil contaminant migration and infiltration than the existing site conditions. Options S-3A and S-3B would be relatively effective in the long-term and would require five-year reviews.

Alternative S-2 relies on institutional controls to limit human exposures to soil contamination. Alternative S-2 would require long-term maintenance of site fencing to maintain its effectiveness. Deed restrictions on access/development would require long-term enforcement to ensure their protectiveness. Due to its limited scope, it would not provide the same degree

of long-term effectiveness, permanence or reliability as Alternative S-3 or S-4. Alternative S-1 would not be effective in the long-term since no controls would be implemented to limit potential exposures to site contamination. Alternatives S-1 and S-2 would require five-year reviews since wastes would remain on-site above levels that allow for unlimited use and unrestricted exposures.

4.3.4 Reduction of Toxicity, Mobility and Volume through Treatment

A comparative analysis of the remedial alternatives with respect to reductions of toxicity, mobility and volume through treatment is presented in Table 4-12.

Alternative S-4 provides the greatest reduction in toxicity and mobility of contaminated soils among the alternatives. Alternative S-4 utilizes either disposal or treatment to reduce the toxicity and mobility of existing contaminated soils. Options S-4B, S-4C and S-4D address the principal threats associated with the PCB contamination (defined as soil contamination at levels exceeding 500 ppm in industrial areas under current USEPA guidance) through treatment. Option S-4A provides no treatment of contaminated soils, but would reduce the mobility of soil contaminants through off-site disposal.

Alternative S-3 provides no treatment or destruction of soil contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume. However, reductions in contaminant mobility due to erosion of surficial contaminants and/or due to infiltration of precipitation through the soils and leaching of PCB contaminants to the ground water would be achieved to various degrees, depending on the selected containment option. While the two containment options would reduce contaminant mobility associated with surficial erosion, Option S-3B would provide a greater barrier in limiting infiltration of precipitation and PCB leaching. Neither option provides treatment of the principal threats associated with the PCB contamination.

Alternative S-2 provides no treatment of soil contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume. However, site access and deed restrictions would limit the potential contaminant exposure pathways associated with current or future site use. Alternative S-1 provides no reduction in contaminant mobility, toxicity or volume except through natural degradation and attenuation. Neither alternative provides treatment of the principal threat.

4.3.5 Short-Term Effectiveness

A comparative analysis of the remedial alternatives with respect to short-term effectiveness is presented in Table 4-13.

Alternative S-4 would result in some increased short-term risks to workers due to the possibility of exposures to contaminants during the removal or treatment of contaminated soils. However, personnel protective equipment would minimize these risks. The potential for contaminant migration during construction due to run-off would be minimized through the use of drainage control measures. Off-site impacts of construction activities would be expected to be minimal. Options S-4C and S-4D would result in minimal off-site impacts since Option S-4C is an on-site treatment option and Option S-4D is an in-situ treatment option. Option S-4C could present additional short-term risks due to the chemical nature of certain solvents that may be used in the extraction process (i.e. flammability, explosivity, or volatility). The estimated implementation time frame to meet remedial action objectives for Options S-4A, S-4B, S-4C and S-4D could vary from a few weeks to one year.

Alternative S-3 would result in some increased short-term risks to workers due to site disturbance activities required to implement this alternative. However, personnel protective equipment would minimize these risks. Off-site impacts of construction activities would be expected to be minimal. Remedial response objectives associated with minimizing potential risks to human health resulting from exposure to surface soil contaminants and minimizing potential environmental impacts by reducing off-site migration of surface soil contaminants would be achieved by this alternative. The estimated implementation time frame for Options S-3A and S-3B would be three months and one year, respectively.

Alternative S-2 would result in minimal short-term risks associated with fence construction. Alternative S-2 has a short implementation time frame. Remedial response objectives regarding the minimization of risks to human health would be achieved but the minimization of potential environmental impacts would not be achieved. Alternative S-1 requires no remedial activities to be conducted and therefore results in no increase in short-term risks. However, it does not achieve remedial response objectives.

4.3.6 Implementability

A comparative analysis of the remedial alternatives with respect to implementability is presented in Table 4-14.

Alternative S-1 requires no implementation other than five-year reviews. This alternative would not limit the implementation of other remedial actions. Alternative S-2 is easily implemented from a technical standpoint, involving the construction and maintenance of site fencing. If deed restrictions prohibit commercial/industrial development, implementation of site deed and access restrictions could contradict the Comprehensive Reuse Plan which specifies that Site 13 be set aside for economic/industrial development. Alternative S-2 would not limit the implementation of other remedial actions.

Alternative S-3 is the most difficult of the alternatives to implement with respect to constructability. Implementation of Alternative S-3 depends on the availability of containment materials and services. Option S-3B is more difficult to implement than Option S-3A because it requires special equipment and materials for geomembrane installation and extra care in placement of overlying cap materials to prevent puncture of the geomembrane. Option S-3A employs commonly used equipment and construction materials and techniques. In addition, the construction of a vegetative layer does not present a significant barrier to the implementation of other remedial actions. Containment features could be impacted if future remedial actions are required.

Implementation of Alternative S-4 would be relatively easy with the possible exception of the treatment options. Option S-4A involves soil excavation and off-site disposal of contaminated soils and is easily implementable. The PCB-contaminated soils would need to be disposed of at an approved TSCA-permitted landfill. The minimal quantity of PCB-contaminated soils at Site 13 is not expected to present a capacity problem for the receiving landfill. Implementation of Alternative S-4A would not affect the implementation of future remedial actions. Option S-4B requires compliance with state and federal regulatory requirements concerning incineration and the destruction of PCBs. Administrative implementability of this option would be dependent on the identification of receiving facility which meets federal and state requirements applicable to the operation of incinerators. Alternatives S-4C and S-4D would

be implementable although they represent emerging technologies and therefore only a limited number of vendors may be available to provide effective services.

4.3.7 Cost

A comparative analysis of the remedial alternatives with respect to cost is presented in Table 4-15. The costs of the alternatives increase with the increasing sophistication of the remedial action. The no action alternative (S-1) represents the least expensive alternative to implement. The nominal costs associated with Alternative S-1 include the costs of conducting the five-year reviews. The second most expensive alternative to implement is the limited action alternative ($71,000). The revegetation containment option is considerably less expensive to implement ($510,000) than the single-barrier cap option ($1,700,000). In addition, the cost associated with the implementation of the off-site disposal option, Option S-4A ($210,000), is significantly less than that associated with the implementation of the off-site incineration option, Option 3-4B ($2,200,000). Options S-4C and S-4D are relatively inexpensive treatment options ($85,000 and $180,000); however, the uncertainties associated with these cost estimates are high, due to the developmental stage of these technologies.

4.4 Ground Water Alternative Individual Descriptions and Evaluations

Four ground water remedial alternatives were developed, as described below.

4.4.1 Alternative GW-1 - No Action Alternative Description

The NCP requires consideration of the no-action alternative; at a minimum it provides a baseline for comparison with other alternatives. This alternative would involve no remedial response activities with respect to ground water at Site 13. No removal or treatment of ground water which contains semi-volatile organic compounds and inorganic compounds at levels exceeding drinking water standards or manganese at levels exceeding the risk-based PRG would be conducted. Because remaining contamination would not allow for unlimited future use of the site (i.e. potable ground water use), five-year reviews of the no action decision would be required.

An evaluation of the no action alternative with respect to federal and state chemical-specific ARARs/TBCs is presented in Table 4-16. Impacts to potential archaeologically significant areas at Site 13 represent location-specific ARARs, as indicated in Table 4-17. Since the alternative involves no actions, no action-specific ARARs/TBCs were identified for this alternative.

4.4.2 Alternative GW-1 - No Action Alternative Evaluation

Overall Protection of Human Health and the Environment - The no action alternative does not address potential risks through the elimination, reduction, or control through treatment of the contaminated ground water. Semi-volatiles and inorganics would remain in the ground water on-site at levels exceeding ARARs. Manganese would remain in the ground water on-site at levels exceeding PRGs. However, based on the site's GB ground water classification, the reduction in inorganic contaminant levels detected in the second phase of RI due to use of a sampling methodology which reduced suspended silts in the samples, the presence of manganese in upgradient wells at all of the Phase II RI sites, and the lack of unacceptable environmental risks within the downgradient Hall Creek Watershed and Mill Creek Watershed, the lack of ground water treatment would not be expected to result in significant risks to human health and the environment unless a potable water supply well was installed at the site. This alternative does not limit future use of the site, and therefore does not limit the potential for future exposures due to changes in site use (e.g., installation of a potable well on-site). Should ground water in the site area ever be considered for potable use, protection of human health may not be provided under the no action alternative. This alternative is not expected to result in adverse impacts to the environment, based on the current lack of significant environmental risks associated with metals in the Hall Creek and Mill Creek Watersheds, although it provides no means of identifying potential environmental impacts, should they occur in the future. Implementation of this alternative results in no short-term impacts to the site.

Compliance with ARARs - Based on the presence of pentachlorophenol, bis(2-ethylhexyl)phthalate and antimony at levels exceeding drinking water standards in one or more ground water wells, this alternative would not meet chemical-specific ARARs, as presented in Table 4-16. Location-specific ARARs would be met since this alternative would not affect any

potentially significant archaeological areas (see Table 4-17). No action-specific ARARs/TBCs were identified for this alternative.

Long-Term Effectiveness and Permanence - The no action alternative would be effective in the long-term provided ground water is not used as a drinking water supply. Potential impacts to the environment are not expected based on the current lack of significant environmental risks attributable to metals and SVOCs within the Hall Creek Watershed and Mill Creek Watershed. However, no controls would be provided to verify the lack of future environmental impacts. Due to the residual risk (should drinking water be used as a drinking water supply) which would be associated with the no action alternative, five-year reviews of the no action decision would be required under the NCP.

Reduction of Toxicity, Mobility, or Volume through Treatment - The no action alternative does not include any treatment methods other than naturally occurring degradation or attenuation processes. Therefore, the alternative offers no significant reductions in the toxicity, mobility, or volume of SVOC and inorganic ground water contaminants through treatment.

Short-Term Effectiveness - The no action alternative does not present any increased short-term risks due to the lack of activities associated with its implementation. The five-year reviews would provide the only means of ensuring continued compliance with remedial action objectives.

Implementability - The no action alternative would require no implementation other than five-year reviews of the no action decision. Its implementation would not limit the future implementation of additional remedial actions.

Cost - The cost associated with the no action alternative would be the nominal cost associated with the five-year reviews.

4.4.3 Alternative GW-2 - Limited Action Alternative Description

Alternative GW-2 consists of the institution of ground water use restrictions and/or ground water monitoring. Ground water use restrictions would provide no active ground water remediation but would limit potential risks to human health through the implementation of institutional controls, such as deed restrictions, to limit future potable ground water use on site. While ground water at Site 13 is classified as GB and is expected to have no value as a potable

water source, there is no regulatory mechanism which limits the potential installation of a well at the site. Therefore, deed restrictions may be appropriate.

Long-term (30-year) ground water monitoring, consisting of annual monitoring of existing monitoring wells, is included in the limited action alternative. The long-term monitoring would provide a means of identifying any ground water quality changes over time.

An evaluation of Alternative GW-2 with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-16 through 4-18, respectively.

4.4.4 Alternative GW-2 - Limited Action Alternative Evaluation

Overall Protection of Human Health and the Environment - Implementation of the limited action option would protect human health by limiting potential future exposures to inorganics and SVOCs in the ground water which could occur should a drinking water supply well be installed on site. This alternative is not expected to result in adverse impacts to the environment, based on the current lack of significant environmental risks associated with SVOCs and metals in the Hall Creek and Mill Creek Watersheds. Ground water monitoring would provide a means of identifying changes in ground water quality and potential resultant impacts to the environment. While this alternative would not provide compliance with drinking water standards through treatment, it would prevent the development of a ground water ingestion exposure pathway.

Compliance with ARARs - Based on the presence of pentachlorophenol, bis(2-ethylhexyl)phthalate and antimony at levels exceeding drinking water standards during the Phase II RI, this alternative would not meet chemical-specific ARARs (See Table 4-16). Since this alternative would not involve the disturbance of any potentially significant archaeologic areas, Alternative GW-2 would meet location-specific ARARs, as presented in Table 4-17. Ground water monitoring will be conducted in accordance with RIDEM's Rules and Regulations for Ground Water Quality, as presented in Table 4-18.

Long-Term Effectiveness and Permanence - Provided deed restrictions are enforced, they can be effective in minimizing the long-term risks associated with the potential construction and use of an on-site well as a source of drinking water. Since contaminants will remain on site at

levels which do not allow for unlimited use and unrestricted exposure, five-year reviews of Alternative GW-2 would be required. The monitoring program would provide a means of monitoring potential changes in ground water quality. If monitoring indicated that ground water quality was deteriorating, additional remedial measures could be implemented.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative GW-2 provides no treatment nor associated reduction in contaminant toxicity, mobility or volume.

Short-Term Effectiveness - Since implementation of deed restrictions is an administrative effort, no short-term risks would result from implementation of this option. Implementation of the monitoring program would have minimal short-term adverse impacts based on the use of existing wells for ground water monitoring purposes. This option would meet remedial response objectives related to minimizing potential human exposures to contaminated ground water by preventing on-site potable well installation.

Implementability - Deed restrictions would have to be implemented as part of the base closure property transfer process. Deed restrictions limiting future installation of on-site potable wells would not be expected to prevent future commercial/industrial use of the site. Implementation of deed restrictions or ground water monitoring would not limit the implementation of future remedial actions.

Cost - The costs associated with the implementation of deed restrictions would primarily be limited to legal costs and could be incorporated into the base closure property transfer process. The costs associated with ground water monitoring include the long-term monitoring costs. The overall cost includes $48,000 in annual operation and maintenance costs ($730,000 net present value). The present worth value of this alternative, including contingency, is estimated at $880,000. A detailed cost estimate is provided in Appendix E.

4.4.5 Alternative GW-3 Extraction/Treatment/Discharge Alternative Description

Alternative GW-3 consists of active remediation of the ground water to meet chemical-specific ARARs and risk-based PRGs. The alternative would provide hydraulic control of the ground water at the site, thereby reducing potential off-site migration, but would not address the presence of manganese in ground water throughout the NCBC Davisville facility.

The extraction/treatment/discharge alternative would consist of separate options which would be combined to form a complete alternative. These options are described in detail in Sections 4.4.7 through 4.4.14. This discussion and the evaluation presented in Section 4.4.6 focuses on the extraction/treatment/discharge alternative in general terms, and will provide a basis for alternative comparisons.

The main contaminants of concern are pentachlorophenol, bis(2-ethylhexyl)phthalate, and antimony. The results of the Phase I RI ground water sampling indicated the presence of antimony, beryllium, cadmium, chromium, lead, and nickel at levels exceeding MCLs. However, during the Phase II RI, in which the low flow sampling methodology was used to minimize the presence of suspended sediments in the samples, only one inorganic analyte (antimony) was detected at a level exceeding the MCL. The presence of beryllium, cadmium, chromium, lead, and nickel in the Phase I RI ground water samples will not be considered indicative of ground water quality and, therefore, will not be considered in the evaluation of the extraction/treatment/discharge options.

Bis(2-ethylhexyl)phthalate was detected in both Phase I RI and Phase II RI ground water samples at levels exceeding the MCL; however, it was detected in only one Phase I RI monitoring well (13-MW4S) during only one sampling round. As noted in Section 2.6.2, the presence of bis(2-ethylhexyl)phthalate in the three Phase II RI samples is suspected to be attributable to the sampling methodology and not representative of actual ground water quality. This is further supported by the fact that bis(2-ethylhexyl)phthalate was detected in only one Phase I RI ground water sample. Therefore, the presence of bis(2-ethylhexyl)phthalate in the Phase II RI ground water samples will not be considered in the evaluation of the extraction/treatment/discharge options, although its presence in the one Phase I RI ground water sample at a level exceeding the MCL will be considered.

Manganese, the other inorganic of concern, was present at the majority of the Site 13 wells at levels exceeding the risk-based PRG. However, as previously discussed in Section 3.1.2, the manganese PRG is within the range of manganese concentrations detected in upgradient wells at all of the NCBC Davisville sites and, therefore, is not considered to be a site-related contaminant. Treatment of manganese will be considered in the evaluation of extraction/ treatment/discharge options, however.

An evaluation of Alternative GW-3 and its associated options with respect to federal and state chemical-specific, location-specific, and action-specific ARARs/TBCs is presented in Tables 4-19 through 4-21, respectively.

4.4.6 Alternative GW-3 - Extraction/Treatment/Discharge Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3 would provide active treatment of ground water at Site 13 and therefore, would provide a reduction in potential future risks to human health and the environment which could be associated with ground water ingestion or migration. Its long-term effectiveness would be good as long as the treatment system was operational. If treatment was discontinued, however, manganese could return to the site based on its presence throughout the facility. The extraction/treatment/ discharge options would be designed to comply with chemical specific, location-specific and action-specific ARARs/TBCs.

Compliance with ARARs - Alternative GW-3 would be designed to treat ground water contaminants present at levels exceeding chemical-specific ARARs, as presented in Table 4-19. The extraction, treatment and discharge systems would be operated in accordance with location-specific and action-specific ARARs, as indicated in Tables 4-20 and 4-21, respectively. A more detailed identification of the action-specific ARARs applicable to this alternative is provided in the individual option evaluations which follow.

Long-Term Effectiveness and Permanence - Ground water treatment would be effective in treating organic and inorganic contaminants which exceed ARARs or risk-based PRGs and in preventing off-site migration of these contaminants during operation but would not necessarily result in a permanent contaminant reduction if ground water treatment is discontinued at some point in the future. Long-term ground water monitoring would be required to evaluate the effectiveness of the alternative after operations cease. Since contaminants would be present on-site during the operating period at levels which do not allow for unlimited use and unrestricted exposure, five-year reviews of Alternative GW-3 would be required.

Reduction of Toxicity, Mobility or Volume Through Treatment - Alternative GW-3 would utilize treatment to reduce the toxicity and mobility of existing contaminated ground water.

Short-Term Effectiveness - No significant risks to on-site workers or off-site risks are anticipated as a result of implementation of this alternative. The degree of short-term risk would be dependent upon the individual options employed. Remedial response objectives would be achieved during operation of the treatment system but may not be maintained if treatment is discontinued.

Implementability - Implementation of a ground water extraction, treatment and discharge system would be relatively easy, with the possible exception of the discharge component. The technical implementability would be dependent upon the individual alternative options selected, with some treatment technologies more easily implemented than others. Services and materials should be readily available for the implementation of all options.

Cost - The cost of this alternative is dependent on the operational period as well as the individual options utilized in the final alternative. Based on the individual option evaluations presented in the following sections, the total cost of Alternative GW-3 is estimated to total approximately $2,500,000.

4.4.7 Alternative GW-3A - Ground Water Extraction via Interceptor Trench Option Description

An interceptor trench would be an effective means of extracting ground water at Site 13, based on the shallow depth to bedrock, the low production rates of existing monitoring wells, and the areal extent of the site. Ground water modeling was conducted to determine optimum trench location and design. Modeling efforts are presented in Appendix F. Two separate trenches would be installed, one in the northern portion of the site, elongated east-west and one trench in the western portion of the site elongated north-south. Since water table contours (see Figures 2-4 and 2-5) indicate the site is located on an apparent ground water divide, the trenches are located to collect ground water flowing in each of the flow directions, as shown on Figure 4-4. Both trenches would be approximately 600 feet long, 3- to 4-feet wide, and 25 feet deep. A typical cross-section through a trench is provided as Figure 4-5. The drains themselves would consist of a perforated pipe placed at an incline within the trenches. The trenches would be filled with a highly-permeable gravel up to a depth of approximately 4 feet below grade. Prior to backfilling with the gravel, the trench would be lined with a geotextile non-woven filter fabric

to prevent silt from clogging the drain. Excavated soil would be backfilled above the gravel layer. The ground water would flow by gravity into and through the pipe to pre-cast manhole sumps where it would be lifted by means of a submersible pump to the surface for treatment. Ground water would be extracted at a rate of approximately 2 gpm from each trench for a total extraction rate of 4 gpm.

4.4.8 Alternative GW-3A - Ground Water Extraction via Interceptor Trench Option Evaluation

Overall Protection of Human Health and the Environment - Use of an interceptor trench to remove ground water for treatment would be protective of both human health and the environment. Ground water would be pumped from the interceptor trench and piped directly to an on-site treatment system. The extraction system would be designed to comply with applicable ARARs, would be effective and reliable in the long-term and would have minimal short-term risks associated with its installation.

Compliance with ARARs - The proposed ground water extraction system has been developed to capture ground water containing pentachlorophenol, bis(2-ethylhexyl)phthalate, and antimony at levels exceeding MCLs and manganese at levels exceeding PRGs. Therefore, it has been developed to provide compliance with chemical-specific ARARs, as presented in Table 4-19. Excavation activities associated with the interceptor trench would have to comply with location-specific and action-specific ARARs concerning potentially significant archaeological areas, as indicated in Tables 4-20 and 4-21.

Long-Term Effectiveness and Permanence - An interceptor trench would be an effective and reliable means of extracting ground water at Site 13 since the average depth to bedrock is only 25 feet. Interceptor trenches are well-proven in their performance and can function with minimal maintenance.

Reduction of Toxicity, Mobility or Volume Through Treatment - The ground water extraction option does not provide treatment although it would be combined with a treatment option in a final alternative. By extracting contaminated ground water, the potential mobility of ground water contaminants is reduced.

Short-Term Effectiveness - Installation of an interceptor trench would present minimal short-term risks to on-site workers and would not be expected to result in any increased off-site risks to human health or the environment. The installation of an interceptor trench could be implemented within a minimal time frame.

Implementability - The implementability of a ground water extraction system is expected to be good. Materials and services are readily available and minimal technical or administrative obstacles to implementation would be anticipated.

Cost - The major cost component associated with implementation of Alternative GW-3A is the cost of construction of the interceptor trench. The estimated cost of Alternative GW-3A consists of $210,000 in direct capital costs, $29,000 in indirect capital costs, $9,600 in annual operation and maintenance costs ($148,000 net present value). The present worth value of this alternative, including contingency, is estimated at $470,000. A detailed cost estimate is presented in Appendix E.

4.4.9 Alternative GW-3B - Carbon Adsorption Organic Treatment Option Description

Alternative GW-3B involves the treatment of extracted ground water for organic contaminants using carbon adsorption. Carbon adsorption is a physical process in which molecules of a contaminant adhere to the surface of the carbon. Adsorption is a reversible process and therefore the carbon can be regenerated by the application of sufficient energy to remove the contaminants which allow for the re-use of the carbon. The effectiveness of carbon adsorption depends on the absorbability of organic compounds on the activated carbon. Specifically, absorbability is enhanced by increasing molecular weight, decreasing solubility in water, and the presence of functional groups such as chlorine substitutions or aromatic structures. Carbon adsorption is applicable to the removal of halogenated and non-halogenated SVOCs, including bis(2-ethylhexyl)phthalate and pentachlorophenol.

A typical carbon adsorption unit is shown in Figure 4-6. The carbon treatment system shown is a two-column unit filled with granular activated carbon where the first column provides the major portion of the treatment and the second column acts as a polishing column. Extracted ground water is pumped to the top of the column and allowed to flow downward through the carbon bed. Due to the relatively low levels of SVOCs within the ground water and the low

estimated ground water extraction rate, a one-column system could be adequate. However, the two-column system provides flexibility in terms of treatment because as one column reaches its adsorptive capacity, the influent can be rerouted to the second vessel while the carbon in the first vessel is replaced. Use of a two-column system also ensures that the partially used carbon provides the majority of the contaminant removal, while the virgin carbon is used for polishing. Small-scale treatment units utilizing small columns or drums filled with activated carbon are available for low-flow applications, as is anticipated for Site 13. In small-scale systems, the spent carbon may be disposed of rather than regenerated.

To prevent fouling of the carbon with inorganics, it may be desirable to place the inorganic treatment unit ahead of the organic treatment unit in the treatment train.

4.4.10 Alternative GW-3B - Carbon Adsorption Organic Treatment Option Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3B is expected to provide overall protection of human health and the environment through treatment of organics contaminants in the ground water. The long-term effectiveness and permanence and short-term effectiveness of the treatment system are expected to be good, and the system would be operated in compliance with ARARs/TBCs.

Compliance with ARARs - The ability of a carbon adsorption treatment system to treat organics such as pentachlorophenol and bis(2-ethylhexyl)phthalate is expected to be good. Treatment system operation would be conducted in compliance with action-specific ARARs, as listed in Table 4-21. The spent carbon would need to be regenerated off-site, which requires thermal reactivation, or would be disposed of off-site. The spent carbon would be handled in accordance with the applicable waste management regulations.

Long-Term Effectiveness and Permanence - The long-term risks associated with the residuals of ground water treatment by carbon adsorption would be relatively small, since carbon adsorption is an efficient means of removing most organics from the wastestream. Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties.

Reduction of Toxicity, Mobility or Volume Through Treatment - This alternative would provide a reduction in the mobility of ground water contaminants through treatment. While carbon adsorption does not destroy contaminants, it adsorbs contaminants to the carbon surface.

The contaminants can subsequently be destroyed through a thermal reactivation process or contained within a landfill.

Short-Term Effectiveness - Short-term risks to workers under this alternative are not expected to be significant. No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation.

Implementability - The implementation of a carbon adsorption treatment system is expected to be good. Treatment units are widely available and easily constructed. Start-up is not expected to result in unanticipated technical problems. The implementation of carbon adsorption will not impact the implementation of any future remedial actions. Operational activities will include replacement of the spent carbon. To minimize fouling of the carbon bed, the organic treatment system should follow the inorganic treatment system in the treatment train. Administrative feasibility is also expected to be good.

Cost - The major costs associated with Alternative GW-3B, assuming use of a small, drum-based treatment system, are the operation and maintenance costs associated with the carbon supply. The overall estimated cost includes $14,000 in annual operation and maintenance costs ($220,000 net present value). The present worth value of this alternative, including contingency, is estimated at $320,000. A detailed cost estimate is presented in Appendix E.

4.4.11 Alternative GW-3C - Precipitation Inorganic Treatment Option Description

Alternative GW-3C involves the treatment of inorganic ground water contaminants using chemical reduction and precipitation. Chemical precipitation is an inorganic removal method often used in industrial as well as ground water remediation applications.

For this evaluation, it is assumed that the chemical precipitation treatment system will include a filtration unit to remove gross solids prior to treatment and a flow equalization tank. The provision of an initial filtration system could result in reduced reagent costs and smaller equipment sizing for the remainder of the treatment system. A typical precipitation system includes the following:

- Reaction tank including mixers and pH control instrumentation;
- Chemical feed system, including a storage tank, mixers, level instrumentation and metering equipment;
- Clarifier;

- pH adjustment tank;
- Filter; and
- Solidification/stabilization system.

A schematic of a typical system is provided in Figure 4-7.

The extracted ground water flows from the filtration system, through the equalization tank, and into the reaction tank. In the reaction tank, a reagent is added to adjust the pH of the wastestream to the level required for optimum precipitation. The selection of an applicable precipitation reagent is dependent upon the flow rate, pH, pollutant loading, and waste/reagent compatibility.

Following the reaction tank, a flocculent such as an anionic or cationic polymer is added and the solution flocculated to aid in the settling of the metal precipitate. In the clarifier, flow is decreased to a point where solids with a specific gravity greater than that of the liquid settle to the bottom. The supernatant is drawn off and discharged to a pH adjustment tank for neutralization. The solids are discharged to a holding tank for subsequent dewatering. Dewatering is accomplished using mechanical dewatering equipment such as a filter press. Once dewatered the sludge is stabilized prior to off-site landfill disposal in accordance with federal and state disposal requirements.

Little data is available on the removal of antimony from water (Sittig, 1976), although removal using lime precipitation has been reported (Palmer, et.al., 1988). Manganese can also be removed at a pH above 9.4 using lime soda type treatment. Removal of manganese generally results in the simultaneous removal of iron, since the conditions under which high soluble iron levels occur are essentially the same as those for soluble manganese.

4.4.12 Alternative GW-3C - Precipitation Inorganic Treatment Option Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3C is expected to provide overall protection of human health and the environment through treatment of inorganic ground water contaminants. The long-term effectiveness and permanence and short-term effectiveness are expected to be good, and the system would be operated in compliance with ARARs/TBCs.

Compliance with ARARs - The ability of a chemical precipitation treatment system to treat inorganics such as antimony and manganese is expected to be good. Treatment system operation would be conducted in compliance with action-specific ARARs, as listed in Table 4-21. Chemical precipitation generates a sludge which requires subsequent disposal off-site. If the sludge meets the definition of a hazardous waste, federal RCRA hazardous waste generator and transporter requirements as well as state hazardous waste management regulations will be followed in the handling of the sludge. If not hazardous, the residuals would be handled in accordance with state solid waste management regulations. The treatment system would be required to treat the inorganic contaminants sufficiently to meet the applicable discharge requirements, also listed in Table 4-21.

Long-Term Effectiveness and Permanence - The long-term risks associated with chemical precipitation will be minimal based on the system's ability to treat antimony and manganese contamination. However, the treatment system does produce a sludge that will require hazardous waste characterization and appropriate disposal. Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties.

Reduction of Toxicity, Mobility or Volume Through Treatment - This alternative will provide a reduction in the toxicity of identified inorganic ground water contaminants through treatment. The volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated sludge residual.

Short-Term Effectiveness - Short-term risks to workers under Alternative GW-3C are not expected to be significant. Maintenance of chemical supplies and sludge handling are the major operation and maintenance activities associated with the chemical precipitation system. No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation.

Implementability - A chemical precipitation system should be easily implemented. Start-up is not expected to result in unanticipated technical problems. Its implementation is not expected to impact the implementation of any future remedial actions. Operational activities include maintenance of the chemical supplies and sludge handling. Administrative feasibility is also expected to be good.

Cost - The major costs associated with the precipitation treatment system are the capital costs associated with the construction of a chemical precipitation unit and associated operation and maintenance costs, including chemical supply costs. The overall estimated cost includes $130,000 in direct capital costs, $26,000 in indirect capital costs and $54,000 in annual operation and maintenance costs ($830,000 net present value). The present worth value of this alternative, including contingency, is estimated at $1,200,000. A detailed cost estimate is presented in Appendix E.

4.4.13 Alternative GW-3D - Discharge to Surface Water Option Description

Alternative GW-3D involves the discharge of treated ground water to surface water, which in this case would be Hall Creek, which flows into Frys Pond. The discharge would be piped from the site to the discharge location, an approximate distance of 2,000 feet. The discharge rate would be equal to the extraction rate, estimated at 4.0 gpm. Implementation of discharge to the surface water is expected to have little, if any, effect on the ground water extraction and treatment system.

4.4.14 Alternative GW-3D - Discharge to Surface Water Option Evaluation

Overall Protection of Human Health and the Environment - Alternative GW-3D would provide overall protection of human health and the environment when combined with ground water extraction and treatment. The long-term effectiveness and permanence of this option are expected to be good, due to its simplicity, and the discharge system would be operated in compliance with ARARs/TBCs.

Compliance with ARARs - Any construction activities (e.g. excavation) associated with the discharge piping at Site 13 would have to comply with location-specific ARARs, as presented in Table 4-20. The water quality of the treatment process effluent would be required to comply with state and federal surface water discharge criteria, including ambient water quality criteria as listed in Table 4-19 and surface water discharge regulations listed in Table 4-21.

Long-Term Effectiveness and Permanence - The long-term risks associated with discharge to surface water will be minimal, provided the treatment system is operating properly. Long-

term operation and maintenance of the discharge piping is not expected to pose any major technical problems. Long-term monitoring of the discharge water quality will be required.

Reduction of Toxicity, Mobility or Volume Through Treatment - This alternative is not expected to significantly impact the extraction or treatment system; therefore, it has little impact on the toxicity, mobility or volume of contamination.

Short-Term Effectiveness - Short-term risks to workers under this alternative are not expected to be significant, involving only the construction of the discharge piping. Maintenance of the system will require maintenance of the piping and discharge monitoring. No significant added risks to the adjacent community or the environment are anticipated.

Implementability - The technical implementation of a discharge to surface water system is affected by the long distance to a discharge point. The estimated distance to Hall Creek from Site 13 is approximately 2,000 feet to the northeast. Maintenance of the system will be limited. Continued monitoring of the discharged water quality will be required. The administrative feasibility of discharging treated ground water to surface water depends on the treatment system's ability to meet surface water discharge criteria.

Cost - The major costs associated with Alternative GW-3D are the on-going maintenance and discharge monitoring costs associated its implementation. The overall estimated cost includes $23,000 in direct capital costs, $3,300 in indirect capital costs and $24,000 in annual operation and maintenance costs ($370,000 net present value). The present worth value of this alternative, including contingency, is estimated at $470,000. A detailed cost estimate is presented in Appendix E.

4.5 Ground Water Alternative Comparative Evaluation

A comparative analysis of the ground water alternatives is conducted to evaluate the significant differences between the alternatives based on the threshold and balancing criteria. Tabular comparisons of the alternatives based on the seven evaluation criteria are presented in Tables 4-22 through 4-29.

4.5.1 Overall Protection of Human Health and the Environment

A comparative analysis of the remedial alternatives with respect to overall protection of human health and the environment is presented in Table 4-22.

Alternative GW-3, ground water extraction/treatment/discharge, could be considered to provide the greatest degree of overall protection of human health and the environment through its active remediation of ground water contamination; however its permanence once treatment is discontinued is not ensured. For the extraction, treatment, and discharge options evaluated under this alternative, all options would provide protection of human health and the environment.

Alternative GW-2, limited action, would provide protection against future impacts to human health by limiting potential future exposures to inorganics and SVOCs in ground water through the institution of deed restrictions (i.e. prohibiting on-site well construction). This alternative does not provide compliance with drinking water standards through treatment; however it would prevent the development of a ground water ingestion exposure pathway.

Alternative GW-1, no action, would provide the least protection of human health and the environment. It does not limit potable use of ground water at the site and does not monitor for potential future environmental impacts associated with contaminant migration. Alternative GW-1 does not meet remedial action objectives.

4.5.2 Compliance with ARARs

A comparative analysis of the remedial alternatives with respect to compliance with ARARs is presented in Table 4-23.

Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there are no regulatory mechanisms to prohibit potable use of the ground water, contaminant concentrations are compared to MCLs and PRGs to assess potential risks associated with the ingestion of ground water. Alternative GW-3 with its treatment options is the only alternative which provides a potential for reduction of ground water contaminant levels for contaminants detected at levels exceeding MCLs and PRGs. However, long-term maintenance of reduced levels for these contaminants is not guaranteed once the remedial system is discontinued. All other alternatives would be constructed in accordance with location-specific criteria, including those which affect potentially significant archaeological areas. All remedial

actions would also comply with the applicable action-specific ARARs, as indicated in Table 4-23.

4.5.3 Long-Term Effectiveness and Permanence

A comparative analysis of the remedial alternatives with respect to long-term effectiveness and permanence is presented in Table 4-24.

Alternative GW-2 would be expected to provide good long-term effectiveness. The limited action alternative would be effective in minimizing the long-term risks associated with the potential construction and use of an on-site well as a source of drinking water. The monitoring program provides a means of monitoring potential changes in ground water quality. Alternative GW-3 would provide effective treatment of contaminants which exceed ARARs or risk-based PRGs and would prevent the off-site migration of contaminants during operation. However, Alternative GW-3 would not necessarily result in a permanent contaminant reduction if the ground water treatment system is discontinued in the future. The extraction, treatment and discharge options are all expected to be effective in the long-term. Carbon adsorption (GW-3B) is effective in treating organic contaminants and easily operated and maintained. Chemical precipitation (GW-3C) is expected to be effective in treating inorganics. The no action alternative (GW-1) is effective in the long-term provided ground water is not used as a drinking water supply. However, Alternative GW-1 provides no long-term protection against the use of an on-site well as a source of drinking water.

4.5.4 Reduction of Toxicity, Mobility or Volume Through Treatment

A comparative analysis of the remedial alternatives with respect to reduction of toxicity, mobility or volume of contamination through treatment is presented in Table 4-25.

Alternative GW-3 is the only alternative which provides a reduction of contaminant toxicity through treatment. Option GW-3A reduces the potential mobility of contaminated ground water through ground water extraction. Option GW-3B provides a reduction in the mobility and/or toxicity of ground water contaminants through treatment (carbon adsorption) and subsequent thermal reactivation or containment within a landfill. Option GW-3C provides a reduction in the toxicity of identified inorganic contaminants through treatment. In addition, the

volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated sludge residual. Alternatives GW-2 and GW-1 provide no reduction in toxicity, mobility or volume through treatment.

4.5.5 Short-Term Effectiveness

A comparative analysis of the remedial alternatives with respect to short-term effectiveness is presented in Table 4-26.

Alternative GW-2 is the most effective alternative in the short-term as implementation of deed restrictions would result in no short-term risks. In addition, implementation of the monitoring program would have minimal short-term adverse impacts based on the use of existing wells for ground water monitoring purposes. Alternative GW-2 would meet remedial response objectives related to minimizing potential human exposures to contaminated ground water by preventing on-site potable well installation. Alternative GW-1 also poses no increased short-term risks but five-year reviews would provide the only means of ensuring compliance with remedial action objectives.

Alternative GW-3 provides a means of complying with remedial response objectives within a short time frame with minimal risk incurred. However, remedial response objectives may not be maintained if treatment is discontinued. No significant added risks to the adjacent community or the environment are anticipated as a result of the treatment system installation or operation. Major operation and maintenance activities associated with chemical precipitation include maintenance of chemical supplies and sludge handling. Both ground water extraction (GW-3A) and discharge to surface water (GW-3D) could be quickly implemented and effective in the short-term.

4.5.6 Implementability

A comparative analysis of the remedial alternatives with respect to implementability is presented in Table 4-27.

Alternative GW-1 would be the most implementable since it requires no actions other than five-year reviews. Alternative GW-2 would be next in terms of implementability, requiring initiation of long-term monitoring and deed restrictions but no on-site construction activities.

Neither Alternative GW-1 nor GW-2 would limit the implementation of other remedial actions at the site. In addition, implementation of deed restrictions in limiting future installation of on-site potable wells would not be expected to prevent future commercial/industrial use of the site.

Alternative GW-3 would require disruption of the site for implementation. However, Alternative GW-3 and the associated options pose no major difficulty in implementation. Both of the treatment options, carbon adsorption and precipitation, are easily implemented as services and materials are readily available. Ground water extraction (GW-3A) would be easily implemented. However, technical implementation of a discharge to surface water system is affected by the long distance (approximately 2,000 feet) to a discharge point. Option GW-3D would require long-term monitoring in accordance with discharge regulations.

4.5.7 Cost

A comparative analysis of the remedial alternatives with respect to cost is presented in Table 4-28. The no action alternative is the least expensive alternative to implement with the only cost being the nominal cost associated with the five-year reviews. Alternative GW-2 is the next most expensive alternative to implement with a total estimated present worth cost of $880,000. Alternative GW-3 would be costly to implement, at an estimate total cost of $2,500,000. For the ground water treatment options of Alternative GW-3, the cost of chemical precipitation ($1,200,000) is significantly higher than the cost of carbon adsorption ($320,000). The costs of ground water extraction via an interceptor trench (Option GW-3A) and the discharge to surface water option (GW-3D) are approximately the same (each $470,000).

4.6 Sediment Alternative Individual Descriptions and Evaluations

Two remedial alternatives, no action and removal and treatment/disposal were considered for addressing catch basin sediments, as described in the following sections.

4.6.1 Alternative SD-1 - No Action Alternative Description

In accordance with the NCP, the no-action alternative is considered. This alternative would involve no remedial response activities with respect to catch basin sediment contamination

at Site 13. Because contaminated sediments would remain under this alternative, five-year reviews of the no action decision would be required.

An evaluation of Alternative SD-1 with respect to location-specific ARARs and TBCs is presented in Table 4-29. No chemical-specific ARARs/TBCs were identified for sediments and, due to the lack of actions associated with the no action alternative, no action-specific ARARs/TBCs are applicable.

4.6.2 Alternative SD-1 - No Action Alternative Evaluation

Overall Protection of Human Health and the Environment - Due to the limited exposure pathway posed by contaminated sediments to humans (based on the fact that the sediments are contained within the on-site catch basins), the no action alternative is considered to be protective of human health. Since the ecological risk assessment concluded that the presence of PCBs and pesticides in the Hall Creek Watershed poses a potential for ecological risk, the presence of PCBs and pesticides in the catch basin sediments may present a continued source of contamination for the watershed. Therefore, this alternative would not offer long-term effectiveness and permanence with respect to protecting the environment. While no chemical-specific ARARs were identified with respect to watershed sediments, the catch basin contaminant levels exceed NOAA ER-M levels. This alternative also does not include any long-term monitoring to identify any potential changes to sediment quality, should they occur in the future. Implementation of this alternative results in no short-term impacts to the site.

Compliance with ARARs - An evaluation of the no action alternative with respect to federal and state location-specific ARARs/TBCs is presented in Table 4-29. Since the no action alternative involves no actions which impact potential archaeologically significant areas of the site, location-specific ARARs are met. No chemical-specific or action-specific ARARs are applicable to this alternative.

Long-Term Effectiveness and Permanence - While a residual risk to the environment exists within the watershed, the potential risk directly associated with the contaminated catch basin sediments is limited by their distance from the discharge point (approximately 600 feet), the relative lack of ecological receptors expected to exist within a catch basin environment, and by the fact that, based on background soil quality at NCBC Davisville, other areas of the facility

may be contributing to the presence of pesticides within the watershed. However, due to the residual catch basin contamination which would be associated with the no action alternative, five-year reviews of the no action decision would be required under the NCP.

Reduction of Toxicity, Mobility, or Volume through Treatment - The no action alternative does not include any treatment methods other than naturally occurring degradation or attenuation processes. Therefore, the alternative offers no reductions in the toxicity, mobility, or volume of catch basin sediment contamination through treatment.

Short-Term Effectiveness - The no action alternative does not present any increased short-term risks due to the lack of activities associated with its implementation. It would not meet remedial action objectives.

Implementability - The no action alternative would require no implementation other than five-year reviews of the no action decision. Its implementation would not limit the future implementation of additional remedial actions.

Cost - The cost associated with the no action alternative would be the nominal cost associated with the five-year reviews.

4.6.3 Alternative SD-2 - Removal and Treatment/Disposal Alternative Description

Alternative SD-2 was developed as an alternative which provides active remediation of the catch basin sediments. The catch basin sediments would be physically removed from the catch basins, contained and transported off-site for treatment or disposal, or treated on-site. Due to the small volume of sediment involved (as presented in Section 3.3.3, estimated to be less than 1 cubic yard), treatment/disposal would be practical only if combined with a soil treatment action. Therefore, separate evaluations of the treatment/disposal alternative options are not presented. The relative merits of each of the options were previously discussed with respect to soil remediation in Sections 4.2.13 through 4.2.20.

An evaluation of Alternative SD-2 with respect to federal and state location-specific and action-specific ARARs/TBCs is presented in Tables 4-30 and 4-31, respectively.

4.6.4 Alternative SD-2 - Removal and Treatment/Disposal Alternative Evaluation

Overall Protection of Human Health and the Environment - Alternative SD-2 provides a degree of protection to the environment by removing the catch basin sediments from acting as a potential source of downgradient watershed contamination. However, the long-term protection offered by this alternative would be dependent upon the absence of an upgradient source which, if present, could result in the re-contamination of the catch basins, and upon the prevention of surface soil erosion which could also re-contaminate the catch basins. The ultimate protection of the watershed would not be ensured since other areas of the facility may also be contributing contaminants to the watershed. The treatment/disposal alternative is effective in the short-term, although it could result in minor increases in short-term risks to remedial workers involved in the removal of the sediments. Remediation would be conducted in accordance with location-specific and action-specific ARARs.

Compliance with ARARs - Since the treatment/disposal alternative involves no actions which would be expected to impact potential archaeologically sensitive areas of the site, it would comply with location-specific ARARs, as indicated in Table 4-30. It would also comply with action-specific ARARs, as identified in Table 4-31.

Long-Term Effectiveness and Permanence - The long-term effectiveness of Alternative SD-2 depends upon the treatment or disposal options selected. It also is dependent on the prevention of recontamination of the catch basin sediments. Since the upgradient catch basin contains PCBs and pesticides at levels exceeding the ER-M value, an upgradient source of contamination may exist. Also, since surface soil contaminants are present at levels which exceed ER-M values but do not warrant remediation based on human health based criteria or ARARs/TBCs, existing surficial contamination could provide a continued source of catch basin contamination unless addressed through a soil remediation alternative (e.g., revegetation or capping). Continued sediment quality monitoring may be desirable to ensure that recontamination does not occur. Since the existing contaminated sediments would be removed and treated, five-year reviews of Alternative SD-2 would not be required.

Reduction in Toxicity, Mobility, or Volume through Treatment - Alternative SD-2 would reduce the toxicity, mobility or volume of contamination, depending on the treatment/disposal option selected.

Short-Term Effectiveness - Alternative SD-2 would be effective in the short-term, although some increased short-term risks could result from removal of the sediments. On-site treatment could also result in some increased short-term risks. The use of personnel protective equipment could reduce the risks associated with these activities. Remedial action objectives would be achieved.

Implementability - Implementation of Alternative SD-2 would be relatively easy, depending on the ultimate handling of the contaminated sediments. Implementation of treatment options would be implementable only if combined with a soil treatment alternative, based on the limited volume of contaminated sediments. Implementation of Alternative SD-2 would not be expected to limit the implementation of future remedial actions.

Cost - Costs associated with the implementation of Alternative SD-2 would be dependent on the selected individual treatment/disposal option. Due to the limited volume of contaminated sediments, the costs would not significantly impact the overall remedial cost for the site, however. Therefore, individual cost estimates were not prepared for the SD-2 treatment/disposal options.

4.7 Catch Basin Sediment Alternative Comparative Analysis

A comparative analysis is conducted to evaluate the significant differences between the alternatives based on the threshold and balancing criteria. Tabular comparisons of the alternatives based on the evaluation criteria are presented in Tables 4-32 through 4-37. A comparative evaluation based on cost is not made because neither of the sediment remedial alternatives is expected to impact the overall cost of remediation at Site 13, due to the limited volume of contaminated sediments.

4.7.1 Overall Protection of Human Health and the Environment

An evaluation of the two catch basin sediment alternatives based on overall protection of human health and the environment is presented in Table 4-32. Both of the sediment remediation alternatives are considered to be protective of human health based on the lack of potential exposures posed by the sediments in the catch basins. The Removal/Treatment Alternative (SD-2) would provide a greater degree of protection to the environment based on the

removal and disposal/treatment of the contaminated sediments. However, the potential presence of an upgradient source of sediment contamination or the potential erosion of surface soil contaminants and recontamination of the catch basins are not addressed by this alternative. The no action alternative provides no overall protection of the environment against potential migration of the existing catch basin sediments into Hall Creek.

4.7.2 Compliance with ARARs

An evaluation of the two catch basin sediment alternatives based on compliance with ARARs is presented in Table 4-33. No chemical-specific ARARs were identified as being applicable to the catch basin sediments. Since implementation of neither alternative results in impacts to potentially significant archaeological areas, both alternatives are considered to comply with location-specific ARARs. No action-specific ARARs would be applicable to the implementation of the no action alternative. Alternative SD-2 would be implemented in compliance with applicable action-specific ARARs. The action-specific ARARs associated with each of the disposal/treatment options were previously discussed in Section 4.3.2.

4.7.3 Long-Term Effectiveness and Permanence

An evaluation of the two catch basin sediment alternatives based on long-term effectiveness and permanence is presented in Table 4-34. Alternative SD-2 provides the greatest long-term effectiveness by removing the identified contaminated catch basin sediments for off-site disposal or treatment. However, its long-term permanence is dependent upon the prevention of re-contamination of the catch basins which could occur either as a result of surface soil contaminant erosion or the potential presence of an upgradient contaminant source. The no action alternative would not be effective in that it would not address the existing catch basin sediment contaminants; however, the degree to which these contaminants contribute to ecological risks within the Hall Creek Watershed is not well-defined.

4.7.4 Reduction of Toxicity, Mobility or Volume Through Treatment

An evaluation of the two catch basin sediment alternatives based on reduction of toxicity, mobility or volume through treatment is presented in Table 4-35. Alternative SD-2 is the only

alternative which includes treatment as a sediment remediation option; however, sediment treatment would only be feasible if combined with a soil treatment option, due to the small volumes of contaminated sediment involved. The disposal option of Alternative SD-2 would provide a reduction in the mobility of sediment contaminants through off-site disposal. Alternative SD-1 would provide no reduction of toxicity, mobility or volume through treatment.

4.7.5 Short-Term Effectiveness

An evaluation of the two catch basin sediment alternatives based on short-term effectiveness is presented in Table 4-36. The no action alternative presents no increase in short-term risks; remedial action objectives are not achieved, however. Alternative SD-2 could present some minor increases in short-term risks during removal of the contaminated sediments. These risks could be addressed through the use of personnel protection measures. Alternative SD-2 would achieve remedial action objectives within a relatively short time frame.

4.7.6 Implementability

An evaluation of the two catch basin sediment alternatives based on implementability is presented in Table 4-37. Alternative SD-1 would be the most easily implemented, requiring no action other than five-year reviews. Alternative SD-2 treatment options are only readily implementable if combined with a soil treatment option due to the small volume of sediments requiring treatment. Neither alternative would limit the implementation of other alternatives at the site.

4.7.8 Cost

As previously mentioned, a comparative analysis of costs has not been conducted. The no action alternative would involve only the nominal costs associated with the five-year review process. Alternative SD-2 would be implemented in combination with a similar soil disposal/treatment option. Due to the small volume of contaminated sediments (less than one cubic yard), the impact on the soil remediation cost estimate would be insignificant.

4.8 Sensitivity Analysis

A sensitivity analysis was conducted to assess the effect that variations in specific assumptions made during alternative development and assessment could have on the total estimated remedial cost. The main uncertainties applicable to the remedial alternatives and associated options include the uncertainty associated with the discount factor over the life of the remedy; uncertainty associated with the remediation period for ground water treatment remedies; uncertainty associated with the cost of treating or disposing of contaminated soils/sediments; and the uncertainty associated with the total volume of PCB-contaminated soil/sediment. Each of these uncertainties and the impacts of varying the associated assumptions on the overall cost evaluations are discussed individually below. The resultant impacts to remedial costs are summarized in Table 4-38.

The discount rate can vary from the 5% rate used in the cost evaluation. Alternatives with large O&M cost components and extended remedial periods can be significantly impacted by a variation in the discount rate. The sensitivity analysis has been conducted assuming a variation in the annual discount rate, with total present worth costs estimated for each alternative at annual discount rates of 3% and 10%. The soil remedial alternatives with associated O&M costs were slightly affected by variations in the discount rate. Ground water remedial alternatives, due to their long-term operation and maintenance costs, were most affected by variations in the discount rate. Ground water extraction (Option GW-3A) was the least affected by the discount rate variations.

Variations in the estimated remediation period also impacted the ground water remedial alternatives. Maximum costs associated with a 40-year operational period were generally 20% to 30% higher than the minimal costs associated with a 20-year operational period. Again, Option GW-3A was the least affected with a cost variation of 12.5% from minimum to maximum.

Variations in the costs of soil/sediment treatment/disposal rates have the greatest potential for affect in the most expensive option, S-4B, and in the innovative options, S-4C and S-4D, where costs are currently not well-defined. Off-site incineration (S-4B) was assumed to vary from $2,000 to $3,000 per ton. The cost differential from minimum to maximum cost was $865,000. Similarly for solvent extraction (S-4C), the treatment cost was assumed to range from

$100 to $900 per ton, the range reported for various technologies in the VISITT database (VISITT, 1993). The resultant cost differential from minimum to maximum cost was $609,000. A wide range in treatment costs is also reported for fungal degradation. The total cost could range from $36,000 to $238,000 based on unit costs ranging from $60 to $400 per cubic yard.

Variations in the total estimated volume of PCB-contaminated soil have the greatest impact on the off-site incineration alternative, based on the high unit treatment cost. The cost differential for varying the soil volume by -20% to +20% was comparable to the differential in cost which would result if the unit treatment cost were varied from $2,000 to $3,000 per ton.

5.0 RECOMMENDATIONS AND CONCLUSIONS

5.1 Site-Wide Assessment

Based on the remedial alternatives evaluated for the individual environmental media at Site 13, several comprehensive alternatives consisting of various combinations of media-specific alternatives could be developed. While it is not possible to describe and evaluate each possible combination of alternatives, a discussion of certain comprehensive alternative types, taking into consideration the interactions between the environmental media, is appropriate to the development of a final remedial alternative recommendation for the site. The general alternatives evaluated include:

- No Action
- Limited Action
- Containment and Monitoring
- Containment, Off-site Soil/Sediment Remediation and Monitoring
- Containment and On-site Soil/Sediment and Ground Water Treatment

The general descriptions of the alternatives presented below are not intended to preclude other possible combinations of media-specific alternatives. Rather, they are presented to allow a presentation of how the alternatives could be combined to form site-wide remedial alternatives.

A summary of the components which are included in each of the comprehensive alternatives described below is presented in Table 5-1.

5.1.1 Alternative 1 - No Action

A comprehensive no action alternative would consist of no action with respect to soil, ground water and catch basin sediments. It would not provide overall protection of human health and the environment, would not achieve remedial action objectives and would not be protective in the long-term.

5.1.2 Alternative 2 - Limited Action

A comprehensive limited action alternative would consist of institutional controls for soil, ground water and catch basin sediments. It could consist of the following:

- Deed restrictions to limit future exposures to surficial soil contamination and contaminated ground water;
- Fencing to prevent human exposures to contaminated surface materials; and
- Long-term monitoring of ground water quality

While this alternative would be protective of human health in terms of limiting potential human exposures to soil and ground water contamination, it would not provide protection against the leaching of PCB contamination to the ground water, the potential migration of surficial soil contamination to the storm drainage system or the potential migration of catch basin sediments to Hall Creek. The presence of fencing and residual contamination would limit future commercial/industrial use of the site, the preferred future site use specified in the Base Reuse Plan.

5.1.3 Alternative 3 - Containment and Monitoring

A comprehensive containment alternative would consist of containment measures combined with institutional controls and long-term monitoring. A possible containment alternative would consist of the following:

- Excavation and consolidation of contaminated sediments beneath a single-barrier cap placed over the entire site area,
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the capping system; and
- Long-term monitoring of ground water quality.

This alternative would provide overall protection of human health and the environment although it would not treat the principal threat posed by the elevated concentration of PCBs detected in one surface soil sample. Direct exposures to contaminated surface soils would be eliminated by the presence of the cap. The cap would also reduce the potential for leaching of PCB contaminants and erosion of surficial contaminants to the catch basins. By providing sediment excavation and consolidation beneath the cap, the potential for migration of existing sediments from the catch basins would be eliminated. Long-term monitoring would allow for the identification of any changes in ground water quality. Deed restrictions would prevent future potable use of the ground water as well as potential disruptions to the integrity of the capping system. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required

to protect the integrity of the cap. It would not be incompatible with surrounding commercial/industrial site use, however.

5.1.4 Alternative 4 - Containment, Off-Site Soil/Sediment Remediation, Monitoring

This comprehensive alternative consists of containment features coupled with active soil remediation and ground water monitoring. It could consist of the following:

- PCB-contaminated soil and sediment excavation and off-site remediation (off-site disposal or incineration) and revegetation of the remainder of the site;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would provide a greater degree of protection of human health and the environment through the removal and off-site disposal or incineration of PCB-contaminated soils and catch basin sediments. The incineration option would provide treatment of the principal threat associated with the presence of PCBs in soils at concentrations greater than 500 ppm. Revegetation of the remainder of the site would limit the potential for erosion of surficial contaminants to the catch basins. Deed restrictions would limit future disruption of the revegetated areas and would prevent future potable use of the ground water. Long-term monitoring would allow for the identification of any future changes in ground water quality. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required to protect the integrity of the revegetated areas. It would not be incompatible with surrounding commercial/industrial site use, however.

5.1.5 Alternative 5 - Containment and On-site Soil/Sediment and Ground Water Treatment

This comprehensive alternative consists of containment features coupled with active soil, sediment and ground water remediation. It could consist of the following:

- PCB-contaminated soil and sediment excavation and remediation (on-site treatment) and revegetation of the remainder of the site;
- Ground water extraction and treatment;

- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would provide protection of human health and the environment through the on-site treatment of PCB-contaminated soils, catch basin sediments and ground water. The on-site treatment options (solvent extraction and fungal degradation) would be expected to provide treatment of the principal threat associated with the presence of PCBs in soils at concentrations greater than 500 ppm, although they represent developing treatment technologies and are not well-proven in full-scale operation. Revegetation of the remainder of the site would limit the potential for future erosion of low-level surficial contaminants to the catch basins. Ground water would be extracted, treated on-site for inorganics and organics, and discharged to surface water. When the active treatment of ground water would be discontinued, re-contamination of ground water at levels which are not protective of human health could occur, based on the detection of manganese throughout the facility. Deed restrictions would limit future disruption of the revegetated areas and would prevent future potable use of the ground water. Long-term monitoring would allow for the identification of any future changes in ground water quality. Implementation of this alternative could limit the potential for future commercial/industrial use of the site, based on the site use restrictions which would be required to protect the integrity of the revegetated areas. It would not be incompatible with surrounding commercial/industrial site use, however.

5.1.6 Comparative Evaluation of Comprehensive Alternatives

A comparison of the five comprehensive remedial alternatives described in Sections 5.1.1 through 5.1.5 against the alternative evaluation criteria is presented in Tables 5-2 through 5-8. A brief discussion of the relative merits of the alternatives with respect to the evaluation criteria is presented below.

Overall Protection of Human Health and the Environment - A comparison of comprehensive alternatives with respect to overall protection of human health and the environment is presented in Table 5-2. Each of Alternatives 3, 4 and 5 are expected to be protective of human health and the environment. They each address surficial soil and catch

basin sediment contamination, preventing direct exposures to contaminants, erosion of the contaminants to the storm drainage system and potential leaching of the PCB contaminants through the provision of physical barriers to exposure (Alternative 3) or through a combination of physical barriers to exposure and removal and treatment/disposal (Alternatives 4 and 5). While Alternative 5 provides active treatment of ground water contaminants, Alternatives 2, 3 and 4 provide a mechanism for long-term monitoring of potential changes to ground water quality and limit potential exposures through the implementation of deed restrictions. Alternative 2 provides no protection of the environment while Alternative 1 is not protective of either human health or the environment.

Compliance with ARARs - A comparison of the comprehensive alternatives with respect to compliance with ARARS is presented in Table 5-3. Alternative 5 is the only alternative which utilizes treatment to address contaminants present in ground water at levels exceeding MCLs. However, based on the ground water classification, the general lack of significant risks associated with the presence of the contaminants (provided ground water is not used as a potable water supply) and the limited detection of contaminants at levels exceeding MCLs, an alternative which does not utilize active treatment could be considered to be protective under the expected future site use scenario. Also, the permanence of Alternative 5 in maintaining treatment levels following discontinuation of treatment is not assured due to the lack of an identified source of the individual contaminants detected at levels exceeding MCLs. Both of Alternatives 4 and 5 would achieve chemical-specific soil ARARs/TBCs through treatment or disposal. Alternative 3 would utilize containment to address soils which exceed chemical-specific ARARs/TBCs. Alternatives 1 and 2 would not achieve chemical-specific soil ARARs/TBCs.

Since Site 13 has been identified as a potentially significant archaeological area, each of the alternatives would be constructed taking into consideration potential impacts to archaeological features. Action-specific ARARs would be followed in the design, construction and operation of remedial actions.

Long-Term Effectiveness and Permanence - A comparison of comprehensive alternatives with respect to long-term effectiveness and permanence is presented in Table 5-4. Alternatives 3, 4 and 5 are expected to be effective in the long-term, providing protection against surface soil and sediment erosion, contaminant leaching and direct contact with surface soil contaminants.

While Alternative 5 provides ground water treatment of contaminants which have been detected at levels exceeding MCLs and PRGs, it may not provide permanent protection against a re-occurrence of these contaminants once treatment is discontinued. While Alternatives 3, 4 and 5 require long-term maintenance of cap or revegetation areas, Alternative 5 also involves long-term ground water treatment system operation. Alternatives 2, 3, 4 and 5 also require implementation of a long-term monitoring program. Alternative 2 would not be effective in the long-term in protecting the environment. Alternative 1 provides the least long-term effectiveness and permanence.

Reduction of Toxicity, Mobility or Volume Through Treatment - A comparison of comprehensive alternatives with respect to reductions of toxicity, mobility or volume through treatment is presented in Table 5-5. Alternative 5 is the only alternative to provide a reduction in ground water contaminant mobility through treatment. However, due to the facility-wide presence of manganese, the permanence of the ground water toxicity reductions is not ensured should treatment be discontinued. Alternatives 4 and 5 provide a reduction in soil and sediment contaminant toxicity or mobility through treatment or off-site disposal containment features. Alternative 3 also provides a reduction in soil and sediment mobility through its on-site containment features. Alternatives 1 and 2 offer no reductions in contaminant toxicity, mobility or volume.

Short-Term Effectiveness - A comparison of the comprehensive alternatives with respect to short-term effectiveness is presented in Table 5-6. Alternatives 3, 4 and 5 may result in minor increases in on-site short-term risks due to the disruption of the site required to revegetate the site, construct the single-barrier cap or excavate contaminated soils. Additional short-term risks could be associated with the operation of on-site soil/sediment and ground water treatment systems under Alternative 5. These risks could be minimized through the use of personnel protective equipment. Remedial action objectives would be achieved for Alternatives 3, 4 and 5. While Alternatives 1 and 2 would have no significant increased short-term risks associated with their implementation, they would not meet remedial action objectives.

Implementability - A comparison of the comprehensive alternatives with respect to implementability is presented in Table 5-7. Alternative 1 is the most implementable alternative since it requires no remedial actions. Alternative 2 is the next most implementable alternative,

requiring only long-term monitoring, fence construction and the implementation of deed restrictions. Alternative 3 and 4 would follow, with Alternative 3 requiring the construction of a cap which requires special materials and installation techniques and Alternative 4 requiring excavation of contaminated soils/sediments and off-site incineration or disposal. Alternative 5 requires the greatest implementation effort, including the implementation of innovative soil/sediment treatment systems which are not widely available and the implementation of a ground water extraction, treatment and discharge system.

Cost - A comparison of comprehensive alternatives with respect to cost is presented in Table 5-8. Costs vary widely, with the no action alternative the least costly to implement, requiring only the implementation of five-year reviews. Alternative 2, the limited action alternative (assumed to consist of media-specific Alternatives S-2 and GW-2) is estimated have a total present worth value of $950,000. Alternative 3, the containment and monitoring alternative (assumed to consist of media-specific alternatives S-3B and GW-2) is estimated to cost $2,600,000. Alternative 4, the containment, off-site soil/sediment remediation and monitoring alternative (assumed to consist of media-specific Alternatives S-3A and GW-2 combined with Alternatives S-4A or S-4B) ranges in value from $1,600,000 to $3,600,000, depending on whether the PCB-contaminated soil is landfilled or incinerated. The most costly alternative to implement would be Alternative 5, the containment and on-site soil/sediment and ground water treatment alternative. Alternative 5 is assumed to consist of media-specific Alternatives S-3A, GW-2 and GW-3 combined with either Alternative S-4C or S-4D. Comprehensive Alternative 5 is estimated to cost in the range of $3,900,000 to $4,000,000, depending on the type of soil/sediment treatment system selected.

5.2 Recommendations and Conclusions

Based on the evaluation presented in the previous section, the recommended remedial alternative for Site 13 is Alternative 4, as described in Section 5.1.4, consisting of the following:

- PCB-contaminated soil and sediment excavation and off-site remediation (off-site disposal or incineration) and revegetation of the remainder of the site;
- Deed restrictions to limit future exposures to contaminated ground water and to prevent disruption of the revegetated areas; and
- Long-term monitoring of ground water quality.

This alternative would be protective of human health and the environment, would be effective in the long-term, and would comply with location-specific and action-specific ARARs as well as chemical-specific ARARs applicable to soil contamination. It would use institutional controls to limit exposures to ground water contaminants at levels exceeding MCLs, which would be consistent with EPA's expectations for Superfund that allow the use of institutional controls when active remediation measures are determined not to be practicable, based on the balancing of trade-offs among alternatives. The potential direct-contact and leaching risks associated with the presence of surficial PCB contamination would be addressed through off-site remediation while the provision of soil cover and revegetaion would prevent the erosion of existing low-level surface soil contamination. Long-term ground water monitoring would be utilized to ensure continued protection of the environment. Deed restrictions would limit the potential for future disruption of the site surface and would prevent future potable use of the ground water. The presence of the revegetated area and associated deed restrictions could limit future use of the site for commercial or industrial development, as specified in the Base Reuse Plan, but the alternative would be compatible with commercial/industrial use of the surrounding area.

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TABLE 2–1

Site 13 – Solvent Disposal Area Northwest
Vertical Hydraulic Gradients

Well Cluster Number	Vertical Distance (ft) (1)		Head Difference (ft) (2)		Gradient (ft/ft)	
	8/13/93	9/17/93	8/13/93	9/17/93	8/13/93	9/17/93
13–MW3	14.45	13.73	0.01	0.00	6.92×10^{-4}	0
13–MW10	11.32	10.23	–0.10	–0.08	-8.83×10^{-3}	-7.82×10^{-3}

NOTES: (1) The vertical distance is the difference in elevation between the water table in the shallow well and the middle of the screened interval in the deep well.

(2) The head difference is the elevation of the deep well piezometric level minus the water table elevation. Thus, negative signs represent downward gradients.

TABLE 2–2

Site 13 – Solvent Disposal Area Northwest
Average Horizontal Hydraulic Gradients and Linear Velocities

Location	Average Horizontal Gradient (ft/ft) 8/13/93	9/17/93	Average Linear Velocity (ft/d) 8/13/93	9/17/93
Shallow Wells				
13–MW1S to 13–MW10S	2.71×10^{-3}	3.30×10^{-3}	0.03	0.04
13–MW2S to 13–MW10S	6.04×10^{-3}	8.03×10^{-3}	0.07	0.09
13–MW3S to 13–MW1S	5.12×10^{-4}	1.07×10^{-3}	0.01	0.01
13–MW3S to 13–MW6S	6.00×10^{-3}	6.48×10^{-3}	0.07	0.07
13–MW4S to 13–MW7S	7.12×10^{-3}	5.75×10^{-3}	0.08	0.06
13–MW4S to 13–MW8S	3.64×10^{-3}	2.49×10^{-3}	0.04	0.03
13–MW5S to 13–MW7S	4.48×10^{-3}	4.35×10^{-3}	0.05	0.05
13–MW11S to 13–MW5S	1.30×10^{-3}	8.67×10^{-4}	0.01	0.01
13–MW11S to 13–MW12S	3.41×10^{-3}	2.15×10^{-3}	0.04	0.02
13–MW11S to 13–MW13S	1.72×10^{-3}	1.09×10^{-3}	0.02	0.01
13–MW13S to 13–MW1S	1.84×10^{-3}	2.52×10^{-3}	0.02	0.03
13–MW13S to 13–MW9S	5.54×10^{-4}	1.08×10^{-3}	0.01	0.01
13–MW14S to 13–MW6S	1.02×10^{-2}	1.15×10^{-2}	0.11	0.13
Deep Wells				
13–MW3D to 13–MW10D	2.68×10^{-3}	3.35×10^{-3}	0.28	0.35

NOTES: The shallow and deep hydraulic conductivities for the site (2.2 ft/d and 21.1 ft/d, respectively) are the median values derived from the Phase II RI slug tests.
An effective porosity of 0.20 for silty sands (EPRI, 1985) was assumed.

TABLE 2–3

Site 13 – Solvent Disposal Area Northwest
Comparison of Background Soils to Surface and Subsurface Soil Samples
Range of Semi–Volatile Organic Compounds Detected

Compound	Surface Soil Range (µg/kg)	Subsurface Soil Range (µg/kg)	Background Range (µg/kg)
Phenol	ND	ND	ND
bis(2–Chloroethyl)ether	ND	ND	ND
2–Chlorophenol	ND	ND	ND
1,3–Dichlorobenzene	ND	ND	ND
1,4–Dichlorobenzene	ND	ND	ND
1,2–Dichlorobenzene	ND	ND	ND
2–Methylphenol	ND	ND	ND
2,2'–Oxybis(1–chloropropane)	ND	ND	ND
4–Methylphenol	ND	ND	ND
N–Nitroso–di–n–propylamine	ND	ND	ND
Hexachloroethane	ND	ND	ND
Nitrobenzene	ND	ND	ND
Isophorone	ND	ND	ND
2–Nitrophenol	ND	ND	ND
2,4–Dimethylphenol	ND	ND	ND
bis(2–Chloroethoxy)methane	ND	ND	ND
2,4–Dichlorophenol	ND	ND	ND
1,2,4–Trichlorobenzene	ND	ND	ND
Naphthalene	ND–57	ND	ND
4–Chloroaniline	ND	ND	ND
Hexachlorobutadiene	ND	ND	ND
4–Chloro–3–methylphenol	ND	ND	ND
2–Methylnaphthalene	ND–120	ND–58	ND
Hexachlorocyclopentadiene	ND	ND	ND
2,4,6–Trichlorophenol	ND	ND	ND
2,4,5–Trichlorophenol	ND	ND	ND
2–Chloronaphthalene	ND	ND	ND
2–Nitroaniline	ND	ND	ND
Dimethyl phthalate	ND	ND	ND
Acenaphthylene	ND–97	ND	ND
2,6–Dinitrotoluene	ND	ND	ND
3–Nitroaniline	ND	ND	ND
Acenaphthene	ND	ND	ND
2,4–Dinitrophenol	ND	ND	ND
4–Nitrophenol	ND	ND	ND
Dibenzofuran	ND	ND	ND
2,4–Dinitrotoluene	ND–180	ND	ND
Diethyl phthalate	ND	ND	ND
4–Chlorophenyl phenyl ether	ND	ND	ND
Fluorene	ND–130	ND	ND
4–Nitroaniline	ND	ND	ND
4,6–Dinitro–2–methylphenol	ND	ND	ND
N–Nitrosodiphenylamine(1)	ND	ND	ND
4–Bromophenyl phenyl ether	ND	ND	ND
Hexachlorobenzene	ND	ND	ND
Pentachlorophenol	ND–100	ND	ND
Phenanthrene	ND–140	ND–83	ND – 140
Anthracene	ND	ND	ND
Carbazole	ND	ND	ND
Di–n–butyl phthalate	ND–140	ND	ND – 67
Fluoranthene	ND–450	ND–100	ND – 250
Pyrene	ND–440	ND–76	ND – 260
Butyl benzyl phthalate	ND–41	ND	ND – 380
3,3'–Dichlorobenzidine	ND	ND	ND
Benzo(a)anthracene	ND–150	ND–51	ND – 110
Chrysene	ND–320	ND–50	ND – 190
bis(2–Ethylhexyl)phthalate	ND–100	ND–360	ND – 580
Di–n–octyl phthalate	ND	ND	ND
Benzo(b)fluoranthene	ND–740	ND–64	ND – 270
Benzo(k)fluoranthene	ND–740	ND–64	ND – 73
Benzo(a)pyrene	ND–130	ND	ND – 77
Indeno(1,2,3–cd)pyrene	ND	ND	ND – 52
Dibenzo(a,h)anthracene	ND	ND	ND
Benzo(g,h,i)perylene	ND–46	ND	ND

Notes:
ND = Not Detected
Subsurface soil range includes test pit soil sample results.

TABLE 2–3, continued

Site 13 – Solvent Disposal Area Northwest
Comparison of Background Soils to Surface and Subsurface Soil Samples
Range of Pesticides/PCBs Detected

Compound	Surface Soil Range (µg/kg)	Subsurface Soil Range (µg/kg)	Background Soil Range (µg/kg)
Alpha–BHC	ND–0.15	ND–0.45	ND
Beta–BHC	ND–8.2	ND	ND
Delta–BHC	ND–1.2	ND–0.051	ND – 0.5
Gamma–BHC (Lindane)	ND	ND	ND
Heptachlor	ND	ND	ND – 0.73
Aldrin	ND–35	ND	ND – 0.16
Heptachlor epoxide	ND–1.4	ND–0.85	ND – 3
Endosulfan I	ND–0.21	ND	ND
Dieldrin	ND–1.4	ND–0.83	ND – 1.2
4,4'–DDE	ND–20	ND–0.49	ND – 550
Endrin	ND–3	ND–0.077	ND – 1.6
Endosulfan II	ND–0.29	ND	ND – 0.1
4,4'–DDD	ND–51	ND–0.55	ND – 62
Endosulfan sulfate	ND–110	ND–0.67	ND – 2.7
4,4'–DDT	ND–110	ND–11	ND – 610
p,p'–Methoxychlor	ND–89	ND	ND – 3
Endrin ketone	ND–830	ND	ND
Endrin aldehyde	ND–5.4	ND–0.57	ND – 4.2
Alpha chlordane	ND–37	ND–0.84	ND – 61
Gamma chlordane	ND–53	ND–0.65	ND – 46
Toxaphene	ND	ND	ND
PCB–1016	ND	ND	ND
PCB–1221	ND	ND	ND
PCB–1232	ND	ND	ND
PCB–1242	ND	ND	ND
PCB–1248	ND–1,200	ND–40	ND
PCB–1254	ND–2,000	ND–24	ND
PCB–1260	ND–600	ND–34	ND – 96

Notes:
ND = Not Detected
Subsurface soil range includes test pit soil sample results.

TABLE 2–3, continued

Site 13 – Solvent Disposal Area Northwest
Comparison of Background Soils to Surface and Subsurface Soil Samples
Range of Inorganics Detected

Element	Surface Soil Ranges (mg/kg)	Subsurface Soil Ranges (mg/kg)	Background Soil Range (mg/kg)
Aluminum	2,330–14,100	2,580–11,000	1,710 – 12,600
Antimony	ND	ND–7.9	ND – 3
Arsenic	ND–2.2	ND–2.5	0.59 – 8.1
Barium	ND–44.6	6.4–19.9	5.6 – 19.8
Beryllium	ND–2.1	ND–0.88	ND – 0.77
Cadmium	ND–1.3	ND–1.2	ND – 0.46
Calcium	148–2,960	332–2,120	62.7 – 628
Chromium	1.8–26.5	2.6–10.1	3.5 – 11
Cobalt	ND–10.6	ND–7.7	ND – 4.6
Copper	ND–144	ND–18.3	ND – 14.8
Iron	2,910–18,100	2,140–16,300	5,960 – 13,200
Lead	1.6–183	1.8–61.5	3.4 – 55.9
Magnesium	261–3,510	340–3,780	325 – 1,220
Manganese	36.8–254	ND–261	23.3 –150
Mercury	ND–0.12	ND–0.11	ND – 0.12
Nickel	ND–64.8	ND–12	ND – 7.5
Potassium	ND–1,460	ND–532	ND – 728
Selenium	ND–0.72	ND–0.68	ND – 0.77
Silver	ND–0.07	ND–0.11	ND – 0.22
Sodium	ND–237	ND–169	ND – 161
Thallium	ND–0.95	ND–0.87	ND – 0.96
Vanadium	2.5–11.5	3.4–14.5	3.3 – 24.6
Zinc	12.9–644	5.5–126	10.3 – 172
Cyanide	ND	ND–0.9	ND – 0.60

Notes:
ND – Not Detected
Subsurface soil range includes test pit soil sample results.

TABLE 2-4
SITE 13 – DISPOSAL AREA NORTHWEST
SUMMARY OF CANCER AND NON-CANCER RISK ESTIMATES
FOR ALL SCENARIOS

Pathway	CANCER RISKS			
	Scenario 1 (Construction Worker)		Scenario 2 (Commercial/Industrial Worker)	
	Geometric Mean	RME	Geometric Mean	RME
Incidental ingestion of soil	8E-07	8E-07	2E-06	3E-04
Dermal contact with soil	3E-09	2E-09	1E-07	7E-04
Inhalation of particulates	1E-09	3E-09	NA	NA
Ingestion of ground water	NA	NA	5E-05	4E-04

= Cancer risk > 1E-6

Pathway	NON-CANCER HAZARD INDICES			
	Scenario 1 (Construction Worker)		Scenario 2 (Commercial/Industrial Worker)	
	Geometric Mean	RME	Geometric Mean	RME
Incidental ingestion of soil	3E-02	7E-02	3E-03	1E-02
Dermal contact with soil	9E-06	8E-06	8E-06	6E-05
Inhalation of particulates	1E-09	3E-09	NA	NA
Ingestion of ground water	NA	NA	3E+00	1E+01

= Cancer risk > 1E+0

TABLE 3–1

Site 13 – Disposal Area Northwest
Comparison of Surface Soil Contaminant Levels to Action Levels

Parameter	Maximum Concentration Detected (ppm) Surface Soils (0–2') Phase I RI	Phase II RI	Federal Action Level (ppm)	State Action Level (ppm)
LEAD	64.1	183	500–1,000[1]	300[2]
PCBs	4,563	2	10[3]	10/50[4]

(1) USEPA, OSWER Directive 9355.4–02, Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites.
(2) RIDEM and RI Dept. of Health–Risk Assessment Guidance Level.
(3) TSCA (40 CFR 761); Requirements for decontaminating spills in nonrestricted areas.
(4) RIDEM Proposed Amendments to the Rules and Regulations for Solid Waste Management Facilities defines solid waste as including any soil debris or other material with a concentration of 10 ppm or greater PCBs.
RIDEM Proposed Amendments to the Rules and Regulations for Hazardous Waste Management defines Type 6 – extremely hazardous waste as including waste which contains 50 ppm or greater PCBs.

TABLE 3–2

Site 13 – Disposal Area Northwest
Comparison of Detected Ground Water Contaminants to
Applicable or Relevant and Appropriate Requirements (ARARs) or To–be–Considered Requirements (TBCs)

	Maximum Concentration Detected in Ground Water		--- FEDERAL ARARs/TBCs ---		RHODE ISLAND -------- ARARs/TBCs --------	
Parameter	Phase I (ppb)	Phase II (ppb)	MCL(1) (ppb)	MCLG(2) (ppb)	MCL(3) (ppb)	Ground Water(4) Quality Standards (ppb)
Volatiles						
1,2 Dichloroethane	2	1	5	0		5
2–Butanone	ND	6				
Trichloroethene	ND	1	5	0		5
Xylenes (Total)	1	1	10000	10000		10000
Semivolatiles						
Phenol	ND	3				
Naphthalene	2	3				
2–Methylnaphthalene	4.5	4				
Diethyl phthalate	ND	1				
Pentachlorophenol	ND	2	1	0		1
Di–n–butyl phthalate	ND	2				
Bis(2–ethylhexyl) phthalate	45	63	6	0		
Inorganics						
Antimony	31.7	36.4	6	6		
Arsenic	45.5	7.4	50	–	50	50
Beryllium	10.3	2.6	4	4		
Cadmium	9.5	1.1	5	5		5
Chromium	166	10.2	100	100	100	100
Copper	236	15.9	1300*			
Lead	158.5	4.4	15*		15	15
Mercury	0.2	ND	2	2		2
Nickel	179	ND	100	100		
Silver	ND	0.64				
Zinc	709	60				
Barium	345	93.1	2000	2000	2000	2000
Iron	188000	34100				
Manganese	2170	3810				
Vanadium	257	22				
Aluminum	144000	6450				
Cobalt	124.5	27				
Magnesium	30100	4270				
Calcium	20400	11800				
Sodium	1070000	50900				
Potassium	20300	6280				

1. MCL – Maximum Contaminant Level. National Primary Drinking Water Regulations.
2. MCLG – Maximum Contaminant Level Goal, based on health considerations only.
3. Rhode Island Maximum Contaminant Level. Rules and Regulations Pertaining to Public Drinking Water (R46–13–DWQ) Sections 6.80(c), 16.1, 16.2(a), and 16.2(b).
4. Water Quality Standards, Class GAA and Class GA ground waters, Rhode Island Regulation DEM–GW–01–92, May 1992. Site 13 is located in a Class GB area.

*–Action levels representative of drinking water quality at the tap, U.S. EPA, May 7, 1991.

ND – Not detected

TABLE 3–3

SUMMARY OF RISK–BASED PRELIMINARY REMEDIATION GOALS – SURFACE SOILS
SITE 13 – DISPOSAL AREA NORTHWEST

Parameter	Surface Soils Maximum Detected Concentration (ppm)	Estimated (1) Reasonable Maximum Exposure Cancer Risk	10^{-6} Risk–Based (2) Preliminary Remediation Goal (ppm)
Beryllium	2.1	1.6×10^{-6}	1.3
Benzo(b)/(k)fluoranthene	1.5 (3)	1.9×10^{-6}	0.78

(1) – Risk estimates represent total cancer risk due to ingestion and dermal contact under future commercial/industrial use, as presented in the Draft Remedial Investigation Report (TRC, 1993).
(2) – See Appendix B for discussion of risk–based preliminary remediation goal calculations.
(3) – Conbined maximum concentrations of benzo (b) fluoranthene and benzo (k) fluoranthene.

TABLE 3–4

Summary of Risk–Based Preliminary Remediation Goals – Ground Water
Site 13 – Disposal Area Northwest

Parameter	Ground Water Maximum Detected Concentration (ppm)	Estimated (1) Non–Cancer Based Hazard Index	Risk–Based (2) Preliminary Remediation Goal (ppm)
Manganese	3.8	7.5	0.51

(1) – Risk estimate represents total non–cancer hazard index ratio due to ingestion of ground water under future commercial/industrial use, as presented in the Draft Remedial Investigation Report (TRC, 1993).

(2) – See Appendix B for discussion of risk–based preliminary remediation goal calculations.

TABLE 3–5

SITE 13 – DISPOSAL AREA NORTHWEST

COMPARISON OF SEDIMENT COC CONCENTRATIONS TO NOAA ER–L AND ER–M VALUES

			Phase I			Phase II		
Parameter	NOAA ER–L (µg/kg)	NOAA ER–M (µg/kg)	SEDIMENT S-13-11-04-S	SEDIMENT S-13-12-04-S	SEDIMENT S-13-13-04-S	SEDIMENT 13-SD01	SEDIMENT 13-SD02	SEDIMENT 13-SD03
Volatile Organic Compounds (µg/kg)								
Chloroform	NA	NA	1	ND	ND	ND	ND	ND
Semivolatile Organic Compounds (µg/kg)								
1,2,4–Trichlorobenzene	NA	NA	NA	NA	NA	ND	41	ND
Naphthalene	340	2100	NA	NA	NA	ND	46	ND
2–Methylnaphthalene	65	670	NA	NA	NA	ND	73	ND
Acenaphthene	150	650	NA	NA	NA	ND	41	ND
Phenanthrene	225	1380	NA	NA	NA	330	100	83
Anthracene	85	960	NA	NA	NA	58	ND	ND
Carbazole	NA	NA	NA	NA	NA	85	ND	ND
Fluoranthene	600	3600	NA	NA	NA	1100	160	140
Pyrene	350	2200	NA	NA	NA	520	120	110
Benzo(a)anthracene	230	1600	NA	NA	NA	240	88	76
Chrysene	400	2800	NA	NA	NA	330	120	140
bis(2–Ethylhexyl)phthalate	NA	NA	NA	NA	NA	140	140	190
Benzo(b)fluoranthene	NA	NA	NA	NA	NA	520	170	220
Benzo(k)fluoranthene	NA	NA	NA	NA	NA	520	170	220
Benzo(a)pyrene	400	2500	NA	NA	NA	140	68	79
Total PAHs (µg/kg)	4000	35000	NA	NA	NA	3758	1156	1068
Pesticides/PCB Organic Compounds (µg/kg)								
4,4'–DDE	2	15	ND	ND	ND	22	4.9	13
4,4'–DDD	2	20	ND	ND	1200	ND	ND	ND
Endrin aldehyde	NA	NA	ND	ND	ND	ND	8.2	ND
Gammma chlordane	0.5	6	ND	ND	ND	ND	5.5	ND
PCB–1248	NA	NA	ND	1300	ND	ND	ND	ND
PCB–1260	NA	NA	3100	6500	5800	1600	860	11000
Total PCBs (µg/kg)	50	400	3100	7800	5800	1600	860	11000
Inorganic Compounds (mg/kg)								
Arsenic	33	85	NA	NA	NA	6	2	1.2
Beryllium	NA	NA	NA	NA	NA	0.69	0.91	0.5
Cadmium	5	9	NA	NA	NA	5.1	0.15	0.16
Cobalt	NA	NA	NA	NA	NA	4.9	6.7	5.5
Copper	70	390	NA	NA	NA	54.4	104	93.5
Lead	35	110	NA	NA	NA	86.9	482	165
Silver	1	2	NA	NA	NA	4.1	ND	ND
Vanadium	NA	NA	NA	NA	NA	43.7	8.4	5.8
Zinc	120	270	NA	NA	NA	240	666	487

Shaded values exceed the ER–M.

ND = Not Detected

NA = Not Available or Not Analyzed

TABLE 3–6

Site 13 – Disposal Area Northwest
Comparsion of Soil Contaminant Levels to Calculated Leaching Model Levels

Constituent	Maximum Modeled[1] Unsaturated Concentration (ppm)	Maximum Concentration Detected in Unsaturated Soils (ppm)
Volatile Organics		
Chloroform	3	0.002
Toluene	184	0.006
Xylenes	3800	0.002
Semivolatile Organics		
Bis(2–ethylhexyl)phthalate	500	0.15
Butylbenzylphthalate	2300	0.041
Chrysene	18	0.32
Benzo(a)anthracene	15	0.15
Benzo(a)pyrene	70	0.13
Benzo(k)fluoranthene	500	0.74
Pesticides/PCBs		
Chlordane	600	0.9
Endrin	300	0.003
PCBs	1500	4653

Notes:
(1) See Appendix C for model description and associated caculations.
Shaded contaminants indicate maximum detected concentration exceeds modeled concentation.

TABLE 3-7

SOIL REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
No Action	None	Not Applicable	No action.	Required for consideration under the NCP.
Institutional Control	Site Use Restrictions	Deed Restrictions	Deed for site would be revised to include restrictions on future site use or development, limiting future exposures to soil contaminants.	Potentially applicable.
		Fencing	Fencing and posting of warning signs to limit public access and exposure to soil contaminants.	While public access to Davisville facility is currently limited, additional fencing could limit future access following base closure.
Containment	Surface Controls	Revegetation	Topsoil would be placed over the site and seeded to provide ample vegetative cover.	By enhancing site surface to encourage vegetative growth, runoff of contaminated soils could be minimized; would not limit leaching of PCBs.
	Capping	Single-Barrier Cap	Placement of a cap with vegetative, drainage and single barrier layers over contaminated soils.	Potentially viable; minimizes infiltration, direct exposure and runoff of contaminated surface soils.
		Double-Barrier Cap	Placement of a cap with vegetative, drainage and soil and synthetic barrier layers over contaminated soils.	Potentially viable; minimizes infiltration, direct exposure and runoff of contaminated surface soils.
Treatment/ Disposal	Excavation and Disposal	On-Site Landfill	Construction of landfill on-site for contaminated soil disposal.	Would require excavation of surface soils and waste materials, and construction of an on-site landfill; requires RCRA characterization of materials to determine if hazardous waste disposal requirements apply; ultimate disposal of material would have to be in accordance with land ban requirements. Small volume of contaminated soil limits viability.
		Off-Site Landfill	Excavation of contaminated soils with disposal at an off-site licensed landfill permitted to accept the waste soils, as characterized.	Would require excavation of contaminated soils; ultimate disposal of material would have to be in accordance with RCRA and TSCA requirements; potentially applicable.

TABLE 3-7 (Continued)

SOIL REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Treatment/ Disposal (cont.)	Excavation and Treatment	Stabilization/ Solidification	Soils are mixed with Portland cement, silaceous materials, lime, and/or proprietary agents, to form a rigid matrix of limited permeability.	Most suitable for immobilizing inorganic material in soils; potentially viable for semivolatile and non-volatile compounds; requires subsequent handling (disposal) of stabilized materials; small volume of contaminated soil limits viability at Site 13.
		On-Site Incineration	Contaminants thermally destroyed on-site.	Mobilization of an on-site incinerator for the treatment of contaminated soils would be impractical due to low volume of contaminated soil; would not treat inorganics.
		Off-Site Incineration	Contaminants thermally destroyed at an off-site facility.	Would be effective for destruction of PCBs; does not treat inorganics.
		Off-Site Slagging	Soils are treated in a two-stage high temperature system where a pre-heating fuel is used to raise temperatures above 2000° C; organics and certain metals are vaporized.	SITE Technology; effective for both organics and inorganics; applicable to hazardous wastes that contain substantial concentrations of metals (5% or greater); levels of metals at Site 13 would not justify implementation of this technology.
		Mechanical/ Thermal Aeration	Volatile compounds are removed from soils through heating and/or mechanical aeration.	Effective for removal of volatile organics from soils; less effective than incineration in treating semi-volatiles; not applicable to PCB or inorganic soil contaminants.
		Plasma Reactor	Heat from a plasma torch creates a molten bath used to detoxify soils; organics are vaporized and residual melt material retains metals in an unleachable matrix.	Most appropriate for soils and sludges contaminated with metals and hard-to-destroy organics; SITE technology; small volume of soils at Site 13 limits viability.
		Thermal Desorption	Organic contaminants are volatilized by an externally-fired rotary dryer and removed as a condensed liquid.	Proven for treatment of VOCs, BNAs, and PCBs; not applicable to contaminants with low vapor pressures and inorganic contaminants; small volume of soils at Site 13 limits viability.
		Soil Washing	Use of an extractant solution to remove contaminants from soils; solutions used include water, surfactants, acids, bases, and/or oxidizing or reducing agents; large volume of soil required to justify mobilization/demobilization costs.	Most applicable to sands and gravels; small volume of soils at Site 13 limits viability.

TABLE 3-7 (Continued)

SOIL REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Treatment Disposal (Cont.)	Excavation and Treatment (cont.)	Acid Extraction	Classified soil is washed with acid and effluent undergoes additional treatment.	Most effective for inorganic contaminants; may also be effective for organic wastes; metal -containing acid solution requires additional treatment; not applicable to PCB contamination.
		Landfarming	Aerobic biodegradation of contaminants in soils applied to the ground surface, with nutrient addition.	Effective for destruction of volatile organics; ineffective for inorganic contaminants; not applicable to PCB or inorganic soil contaminants.
		Dechlorination	Alkali metals or alkali metal/polyethylene glycol used to strip chlorine atoms from hazardous halogenated hydrocarbons.	Effective for destruction of liquid-phase chlorinated organics, dioxins and PCBs; ineffective for inorganic contaminants; may be applicable to small-scale operations.
		Slurry Phase Biodegradation	Excavated soil is prepared into a pumpable slurry to which a nutrient rich bacteria is added for degradation in a reactor system; additional unit processses may be added.	Not effective for inorganics and certain high molecular weight semi-volatile compounds; not applicable to PCB soil contaminants.
		Solvent Extraction	Solvents preferentially dissolve contaminants from a soil matrix and are removed with the solvent for further processing or disposal.	Solvents extract contaminants by preferential solubility; effective for VOCs, BNAs, and PCBs; contaminated solvent solution requires addtional treatment; does not address inorganic contaminants.
	In Situ Treatment	Biodegradation	Stimulation of indigenous bacteria or introduced strains, with nutrient addition.	Effective for destruction of volatile organics, especially proven for degradation of fuel spill contaminants; less effective for semi-volatile contaminants; ineffective for PCBs or inorganics.
		Soil Venting	Subsurface soil aerated or vacuumed through use of air "wells" to remove volatile contaminants.	Ineffective for non-volatile organics or inorganic contaminants.
		Radio Frequency Heating	Radio frequency waves heat soil and thermally decompose, vaporize, and distill hazardous constituents.	Application limited to treatment of volatile organic contaminants; not effective for PCB or inorganic removal; not demonstrated on a large scale.

TABLE 3-7 (Continued)

SOIL REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Treatment/ Disposal (cont)	In Situ Treatment (cont)	Fungal Degradation	Organic material innoculated with contaminant-specific fungi are mixed with soils and additional organic material; as the fungi degrade the organic material, they also degrade the contaminants.	White rot fungi have been proven in the treatment of creosote and pentachlorophenol; additional applications for the treatment of PCBs are being developed; not applicable to inorganic contaminants.
		Soil Flushing	Contaminated soils are flooded with water, acids, bases, or surfactants and the elutriated solution is collected.	Applicable to medium solubility organics; acid solutions used for inorganic contaminants; pilot scale systems have been developed for PCB and semivolatile removal.
		Vitrification	Contaminated soils are melted via energy supplied by an electric current, resulting in a glassy crystalline monolith.	Promising technology for in situ treatment of underground wastes and debris; not applicable to surficial soil contamination or low volumes of contaminated material.
		In Situ Solidification/ Stabilization	A soil mixing system, consisting of augers through which fixation chemicals are injected, is used to deliver and mix stabilization chemicals at depth in situ.	Proven for PCBs but not for metals or organics; best in soils with little or no fines; sites with large subsurface obstructions should be avoided; freeze/thaw processes can limit long-term effectiveness; not applicable to surficial soil contamination.
		Steam Injection and Vacuum Extraction	Steam is forced into soil via injection wells to enhance vapor extraction; extracted gases are treated using carbon filters.	Applicable to soils contaminated with VOCs and SVOCs; ineffective for compounds with low vapor pressures; not applicable to surficial soil contamination.

TABLE 3-8

GROUND WATER REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened On Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
No Action	None	Not Applicable	No action.	Fulfills NCP requirement for consideration of no action alternative.
Institutional Control	Ground Water Monitoring	Not Applicable	Continued ground water monitoring.	Would provide monitoring of water quality and potential contaminant migration.
	Ground Water Use Restrictions	Deed Restrictions	Legal restrictions on ground water use in the contaminated area.	Would prevent future exposures to existing ground water contamination by restricting future installation of on-site potable wells. May be difficult to enforce due to scheduled base closure.
		Alternate Water Supply	Provision of alternate water supply to receptors impacted by ground water contamination.	No potable water receptors have been impacted.
Extraction/ Treatment/ Discharge	Extraction	Extraction Wells	Wells and pumping system used for extraction of contaminated ground water.	Potentially viable, proven technology.
		Well Points	Manifold system of extraction points connected to common collection source.	Potentially viable, proven technology; silty soils could limit effectiveness.
		Interceptor Trench	Placement of trench with high permeability materials, used to divert ground water flow.	Potentially viable, proven technology, suitable for shallow ground water extraction only.
	Off-Site Treatment	Off-site POTW	Extracted ground water discharged to local POTW for treatment.	Regulations often prohibit discharge of subsurface water to sewer systems; preliminary evaluation indicates POTW will not be amenable to accepting extracted ground water.
		Off-site RCRA Facility	Extracted ground water discharged to licensed RCRA facility for treatment and/or disposal.	High ground water extraction rates or extended extraction can prohibit feasibility of this treatment option.
	Organic Treatment	Bioreactor	Activated sludge process utilizes acclimated bacteria for aerobic degradation of contaminants.	Proven effective for VOCs and some BNA compounds, ineffective for inorganics and PCBs. Used for treatment of pentachlorophenol levels (approximately 45 ppm) in site demostration.

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TABLE 3-8(Continued)

GROUND WATER REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened On Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Extraction/ Treatment/ Discharge (Cont.)	Organic Treatment (Cont.)	PACT	Organic contaminants removed from ground water using powdered activated carbon combined with conventional biological treatment.	Applicable to VOCs, including aromatic hydrocarbons, BNAs, and pesticides; ineffective for inorganics; most applicable to highly contaminated wastestreams.
		Air Stripping	Transfer of volatile organic compounds to gaseous fraction through mixing with large volumes of air in a packed column.	Applicable to VOC contaminants, including aromatic hydrocarbons; ineffective for inorganics, or compounds with low vapor pressures.
		Steam Stripping	Similar to air stripping but the use of steam increases contaminant volatilization.	Applicable to volatile organic contaminants and organics not readily stripped in a regular air stripping system; inapplicable to inorganic or semi-volatile contaminants.
		Carbon Adsorption	Contaminants adsorbed to activated carbon by internal pores of carbon granules.	Applicable to a variety of organic contaminants, ineffective for inorganics.
		Resin Adsorption	Similar to carbon adsorption but synthetic resins are used.	Can be effective for organic removal; inapplicable to inorganic contaminants.
		UV Oxidation	An oxidizing agent such as hydrogen peroxide is mixed with the waste stream and exposed to ultraviolet light to oxidize contaminants.	Proven for treatment of VOCs, semi- volatiles & pesticides/PCBs in EPA SITE testing; ineffective in treatment of single-bonded hydrocarbons (e.g., 1,1,1-TCA); inapplicable to inorganic contaminants.
	Inorganic Treatment	Ion Exchange	Contaminants removed from aqueous phase by exchanging places with ions held by ion exchange material.	Effective for inorganics; ineffective for organics; inapplicable to semi-volatile contaminants.
		Precipitation	Contaminants removed by decreasing solubility.	Effective for inorganics; ineffective for organics, whose solubilities are less affected by pH adjustments. Inapplicable to semi-volatile contaminants.

TABLE 3-8(Continued)

GROUND WATER REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened On Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
Extraction/ Treatment/ Discharge (Cont.)	Inorganic Treatment (cont)	Membrane Microfiltration	Solid particles removed from liquids using pressure filter.	SITE program technology; applicable to ground water contaminated with suspended heavy metals; would not remove dissolved inorganics.
		Filtration	Suspended particles are removed from the ground water stream using conventional filtration methods.	Inapplicable to semi-volatile contaminants. Effective for removal of suspended solids contaminated with heavy metals; would not remove dissolved inorganics.
		Electrochemical	Utilizes the oxidation/reduction properties of ferrous ions for removing heavy metals from aqueous solutions.	Proven for treatment of heavy metals; ineffective for organics; inapplicable to semi-volatile contaminants.
	In-Situ Treatment	Air Sparging	Removal of volatile ground water components through the addition of air injected into ground water; nutrients may be added to augment biodegradation.	Effective in treating hydrocarbons, high vapor pressure compounds, and compounds which are readily biodegraded; less effective on semi-volatiles; not effective for PCBs or inorganics; ineffective in low permeability geology.
		Biodegradation	Nutrients and/or enhanced microorganisms are added to ground water to augment natural biodegradation.	Effective for fuel products; not effective for inorganics or compounds resistant to degradation; limited to geologies favoring aerobic conditions.
	Discharge	Ground Water	Treated water is recharged to the ground water via wells and/or infiltration galleries.	Potentially viable.
		Surface Water	Treated water is discharged directly or indirectly (via storm sewer) into surface water.	Potentially viable.
		Sanitary Sewer/ POTW	Treated water is discharged indirectly to surface water body via sanitary sewer and POTW.	Regulations may prohibit discharge of ground water to sewer system; preliminary evaluation indicates POTW will not be amenable to accepting treated ground water.

TABLE 3-9

SEDIMENT REMEDIAL TECHNOLOGY SCREENING
SITE 13 - DISPOSAL AREA NORTHWEST
NCBC-DAVISVILLE

Screened on Basis of Technical Implementability

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	DESCRIPTION	COMMENTS
No Action	None	Not Applicable	No action.	Required for consideration under the NCP.
Institutional Control	Site Use Restrictions	Deed Restrictions	Deed for site would be revised to include restrictions on future site use or development, limiting future exposures to sediment contaminants.	Deed restrictions would be of limited use in preventing exposures to or migration of catch basin sediments.
		Fencing	Fencing and posting of warning signs to limit public access and exposure to sediment contaminants.	Fencing would be of limited use in preventing exposures to or migration of catch basin sediments.
Removal	Flushing	Not Applicable	Water under high pressure flushes piping to remove contaminated sediments.	Long runs of piping and intermittent catch basins limit implementability.
	Physical Removal	Not Applicable	Accumulated sediments in catch basins are manually or mechanically removed and contained.	Effective in removing identified contaminated sediments.
Treatment/ Disposal	Disposal	On-Site Disposal	Construction of landfill on-site for contaminated sediment disposal.	Small volume of contaminated sediment limits viability.
		Off-Site Disposal	Excavation of contaminated sediments with disposal at an off-site licensed landfill permitted to accept the waste soils, as characterized.	Ultimate disposal of material would be in accordance with RCRA and TSCA requirements.
	Treatment	On- Site Treatment	Extracted sediments treated on-site in soil treatment system.	Low volumes of materials requiring treatment limit implementability unless combined with on-site soil treatment.
		Off-Site Treatment	Residual sediments would be contained and transported off-site for treatment at a licensed facility permitted to accept wastes as characterized.	Potentially applicable.
		In Situ Treatment	Various technologies have been developed to treat contaminated soils in situ (see Table 3-7)	Not applicable to sediments contained within catch basins or storm drain piping

TABLE 3–10

SOIL PROCESS OPTION SCREENING
SITES 13 – DISPOSAL AREA NORTHWEST
NCBC–DAVISVILLE

● Representative Process Option

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
No Action	None	Not Applicable	● May be effective if ARARs/TBCs are not exceeded and if the site poses no unacceptable risks.	No implementation is required.	No cost.
Institutional Control	Site Use Restrictions	Deed Restrictions	● Limits disturbance of existing contamination, unacceptable future site use, or introduction of additional contaminated materials.	Requires appropriate legal authority; enforcement may be hampered by base closure.	Low capital cost.
		Fencing	● Limits human exposure to site.	Easily implemented; maintenance may be hampered by base closure.	Low capital cost; low maintenance cost.
Containment	Surface Controls	Revegetation	● Effective in minimizing erosion and direct contact with surficial contamination; does not prevent contaminant leaching.	Easily implemented.	Low capital cost; low O&M.
	Capping	Single–Barrier Cap	● Effective in minimizing erosion and direct contact with surficial contamination and minimizing potential contaminant leaching.	Fairly easily implemented.	Moderate capital cost; low O&M.
		Double–Barrier Cap	Effective in minimizing erosion and direct contact with surficial contamination and minimizing potential contaminant leaching.	Fairly easily implemented.	Moderate to high capital cost; low O&M.
Treatment/ Disposal	Excavation and Disposal	Off–Site Landfill	● Removes soil contaminants as a future source of potential human exposure and contaminant erosion or leaching.	Requires compliance with land disposal restrictions.	Moderate capital; no O&M.

TABLE 3-10(Continued)

SOIL PROCESS OPTION SCREENING
SITES 13 – DISPOSAL AREA NORTHWEST
NCBC–DAVISVILLE

● Representative Process Option

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
Treatment/ Disposal (cont)	Excavation and Treatment	Off–Site Incineration	● Effective for destruction of organic contaminants; requires ash disposal.	Due to high demand, delays may be encountered for waste acceptance.	High capital, low O&M.
		Dechlorination	Under development, shown to be effective for PCBs in soils, does not treat inorganics.	Not widely available; limited number of full–scale applications; limited number of vendors.	Moderate capital; low to moderate O&M.
		Solvent Extraction	● Under development; shown to be effective in treating PCBs, pesticides and PAHs.	Not widely available, although more vendors identified for this technology than for dechlorination.	Moderate capital; low to moderate O&M.
	In–Situ Treatment	Fungal Degradation	● Effective for wood preserving wastes, pesticides and PCBs; does not treat inorganics.	Not widely available; some technology applications require excavation of soils prior to treatment.	Moderate capital; low to moderate O&M.
		Soil Flushing	Under developmnent for application to semivolatile–, PCB–, and inorganic–contaminated soils.	Requires recapture of flushing solutions; site soils at lower boundary of acceptable permeability range for implementation.	Moderate capital; low to moderate O&M.

TABLE 3–11

GROUND WATER PROCESS OPTION SCREENING
SITE 13 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY (• Representative Process Option)	COST
No Action	None	Not Applicable	• Not effective in prohibiting or monitoring contaminant migration.	No implementation required.	No cost.
Institutional Control	Ground Water Monitoring	Not Applicable	• Would provide means of monitoring potential contaminant migration but provides no treatment.	Easily implemented.	Low capital; moderate O&M.
	Ground Water Use Restrictions	Deed Restrictions	• Effective in limiting public ingestion of ground water contaminants by eliminating installation of potable wells in contaminated areas.	Requires legal authority.	Moderate capital.
Treatment/ Discharge	Extraction	Extraction Wells	Effective; best suited for steep hydraulic gradients and miscible contaminants.	Easily implemented.	Moderate capital; moderate O&M.
		Interceptor Trench	• Effective; best suited to shallow aquifers or floating contaminants.	Easily implemented; mechanically simple.	Moderate capital; moderate O&M.
	Organic Treatment	Bioreactor	Most effective for non–halogenated volatile and semi–volatile organics; proven for treatment of pentachlorophenol in SITE demonstration.	Easily implemented; limited number of vendors.	High capital; moderate to high O & M.
		Carbon Adsorption	• Effective for low solubility organics.	Readily implemented; requires on– or off–site regeneration of carbon.	Moderate capital; moderate O & M.
		Resin Adsorption	Effective for organic removal.	Prior to implementation, identification of resin applicable to contaminants in ground water is required.	High capital, moderate O&M.
		UV Oxidation	Effective for treatment of volatiles and semivolatiles; no emission or waste products produced.	Readily implemented.	High capital; moderate O & M.

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TABLE 3–11 (Continued)

GROUND WATER PROCESS OPTION SCREENING
SITE 13 – SOLVENT DISPOSAL AREA
NCBC–DAVISVILLE

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY (• Representative Process Option)	COST
Extraction/ Treatment/ Discharge (Cont.)	Inorganic Treatment	Ion Exchange	Effective for inorganic removal; requires selection of resin suitable for contaminants of concern.	Fairly easily implemented; operation is relatively simple; requires filtration prior to treatment to prevent fouling.	Moderate capital; moderate O&M.
		• Precipitation	Effective for removal of dissolved inorganics; precipitate must be disposed of.	Readily implemented.	Low to moderate capital; moderate O&M.
		Electrochemical	Effective in producing metal hydroxide precipitates of such inorganic species as arsenic, cadmium, zinc and copper.	Newly developing technology; may not be widely available; more complicated than other inorganic treatment systems.	Moderate capital, moderate O&M.
	Discharge	Ground Water	Effective with permeable soils and relatively low flow rates; requires identification of appropriate recharge location.	Requires construction of a recharge system; requires compliance with discharge criteria.	Moderate capital; low to moderate O&M.
		• Surface Water	Effective for discharge of treated ground water.	Requires installation of a discharge pipe; requires compliance with discharge criteria.	Moderate capital; low O&M.

TABLE 3-12

SEDIMENT PROCESS OPTION SCREENING
SITES 13 – DISPOSAL AREA NORTHWEST
NCBC–DAVISVILLE

● Representative Process Option

GENERAL RESPONSE ACTION	TECHNOLOGY	PROCESS OPTION	EFFECTIVENESS	IMPLEMENTABILITY	COST
No Action	None	Not Applicable	● May be effective if ARARs/TBCs are not exceeded and if the site poses no unacceptable risks.	No implementation is required.	No cost.
Removal	Physical Removal	Not Applicable	● Removes identified contaminated sediments; prevents their migration to Hall Creek.	Easily implemented.	Low capital, no O&M.
Treatment/ Disposal	Disposal	Off–Site Landfill	● Removes sediment contaminants as a future source of potential human exposure.	Requires compliance with land disposal restrictions.	High capital; no O&M.
	Treatment	On–Site Treatment	● On–site treatment soil technologies under consideration have been proven in the treatment of pesticides and PCBs; do not treat inorganics.	Easily implemented if combined with on–site soil treatment.	High capital; low O&M.
		Off–Site Treatment	● Off–site incineration would be effective in treating pesticides and PCBs; would not treat inorganics.	Easily implemented if combined with off–site soil treatment.	High capital; low O&M.

TABLE 3–13

TECHNOLOGIES WHICH PASSED SCREENING
SOIL/GROUND WATER/SEDIMENT
SITE 13 – DISPOSAL AREA NORTHWEST

Soil

No Action
- No Action

Institutional Control
- Deed Restrictions
- Fencing

Containment
- Revegetation
- Single–Barrier Cap
  Double–Barrier Cap

Treatment/Disposal
- Off–Site Landfill
- Off–Site Incineration
  Dechlorination
- Solvent Extraction
- Fungal Degradation
  Soil Flushing

Ground Water

No Action
- No Action

Institutional Control
- Ground Water Monitoring
- Deed Restrictions

Treatment/Disposal/Discharge
  Extraction Wells
- Interceptor Trench
  Bioreactor
- Carbon Adsorption
  Resin Adsorption
  UV Oxidation
  Ion Exchange
- Precipitation
  Electrochemical
  Discharge to Ground Water
- Discharge to Surface Water

Sediment

No Action
- No Action

Removal
- Physical Removal

Treatment/Disposal
- Off–Site Landfill
- Off–Site Treatment
- On–Site Treatment

• – Process Technology Used to Formulate Remedial Alternatives

TABLE 3-14

ALTERNATIVES UNDERGOING DETAILED ANALYSIS
SOIL/GROUND WATER/SEDIMENT
SITE 13 - DISPOSAL AREA NORTHWEST

Soil

Alternative S-1

No Action

Alternative S-2

Limited Action (Institutional Controls)

A. Fencing/Deed Restrictions

Alternative S-3

Containment

A. Revegetation
B. Single-Barrier Cap

Alternative S-4

Soil Treatment/Disposal

A. Soil Excavation and Disposal
B. Soil Excavation and Off-Site Incineration
C. Soil Excavation and On-Site Solvent Extraction
D. Soil Excavation and In-Situ Fungal Degradation

Ground Water

Alternative GW-1

No Action

Alternative GW-2

Limited Action (Institutional Controls)

A. Deed Restrictions/Ground Water Monitoring

Alternative GW-3

Extraction/Treatment/Discharge

A. Interceptor Trench
B. Carbon Adsorption
C. Precipitation
D. Discharge to Surface Water

Catch Basin Sediment

Alternative SD-1

No Action

Alternative SD-2

Removal and Treatment/Disposal

A. Physical Removal
B. Off-Site Disposal
C. Off-Site Treatment
D. On-Site Treatment

TABLE 4–1
FEDERAL AND STATE CHEMICAL–SPECIFIC ARARs AND TBCs
ALTERNATIVE S–1 – NO ACTION
ALTERNATIVE S–2 – LIMITED ACTION
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Soils/Surfaces– –				
	Toxic Substances Control Act (40 CFR 761.125)	Relevant and Appropriate	Establishes PCB cleanup levels for soils and solid surfaces.	Applicable to spills of materials containing PCBs at concentrations of 50ppm or greater that occurred after May 4, 1987. These requirements may be relevant and appropriate to the evaluation of PCB levels in site soils.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4–01)	To Be Considered	Provides guidance on identifying principal threat and low–threat areas of PCB contamination. At industrial sites PCBs at concentrations of 500 ppm or greater generally pose a principal threat.	Will be considered at Site 13 with respect to soil PCB contamination.
STATE				
Soils/Surfaces– –				
	RI Hazardous Waste Management Act of 1987 (RIGL 23–19.1 et seq.) Rules and Regulations for Hazardous Waste Management	Relevant and Appropriate	Defines Type 6 – extremely hazardous waste as including wastes which contain PCBs at a concentration of 50 ppm or greater or showing 10 micrograms/ 100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
	Rules and Regulations for Solid Waste Management Facilities	Relevant and Appropriate	Defines solid waste as including any soil, debris or other material with a concentration of PCBs of 10 ppm or greater or containing 2 micrograms/100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.

TABLE 4–2
FEDERAL LOCATION–SPECIFIC ARARs AND TBCs
ALTERNATIVE S–1 – NO ACTION
ALTERNATIVE S–2 – LIMITED ACTION
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. ARAR for fencing.

TABLE 4–3
FEDERAL AND STATE CHEMICAL–SPECIFIC ARARs AND TBCs
ALTERNATIVE S–3 – CONTAINMENT
OPTION S–3A – REVEGETATION
OPTION S–3B – SINGLE–BARRIER CAP
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Soils/Surfaces– –				
	Toxic Substances Control Act (40 CFR 761.125)	Relevant and Appropriate	Establishes PCB cleanup levels for soils and solid surfaces.	Applicable to spills of materials containing PCBs at concentrations of 50ppm or greater that occurred after May 4, 1987. These requirements may be
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4–01)	To Be Considered	Provides guidance on identifying principal threat and low–threat areas of PCB contamination. At industrial sites PCBs at concentrations of 500 ppm or greater generally pose a principal threat.	Will be considered at Site 13 with respect to soil PCB contamination.
STATE				levels in site soils.
Soils/Surfaces– –				
	RI Hazardous Waste Management Act of 1987 (RIGL 23–19.1 et seq.) Rules and Regulations for Hazardous Waste Management	Relevant and Appropriate	Defines Type 6 – extremely hazardous waste as including wastes which contain PCBs at a concentration of 50 ppm or greater or showing 10 micrograms/ 100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
	Rules and Regulations for Solid Waste Management Facilities	Relevant and Appropriate	Defines solid waste as including any soil, debris or other material with a concentration of PCBs of 10 ppm or greater or containing 2 micrograms/100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.

TABLE 4–4
FEDERAL LOCATION–SPECIFIC ARARs AND TBCs
ALTERNATIVE S–3 – CONTAINMENT
OPTION S–3A – REVEGETATION
OPTION S–3B – SINGLE–BARRIER CAP
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeologic data. ARAR for revegetation and capping.

TABLE 4-5
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-3 - CONTAINMENT
OPTION S-3A - REVEGETATION
OPTION S-3B - SINGLE-BARRIER CAP
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL Containment				
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To Be Considered	Allows for the consideration of various cap designs for addressing low-threat PCB contamination.	Soil caps and single-barrier caps may be appropriate for low-level PCB-contamination; would not provide treatment of principal threat (>500 ppm) PCB-contaminated soils.

TABLE 4-6
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Soils/Surfaces--				
	Toxic Substances Control Act (40 CFR 761.125)	Relevant and Appropriate	Establishes PCB cleanup levels for soils and solid surfaces.	Applicable to spills of materials containing PCBs at concentrations of 50ppm or greater that occurred after May 4, 1987. These requirements may be relevant and appropriate to the evaluation of PCB levels in site soils.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To Be Considered	Provides guidance on identifying principal threat and low-threat areas of PCB contamination. At industrial sites, PCBs at concentrations of 500 ppm or greater generally pose a principal threat.	Will be considered at Site 13 with respect to soil PCB contamination.
	Toxicity Characteristic (40 CFR 261.24)	To be determined	Establishes maximum concentrations of contaminants for the toxicity characteristic using the test method described in 40 CFR 261 Appendix II.	Applicable where wastes produced as a byproduct of a remedial action require handling as a hazardous waste on the basis of the Toxic Characteristic Leachate Parameter (TCLP) analysis.
	Land Disposal Restrictions (40 CFR 268)	To be determined	Establishes maximum concentrations of contaminants on the basis of which hazardous wastes are restricted from land disposal.	This regulation will be applicable to remedial alternatives which utilize land disposal of hazardous waste.
STATE				
Soils/Surfaces--				
	RI Hazardous Waste Management Act of 1987 (RIGL 23-19.1 et seq.) Rules and Regulations for Hazardous Waste Management	Relevant and Appropriate or Applicable	Defines Type 6 - extremely hazardous waste as including wastes which contain PCBs at a concentration of 50 ppm or greater or showing 10 micrograms/ 100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil, and applicable to the handling of excavated PCB-contaminated soils.
	Rules and Regulations for Solid Waste Management Facilities	Relevant and Appropriate or Applicable	Defines solid waste as including any soil, debris or other material with a concentration of PCBs of 10 ppm or greater or containing 2 micrograms/100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil, and applicable to the handling of excavated PCB-contaminated soils.

TABLE 4-7
FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
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MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeologic data. ARAR for actions which involve soil excavation or disturbance.

TABLE 4-8
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL				
On-site/ Off-site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off-Site Disposal	Applicable	Standards for manifesting, marking and recording off-site hazardous waste shipments for treatment/disposal.	If excavated soil or treatment residuals require off-site disposal/treatment as a hazardous waste, generator requirements will be followed.
	RCRA (40 CFR 263) Transporter Requirements for Off-Site Disposal	Applicable	Standards for transporters of hazardous waste materials.	If excavated soil or treatment residuals require off-site disposal/treatment as a hazardous waste, transporter requirements will be followed.
	RCRA (40 CFR 264 and 265) Requirements for Hazardous Waste Treatment Facility Design and Operating Standards for Treatment and Disposal Systems	Applicable	Outlines specifications and standards for design, operation, closure and monitoring of performance for hazardous waste storage, treatment and disposal facilities.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.10-264.18) Subpart B - General Facility Standards	Applicable	General requirements regarding waste analysis, security, training, inspections, and location applicable to a facility which stores, treats or disposes of hazardous wastes (a TSDF facility).	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.30-264.37) Subpart C - Preparedness and Prevention	Applicable	Requirements applicable to the design and operation, equipment, and communications associated with a TSDF facility, and to arrangements with local response departments.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.50-264.56) Subpart D - Contingency Plan and Emergency Procedures	Applicable	Emergency planning procedures applicable to a TSDF facility.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.

TABLE 4-8(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	RCRA (40 CFR 264) Subpart G Closure/Post Closure Requirements	Applicable	Establishes requirements for the closure and long-term management of a hazardous disposal facility.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	Applicable	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.600-264.999) Subpart X Miscellaneous Units	Applicable	Environmental performance standards, monitoring requirements and post-closure care requirements applicable to miscellaneous units (not otherwise defined in the RCRA regulations) used to treat, store or dispose of hazardous waste.	If excavated soils are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/ treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 268) Land Disposal Restrictions	Applicable	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	If excavated soils or treatment residuals are characteristically hazardous, land disposal will comply with these restrictions.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	Applicable	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	If excavated soils or treatment residuals are characteristically hazardous, off-site transport requirements will be followed.

TABLE 4-8(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
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MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	Toxic Substances Control Act (15 USC. Sect. 2601) Subpart D - Storage and Disposal Requirements for PCBs	Applicable	Establishes requirements for the storage, landfilling, and incineration of PCBs.	Handling of PCB-contaminated materials will be conducted in accordance with these requirements.
	• PCB Marking Requirements (40 CFR 761.40)	Applicable	Presents requirements for marking PCB containers and storage areas applicable to the PCB soil stored on-site.	All on-site areas used for the storage of PCB-contaminated materials will be marked as required by this regulation.
	• PCB Marking Format (40 CFR 761.45)	Applicable	Presents format requirements for marking on-site containers.	All on-site areas used for the storage of PCB-contaminated materials will be marked as required by this regulation.
	• Disposal Requirements for PCBs (40 CFR761.60(a)4)	Applicable	Establishes requirements for the disposal of non-liquid PCBs at concentrations of 50 ppm or greater in the form of contaminated soil, rags or other debris.	All soils contaminated with PCBs at a concentration greater than 50 ppm will be disposed of in accordance with this requirement.
	• Storage for Disposal (40 CFR 761.65)	Applicable	Establishes requirements for the storage of PCBs and PCB items.	The on-site storage of PCB-contaminated materials will comply with this regulation.
	• Decontamination (40 CFR 761.79)	Relevant and Appropriate	Establishes requirements applicable to the decontamination of containers and movable equipment used in PCB storage.	This regulation is relevant and appropriate to the disposal of PCB-contaminated materials.
	CERCLA Off-site Disposal Policy, OSWER Dir. No. 9834.11 (Nov 13, 1987)	To Be Considered	Provides approval for off-site disposal facilities.	All off-site disposal and incineration of PCB-contaminated materials will take place at a TSCA-regulated landfill or incinerator.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To Be Considered	Describes the recommended approach for remediating Superfund sites with PCB contamination.	This guidance will be considered in the off-site disposal or treatment of PCB-contaminated soils.
Excavation	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeologic data. ARAR for actions which involve soil excavation or disturbance.

TABLE 4-8(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE S-4 - SOIL TREATMENT/DISPOSAL
INCLUDING OPTIONS S-4A THROUGH S-4D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE On-site/ Off-site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) • Hazardous Waste Management Rules and Regulations	Applicable	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal; also regulates disposal of PCB-containing materials.	Remedial actions which involve the on- or off-site management of hazardous wastes or soils contaminated with 50 ppm or greater PCBs will comply with these requirements.
	- Section 5.03 Waste Management	Applicable	Sets forth packaging and manifesting requirements for the off-site disposal of hazardous waste.	Off-site disposal of PCB-contaminated materials will meet these requirements.
	- Section 5.04 Labelling	Applicable	Sets forth labelling requirements for hazardous waste.	Off-site disposal of PCB-contaminated materials will meet these requirements.
	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) (cont.) • Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	To be determined	Rules and regulations for the investigation and remediation of releases of hazardous materials.	The design and operation of remedial systems will comply with these regulations.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right-to-Know Requirements	To be determined	Establishes rules for the public's right-to-know concerning hazardous waste storage and transportation.	Alternatives which involve the on- or off-site management of hazardous wastes will comply with these regulations.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	To be determined	Rules and regulations for solid waste management facilities.	Alternatives involving the on-site storage and disposal of solid wastes or soils contaminated with 10 ppm or greater PCBs will comply with these regulations.

TABLE 4-9
COMPARISON AMONG SOIL ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-1 – No Action	Least protective alternative; No control of potential exposures to soil contamination is provided; Provides no protection against erosion of surficial contamination or leaching of contaminants from the soil; Does not comply with chemical-specific ARARs; Not effective in the short-term or long-term and does not meet remedial action objectives
Alternative S-2 – Limited Action	Provides a limited degree of protection of human health by limiting potential exposures to soil contaminants through site fencing and deed restrictions; Provides no additional protection of the environment; Does not comply with chemical-specific ARARs/TBCs; Effective in the short-term but does not provide the long-term effectiveness offered by Alternatives S-3 and S-4
Alternative S-3 – Containment Alternative	Provides a greater degree of long-term protection of human health and the environment through the minimization of potential exposures to the soil contaminants and by minimizing the potential migration of soil contaminants due to erosion and/or leaching; Complies with chemical-specific, action-specific and location-specific ARARs/TBCs; Effective in the short- and long-term
Option S-3A – Revegetation	Provides protection of human health and the environment by providing a physical barrier to exposures to surficial contamination; Does not address the potential leaching of PCB contaminants from the soil; Some increased short-term risks would result during implementation; Would be effective in the long-term, provided continued maintenance of the vegetative layer; Could be combined with a treatment/disposal alternative to provide overall protection of human health and the environment
Option S-3B – Single-Barrier Cap	Provides protection of human health and the environment by minimizing potential exposures to soil contaminants, minimizing the potential migration of soil contaminants due to erosion, and by minimizing the potential leaching of PCBs from the soil; Some increased short-term risks would result during implementation; Would be effective in the long-term
Alternative S-4 – Soil Treatment/Disposal Alternative	Provides protection of human health and the environment through disposal or treatment of soil contaminants; Does not address other low-level surficial contaminants which could potentially erode and be carried into the storm drainage system; Complies with chemical-specific and action-specific ARARs/TBCs; Would need to comply with location-specific ARARs concerning potential archaeologically significant areas; Could be combined with a containment alternative to provide overall protection of human health and the environment

TABLE 4–9 (Continued)
COMPARISON AMONG SOIL ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Option S–4A – Soil Excavation and Off–Site Disposal	Provides protection of human health and the environment through the removal and off–site disposal of soil contaminants; Some increased short–term risks would result during implementation; Would be effective in the long–term since the soil contaminants of concern are permenantly removed from the site
Option S–4B – Soil Excavation and Off–Site Incineration	Provides protection of human health and the environment through the removal and off–site incineration of soil contaminants; Some increased short–term risks would result during implementation; Would be effective in the long–term since the soil contaminants are destroyed through the incineration process
Option S–4C – Soil Excavation and On–Site Solvent Extraction	Provides protection of human health and the environment through the removal and on–site treatment of PCB–contaminated soils through the solvent extraction process; Some increased short–term risks would result during implementation; Would be effective in the long–term since the PCBs contaminants would be removed from soils through the solvent extraction process
Option S–4D – In–Situ Fungal Degradation	Provides protection of human health and the environment through the treatment of PCB–contaminated soils through in–situ fungal degradation; Some increased short–term risks would result during implementation; Would be effective in the long–term since the PCBs contaminants would be effectively treated through the fungal degradation process; Requires performance of treatability studies

TABLE 4–10
COMPARISON AMONG SOIL ALTERNATIVES
COMPLIANCE WITH ARARs/TBCs
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE, RI

ACTION	CHEMICAL–SPECIFIC	LOCATION–SPECIFIC	ACTION–SPECIFIC
Alternative S–1 – No Action	Does not meet criteria	Meets criteria; Involves no actions which impact potential archaeologically significant areas	Not applicable
Alternative S–2 – Limited Action	Does not meet criteria	Implementation of fencing activities would comply with criteria applicable to potential archaeologically significant areas	Not applicable
Alternative S–3 – Containment Alternative	Would meet criteria by preventing exposures to PCBs in soils in the future	Implementation of construction activities would comply with criteria applicable to potential archaeologically significant areas	Current EPA guidance on PCB remediation would be considered in design and implementation
Option S–3A – Revegetation	See S–3	See S–3	See S–3
Option S–3B – Single–Barrier Cap	See S–3	See S–3	See S–3
Alternative S–4 – Soil Treatment/ Disposal Alternative	By removal or treatment of soil contaminants, criteria would be met	Implementation of construction activities would comply with criteria applicable to potential archaeologically significant areas	See Below
Option S–4A – Soil Excavation and Off–Site Disposal	See S–4	See S–4	Would comply with waste management, transportation and disposal requirements
Option S–4B – Soil Excavation and Off–Site Incineration	See S–4	See S–4	Would comply with waste management, transportation and incineration requirements
Option S–4C – Soil Excavation and On–Site Solvent Extraction	See S–4	See S–4	Would comply with waste management, and treatment requirements
Option S–4D – In–Situ Fungal Degradation	See S–4	See S–4	Would comply with site remediation requirements

TABLE 4-11
COMPARISON AMONG SOIL ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-1 – No Action	Existing potential soil-related risks to human health and the environment remain; No controls provided to manage exposures to soil contaminants; Requires five-year reviews
Alternative S-2 – Limited Action	Relies on institutional controls to limit human exposures to the site to reduce risk from direct contact; Fencing may limit access but may not be totally effective; Deed restrictions on access/develpment would require long-term enforcement to ensure their protectiveness; Does not limit soil erosion or leaching of contaminants; Requires five-year reviews
Alternative S-3 – Containment Alternative	Reduces the potential risks associated with direct contact with and erosion of soil-related contaminants but some residual risk would remain since the contaminated soils are not treated or removed; Containment options are expected to be relatively reliable in the long-term although periodic maintenance may be required; Requires five-year reviews
Option S-3A – Revegetation	Provides more protection against direct exposures, surface soil contaminant migration and infiltration than existing site conditions; Potential for leaching of PCBs from the soil would remain; Effective in the long-term in limiting risks associated with direct contact with contaminants and surface migration of contaminants but is not as effective as Option S-3B in limiting the potential for leaching of PCBs from the soil; Requires five-year reviews
Option S-3B – Single-Barrier Cap	Provides more protection against infiltration than Option S-3A; Effective in the long-term in limiting risks associated with direct contact with contaminants, surface migration of contaminants, surface water infiltration and subsequent leaching of PCBs from the soil ; Requires five-year reviews

TABLE 4-11 (Continued)
COMPARISON AMONG SOIL ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 - SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC - DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-4 - Soil Treatment/Disposal Alternative	Off-site disposal or treatment of contaminated soils permanently addresses on-site PCB contamination; Does not provide protection against the potential erosion of low-level surficial contaminants into the storm water drainage system; Verification sampling would be required to verify the effectiveness of the removal or treatment options; Five-year reviews would not be required; The degree of long-term effectiveness and permanence of the options is discussed below
Option S-4A - Soil Excavation and Off-Site Disposal	Off-site disposal of contaminated soils would be effective in preventing future direct contact with the soils and migration of PCBs into surface water and ground water; Requires no long-term maintenance; Long-term operating and maintenance procedures at the receiving landfill will affect the ultimate long-term effectiveness of the option
Option S-4B - Soil Excavation and Off-Site Incineration	PCBs are readily destroyed by incineration; Long-term effectiveness and permanence would be good
Option S-4C - Soil Excavation and On-Site Solvent Extraction	Long-term effectiveness and permanence is expected to be good but would depend upon the treatment system's ability to remove the PCB contaminants and the ultimate destruction of the concentrated solvent in an incinerator; Some solvent residual may remain in the soils following treatment
Option S-4D - In-Situ Fungal Degradation	Long-term effectiveness and permenance depends upon site factors such as climatic conditions, soil characteristics (e.g. permeability, temperature, and pH), and the presence of competing microbes

TABLE 4–12
COMPARISON AMONG SOIL ALTERNATIVES
REDUCTION IN TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	Provides no reduction in toxicity, mobility or volume through treatment; Treatment of principal threat is not provided
Alternative S–2 – Limited Action	Provides no treatment of soil contamination and therefore no associated reduction in contaminant toxicity, mobility, or volume; Does not treat principal threat; Site access and deed restrictions would limit the potential contaminant exposure pathways associated with current or future site use
Alternative S–3 – Containment Alternative	Provides no treatment or destruction of soil contamination; Reductions in contaminant mobility due to the erosion of surficial contaminants and/or due to infiltration of precipitation through the soils and leaching of the contaminants to the ground water would be achieved to various degrees depending on the selected containment option
Option S–3A – Revegetation	Provides no treatment or destruction of soil contamination; Reductions in contaminant mobility associated with surficial erosion would be achieved through the revegetation of the entire site
Option S–3B – Single–Barrier Cap	Provides no treatment or destruction of soil contamination; Reductions in contaminant mobility due to erosion of surficial contaminants and due to infiltration of precipitation and contaminant leaching would be achieved through the construction of the single–barrier cap
Alternative S–4 – Soil Treatment/Disposal Alternative	Provides the greatest reduction in toxicity and mobility of contaminated soils among the alternatives; Utilizes either disposal or treatment to reduce the toxicity and mobility of existing contaminated soils
Option S–4A – Soil Excavation and Off–Site Disposal	Provides no treatment of contaminated soils; Off–site disposal of soils would reduce the mobility of the soil contaminants
Option S–4B – Soil Excavation and Off–Site Incineration	Provides a reduction in the toxicity of PCB contaminants through excavation, off–site transportation and incineration; Treats principal threat; Mobility of inorganics would be reduced through containment under Scenario 1
Option S–4C – Soil Excavation and On–Site Solvent Extraction	Provides a reduction in the volume of contaminants through on–site solvent extraction; Treats principal threat; Incineration of the residual solvent reduces the toxicity of the contaminants
Option S–4D – In–Situ Fungal Degradation	Provides a reduction in the toxicity of PCB contaminants through on–site fungal degradation; Treats principal threat

TABLE 4–13
COMPARISON AMONG SOIL ALTERNATIVES
SHORT–TERM EFFECTIVENESS
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S–1 – No Action	No remedial activities conducted; Therefore, no short–term risks result; Does not provide any short–term reduction in potential risks to human health or the environment; Potential migration pathways would not be addressed; Therefore potential contaminant migration due to surface water runoff into storm drains could occur; Remedial response objectives not achieved
Alternative S–2 – Limited Action	Minimal short–term risks associated with fence construction; No increased off–site risks would result from the implementation activities; Short implementation time frame; Remedial response objectives regarding the minimization of risks to human health would be achieved but the minimization of potential environmental impacts would not be achieved
Alternative S–3 – Containment Alternative	Due to site disturbance required to implement Alternative S–3, some increased short–term risks to workers could result; Personnel protective equipment would minimize risks; Off–site impacts of construction would be expected to be minimal; Remedial action objectives associated with minimizing potential risk to human health resulting from exposure to surface soil contaminants and minimizing potential environmental impacts by reducing off–site migration of surface soil contaminants would be met by this alternative
Option S–3A – Revegetation	See S–3; Potential short–term risks associated with implementation include the possibility of exposures to contaminants during placement of the vegetative layer over the site; Remedial response objectives would be partially addressed by limiting direct contact with soil and minimizing runoff of contaminated soil; Potential leaching of PCBs from the soils would not be addressed; Estimated implementation time frame is three months
Option S–3B – Single–Barrier Cap	See S–3; Potential short–term risks associated with implementation include the possibility of exposures to contaminants during the construction of the cap; Estimated implementation time frame to meet remedial response objectives is one year

TABLE 4-13 (Continued)
COMPARISON AMONG SOIL ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-4 – Soil Treatment/Disposal Alternative	Potential short-term risks associated with the implementation of Alternative S-4 include the possibility of exposures to contaminants during the removal or treatment of contaminated soils; Personnel protective equipment would minimize risks; Potential migration of contamination during construction due to run-off would be minimized through the use of drainage control measures; Off-site impacts of construction would be expected to be minimal
Option S-4A – Soil Excavation and Off-Site Disposal	See S-4; Short-term risks could result due to the disruption of contaminated soils during the excavation and removal activities; Remedial action objectives could be achieved within a relatively short time frame
Option S-4B – Soil Excavation and Off-Site Incineration	See S-4; Short-term risks could result due to the disruption of contaminated soils during the excavation and removal activities; Remedial action objectives could be achieved in approximately 6 months
Option S-4C – Soil Excavation and On-Site Solvent Extraction	See S-4; Short-term risks could result due to the disruption of contaminated soils during excavation and solvent extraction activities; Off-site impacts are expected to be minimal since Alternative S-4C is an on-site treatment; Depending on the solvent extraction process used, solvent flammability, explosivity, or volatility could present additional short-term risks; Remedial action objectives could be achieved in approximately 6 months
Option S-4D – In-Situ Fungal Degradation	See S-4; Risks to workers would be minimal since limited contact with soil contaminants would occur; Off-site impacts are expected to be minimal since Alternative S-4D is an on-site treatment; Remedial action objectives could be achieved in approximately one year or less, depending on site-specific conditions

TABLE 4-14
COMPARISON AMONG SOIL ALTERNATIVES
IMPLEMENTABILITY
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative S-1 – No Action	Requires no implementation other than five-year reviews; Would not limit the implementation of other remedial actions
Alternative S-2 – Limited Action	Fencing construction easily implemented; Deed restrictions would have to be incorporated in the base closure property transfer process; If deed restrictions prohibit commercial/industrial development, implementation of site deed and access restrictions could contradict the Comprehensive Reuse Plan which specifies that Site 13 be set aside for economic/industrial development; Would not limit the implementation of other remedial actions
Alternative S-3 – Containment Alternative	Most difficult to implement with respect to constructability; Implementation depends on the availability of containment materials; Containment features could be impacted if future remedial actions are required
Option S-3A – Revegetation	Easy to implement; Employs commonly used and widely accepted equipment, materials, and techniques; Not a significant barrier to the implementation of other remedial actions
Option S-3B – Single-Barrier Cap	More difficult to implement than Option S-3A, requiring special equipment and materials for geomembrane installation and extra care in placement of overlying cap materials to prevent puncture of the geomembrane; Presence of cap could complicate implementation of other remedial actions
Alternative S-4 – Soil Treatment/Disposal Alternative	Implementation of Alternative S-4 would be relatively easy, with the possible exception of the treatment options; Technical implementability would be dependent upon the individual alternative options selected, with some treatment technologies more easily implemented than others
Option S-4A – Soil Excavation and Off-Site Disposal	Relatively easy to implement; Services are readily available for the excavation of contaminated soils; Minimal quantity of PCB-contaminated soils at Site 13 is not expected to present a capacity problem for the receiving landfill; PCB-contaminated soils would need to be disposed of at an approved TSCA-permitted landfill; Implementation of Alternative S-4A would not affect the implementation of future remedial actions
Option S-4B – Soil Excavation and Off-Site Incineration	Requires compliance with regulatory requirements; Administrative implementability would be dependent on the identification of receiving facility which meets federal and state requirements applicable to the operation of incinerators, including regulations applicable to the destruction of PCBs
Option S-4C – Soil Excavation and On-Site Solvent Extraction	Alternative S-4C would be implementable although it represents an emerging technology and therefore only a limited number of vendors may be available to provide effective services; Due to small contaminant volume, it may be impractical to implement certain vendors' solvent extraction
Option S-4D – In-Situ Fungal Degradation	Alternative S-4D would be implementable although it represents an emerging technology and therefore only a limited number of vendors may be available to provide effective services; Full-scale applications have been limited to date

TABLE 4–15
COMPARISON AMONG SOIL ALTERNATIVES
COST
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE, RI

ACTION		TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST [1]	TOTAL PRESENT WORTH [2]
Alt mative S–1 – No Action		--	--	--	Nominal [3]
Alternative S–2 – Limited Action		$51,000	$500	$7,700	$71,000
Alt mative S–3 – Containment Alternative					
Option S–3A – Revegetation		$410,000	$1,200	$18,000	$510,000
Option S–3B – Single–Barrier Cap		$1,300,000	$5,900	$91,000	$1,700,000
Alt mative S–4 – Soil Treatment/Disposal Alternative					
Option S–4A – Soil Excavation and Off–Site Disposal	Scenario 1 [4]	$290,000	--	--	$350,000
	Scenario 2	$180,000	--	--	$210,000
Option S–4B – Soil Excavation and Off–Site Incineration	Scenario 2	$1,800,000	--	--	$2,200,000
Option S–4C – Soil Excavation and On–Site Solvent Extraction	Scenario 2	$71,000	--	--	$85,000 [5]
Option S–4D – In–Situ Fungal Degradation	Scenario 2	$150,000	--	--	$180,000 [5]

(1) – Based on 5% discount rate.
(2) – Includes 20% contingency on all components.
(3) – The only cost associated with the implementation of Alternative S–1 would be that associated with conducting five–year reviews of the no action decision.
(4) – Scenario 1 involves remediation of soils exceeding ARARs/TBCs and risk–based PRGs.
Scenario 2 involves remediation of soils exceeding ARARs/TBCs only.
(5) – Uncertainties associated with these cost estimates are high, due to the developmental stage of the treatment technologies.

TABLE 4-16
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-1 - NO ACTION
ALTERNATIVE GW-2 - LIMITED ACTION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.
STATE				
Ground Water--				
	RI Ground Water Protection Act (RIGL, 46-13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.

TABLE 4-17
FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-1 - NO ACTION
ALTERNATIVE GW-2 - LIMITED ACTION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. Due to the lack of site disturbance under these alternatives, the alternatives would comply with this ARAR.

TABLE 4–18
FEDERAL AND STATE ACTION–SPECIFIC ARARs AND TBCs
ALTERNATIVE GW–2 – LIMITED ACTION
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE Monitoring	Rules and Regulations for Ground Water Quality	Applicable	Rules and regulations intended to protect and restore the quality of the State's ground water. Includes ground water program monitoring requirements and monitoring well construction and abandonment.	Ground water monitoring programs and well construction/abandonment methodologies will comply with these regulations.

TABLE 4-19
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.

TABLE 4-19(continued)
FEDERAL AND STATE CHEMICAL-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Surface Water --				
	Clean Water Act (40 CFR 121) Ambient Water Quality Criteria (AWQC)	Applicable	Non-enforceable guidelines established for the protection of human health and/or aquatic organisms.	AWQC will be applicable to remedial alternatives which involve discharges to surface water.
	Clean Water Act (40 CFR 401.15) Effluent Discharge Limitations	Applicable	Regulates the discharge of contaminants from an industrial point source.	Regulations will be applicable to remedial alternatives which involve discharges to surface water.
STATE				
Ground Water--				
	RI Ground Water Protection Act (RIGL, 46-13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.
Surface Water --				
	RI Water Pollution Control Law (RIGL 46-12 et seq.) RI Water Quality Standards	Applicable	Establishes water use classification and water quality criteria for all waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	Regulation will be applicable for remedial alternatives which involve discharges to surface water.

TABLE 4-20
FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. ARAR for construction of interceptor trench and discharge piping.

TABLE 4–21
FEDERAL AND STATE ACTION–SPECIFIC ARARs AND TBCs
ALTERNATIVE GW–3 – EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW–3A THROUGH GW–3D
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL				
Discharge/ Extraction	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. ARAR for construction of interceptor trench and discharge piping.
	Clean Water Act (40 CFR 122–125) National Pollutant Discharge Elimination System (NPDES) Permit Requirements	Applicable	Permits contain applicable effluent standards (i.e., technology–based and/or water quality–based), monitoring requirements, and standards and special conditions for discharge.	Discharges of treated water to surface waters will meet these requirements.
On–site/ Off–site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off–Site Disposal	Applicable	Standards for manifesting, marking and recording off–site hazardous waste shipments for treatment/disposal.	If treatment system by–product requires off–site disposal/treatment as a hazardous waste, generator requirements will be followed.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	Applicable	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	Remedial actions which require storage of hazardous waste in containers will comply with these requirements.
	RCRA (40 CFR 263) Transporter Requirements for Off–Site Disposal	Applicable	Standards for transporters of hazardous waste materials.	If treatment system by–product requires off–site disposal/treatment as a hazardous waste, transporter requirements will be followed.

TABLE 4-21 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 – EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	RCRA (40 CFR 268) Land Disposal Restrictions	Applicable	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	If treatment system by-product requires off-site disposal as a hazardous waste, land disposal restrictions will be followed.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	Applicable	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	If treatment system by-product is determined to be hazardous, transport procedures will be followed.
STATE				
Discharge	RI Water Pollution Control Act			
	• RI Water Quality Regulations for Water Pollution Control (RIGL 46-12 et seq.) RI Water Quality Standards	Applicable	Establishes general requirements and effluent limits for discharge to area waters.	Discharges of treated water to area surface water will meet these requirements.
	• Regulations for the RI Pollutant Discharge Elimination Systems (RIGL 46-12 et seq.)	Applicable	Permits contain applicable effluent standards (i.e., technology-based and/or water quality-based), monitoring requirements, and standards and special conditions for discharge.	Discharges of treated water to area surface water will meet these requirements.
On-site/ Off-site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) • Hazardous Waste Management Rules and Regulations	Applicable	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal.	If treatment system by-product is determined to be hazardous, these rules will be followed.
	• Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	Applicable	Rules and regulations for the investigation and remediation of releases of hazardous materials.	Remedial systems will be designed and operated in accordance with these requirements.

TABLE 4-21 (continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE GW-3 - EXTRACTION/TREATMENT/DISCHARGE
INCLUDING OPTIONS GW-3A THROUGH GW-3D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Disposal/ Treatment (cont.)	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right-to-Know Requirements	Applicable	Establishes rules for the public's right-to-know concerning hazardous waste storage and transportation.	These rules will be followed if treatment system by-product requires management as a hazardous waste.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	Applicable	Rules and regulations for solid waste management facilities.	These rules will be followed if treatment system by-product requires management as a solid waste.

TABLE 4-22
COMPARISON AMONG GROUND WATER ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW-1 – No Action	Least protective alternative; Does not limit potable use of ground water at the site and does not monitor for potential future environmental impacts due to ground water migration; Does not present any short-term impacts; Does not meet remedial response objectives
Alternative GW-2 – Limited Action	Provides protection of human health by limiting potential future exposures to inorganics and SVOCs in ground water through the institution of deed restrictions; Does not provide compliance with drinking water standards through treatment, however, would prevent the development of a ground water ingestion exposure pathway
Alternative GW-3 – Extraction/Treatment/ Discharge	Provides a reduction in potential risks to human health and the environment associated with ground water ingestion or migration through active treatment; Would comply with chemical-specific, location-specific and action-specific ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term as long as the treatment system is operational; Inorganic contamination (e.g., manganese) could re-occur upon discontinuation of treatment
Option GW-3A – Ground Water Extraction via Interceptor Trench	Provides protection of the environment and human health by limiting potential ground water migration and by removing ground water for treatment; Would comply with applicable ARARs; No increased short-term risks would be associated with implementation as interceptor trenches would be constructed outside of the area of soil contamination; Would be effective in the long-term
Option GW-3B – Carbon Adsorption Organic Treatment	Provides protection of the environment and human health through treatment of organic contaminants in ground water; Would comply with applicable ARARs; Minimal short-term risks would be associated with implementation; Would be effective in the long-term
Option GW-3C – Precipitation Inorganic Treatment	Provides protection of the environment and human health through treatment of inorganic contaminants in ground water; Would comply with applicable ARARs; Some increased short-term risks would result during implementation; Would be effective in the long-term
Option GW-3D – Discharge to Surface Water	Provides protection of the environment and human health when combined with ground water extraction and treatment; Would comply with applicable ARARs; Minimal short-term risks would be associated with implementation; Would be effective in the long-term

TABLE 4-23
COMPARISON AMONG GROUND WATER ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1
NCBC – DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative GW-1 – No Action	Does not meet criteria	Meets criteria; Involves no actions which affect potentially significant archaeological areas	Not applicable
Alternative GW-2 – Limited Action	Does not meet criteria	Meets criteria; Involves no actions which affect potentially significant archaeological areas	Monitoring would comply with RIDEM's Rules and Regulations for Ground Water Quality
Alternative GW-3 – Extraction/Treatment/ Discharge	Treatment would meet criteria	Extraction/Treatment/Discharge systems would comply with criteria applicable to potentially significant archaeological areas	Extraction/Treatment/Discharge systems would comply with action-specific criteria
Option GW-3A – Ground Water Extraction via Interceptor Trench	Meets criteria by capturing contaminants that exceed MCLs and PRGs	Excavation activities would comply with criteria applicable to potentially significant archaeological areas	Would comply with criteria
Option GW-3B – Carbon Adsorption Organic Treatment	Meets criteria by treating organic contaminants that exceed MCLs	See GW-3	Treatment system operation would comply with criteria; Spent carbon would be handled in accordance with applicable waste management regulations
Option GW-3C – Precipitation Inorganic Treatment	Meets criteria by treating inorganic contaminants that exceed MCLs and risk-based PRGs	See GW-3	Treatment system operation would comply with criteria; Off-site disposal of sludge would need to comply with either hazardous or non-hazardous waste management regulations
Option GW-3D – Discharge to Surface Water	Water quality of the treatment process effluent would be required to meet ambient water quality criteria	Construction activities associated with the discharge piping (e.g. excavation) would comply with criteria applicable to potentially significant archaeological areas	Would comply with criteria applicable to surface water discharge

TABLE 4-24
COMPARISON AMONG GROUND WATER ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW-1 – No Action	Effective in the long-term provided ground water is not used as a drinking water supply; Provides no long-term protection against use of an on-site well as a source of drinking water, or ground water migration; Requires 5-year reviews
Alternative GW-2 – Limited Action	Effective in minimizing the long-term risks associated with the potential construction and use of an on-site well as a source of drinking water; Monitoring program provides a means of monitoring potential changes in ground water quality; Additional measures could be implemented; Requires 5-year reviews
Alternative GW-3 – Extraction/Treatment/ Discharge	Treatment effective in treating contaminants which exceed ARARs or risk-based PRGs and in preventing off-site migration of contaminants during operation;Permanent contaminant reduction would not necessarily result if ground water treatment is discontinued in the future
Option GW-3A – Ground Water Extraction via Interceptor Trench	Provides an effective and reliable means of extracting ground water; Well-proven in performance and can function with minimal maintenance
Option GW-3B – Carbon Adsorption Organic Treatment	Effective in the removal of most organics from the wastestream; Long-term risks associated with the residuals of ground water treatment would be relatively small; Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties
Option GW-3C – Precipitation Inorganic Treatment	Effective in the removal of inorganics from the wastestream; Long-term risks associated with the residuals of ground water treatment would be relatively small; Sludge produced will require hazardous waste characterization and appropriate disposal; Long-term operation and maintenance of the treatment system is expected to pose no significant difficulties
Option GW-3D – Discharge to Surface Water	Long-term risks associated with discharge to surface water will be minimal, provided treatment system is operating properly; Long-term operation and maintenance of discharge piping is not expected to pose any major technical problems; Requires long-term monitoring of the quality of discharged water

TABLE 4–25
COMPARISON AMONG GROUND WATER ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4, AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW–1 – No Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternative GW–2 – Limited Action	Provides no reduction in toxicity, mobility or volume through treatment
Alternative GW–3 – Extraction/Treatment/ Discharge	Provides a reduction in toxicity and mobility through treatment
Option GW–3A – Ground Water Extraction via Interceptor Trench	Ground water extraction does not provide treatment but would be combined with a treatment option; Reduces the potential mobility of contaminated ground water
Option GW–3B – Carbon Adsorption Organic Treatment	Provides a reduction in the toxicity of ground water contaminants through treatment; Contaminants can be destroyed through a thermal reactivation process or contained within a landfill
Option GW–3C – Precipitation Inorganic Treatment	Provides a reduction in the toxicity of identified inorganic contaminants through treatment; Volume of contaminated media is reduced through removal of contaminants from the ground water and subsequent production of a concentrated sludge residual
Option GW–3D – Discharge to Surface Water	Not expected to significantly affect the extraction or treatment system; therefore, it has little impact on the toxicity, mobility, or volume of contamination

TABLE 4–26
COMPARISON AMONG GROUND WATER ALTERNATIVES
SHORT–TERM EFFECTIVENESS
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4, AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alt rnative GW–1 – No Action	No remedial activities conducted; Therefore, no short–term risks result; Five–year reviews would provide the only means of ensuring compliance with remedial action objectives
Alternative GW–2 – Limited Action	Implementation of deed restrictions would result in no short–term risks; Implementation of the monitoring program would have minimal short–term adverse impacts based on the use of existing wells for ground water monitoring purposes; Would meet remedial response objectives related to minimizing potential human exposures to contaminated ground water by preventing on–site potable well installation
Alternative GW–3 – Extraction/Treatment/ Discharge	No significant risks to on–site workers or off–site risks are anticipated; Degree of short–term risk would be dependent upon the individual options employed; Remedial response objectives would be achieved during operation of the treatment system but may not be maintained if treatment is discontinued
Option GW–3A – Ground Water Extraction via Interceptor Trench	Presents minimal short–term risks to on–site workers and would not be expected to result in any increased off–site risks to human health or the environment; Easily implemented within a minimal time frame
Option GW–3B – Carbon Adsorption Organic Treatment	No significant short–term risks to workers are expected; No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation
Option GW–3C – Precipitation Inorganic Treatment	No significant short–term risks to workers are expected; Major operation and maintenance activities associated with chemical precipitation include maintenance of chemical supplies and sludge handling; No significant added risks to the adjacent community or the environment are anticipated as a result of treatment system installation or operation
Option GW–3D – Discharge to Surface Water	Short–term risks to workers associated with the construction of discharge piping would not be significant; Maintenance of the system will require maintenance of the piping and discharge monitoring; No added risks to the adjacent community or the environment are anticipated

TABLE 4–27
COMPARISON AMONG GROUND WATER ALTERNATIVES
IMPLEMENTABILITY
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4, AND T–1
NCBC – DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative GW–1 – No Action	Requires no implementation other than five–year reviews; Would not limit the implementation of other remedial actions
Alternative GW–2 – Limited Action	Deed restrictions would have to be implemented as part of the base closure property transfer process; Deed restrictions limiting future installation of on–site potable wells would not be expected to prevent future commercial/industrial use of the site; Implementation of deed restrictions or ground water monitoring would not limit the implementation of future remedial actions
Alternative GW–3 – Extraction/Treatment/ Discharge	Relatively easy to implement, with the possible exception of the discharge component; Technical implementability would be dependent upon the individual alternative options selected; Some treatment technologies are more easily implemented than others; Services and materials should be readily available for the implementation of all options
Option GW–3A – Ground Water Extraction via Interceptor Trench	Implementation of a ground water extraction system is expected to be good; Materials and services are readily available; Minimal technical or administrative obstacles to implementation would be anticipated
Option GW–3B – Carbon Adsorption Organic Treatment	Implementation of a carbon adsorption treatment system is expected to be good; Treatment units are widely available and easily constructed; Implementation of carbon adsorption will not impact the implementation of future remedial actions; Operational activities include replacement of the spent carbon; To prevent fouling of the carbon bed, organic treatment should follow the inorganic treatment system in the treatment train; Administrative feasibility is also expected to be good
Option GW–3C – Precipitation Inorganic Treatment	Easily implemented; Startup is not expected to result in unanticipated technical problems; Implementation is not expected to impact the implementation of any future remedial actions; Operational activities include maintenance of chemical suplies and sludge handling; Administrative feasibility is also expected to be good
Option GW–3D – Discharge to Surface Water	Technical implementation of a discharge to surface water system is affected by the long distance (approximately 2,000 feet) to a discharge point; Continued monitoring of the discharged water quality will be required; Administrative feasibility of discharging treated ground water to surface water depends on the treatment system's ability to meet surface water discharge criteria

TABLE 4–28
COMPARISON AMONG GROUND WATER ALTERNATIVES
COST
SITE 13 – SOLVENT DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4, AND T–1
NCBC – DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST (1)	TOTAL PRESENT WORTH (2)
Alternative GW–1 – No Action	--	--	--	Nominal (3)
Alt mative GW–2 – Limited Action	--	$48,000	$730,000	$880,000
Alt mative GW–3 – Extraction/Treatment/ Discharge				
Option GW–3A – Ground Water Extraction via Interceptor Trench	$240,000	$9,600	$150,000	$470,000
Option GW–3B – Carbon Adsorption Organic Treatment	$48,000	$14,000	$220,000	$320,000
Option GW–3C – Precipitation Inorganic Treatment	$150,000	$54,000	$830,000	$1,200,000
Option GW–3D – Discharge to Surface Water	$27,000	$24,000	$370,000	$470,000

(1) – Based on 5% discount rate
(2) – Includes 20% contingency on all components
(3) – The only cost associated with the implementation of Alternative GW–1 would be that associated with conducting five–year reviews of the no action decision. Deed restrictions would be implemented under the base closure property transfer process.

TABLE 4-29
FEDERAL LOCATION-SPECIFIC ARARs AND TBCs
ALTERNATIVE SD-1 - NO ACTION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. Since no action will not impact areas of archaeological significance, Alternative SD-1 complies with this ARAR.

TABLE 4–30
FEDERAL LOCATION–SPECIFIC ARARs AND TBCs
ALTERNATIVE SD–2 – REMOVAL AND TREATMENT/DISPOSAL
INCLUDING OPTIONS SD–2A THROUGH SD–2D
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
FEDERAL				
Historic Places--				
	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	Applicable	Restricts the use of land of known archaeological or historical significance.	Remedial actions must be coordinated with preservation agencies or societies to minimize loss of significant historic or archaeological data. Since sediment remediation activities do not impact potential areas of archaeological significance, this ARAR will be met.

TABLE 4-31
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE SD-2 - REMOVAL AND TREATMENT/DISPOSAL
INCLUDING OPTIONS SD-2A THROUGH SD-2D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
FEDERAL				
On-site/ Off-site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off-Site Disposal	Applicable	Standards for manifesting, marking and recording off-site hazardous waste shipments for treatment/disposal.	If excavated sediments or treatment residuals require off-site disposal/treatment as a hazardous waste, generator requirements will be followed.
	RCRA (40 CFR 263) Transporter Requirements for Off-Site Disposal	Applicable	Standards for transporters of hazardous waste materials.	If excavated sediments or treatment residuals require off-site disposal/treatment as a hazardous waste, transporter requirements will be followed.
	RCRA (40 CFR 264 and 265) Requirements for Hazardous Waste Treatment Facility Design and Operating Standards for Treatment and Disposal Systems	Applicable	Outlines specifications and standards for design, operation, closure and monitoring of performance for hazardous waste storage, treatment and disposal facilities.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.10-264.18) Subpart B - General Facility Standards	Applicable	General requirements regarding waste analysis, security, training, inspections, and location applicable to a facility which stores, treats or disposes of hazardous wastes (a TSDF facility).	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.30-264.37) Subpart C - Preparedness and Prevention	Applicable	Requirements applicable to the design and operation, equipment, and communications associated with a TSDF facility, and to arrangements with local response departments.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.50-264.56) Subpart D - Contingency Plan and Emergency Procedures	Applicable	Emergency planning procedures applicable to a TSDF facility.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.

TABLE 4-31(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE SD-2 - REMOVAL AND TREATMENT/DISPOSAL
INCLUDING OPTIONS SD-2A THROUGH SD-2D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	RCRA (40 CFR 264) Subpart G Closure/Post Closure Requirements	Applicable	Establishes requirements for the closure and long-term management of a hazardous disposal facility.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	Applicable	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 264.600-264.999) Subpart X Miscellaneous Units	Applicable	Environmental performance standards, monitoring requirements and post-closure care requirements applicable to miscellaneous units (not otherwise defined in the RCRA regulations) used to treat, store or dispose of hazardous waste.	If excavated sediments are characteristically hazardous and on-site treatment utilizes miscellaneous treatment units for on-site storage/disposal/treatment of the hazardous wastes, these requirements will be followed.
	RCRA (40 CFR 268) Land Disposal Restrictions	Applicable	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	If excavated sediments or treatment residuals are characteristically hazardous, land disposal will comply with these restrictions.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	Applicable	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	If excavated sediments or treatment residuals are characteristically hazardous, off-site transport requirements will be followed.

TABLE 4-31(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE SD-2 - REMOVAL AND TREATMENT/DISPOSAL
INCLUDING OPTIONS SD-2A THROUGH SD-2D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	Toxic Substances Control Act (15 USC. Sect. 2601)			
	• Subpart D - Storage and Disposal Requirements for PCBs	Applicable	Establishes requirements for the storage, landfilling, and incineration of PCBs.	Handling of PCB-contaminated materials will be conducted in accordance with these requirements.
	• PCB Marking Requirements (40 CFR 761.40)	Applicable	Presents requirements for marking PCB containers and storage areas applicable to the PCB soil stored on-site.	All on-site areas used for the storage of PCB-contaminated materials will be marked as required by this regulation.
	• PCB Marking Format (40 CFR 761.45)	Applicable	Presents format requirements for marking on-site containers.	All on-site areas used for the storage of PCB-contaminated materials will be marked as required by this regulation.
	• Disposal Requirements for PCBs (40 CFR761.60(a)4)	Applicable	Establishes requirements for the disposal of non-liquid PCBs at concentrations of 50 ppm or greater in the form of contaminated soil, rags or other debris.	All soils contaminated with PCBs at a concentration greater than 50 ppm will be disposed of in accordance with this requirement.
	• Storage for Disposal (40 CFR 761.65)	Applicable	Establishes requirements for the storage of PCBs and PCB items.	The on-site storage of PCB-contaminated materials will comply with this regulation.
	• Decontamination (40 CFR 761.79)	Relevant and Appropriate	Establishes requirements applicable to the decontamination of containers and movable equipment used in PCB storage.	This regulation is relevant and appropriate to the disposal of PCB-contaminated materials.
	CERCLA Off-site Disposal Policy, OSWER Dir. No. 9834.11 (Nov 13, 1987)	To Be Considered	Provides approval for off-site disposal facilities.	All off-site disposal and incineration of PCB-contaminated materials will take place at a TSCA-regulated landfill or incinerator.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To Be Considered	Describes the recommended approach for remediating Superfund sites with PCB contamination.	This guidance will be considered in the off-site disposal or treatment of PCB-contaminated sediments.

TABLE 4-31(continued)
FEDERAL AND STATE ACTION-SPECIFIC ARARs AND TBCs
ALTERNATIVE SD-2 - REMOVAL AND TREATMENT/DISPOSAL
INCLUDING OPTIONS SD-2A THROUGH SD-2D
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
STATE On-site/ Off-site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) • Hazardous Waste Management Rules and Regulations	Applicable	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal; also regulates disposal of PCB-containing materials.	Remedial actions which involve the on- or off-site management of hazardous wastes or sediments with 50 ppm or greater PCBs will comply with these requirements.
	- Section 5.03 Waste Management	Applicable	Sets forth packaging and manifesting requirements for the off-site disposal of hazardous waste.	Off-site disposal of PCB-contaminated materials will meet these requirements.
	- Section 5.04 Labelling	Applicable	Sets forth labelling requirements for hazardous waste.	Off-site disposal of PCB-contaminated materials will meet these requirements.
	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) (cont.) • Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	To be determined	Rules and regulations for the investigation and remediation of releases of hazardous materials.	The design and operation of remedial systems will comply with these regulations.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right-to-Know Requirements	To be determined	Establishes rules for the public's right-to-know concerning hazardous waste storage and transportation.	Alternatives which involve the on- or off-site management of hazardous wastes will comply with these regulations.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	To be determined	Rules and regulations for solid waste management facilities.	Alternatives involving the on-site storage and disposal of solid wastes or sediments containing 10 ppm or greater PCBs will comply with these regulations.

TABLE 4-32
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative SD-1 - No Action	Provides no overall protection of the environment; Does not meet remedial action objectives; Not effective in the long-term
Alternative SD-2 - Removal/Treatment	Provides protection of the environment through the removal of contaminated catch basin sediments; Does not address the potential existence of an upgradient source of sediment contamination or the potential erosion of contaminants from site surface soils; Effective in the short-term; Remediation would comply with location-specific and action-specific ARARs

TABLE 4-33
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative SD-1 - No Action	No chemical-specific ARARs/TBCs identified for catch basin sediments	Meets criteria; involves no actions which impact potential archaeologically significant areas	Not applicable
Alternative SD-2 - Removal/Treatment	No chemical-specific ARARs/TBCs identified for catch basin sediments	Meets criteria; involves no actions which impact potential archaeologically significant areas	Would comply with action-specific ARARs applicable to individual soil disposal or treatment options, as previously identified in Table 4-10

TABLE 4-34
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative SD-1 - No Action	Residual risk to the environment remains within the watershed, however degree to which Site 13 contributes to this risk is difficult to define; Due to residual sediment contamination within the catch basins, 5-year reviews required
Alternative SD-2 - Removal/Treatment	Long-term effectiveness and permanence dependent on prevention of recontamination of sediments due to soil erosion or potential upgradient source; long-term effectiveness of disposal and treatment options described previously for soil alternatives in Table 4-11; Based on removal of contaminated sediment, 5-year reviews not required

TABLE 4-35
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative SD-1 - No Action	Provides no reduction of contaminant toxicity, mobility or volume through treatment
Alternative SD-2 - Removal/Treatment	Provides a reduction in sediment contaminant mobility through removal and off-site disposal or a reduction in toxicity through off-site incineration or on-site treatment;

TABLE 4-36
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative SD-1 - No Action	Effective in short-term; However, remedial action objectives are not achieved
Alternative SD-2 - Removal/Treatment	Could result in increased short-term risks due to removal of contaminated sediments; Remedial action objectives achieved

TABLE 4-37
COMPARISON AMONG CATCH BASIN SEDIMENT ALTERNATIVES
IMPLEMENTABILITY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative SD-1 - No Action	Requires no implementation other than five-year reviews; Would not limit the implementation of other remedial actions
Alternative SD-2 - Removal/Treatment	Relatively easily implemented, depending on the ultimate handling of the contaminated sediments; Treatment options only implementable if combined with a soil treatment alternative due to small volume of contaminated sediments; Would not limit the implementation of other remedial actions

TABLE 4-38
COST SENSITIVITY ANALYSIS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item Varied (Minimum - Maximum)	Alternative	Minimum Cost	Maximum Cost
Discount Factor (3% - 10%)	Soil	**10%**	**3%**
	S-2	$67,000	$73,000
	S-3A	$503,000	$518,000
	S-3B	$1,654,000	$1,726,000
	Ground Water		
	GW-2	$579,000	$1,091,000
	GW-3A	$397,000	$515,000
	GW-3B	$217,000	$389,000
	GW-3C	$793,000	$1,451,000
	GW-3D	$301,000	$591,000
Remediation Period (20 yrs - 40 yrs)	Ground Water	**20 yrs**	**40 yrs**
	GW-3A	$432,000	$486,000
	GW-3B	$268,000	$348,000
	GW-3C	$989,000	$1,293,000
	GW-3D	$387,000	$521,000
PCB-Contaminated Material Disposal Cost ($200/cy -$400/cy)	Soil	**$200/cy**	**$400/cy**
	S-4A, Scenario 1	$282,000	$410,000
	S-4A, Scenario 2	$147,000	$275,000
Off-Site Incineration Cost ($2,000/ton - $3,000/ton)	Soil	**$2,000/ton**	**$3,000/ton**
	S-4B	$1,747,000	$2,612,000
Solvent Extraction Cost ($100/ton - $900/ton)	Soil	**$100/ton**	**$900/ton**
	S-4C	$76,000	$685,000
Fungal Degradation Cost ($60/cy - $400/cy)	Soil	**$60/cy**	**$400/cy**
	S-4D	$36,000	$238,000
PCB-Contaminated Soil Volume (-20% to +20%)	Soil	**-20%**	**+20%**
	S-4A, Scenario 1	$280,000	$413,000
	S-4A, Scenario 2	$222,000	$327,000
	S-4B	$1,746,000	$2,613,000
	S-4C	$68,000	$102,000
	S-4D	$143,000	$214,000

TABLE 5–1
DESCRIPTIONS OF GENERAL COMPREHENSIVE ALTERNATIVES
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	• No action
Alternative 2 – Limited Action	• Deed restrictions to limit future exposures to surficial soil and ground water contamination • Fencing to prevent human exposures to contaminated surface materials • Long–term monitoring of ground water quality
Alternative 3 – Containment and Monitoring	• Sediment excavation and consolidation on–site beneath a single–barrier cap • Deed restrictions to limit future exposures to surficial soil and ground water contamination • Long–term monitoring of ground water quality
Alternative 4 – Containment, Off–Site Soil/ Sediment Remediation, Monitoring	• PCB–contaminated soil and sediment excavation and remediation off–site (off–site disposal or incineration) • Revegetation of the remainder of the site • Deed restrictions to limit future exposures to ground water contamination and to prevent disruption of revegetated areas • Long–term ground water monitoring
Alternative 5 – Containment and On–Site Soil/ Sediment and Ground Water Treatment	• PCB–contaminated soil and sediment excavation and on–site treatment (solvent extraction or fungal degradation) • Revegetation of the remainder of the site • Ground water extraction, treatment and discharge • Deed restrictions to limit future exposures to ground water contamination and to prevent disruption of revegetated areas • Long–term ground water monitoring

TABLE 5-2
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Provides no overall protection of human health and the environment; Does not meet remedial action objectives; Not effective in the long-term
Alternative 2 – Limited Action	Provides protection of human health but not the environment; Does not address potential leaching of PCB-contamination from site soil or potential migration of surface soil contaminants to storm drainage system or migration of catch basin sediments to Hall Creek; Does not meet remedial action objectives; Not effective in the long-term
Alternative 3 – Containment and Monitoring	Protective of human health and the environment; Limits potential exposures to human receptors through physical containment and deed restrictions; Limits potential erosion and contaminant migration through physical containment of contaminated surface soils and sediments; Potential contaminant migration due to leaching is minimized by presence of cap; Does not treat principal threat; Provides long-term monitoring to identify any changes in ground water quality in the future
Alternative 4 – Containment, Off-Site Soil/ Sediment Remediation, Monitoring	Protective of human health and the environment; Limits potential exposures to human receptors and potential for contaminant leaching through removal and disposal or treatment of PCB-contaminated soils and sediments; Limits potential erosion of low-level surficial contamination through physical containment; Incineration would provide treatment of principal threat; Provides long-term monitoring to identify any changes in ground water quality in the future; Limits potential exposures to ground water through deed restrictions which would prohibit installation of an on-site potable well
Alternative 5 – Containment and On-Site Soil/ Sediment and Ground Water Treatment	Protective of human health and the environment; Limits potential exposures to human receptors and potential for contaminant leaching through removal and treatment of PCB-contaminated soils and sediments; Limits potential erosion of low-level surficial contamination through physical containment; Provides treatment of principal threat; Provides active treatment of ground water; Protection against contaminated ground water migration may not be permanent following treatment system discontinuation

TABLE 5-3
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COMPLIANCE WITH ARARS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	CHEMICAL-SPECIFIC	LOCATION-SPECIFIC	ACTION-SPECIFIC
Alternative 1 -- No Action	Does not meet ARARs/TBCs applicable to PCBs in soil or MCLs in ground water	Meets criteria; involves no actions which impact potential archaeologically significant areas	Not applicable
Alternative 2 -- Limited Action	Does not meet ARARs/TBCs applicable to PCBs in soil or MCLs in ground water but limits potential exposures through deed restrictions and fencing	Construction of fencing would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring
Alternative 3 -- Containment and Monitoring	Meets ARARs/TBCs applicable to PCBs in soil through containment; Does not achieve MCLs in ground water but limits potential exposures through deed restrictions	Capping would be conducted in coordination with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring; EPA Guidance on Remedial Actions for Superfund Sites with PCB Contamination would be considered in design and implementation of cap
Alternative 4 -- Containment, Off-Site Soil/Sediment Remediation, Monitoring	Meets ARARs/TBCs applicable to PCBs in soil through off-site disposal or treatment; Does not achieve MCLs in ground water but limits potential exposures through deed restrictions	Soil excavation would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring, hazardous waste characterization, waste generation, transport, off-site disposal or incineration
Alternative 5 -- Containment and On-Site Soil/Sediment and Ground Water Treatment	Meets ARARs/TBCs applicable to PCBs in soil through off-site disposal or treatment; Achieves MCLs in ground water through treatment	Soil excavation and on-site treatment system construction would be coordinated with preservation agencies and societies to minimize loss of significant historic or archaeological data	Would comply with action-specific ARARs applicable to monitoring, hazardous waste characterization, waste generation, transport, and treatment or disposal

TABLE 5-4
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
LONG-TERM EFFECTIVENESS AND PERMANENCE
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Residual risk to human health and the environment remains; Provides no long-term protection; 5-year reviews required
Alternative 2 – Limited Action	May be effective in the long-term in reducing risks to humans but residual risk to the environment remains; Provides no long-term protection against leaching of PCBs, migration of surficial soil contamination to the storm drainage system or migration of catch basin sediments to Hall Creek; Monitoring would identify any changes in ground water quality; 5-year reviews required
Alternative 3 – Containment and Monitoring	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as limiting potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of cap area required; Long-term monitoring would provide a means of monitoring any changes in ground water; 5-year reviews required
Alternativ 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as eliminating potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of revegation area required; Long-term monitoring would provide a means of monitoring any changes in ground water quality; 5-year reviews required
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Effective in the long-term in eliminating exposures to surficial contaminants and sediment as well as eliminating potential for PCB leaching or erosion of surficial contaminants; Long-term maintenance of revegetation area required; Effective in the treatment of ground water contaminants; Long-term maintenance of treatment systems required; Long-term ground water monitoring would provide a means of monitoring any changes in ground water once treatment is discontinued; Permanence in eliminating future re-contamination of ground water is not ensured once treatment is discontinued; 5-year reviews required

TABLE 5–5
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Provides no reduction of contaminant toxicity, mobility or volume through treatment
Alternative 2 – Limited Action	Provides no reduction of contaminant toxicity, mobility or volume through treatment
Alternative 3 – Containment and Monitoring	Provides no reduction in contaminant toxicity, mobility or volume through treatment; Reduces contaminant mobility through containment features
Alternative 4 – Containment, Off–Site Soil/Sediment Remediation, Monitoring	Provides a reduction in soil and sediment contaminant mobility through off–site disposal or a reduction in toxicity through off–site incineration; Incineration would treat principal threat associated with PCB contamination; provides no reduction of ground water toxicity, mobility or volume through treatment
Alternative 5 – Containment and On–Site Soil/Sediment and Ground Water Treatment	Provides a reduction in soil and sediment contaminant mobility through on–site treatment; Treats principal threat associated with PCB contamination; Reduces mobility and toxicity of ground water contaminants through treatment

TABLE 5-6
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
SHORT-TERM EFFECTIVENESS
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alt rnative 1 – No Action	Effective in short-term; However, remedial action objectives are not achieved
Alternative 2 – Limited Action	Effective in short-term; However, remedial action objectives are not achieved
Alternative 3 – Containment and Monitoring	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments; Remedial action objectives achieved
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments; Remedial action objectives achieved
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Could result in increased short-term risks due to potential disruption of contaminated surficial materials and sediments and operation of on-site treatment systems; Remedial action objectives achieved

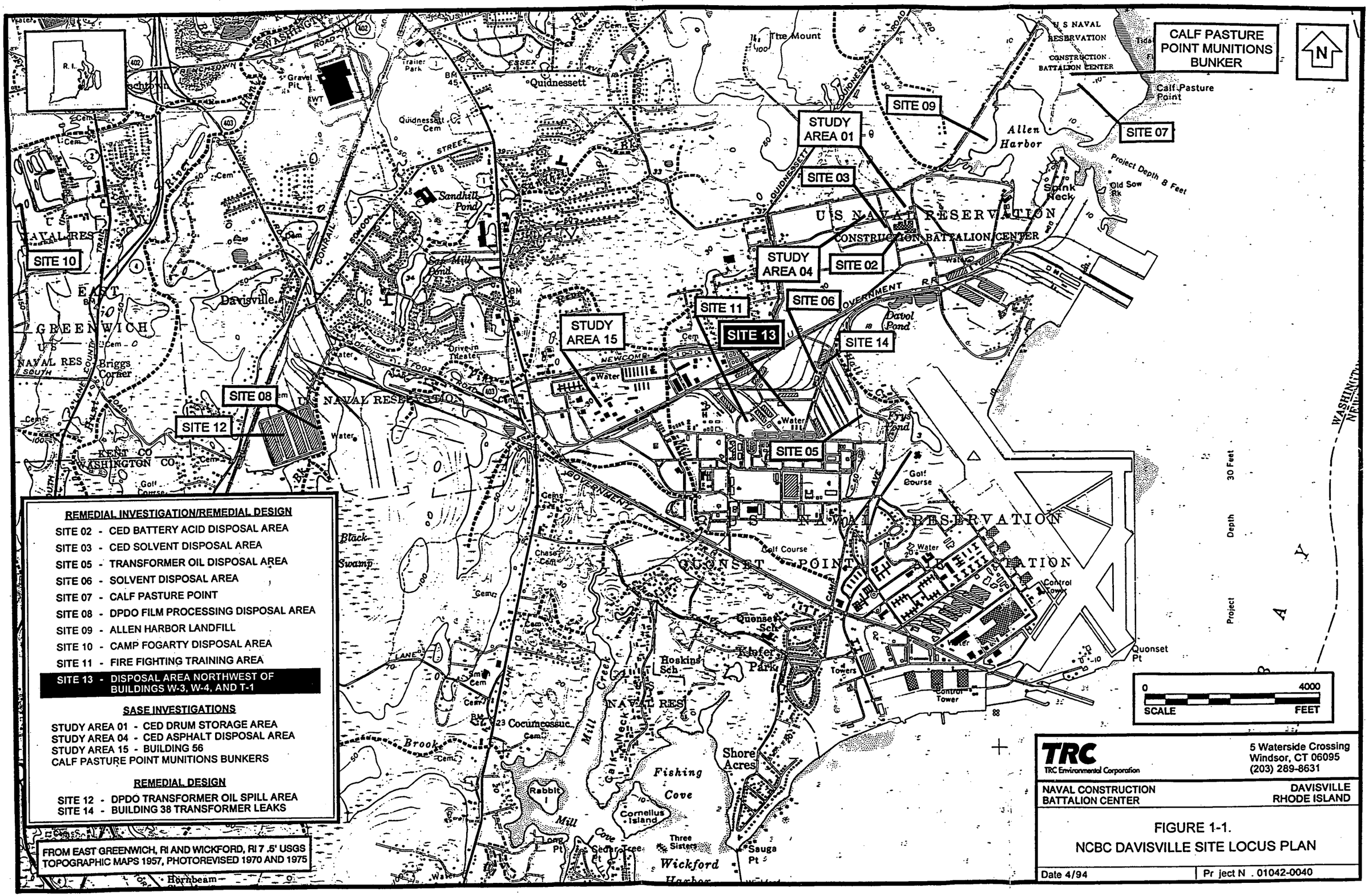
TABLE 5-7
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
IMPLEMENTABILITY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE, RI

ACTION	DESCRIPTION
Alternative 1 – No Action	Requires no implementation other than five-year reviews; Would not limit the implementation of other remedial actions
Alternative 2 – Limited Action	Long-term monitoring program and fencing easily implemented; Deed restrictions would be incorporated into the base closure property transfer process; Would not limit the implementation of other remedial actions; Would limit feasibility of utilizing the site for future commercial/industrial uses, as specified within the Base Reuse Plan
Alternative 3 – Containment and Monitoring	Materials and services readily available; Cap construction requires special materials and installation expertise; Could limit future site development although it would not be incompatible with surrounding commercial/industrial site use; Presence of cap could impact implementation of other remedial actions, if required; Deed restrictions would be incorporated into the base closure property transfer process
Alternative 4 – Containment, Off-Site Soil/Sediment Remediation, Monitoring	Materials and services readily available; Could limit future site development although it would not be incompatible with surrounding commercial/industrial site use; Not expected to limit the implementation of other remedial actions, if required; Deed restrictions would be incorporated into the base closure property transfer process
Alternative 5 – Containment and On-Site Soil/Sediment and Ground Water Treatment	Innovative soil/sediment treatment technologies would require treatability studies and utilize technologies which are not widely available; Ground water treatment technologies fairly easily implemented; Not expected to limit the implementation of other remedial actions, if required; Deed restrictions would be incorporated into the base closure property transfer process

TABLE 5–8
COMPARISON AMONG COMPREHENSIVE ALTERNATIVES
COST
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE, RI

ACTION	TOTAL CAPITAL COST	ANNUAL O&M COST	PRESENT WORTH O&M COST (1)	TOTAL PRESENT WORTH (2)
Alt mative 1 – No Action	--	--	--	Nominal (3)
Alt mative 2 – Limited Action (4)	$51,000	$49,000	$740,000	$950,000
Alt mative 3 – Containment and Monitoring (5)	$1,300,000	$54,000	$820,000	$2,600,000
Alt mativ 4 – Containment, Off–Site Soil/Sediment Remediation, Monitoring (6)				
Off–Site Disposal	$590,000	$49,000	$750,000	$1,600,000
Off–Site Incineration	$2,200,000	$49,000	$750,000	$3,600,000
Alt mative 5 – Containment and On–Site Soil/Sediment and Ground Water Treatment (7)				
Solvent Extraction	$950,000	$150,000	$2,300,000	$3,900,000
Fungal Degradation	$1,000,000	$150,000	$2,300,000	$4,000,000

Note: Costs are presented based on a combination of individual alternative costs as presented in Section 4 tables.
(1) – Based on 5% discount rate
(2) – Includes 20% contingency on all components
(3) – The only cost associated with the implementation of Alternative 1 would be that associated with conducting five–year reviews of the no action decision.
(4) – For costing purposes, Alternative 2 consists of Alternatives S–2 and GW–2
(5) – For costing purposes, Alternative 3 consists of Alternatives S–3B and GW–2
(6) – For costing purposes, Alternative 4 consists of Alternatives S–3A and GW–2 combined with Alternatives S–4A or S–4B
(7) – For costing purposes, Alternative 5 consists of Alternatives S–3A, GW–2, and GW–3 combined with Alternatives S–4C or S–4D



REMEDIAL INVESTIGATION/REMEDIAL DESIGN

SITE 02 - CED BATTERY ACID DISPOSAL AREA
SITE 03 - CED SOLVENT DISPOSAL AREA
SITE 05 - TRANSFORMER OIL DISPOSAL AREA
SITE 06 - SOLVENT DISPOSAL AREA
SITE 07 - CALF PASTURE POINT
SITE 08 - DPDO FILM PROCESSING DISPOSAL AREA
SITE 09 - ALLEN HARBOR LANDFILL
SITE 10 - CAMP FOGARTY DISPOSAL AREA
SITE 11 - FIRE FIGHTING TRAINING AREA
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1

SASE INVESTIGATIONS

STUDY AREA 01 - CED DRUM STORAGE AREA
STUDY AREA 04 - CED ASPHALT DISPOSAL AREA
STUDY AREA 15 - BUILDING 56
CALF PASTURE POINT MUNITIONS BUNKERS

REMEDIAL DESIGN

SITE 12 - DPDO TRANSFORMER OIL SPILL AREA
SITE 14 - BUILDING 38 TRANSFORMER LEAKS

FROM EAST GREENWICH, RI AND WICKFORD, RI 7.5' USGS TOPOGRAPHIC MAPS 1957, PHOTOREVISED 1970 AND 1975

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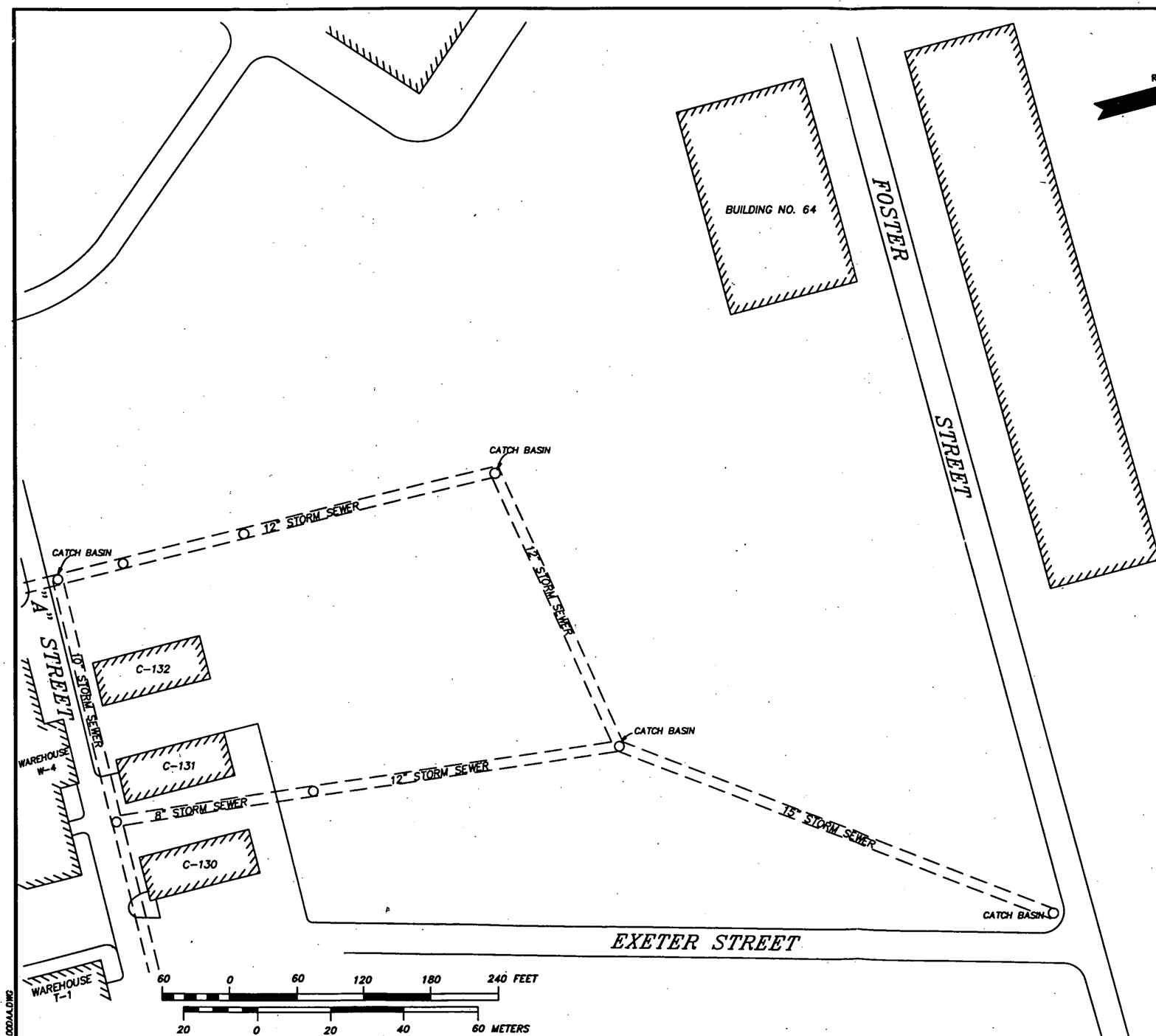
NAVAL CONSTRUCTION BATTALION CENTER

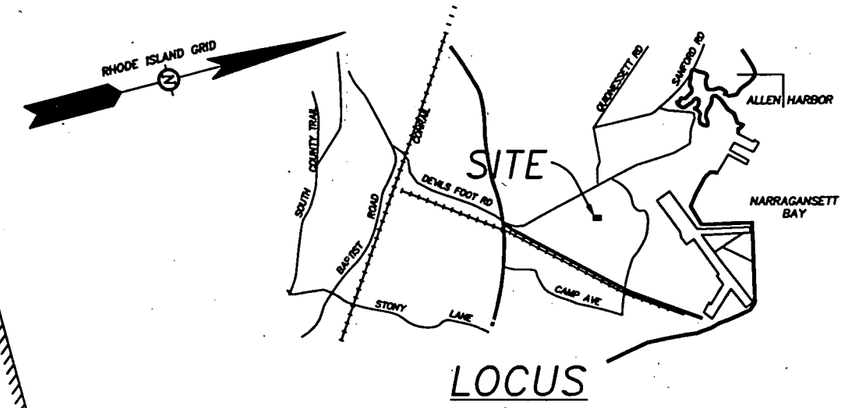
DAVISVILLE RHODE ISLAND

FIGURE 1-1.
NCBC DAVISVILLE SITE LOCUS PLAN

Date 4/94

Pr ject N . 01042-0040





NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. STORM SEWER PIPE AND CATCH BASIN LOCATIONS ARE APPROXIMATE

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

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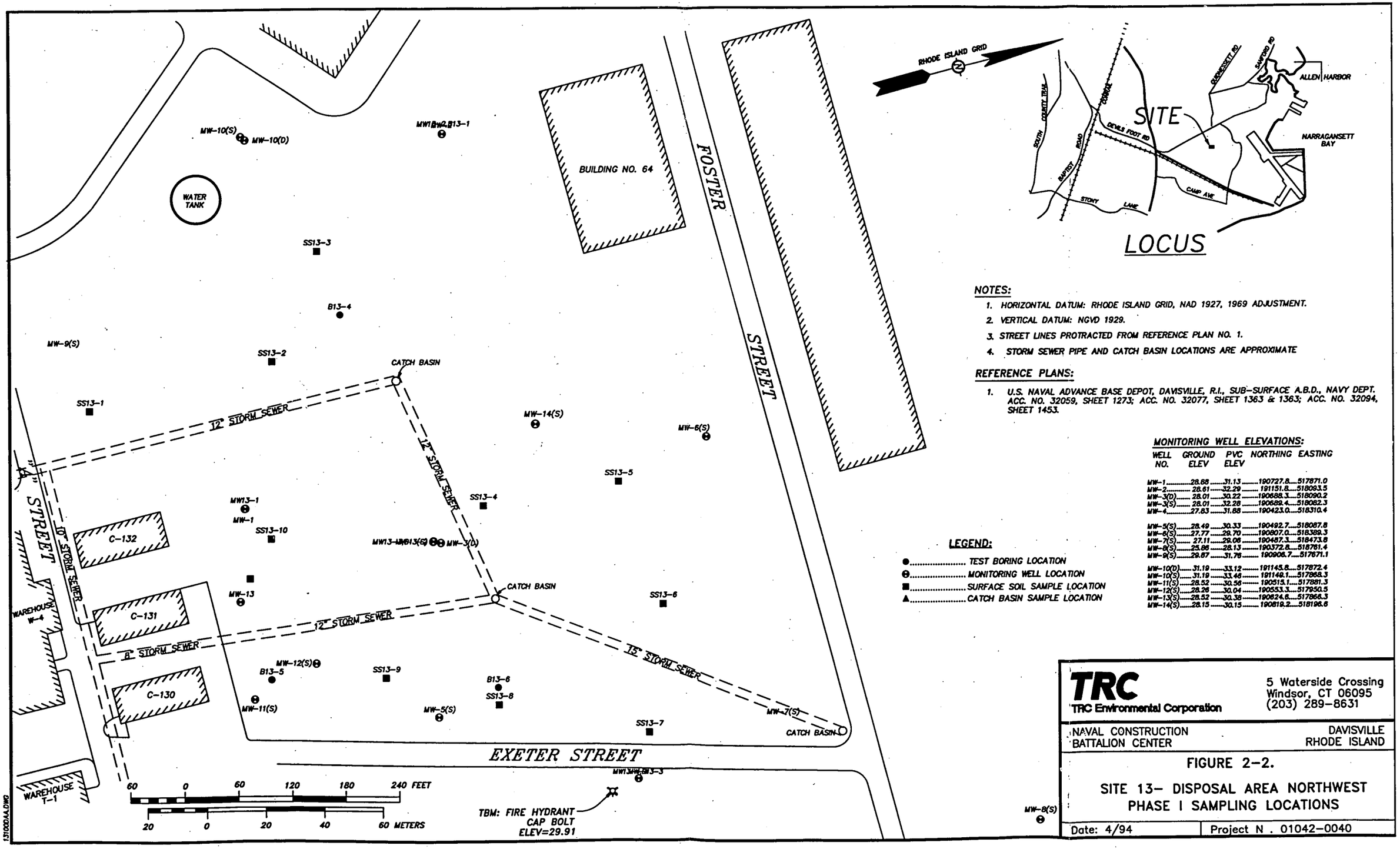
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 2-1.
SITE 13-DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4, AND T-1

Date: 4/94 | Project No. 01042-0040

131000AA.DWG



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. STORM SEWER PIPE AND CATCH BASIN LOCATIONS ARE APPROXIMATE

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190824.6	517866.3
MW-14(S)	28.15	30.15	190819.2	518196.6

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- ▲ ..... CATCH BASIN SAMPLE LOCATION

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NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 2-2.

SITE 13- DISPOSAL AREA NORTHWEST PHASE I SAMPLING LOCATIONS

Date: 4/94 | Project N . 01042-0040

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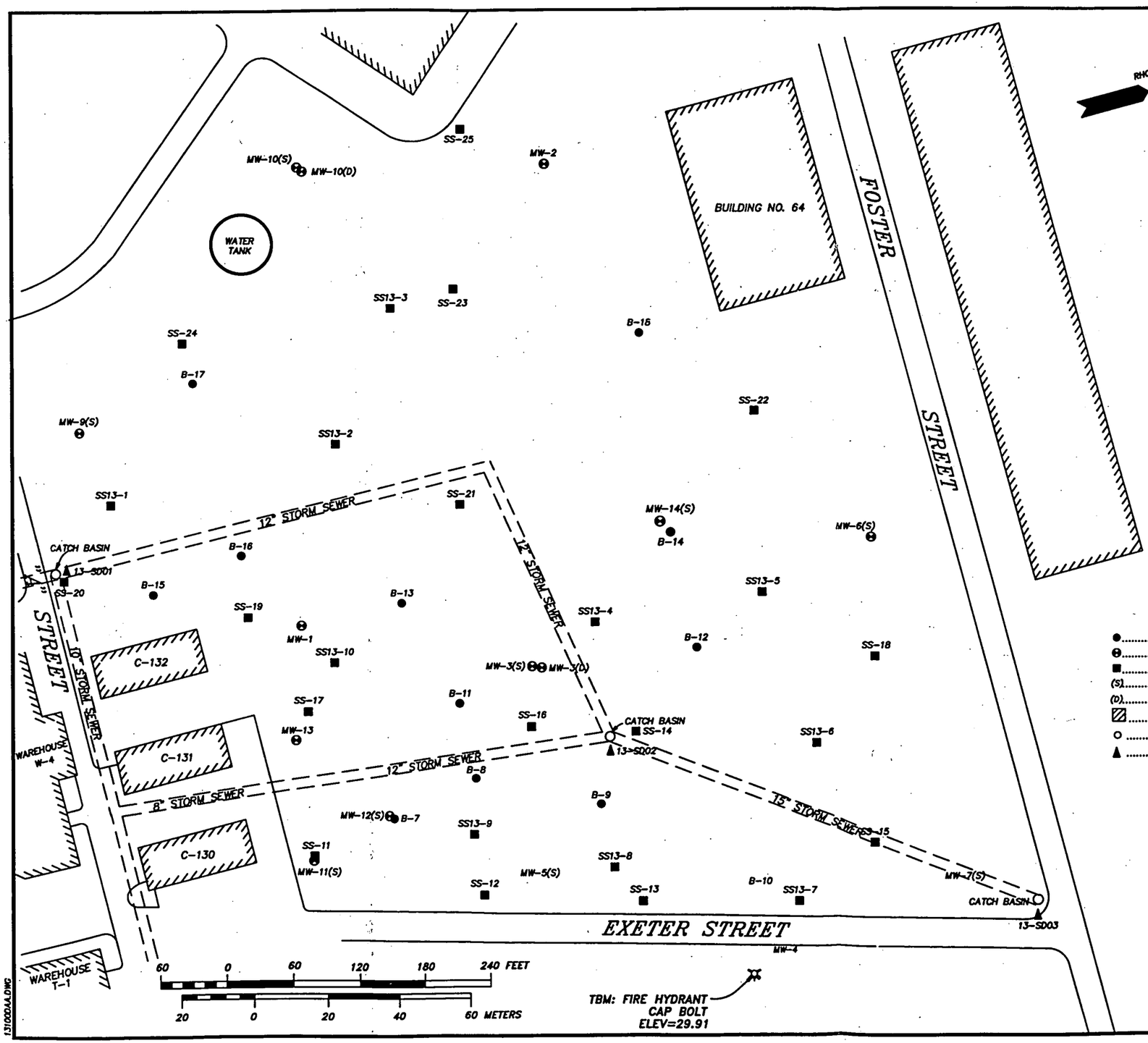

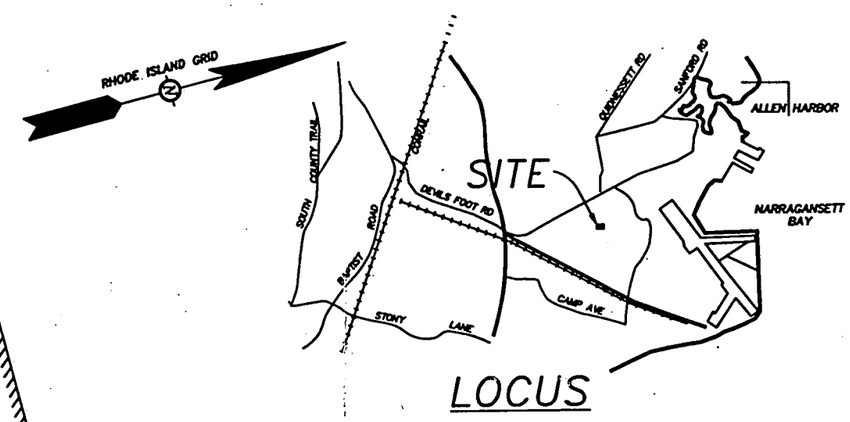

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. STORM SEWER PIPE AND CATCH BASIN LOCATIONS ARE APPROXIMATE

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517868.3
MW-14(S)	28.15	30.15	190819.2	518196.6

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NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE, RHODE ISLAND

FIGURE 2-3.

SITE 13-DISPOSAL AREA NORTHWEST PHASE II SAMPLING LOCATIONS

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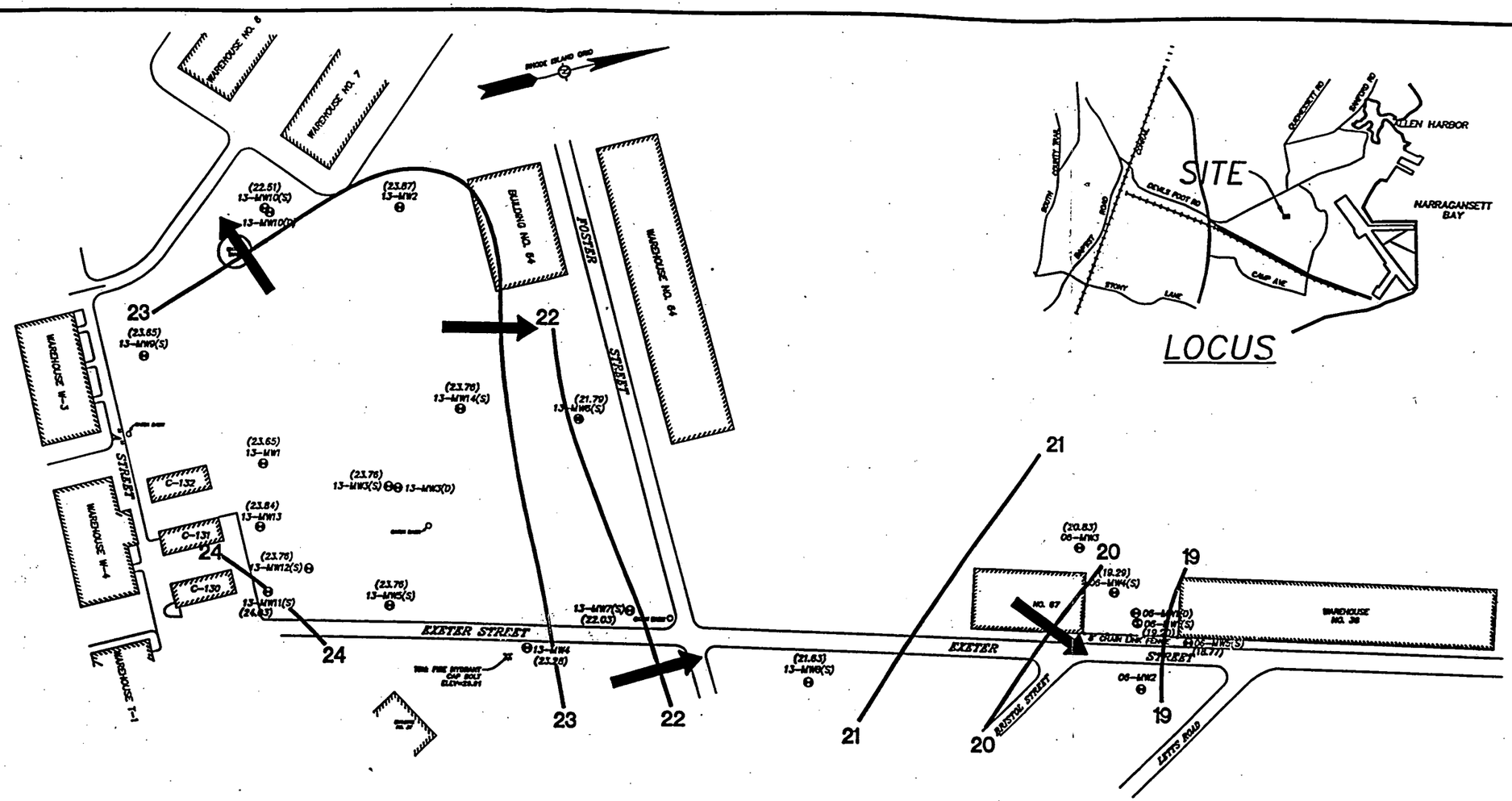

LEGEND:

- ——— MONITORING WELL LOCATION
- (23.65) ——— GROUND WATER ELEVATION (MSL)
- (S) ——— SHALLOW WELL
- (D) ——— DEEP WELL
- 23 ——— GROUND WATER CONTOUR (MSL)
- ➡ ——— GROUND WATER FLOW DIRECTION

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

60 0 60 120 180 240 FEET
20 0 20 40 60 METERS

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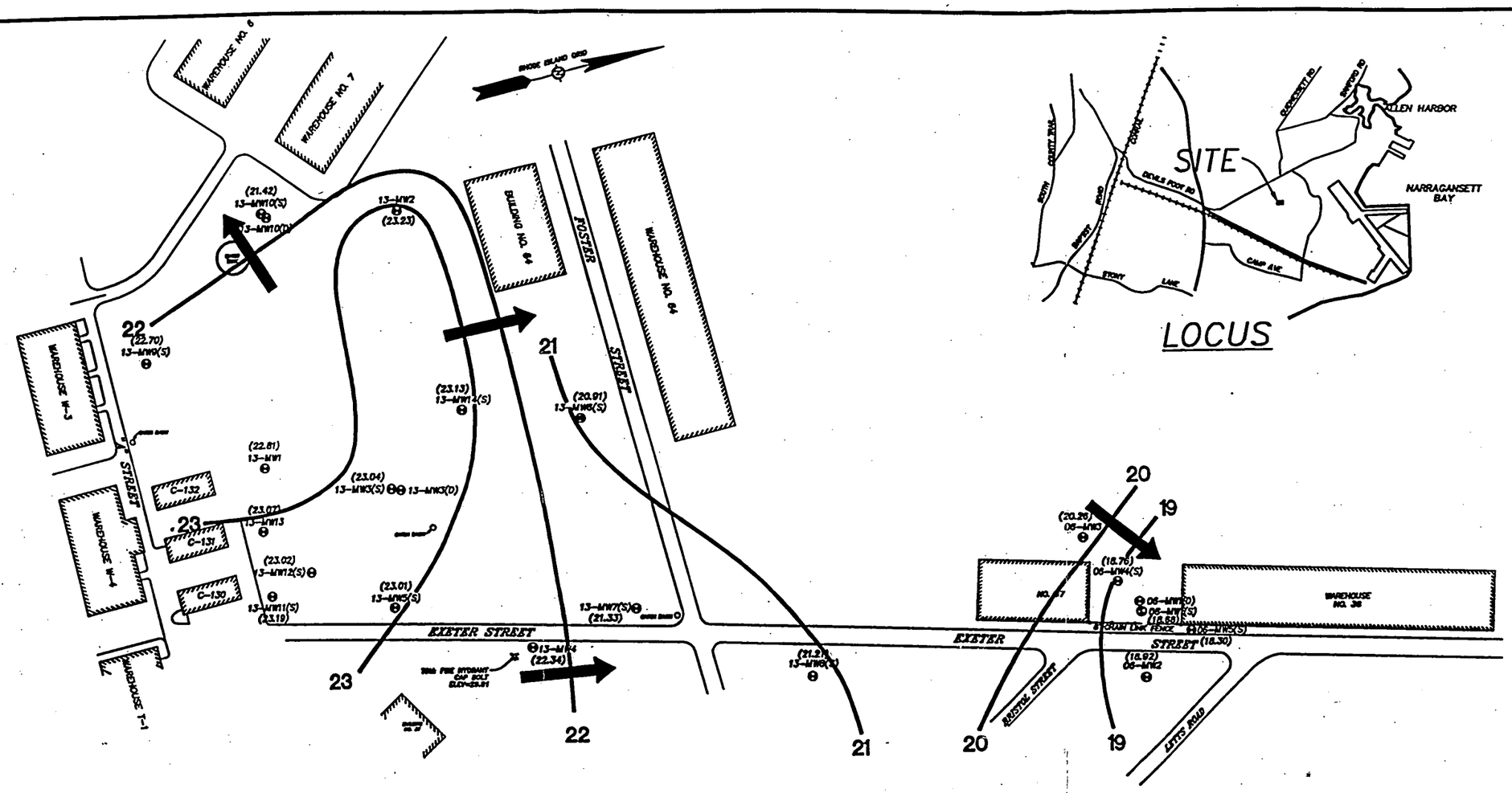
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 2-4.
SITE 06-SOLVENT DISPOSAL AREA
SITE 13-SOLVENT DISPOSAL AREA NW
SHALLOW GROUND WATER LEVEL CONTOUR MAP
AUGUST 13, 1993

Date: 4/94 | Project No. 01042-0040



LEGEND:

- ——— MONITORING WELL LOCATION
- (22.70) ——— GROUND WATER ELEVATION (MSL)
- (S) ——— SHALLOW WELL
- (D) ——— DEEP WELL
- 22 ——— GROUND WATER CONTOUR (MSL)
- ➡ ——— GROUND WATER FLOW DIRECTION

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

60 0 60 120 180 240 FEET

20 0 20 40 60 METERS

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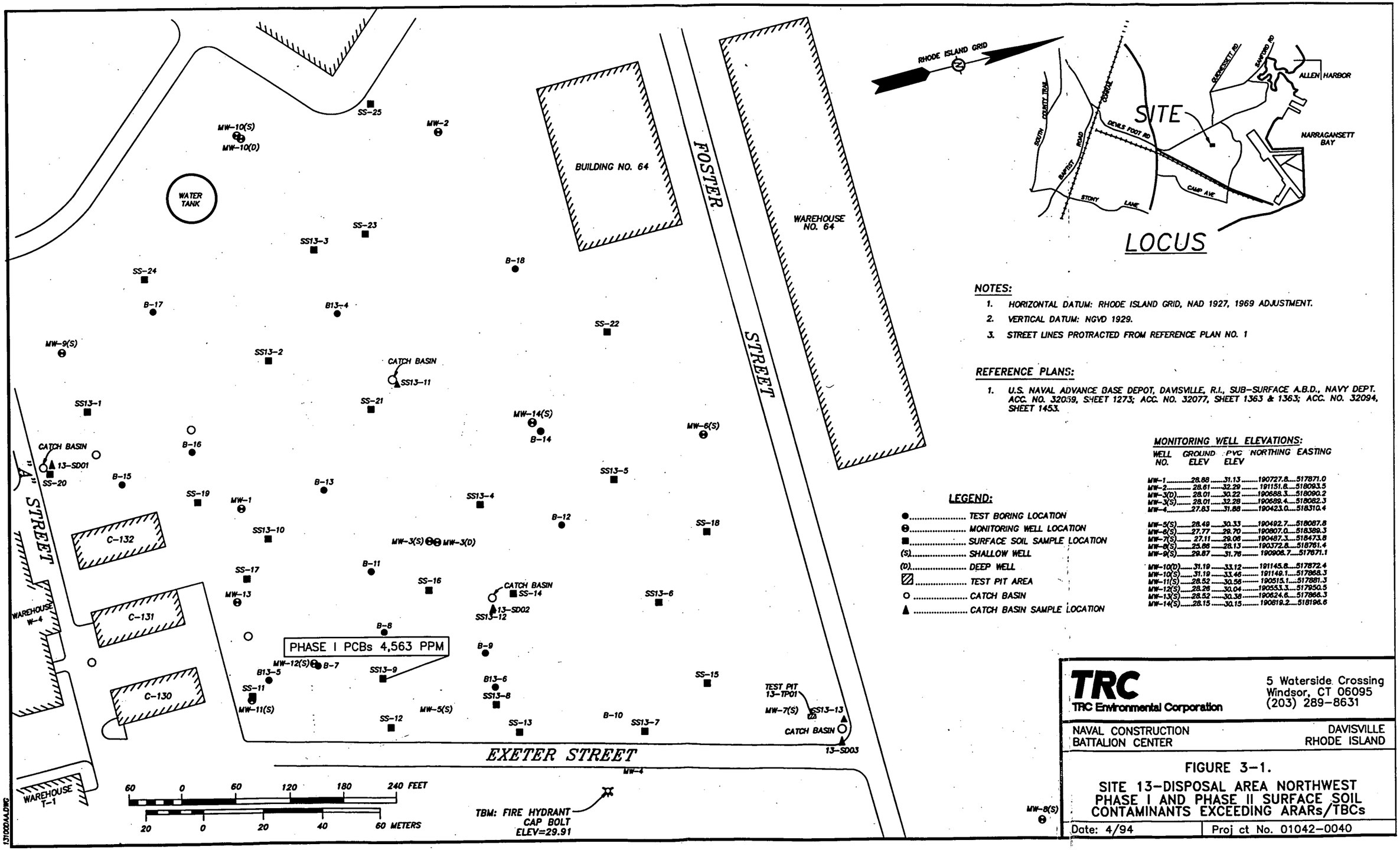
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE, RHODE ISLAND

FIGURE 2-5.
SITE 06-SOLVENT DISPOSAL AREA
SITE 13-SOLVENT DISPOSAL AREA NW
SHALLOW GROUND WATER LEVEL CONTOUR MAP
SEPTEMBER 17, 1993

Date: 4/94 | Project No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190908.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517866.3
MW-14(S)	28.15	30.15	190819.2	518196.6

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

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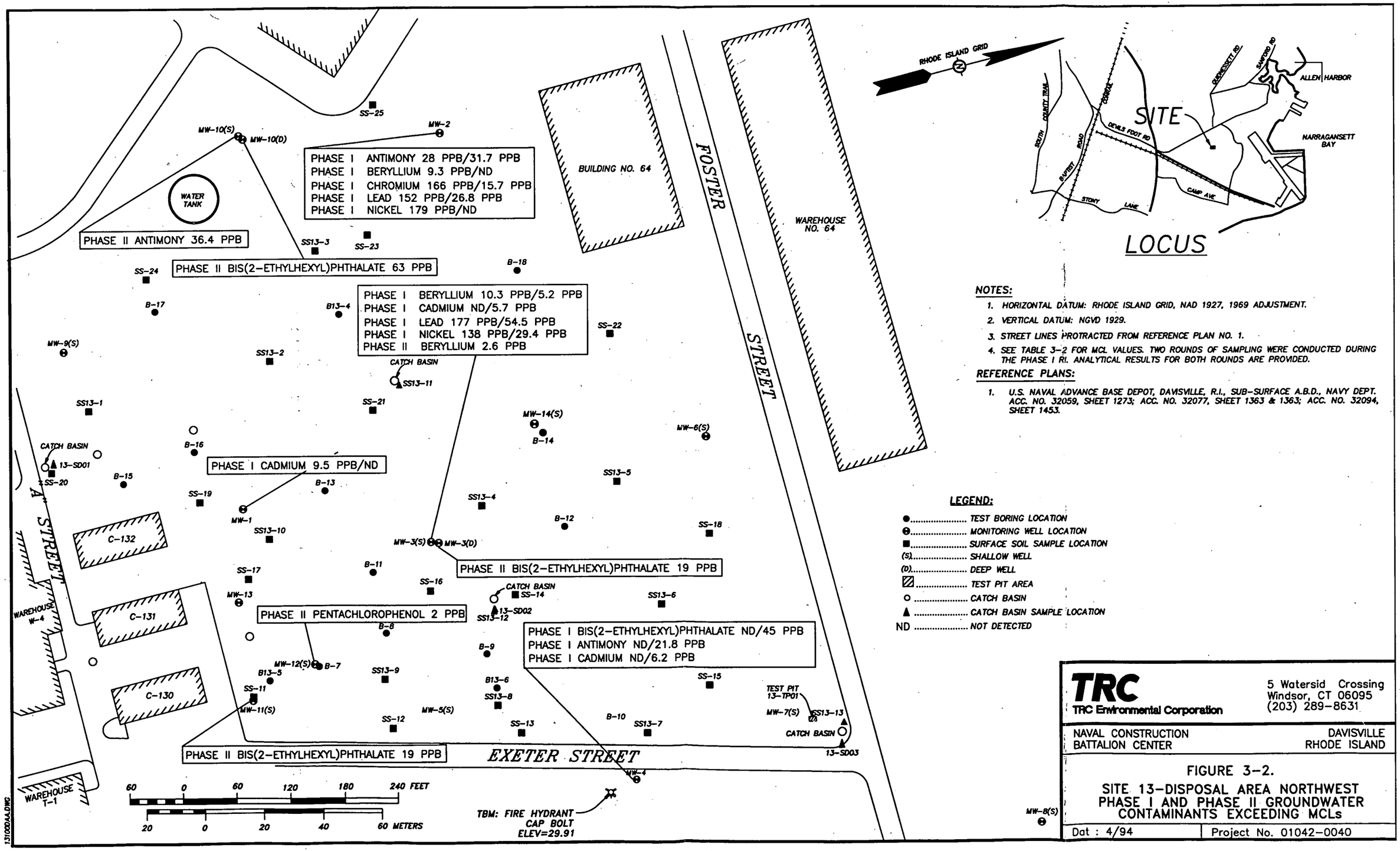
FIGURE 3-1.

SITE 13-DISPOSAL AREA NORTHWEST PHASE I AND PHASE II SURFACE SOIL CONTAMINANTS EXCEEDING ARARs/TBCs

Date: 4/94 | Proj ct No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. SEE TABLE 3-2 FOR MCL VALUES. TWO ROUNDS OF SAMPLING WERE CONDUCTED DURING THE PHASE I RI. ANALYTICAL RESULTS FOR BOTH ROUNDS ARE PROVIDED.

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION
- ND ..... NOT DETECTED

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NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE 3-2.
SITE 13-DISPOSAL AREA NORTHWEST PHASE I AND PHASE II GROUNDWATER CONTAMINANTS EXCEEDING MCLs

Dat : 4/94 | Project No. 01042-0040

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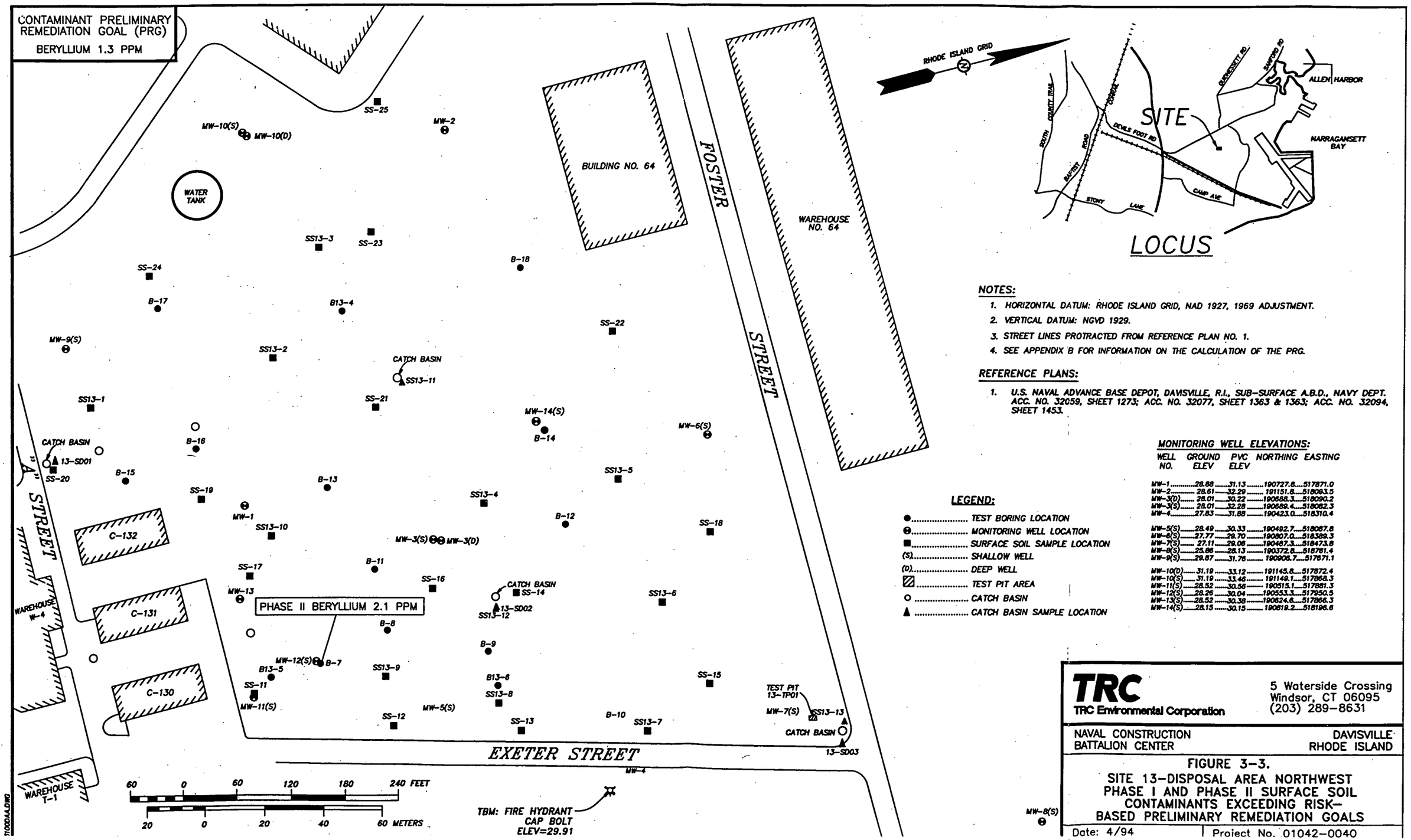

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. SEE APPENDIX B FOR INFORMATION ON THE CALCULATION OF THE PRG.

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.6	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517866.3
MW-14(S)	28.15	30.15	190819.2	518196.6

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FIGURE 3-3.
SITE 13-DISPOSAL AREA NORTHWEST PHASE I AND PHASE II SURFACE SOIL CONTAMINANTS EXCEEDING RISK-BASED PRELIMINARY REMEDIATION GOALS

Date: 4/94 | Project No. 01042-0040

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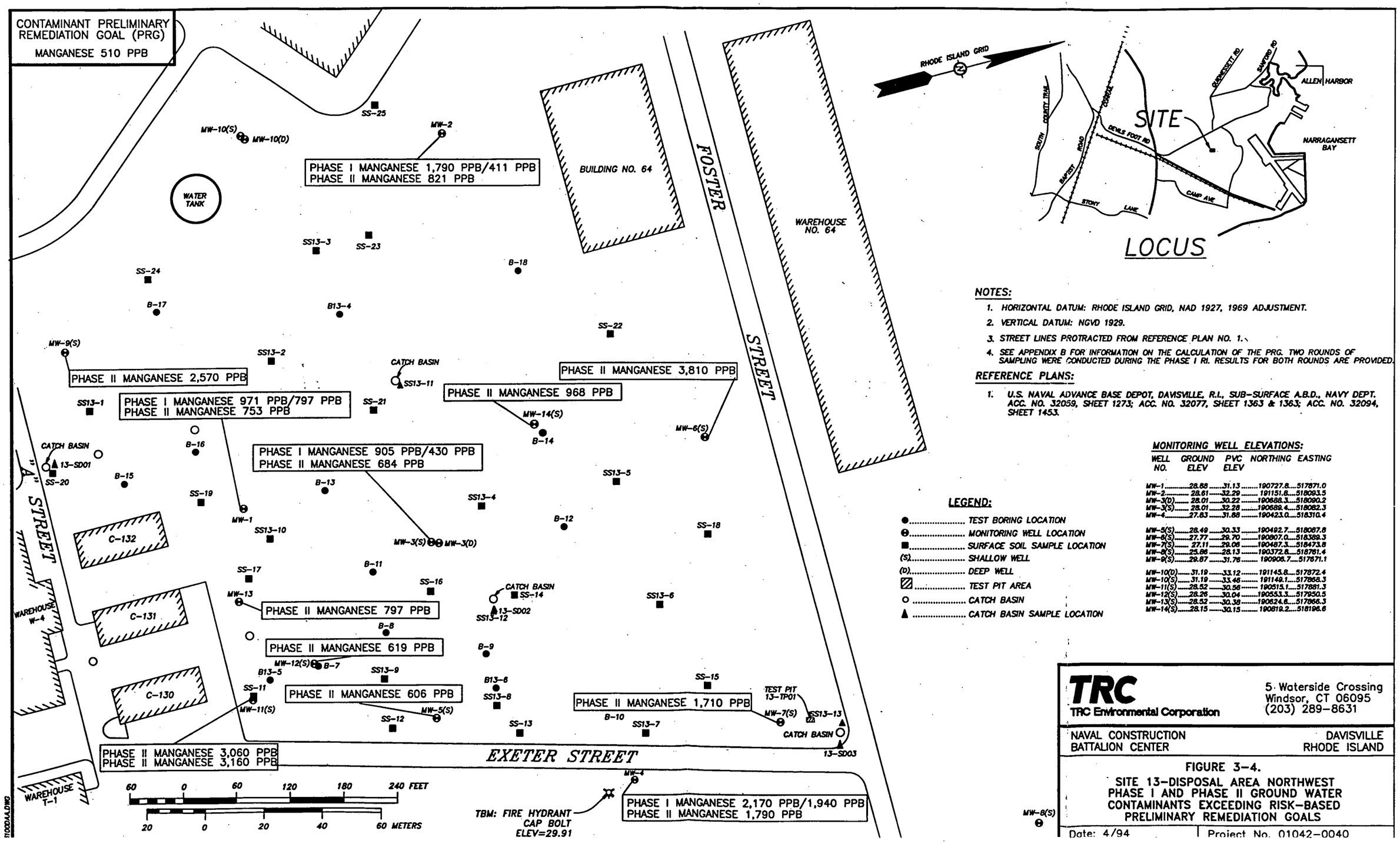

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1.
4. SEE APPENDIX B FOR INFORMATION ON THE CALCULATION OF THE PRG. TWO ROUNDS OF SAMPLING WERE CONDUCTED DURING THE PHASE I RI. RESULTS FOR BOTH ROUNDS ARE PROVIDED.

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190688.3	518090.2
MW-3(S)	28.01	32.28	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517866.3
MW-14(S)	28.15	30.15	190819.2	518196.6

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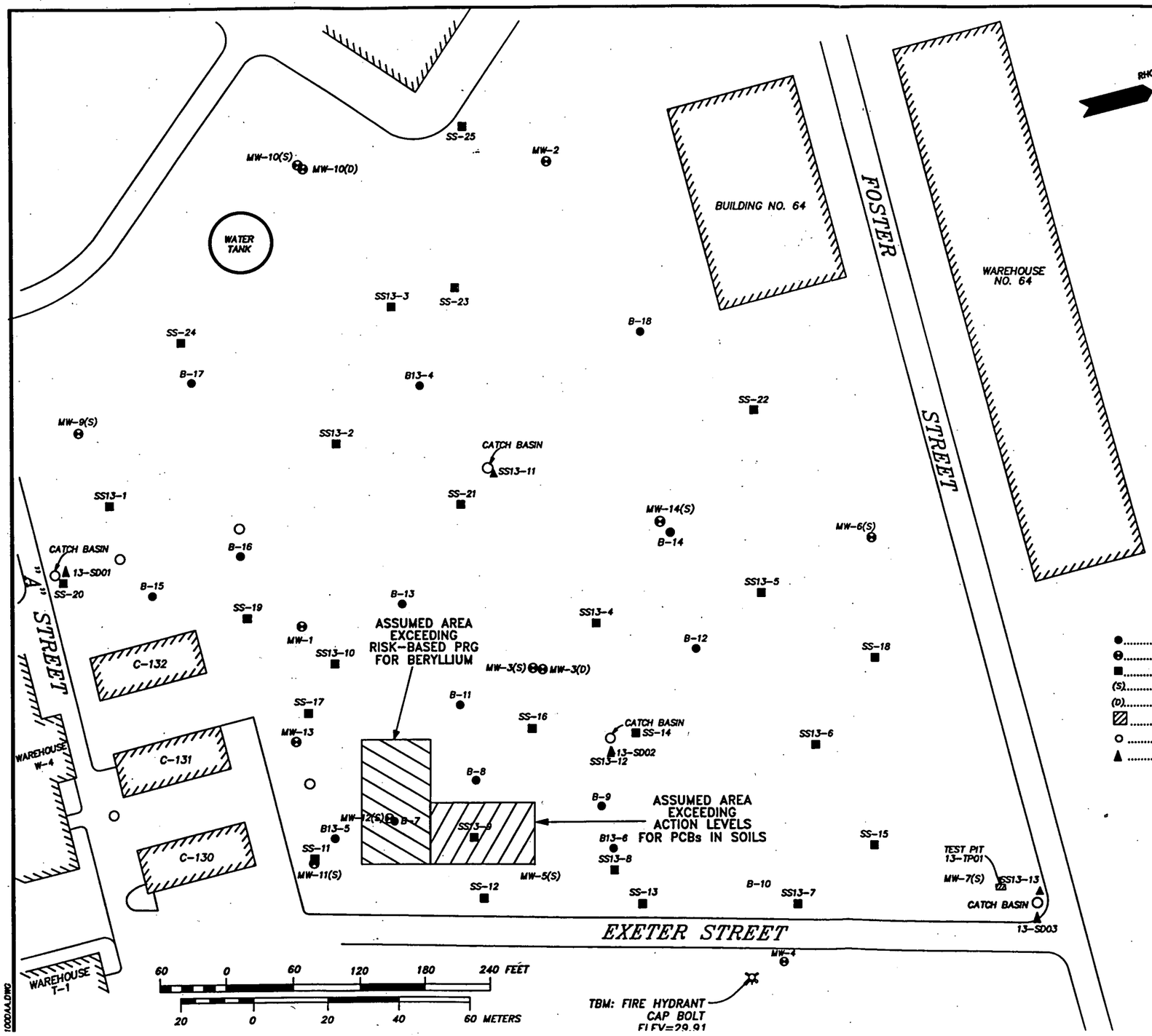
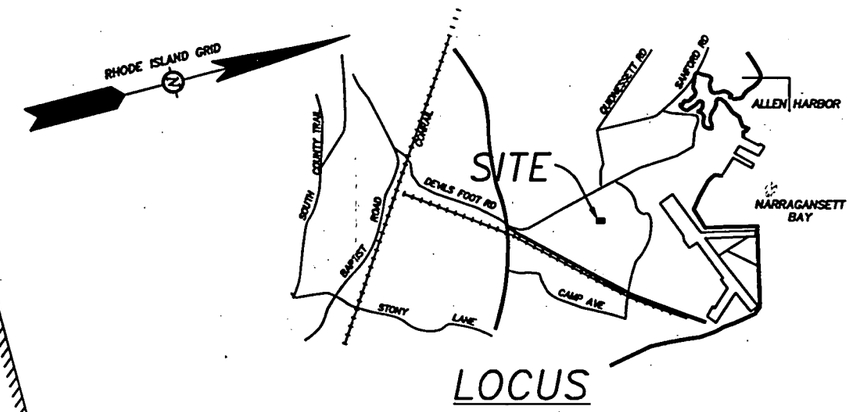
FIGURE 3-4.
SITE 13-DISPOSAL AREA NORTHWEST
PHASE I AND PHASE II GROUND WATER CONTAMINANTS EXCEEDING RISK-BASED PRELIMINARY REMEDIATION GOALS

Date: 4/94 | Project No. 01042-0040





NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
MW-3(D)	28.01	30.22	190888.3	518090.2
MW-3(S)	28.01	32.28	190889.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518067.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.6	517866.3
MW-14(S)	28.15	30.15	190619.2	518196.6

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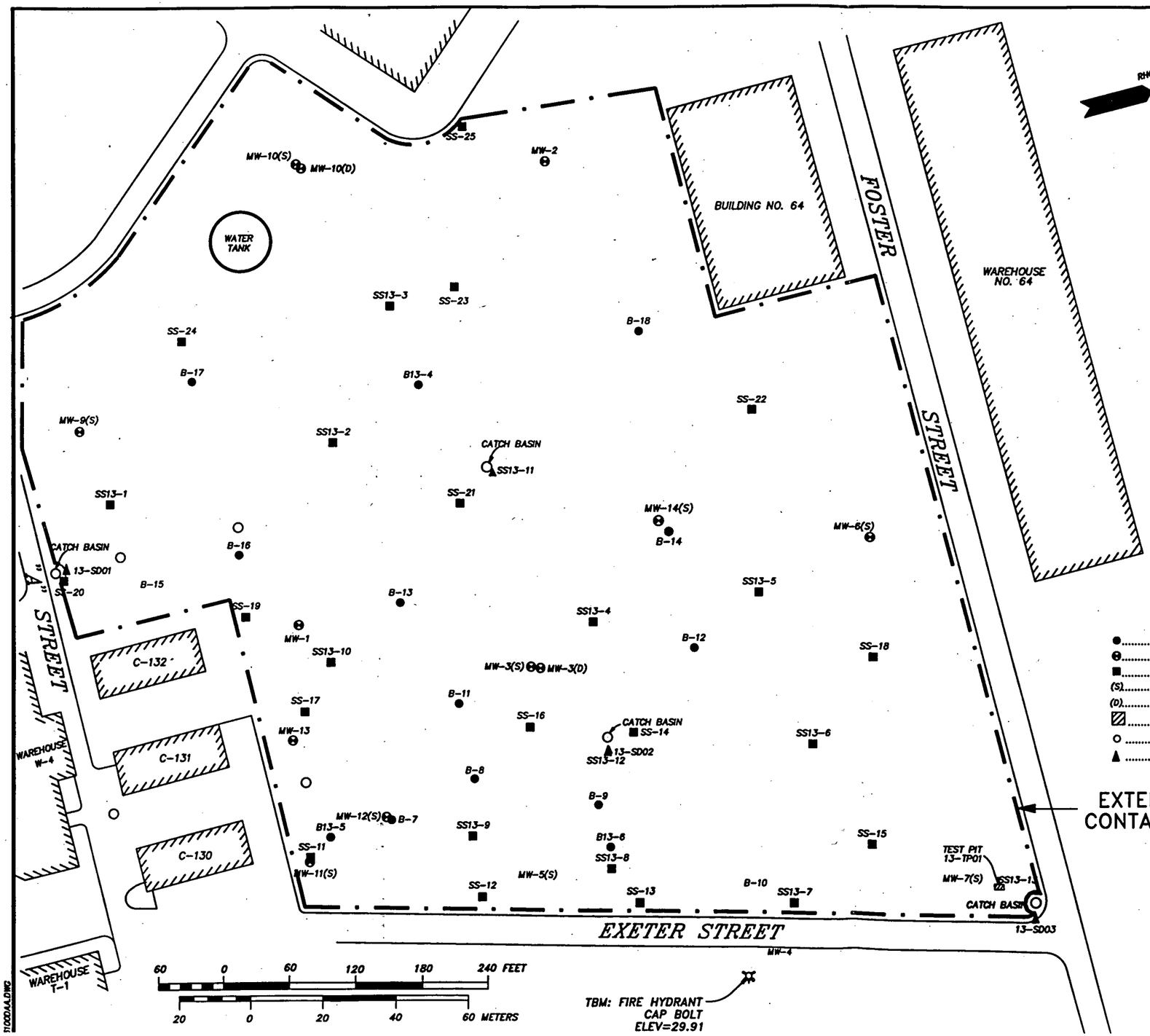
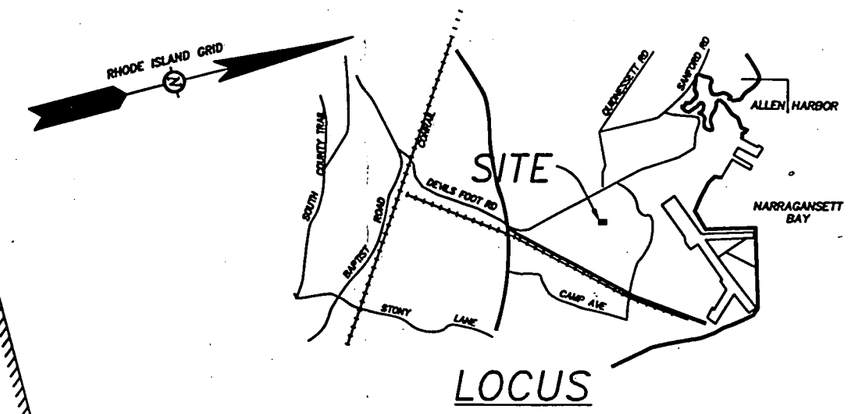
FIGURE 3-5.
SITE 13-DISPOSAL AREA NORTHWEST
ASSUMED AREAS EXCEEDING ACTION LEVELS AND RISK-BASED PRG

Date: 4/94 | Project No. 01042-0040





NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453.

LEGEND:

- ● ..... TEST BORING LOCATION
- ⊖ ..... MONITORING WELL LOCATION
- ■ ..... SURFACE SOIL SAMPLE LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▨ ..... TEST PIT AREA
- ○ ..... CATCH BASIN
- ▲ ..... CATCH BASIN SAMPLE LOCATION

MONITORING WELL ELEVATIONS:

WELL NO.	GROUND ELEV	PVC ELEV	NORTHING	EASTING
MW-1	28.88	31.13	190727.8	517871.0
MW-2	28.61	32.29	191151.8	518093.5
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MW-3(S)	28.01	32.26	190689.4	518082.3
MW-4	27.83	31.88	190423.0	518310.4
MW-5(S)	28.49	30.33	190492.7	518087.8
MW-6(S)	27.77	29.70	190807.0	518389.3
MW-7(S)	27.11	29.06	190487.3	518473.8
MW-8(S)	25.86	28.13	190372.8	518761.4
MW-9(S)	29.87	31.76	190906.7	517671.1
MW-10(D)	31.19	33.12	191145.8	517872.4
MW-10(S)	31.19	33.46	191149.1	517868.3
MW-11(S)	28.52	30.56	190515.1	517881.3
MW-12(S)	28.26	30.04	190553.3	517950.5
MW-13(S)	28.52	30.38	190624.8	517866.3
MW-14(S)	28.15	30.15	190619.2	518196.6

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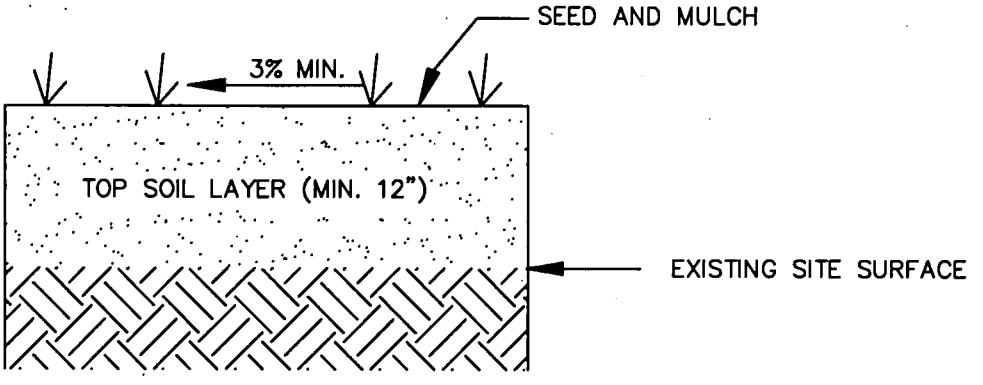
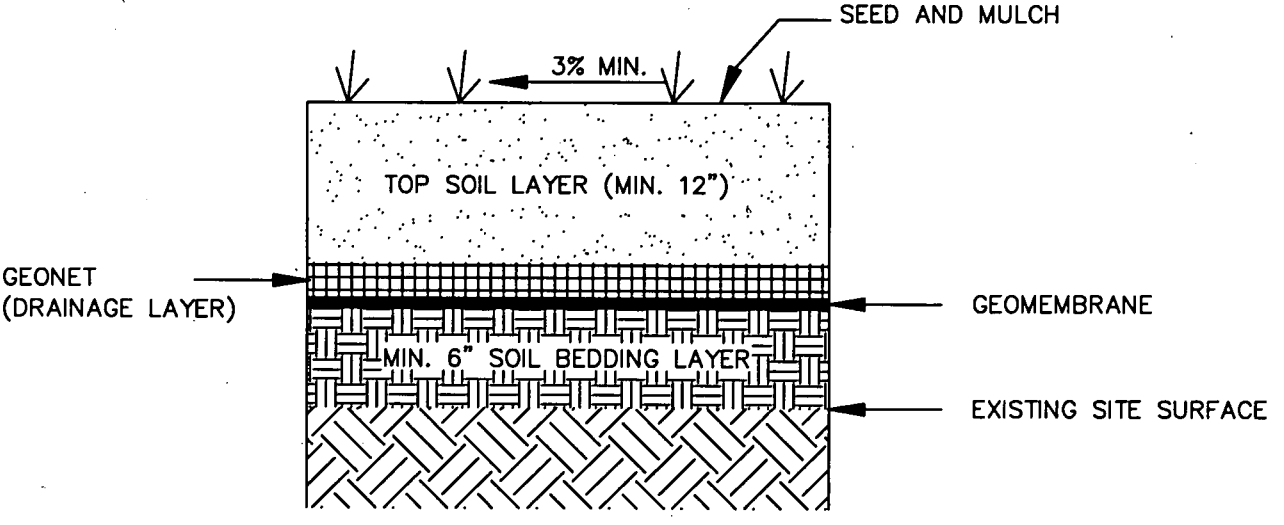
FIGURE 4-1.
SITE 13-DISPOSAL AREA NORTHWEST
EXTENT OF CONTAINMENT
ALTERNATIVE S-3

Date: 4/94 | Project No. 01042-0040

ALTERNATIVE S-3, OPTION A
REVEGETATION



ALTERNATIVE S-3, OPTION B
SINGLE - BARRIER CAP



NOT TO SCALE

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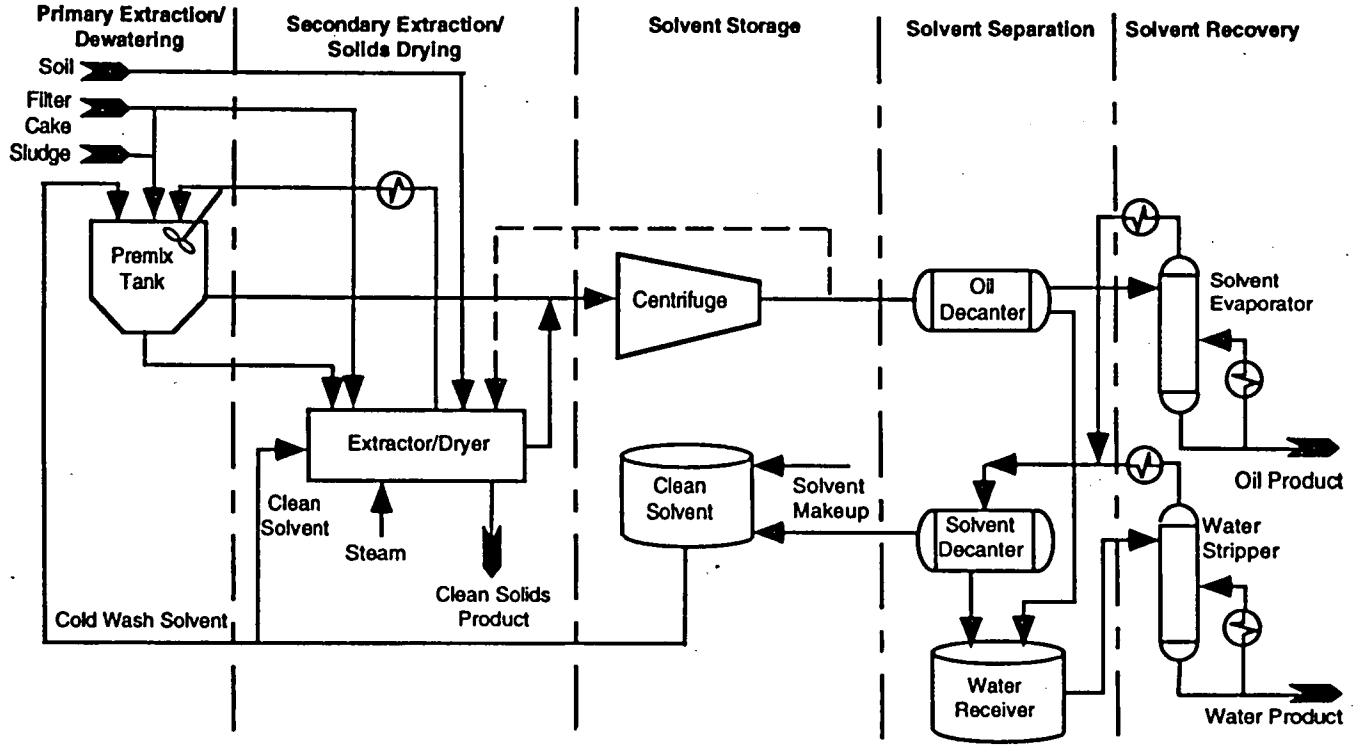
DAVISVILLE RHODE ISLAND

FIGURE 4-2.
SITE 13-DISPOSAL AREA NORTHWEST CAP DESIGN DETAIL

Date: 4/94

Project No. 01042-0040

13CAPDET



SOURCE: RESOUCES CONSERVATION COMPANY B.E.S.T SOLVENT EXTRACTION TECHNOLOGY: APPLICATIONS ANALYSIS REPORT; SUPERFUND INNOVATIVE TECHNOLOGY ELEVATION.

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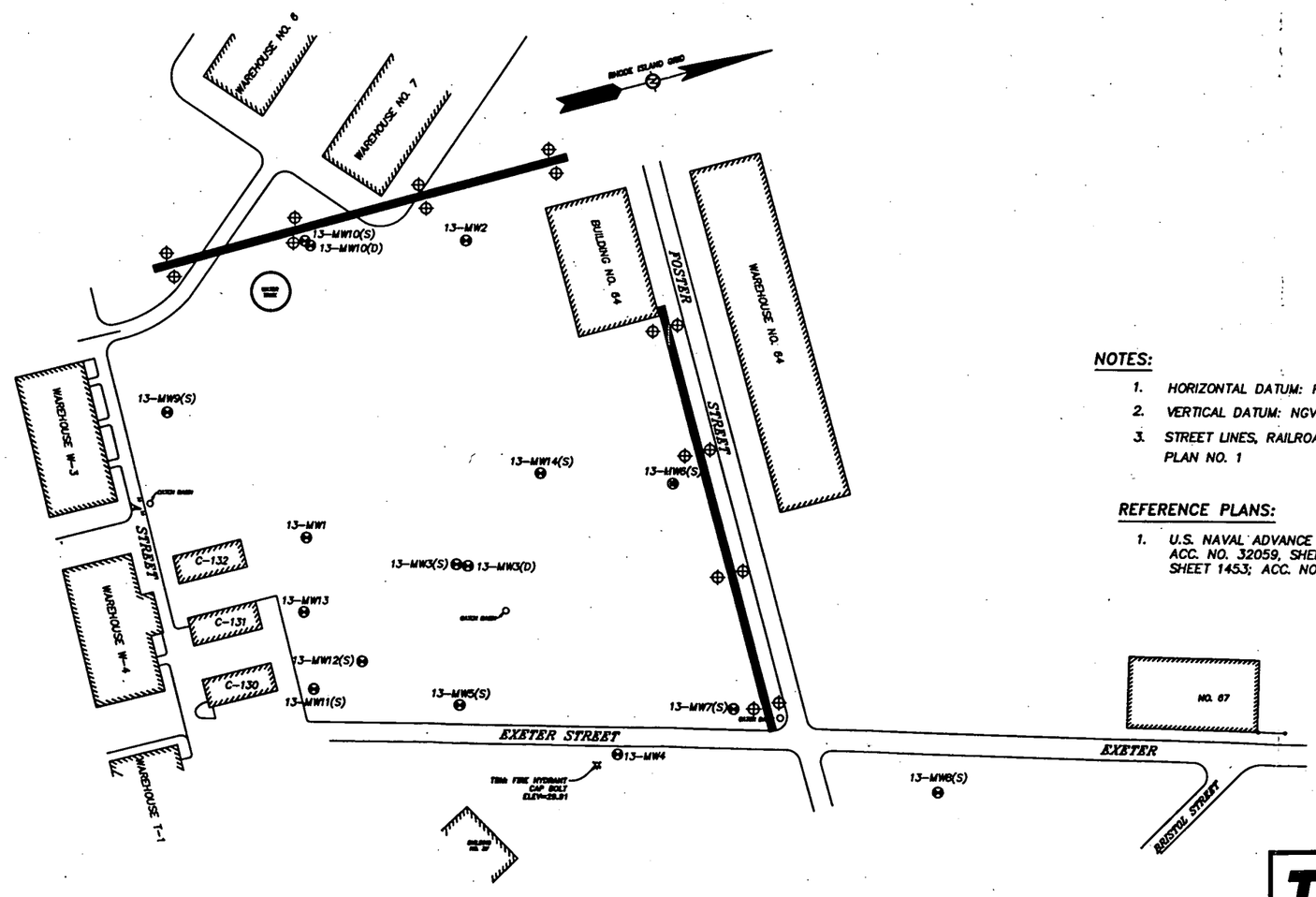
FIGURE 4-3.

SITE 13 - DISPOSAL AREA NORTHWEST GENERALIZED DIAGRAM OF THE B.E.S.T. SOLVENT EXTRACTION PROCESS

Date 4/94 | Project No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

LEGEND:

- ⊕ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▬ ..... PROPOSED INTERCEPTOR TRENCH
- ⊕ ..... PROPOSED PIEZOMETER

60 0 60 120 180 240 FEET
20 0 20 40 60 METERS

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FIGURE 4-4.
SITE 13-DISPOSAL AREA NORTHWEST
ALTERNATIVE GW-3A
LOCATIONS OF PROPOSED
INTERCEPTOR TRENCHES

Date: 4/94 | Project No. 01042-0040

13942200

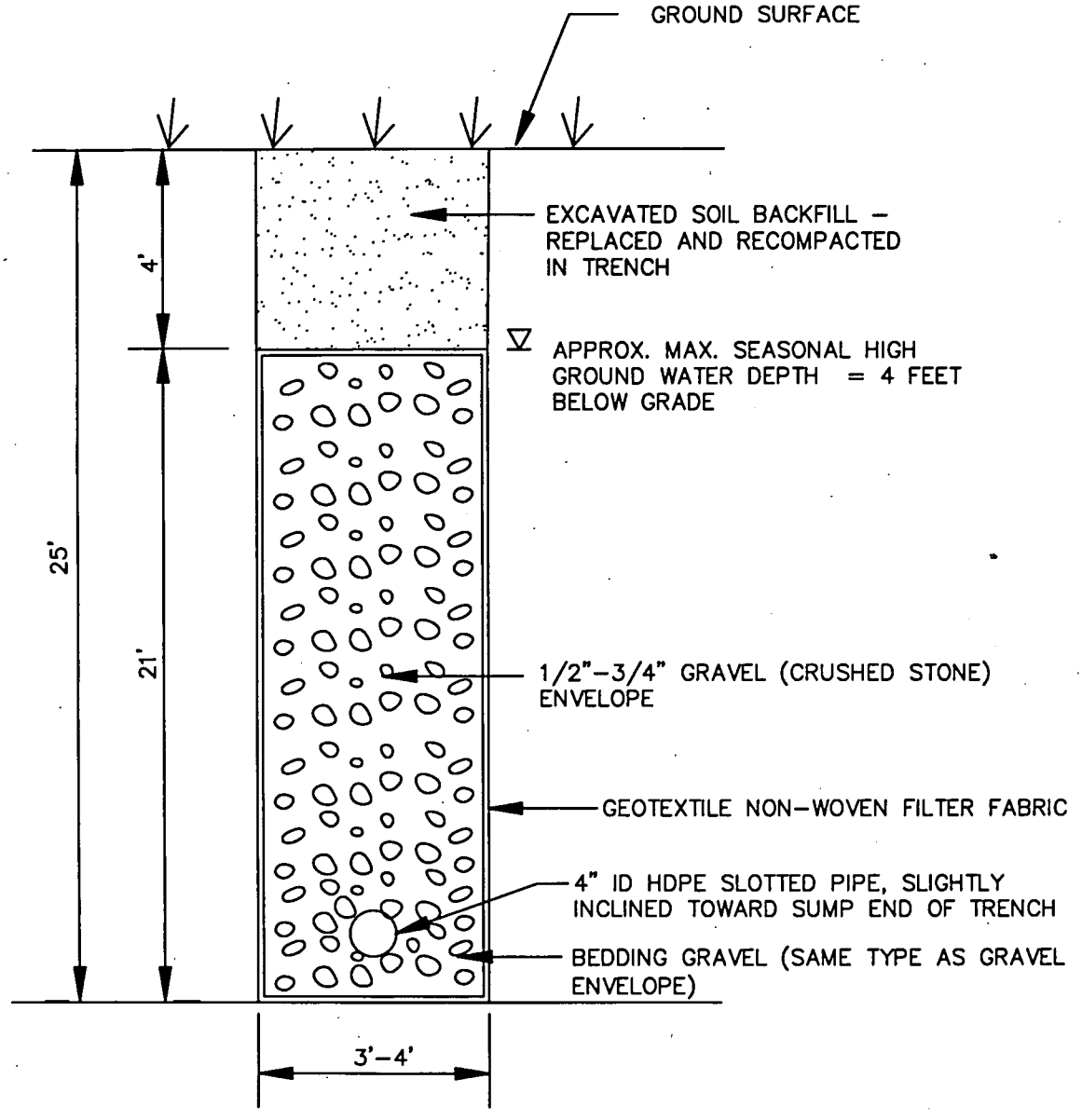

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FIGURE 4–5.

SITE 13–DISPOSAL AREA NORTHWEST GROUND WATER INTERCEPTOR TRENCH CROSS–SECTION

Date: 4/94 | Project No. 01042–0040

13TRENCH

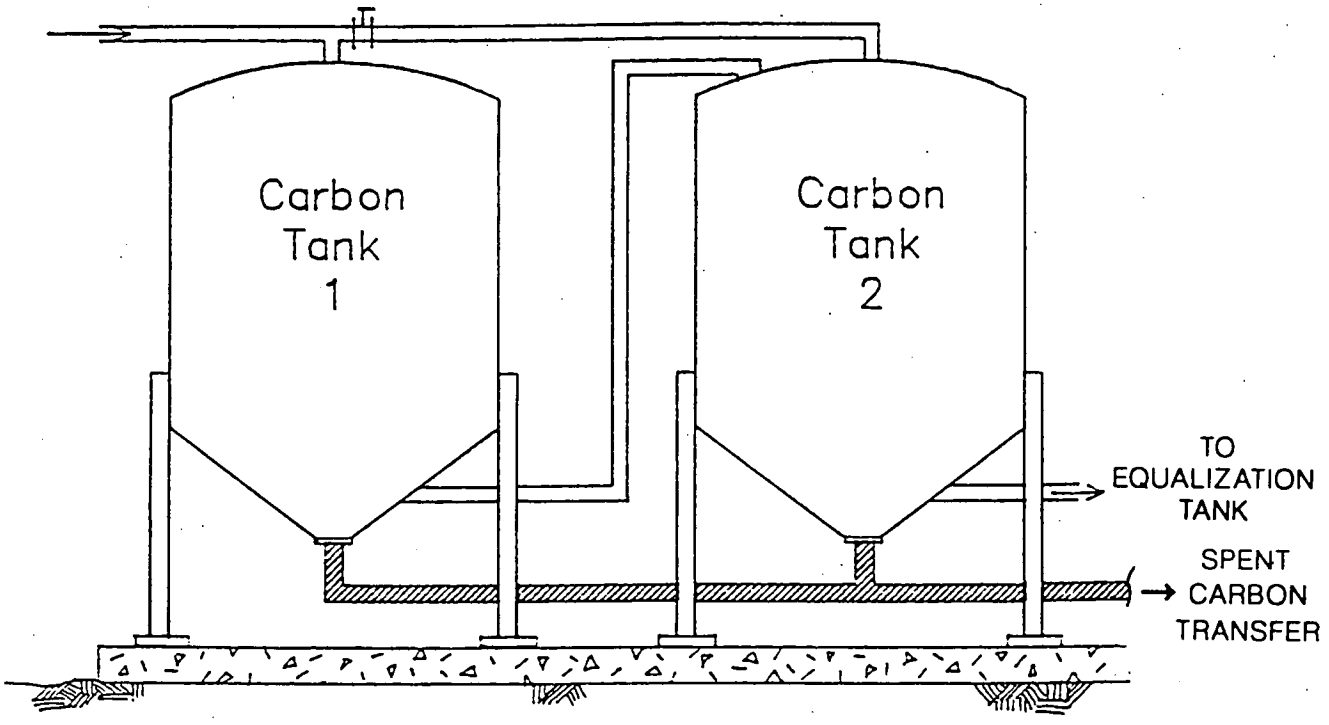

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FIGURE 4-6.

SITE 13 - DISPOSAL AREA NORTHWEST CARBON ADSORPTION SYSTEM

Date 4/94

Project No. 01042-0040

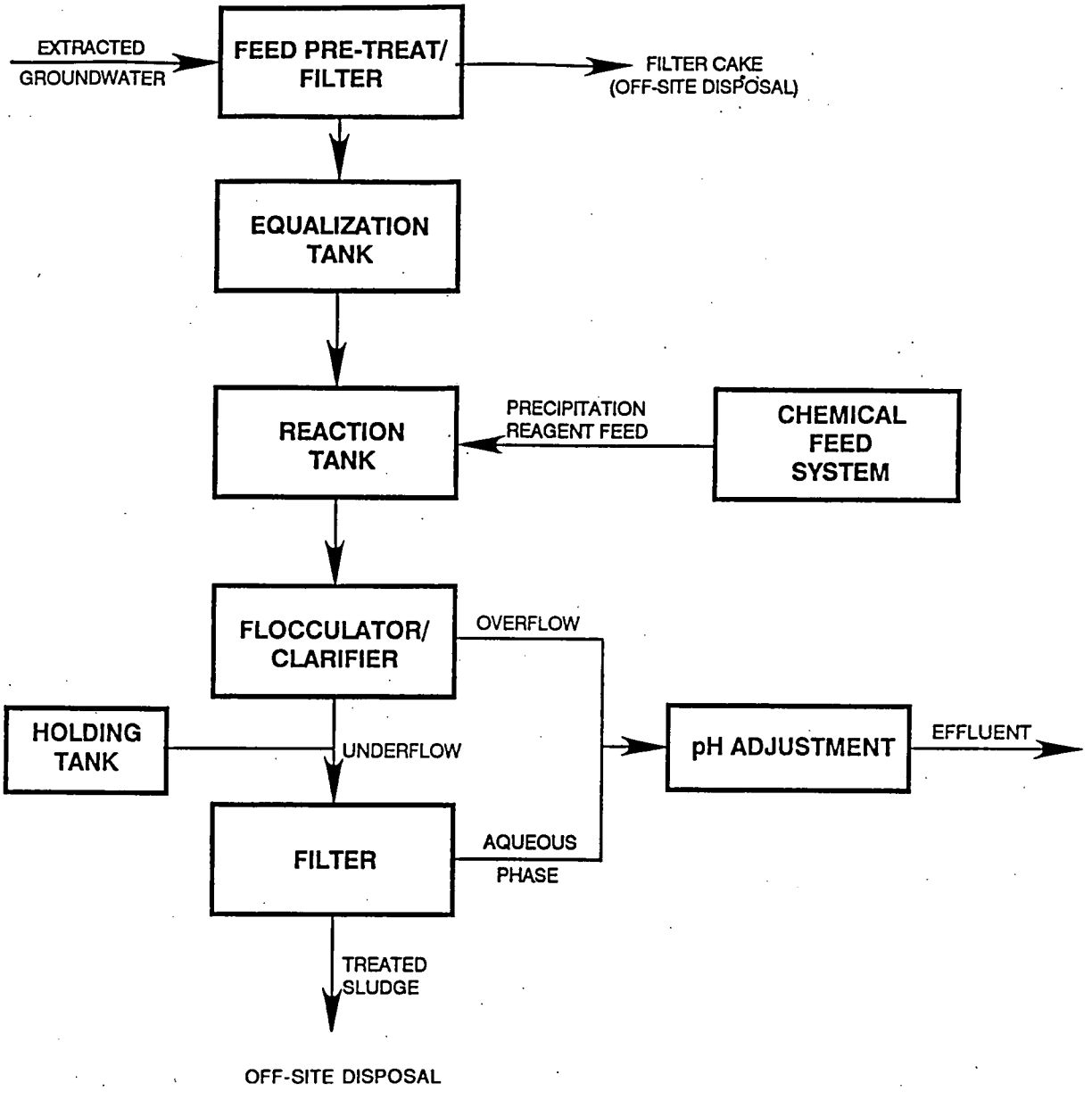

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FIGURE 4-7.

SITE 13 - DISPOSAL AREA NORTHWEST CHEMICAL PRECIPITATION SCHEMATIC

Date: 4/94

Project No. 01042-0040

APPENDIX A

APPENDIX A

IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

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APPENDIX A

IDENTIFICATION OF POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

A.1 Introduction

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA, 1986), and the NCP (1990) require that all remedial response actions attain or exceed applicable or relevant and appropriate requirements of Federal and more stringent promulgated requirements of State environmental statute(s). The NCP defines applicable requirements as "those cleanup standards, standards of control, other substantive environmental protection requirements or criteria, or limitations promulgated under federal environmental or state environmental facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstances found at a CERCLA site." Relevant and appropriate requirements are defined in the NCP as "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" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at the CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site."

To-Be-Considered materials (TBCs) are non-promulgated advisories or guidance issued by federal or state government that are not legally binding and do not have the status of potential ARARs. However, in many circumstances TBCs may be considered along with ARARs in determining the necessary level of cleanup for protection of health or the environment.

Current EPA CERCLA guidance calls for a preliminary identification of potential ARARs during the RI scoping phase to assist in initial identification of remedial alternatives. Early identification also facilitates communications with support agencies to evaluate ARARs, and may help planning of field activities. Because of the iterative nature of the RI/FS process, ARAR identification continues throughout the RI/FS as better understanding is gained of the site conditions, site contaminants, and remedial action alternatives. Findings of the Phase I RI aided

in the selection of ARARs as presented in Volume II of the Phase II RI/FS Work Plan (TRC, 1992). ARARs were further evaluated in the Initial Screening of Alternatives Report (TRC, May 1993). This section revisits the information provided in that report, updating it on the basis of the specific information related to Site 13, as addressed herein, as well as on the basis of evolving regulatory requirements.

ARARs may be categorized as: 1) chemical-specific requirements, which may define acceptable exposure levels and, therefore, be used in establishing preliminary remediation goals; 2) location-specific requirements, which may set restrictions on activities within specific locations such as coastal areas or wetlands; and 3) performance, design or other action-specific requirements, which may set controls or restrictions for particular treatment and disposal activities related to the management of hazardous wastes. The documents "CERCLA Compliance With Other Laws Manual" (USEPA, 1988), and "CERCLA Compliance with Other Laws Manual: Part II. Clean Air Act and Other Environmental Statutes and State Requirements" (USEPA, 1989), contain detailed information on identifying and complying with ARARs. In addition, Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991) provides guidance on the use of ARARs for the development of preliminary remediation goals (PRGs).

A.2 Approach

This evaluation focuses on the identification of potential chemical-specific ARARs/TBCs which will guide the development of PRGs at Site 13. Preliminary location-specific and action-specific ARARs/TBCs are also evaluated herein, but are further evaluated with respect to the individual remedial alternatives in the detailed alternative analysis portion of this report.

To determine the chemical-specific requirements which may be applicable to remediation at Site 13 (i.e., to identify preliminary remediation goals (PRGs) and chemical-specific ARARs which may be applicable to certain remedial actions), an evaluation of federal and State of Rhode Island chemical-specific ARARs was conducted. Those federal and state chemical-specific ARARs considered to potentially be applicable or relevant and appropriate to remedial actions at Site 13 have been compiled, as presented in Tables A-1 and A-2.

A.3 Potential Federal Chemical-Specific ARARs/TBCs

Potential federal chemical-specific ARARS and TBC criteria are presented in Table A-1. Chemical-specific ARARs/TBCs which may be applicable to the development of preliminary remediation goals for the various media at the site are addressed by media below. Following this discussion is a presentation of potential chemical-specific ARARs/TBCs which may be considered in the evaluation of specific remedial actions at the site.

A.3.1 Ground Water

Ground water at NCBC Davisville is not a current source of drinking water, and ground water at Site 13 is classified as GB. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991) provides guidance on the development of PRGs for ground water. Safe Drinking Water Act (SDWA) maximum contaminant levels (MCLs), non-zero maximum contaminant level goals (MCLGs), and state drinking water standards are common ARARs and therefore PRGs for ground water that is a current or potential source of drinking water. Although the ground water at Site 13 is classified as GB, indicating that it would not be suitable for use as a drinking water supply without treatment, there currently is no regulatory mechanism which would prevent the installation of a potable well on-site. Therefore, MCLs, MCLGs and state drinking water standards are considered to be relevant and appropriate to Site 13. Where MCLs, MCLGs and state drinking water standards are unavailable for a particular ground water contaminant, USEPA Risk Reference Doses, Lifetime Health Advisories and Human Health Assessment Group Cancer Slope Factors will be used to develop risk-based PRGs.

A.3.2 Soils

The Toxic Substances Control Act provides PCB cleanup levels for solid surfaces and soils where spills occurred after May 4, 1987. These levels may be relevant and appropriate to the evaluation of any PCB contamination in Site 13 soils. In addition, the Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02) will represent TBC criteria for lead in soils.

A.3.3 Chemical-Specific ARARs Potentially Applicable to Remedial Actions

Chemical-specific federal ARARs/TBCs which are applicable to the implementation of certain remedial actions include Ambient Water Quality Criteria (AWQC) and Effluent Discharge Limitations, both promulgated under the Clean Water Act, which represent potential chemical-specific ARARs for alternatives which involve discharges to surface waters.

The Toxicity Characteristic Leachate Parameter (TCLP) maximum concentrations (40 CFR 261.24) and the land disposal restrictions (40 CFR 268) will be applicable to any action which requires a hazardous waste determination and disposal option evaluation.

Sections of the Clean Air Act which establish maximum concentrations for particulates and fugitive dust emissions, emissions limitations for new sources, and emissions limitations for hazardous air pollutants, are considered potential chemical-specific ARARs for remedial alternatives which impact ambient air.

A.4 Potential Rhode Island Chemical-Specific ARARs/TBCs

A.4.1 Ground Water

Potential Rhode Island chemical-specific ARARs and TBC criteria are presented in Table A-2. As discussed in Section A.3.1, Rhode Island Public Drinking Water Regulations are not applicable to Site 13, based on its GB ground water classification, but are considered to be relevant and appropriate based on the lack of a regulatory mechanism to prohibit installation of a potable well on-site.

A.4.2 Soil

Rhode Island's Rules and Regulations for Solid Waste Management Facilities define solid wastes as including wastes which contain a concentration of 10 ppm or greater PCBs. The Rules and Regulations for Hazardous Waste Management define Type 6 - extremely hazardous waste as including wastes which contain a concentration of 50 ppm or greater PCBs. These regulations may be relevant and appropriate to the evaluation of soil PCB contaminant levels at Site 13. RIDEM and the Rhode Island Department of Health-Risk Assessment consider a safe lead level in soil (total) as under 300 ppm, a TBC in the identification of PRGs at Site 13.

A.4.3 Chemical-Specific ARARs Potentially Applicable to Remedial Actions

Chemical-specific ARARs/TBCs which may be applicable to the implementation of certain remedial actions include the Rhode Island Water Quality Standards, established under the RI Water Pollution Control Law (RIGL, Title 46, Chapter 12), which will be applicable to remedial actions which involve discharges to surface water. The RI Clean Air Act (RI Title 23, Chapter 23) establishes maximum ambient levels for criteria pollutants under the Air Pollution Control Regulation Standards. These levels constitute potential chemical-specific ARARs for remedial alternatives which emit pollutants into the air.

A.5 Potential Location-Specific ARARs/TBCs

A site's location is a fundamental determinant of its impact on human health and the environment. Location-specific ARARs are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they are in a specific location (U.S. EPA, 1988).

A.5.1 Potential Federal Location-Specific ARARs/TBCs

Potential federal location-specific ARARs and TBCs identified as being potentially applicable to Site 13 are listed in Table A-3. Based on the results of a cultural resources survey conducted at the NCBC facility, as described in Cultural Resource Assessment for Base Closure and Realignment, Redevelopment and Reuse at the Naval Construction Battalion Center, Davisville, Rhode Island, prepared by Ecology and Environment, Inc. and dated November 1993, the Archaeological and Historic Preservation Act of 1974 is a potential ARAR for remedial actions at Site 13. The cultural resource survey report concluded that a large portion of Site 13 (approximately 6 acres) has the potential to be an archaeologically sensitive area, based on the fact that the intensity of land modifications in this area is relatively less severe than in other portions of the facility, and subsurface archaeological deposits may remain intact. An archaeological survey has been recommended.

The nearest wetlands are located approximately 1,500 feet northeast of Site 13. Therefore, wetlands/water resources regulations, including Executive Orders 11988 and 11990, Statement of Proceedings of Floodplain Management and Wetlands Protection, the Clean Water

Act Section 404 Requirements for Discharge of Dredge or Fill Material and the Rivers and Harbors Act Prohibition of Filling a Navigable Water will not apply to remedial actions conducted on-site. Coastal area and harbor protection regulations are not applicable due to the site's distance from coastal areas.

The Fish and Wildlife Coordination Act of 1958 was enacted to protect fish and wildlife when federal actions result in the control or structural modification of a natural stream or water body. Since no water bodies are located on or immediately adjacent to the site, the Fish and Wildlife Coordination Act is not expected to be applicable to remedial actions conducted on-site. The Endangered Species Act of 1973, which restricts activities in areas inhabited by registered endangered species, is not considered to be a potential ARAR for Site 13 based on the conclusion of an endangered species survey conducted in 1989 by RIDEM (RIDEM, 1989).

To determine the potential applicability of the Farmland Protection Policy Act, the U.S. Department of Agriculture Important Farmlands Map for Kent County was reviewed. This map, developed on the basis of soil survey information, indicates that limited areas designated as Prime Farmland and Additional Farmland of Statewide Importance are located in the general vicinity of the NCBC Davisville facility but do not encompass or abut Site 13. Therefore, farmland protection regulations are not considered to be applicable to remedial actions at Site 13.

A.5.2 Potential State Location-Specific ARARs/TBCs

No state location-specific ARARs/TBCs were identified as being potentially applicable to Site 13. As noted in Section A.5.1, Site 13 does not encompass or abut any wetland areas. Therefore, the Rhode Island Wetlands Laws are not considered to be potential ARARs for Site 13. Also, since Site 13 is not located adjacent to the coast, Rhode Island Coastal Resources Management Law and Regulations are not applicable to the site.

A.6 Potential Action-Specific ARARs/TBCs

Based on the identification of contaminants in soil and ground water at Site 13, remediation activities may be required and numerous state and federal requirements could apply to the implementation of these activities. As discussed previously, potential action-specific

ARARs/TBCs cannot be well-defined until remedial alternatives are developed and response actions defined. Action-specific ARARs will be defined in more detail in the detailed analysis of alternatives (Section 4 of this report).

A.6.1 Potential Federal Action-Specific ARARs/TBCs

Numerous federally promulgated action-specific ARARs and TBC criteria could potentially affect the implementation of remedial measures. A preliminary evaluation of federal regulatory requirements potentially applicable to remedial activities at Site 13 is presented in Table A-3.

A.6.2 Potential State Action-Specific ARARs/TBCs

The State of Rhode Island has promulgated regulations similar to those of the federal government. A preliminary evaluation of potential state action-specific ARARs which may be applicable to remedial activities at Site 13 is presented in Table A-4.

References

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USEPA, 1988. CERCLA Compliance with Other Laws Manual, Draft Guidance, Part I, OSWER Directive 9234.1-01, August 8, 1988.

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TABLE A-1
FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Ground Water--				
	Safe Drinking Water Act (40 CFR 141.11-.16 and 141.60-.63) Maximum Contaminant Levels (MCL's)	Relevant and Appropriate	MCL's directly apply to "public water systems", defined as systems with at least 15 connections which service a minimum of 25 persons.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLs are relevant and appropriate. Contaminant concentrations are compared to MCLs to assess potential risks associated with ingestion of ground water.
	Safe Drinking Water Act (40 CFR 141.50-.52) Maximum Contaminant Level Goals (MCLGs)	Relevant and Appropriate	Non-enforceable health goals for public water supply systems, set at levels which result in no known or anticipated adverse health effects.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, MCLGs are relevant and appropriate. Non-zero MCLGs are to be used as remedial goals for current or potential sources of drinking water, per the NCP (40 CFR 300). Contaminant concentrations are compared to MCLGs to assess potential risks associated with ingestion of ground water.
	USEPA Risk Reference Doses (RfDs)	To Be Considered	Toxicity values for evaluating noncarcinogenic effects resulting from exposures to contamination.	USEPA RfDs are used to characterize risks due to noncarcinogens in ground water.
	Lifetime Health Advisories	To Be Considered	Guidelines developed based on toxicity for noncarcinogenic compounds	TBC criteria due to the presence of contaminants in ground water.
	USEPA Human Health Assessment Group Cancer Slope Factors (CSFs)	To Be Considered	A slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.	USEPA CSFs are used to compute the individual incremental cancer risk resulting from exposure to certain compounds.

TABLE A-1 (continued)
FEDERAL CHEMICAL-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Surface Water --				
	Clean Water Act (40 CFR 121) Ambient Water Quality Criteria (AWQC)	To be determined	Non-enforceable guidelines established for the protection of human health and/or aquatic organisms.	AWQC will be applicable to remedial alternatives which involve discharges to surface water.
	Clean Water Act (40 CFR 401.15) Effluent Discharge Limitations	To be determined	Regulates the discharge of contaminants from an industrial point source.	Regulations will be applicable to remedial alternatives which involve discharges to surface water.
Soils/Surfaces--				
	Toxic Substances Control Act (40 CFR 761.125)	Relevant and Appropriate	Establishes PCB cleanup levels for soils and solid surfaces.	Applicable to spills of materials containing PCBs at concentrations of 50ppm or greater that occurred after May 4, 1987. These requirements may be relevant and appropriate to the evaluation of PCB levels in site soils.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To Be Considered	Provides guidance on identifying principal threat and low-threat areas of PCB contamination. At industrial sites, PCBs at concentrations of 500 ppm or greater generally pose a principal threat.	Will be considered at Site 13 with respect to soil PCB contamination.
	Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites (OSWER Directive 9355.4-02)	To Be Considered	Sets forth an interim soil cleanup level for lead at 500 to 1000 ppm.	Will be considered at Site 13 with repect to soil lead contamination.
	Toxicity Characteristic (40 CFR 261.24)	To be determined	Establishes maximum concentrations of contaminants for the toxicity characteristic using the test method described in 40 CFR 261 Appendix II.	Applicable where wastes produced as a byproduct of a remedial action require handling as a hazardous waste on the basis of the Toxic Characteristic Leachate Parameter (TCLP) analysis.

TABLE A–1 (continued)
FEDERAL CHEMICAL–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Soils/Surfaces-- (cont.)	Land Disposal Restrictions (40 CFR 268)	To be determined	Establishes maximum concentrations of contaminants on the basis of which hazardous wastes are restricted from land disposal.	This regulation will be applicable to remedial alternatives which utilize land disposal of hazardous waste.
Air--	Clean Air Act (40 CFR 50) National Ambient Air Quality Standards (NAAQS)	To be determined	Establishes maximum levels for pollutants and particulates within air quality control districts.	Potential ARARS for alternatives involving remedial actions which impact ambient air (i.e. incinerators, soil venting, etc.).
	Clean Air Act (40 CFR 60) New Source Performance Standards (NSPS)	To be determined	Establishes emissions limitations for new sources.	Potential ARARS for alternatives involving treatment methods which emit pollutants.
	Clean Air Act (40 CFR 61) National Emissions Standard for Hazardous Air Pollutants	To be determined	Establishes emissions standards for hazardous air pollutants.	Potential ARARS for alternatives involving treatment methods which emit hazardous air pollutants.

TABLE A–2
STATE CHEMICAL–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Ground Water– –				
	RI Ground Water Protection Act (RIGL, 46–13 et seq.) Public Drinking Water Regulations	Relevant and Appropriate	Establishes provisions for the protection and management of potable drinking waters, including the development of ground water classifications and associated standards which specify maximum contaminant levels for each classification.	Ground water at NCBC is not a current source of drinking water, but is classified as GB at Site 13. Since there is no regulatory mechanism to prohibit potable use of the ground water, these regulations are relevant and appropriate and contaminant concentrations will be compared to the established ground water quality standards.
Surface Water – –				
	RI Water Pollution Control Law (RIGL 46–12 et seq.) RI Water Quality Standards	To be determined	Establishes water use classification and water quality criteria for all waters of the state. Also establishes acute and chronic water quality criteria for the protection of aquatic life.	Regulation will be applicable for remedial alternatives which involve discharges to surface water.
Soils/Surfaces– –				
	Lead Soil Cleanup Standards (Guidance)	To Be Considered	RIDEM and the Rhode Island Department of Health–Risk Assessment consider a safe lead level in soil (total) to be under 300 ppm.	To be considered with respect to lead soil contamination.
	RI Hazardous Waste Management Act of 1987 (RIGL 23–19.1 et seq.) Rules and Regulations for Hazardous Waste Management	Relevant and Appropriate or Applicable	Defines Type 6 – extremely hazardous waste as including wastes which contain PCBs at a concentration of 50 ppm or greater or showing 10 micrograms/ 100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
	Rules and Regulations for Solid Waste Management Facilities	Relevant and Appropriate or Applicable	Defines solid waste as including any soil, debris or other material with a concentration of PCBs of 10 ppm or greater or containing 2 micrograms/100 sq. cm. or greater as measured by a standard wipe test.	Relevant and appropriate to the development of PRGs for soil.
Air– –				
	RI Clean Air Act (RIGL Title 23, Chapter 23) Air Pollution Control Regulation Standards	To be determined	Establishes maximum ambient levels for criteria pollutants.	Potential ARARs for remedial alternatives involving treatment methods which emit criteria pollutants.

TABLE A–3
FEDERAL LOCATION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC – DAVISVILLE

MEDIA	REQUIREMENT	STATUS	SYNOPSIS	APPLICABILITY TO SITE CONDITIONS
Historic Places– –	Archaeological and Historic Preservation Act of 1974 (132 CFR 229 & 229.4, 43 CFR 7 & 7.4) Protection of Archaeological and Historic Lands	To be determined	Restricts the use of land of known archaeological or historical significance.	Potential ARAR since Site 13 is located within a potential archaeologically significant area.

TABLE A–4
FEDERAL ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On–site/ Off–site Treatment/ Disposal	Resource Conservation and Recovery Act (RCRA) (40 CFR 262) Generator Requirements for Manifesting Waste for Off–Site Disposal	To be determined	Standards for manifesting, marking and recording off–site hazardous waste shipments for treatment/disposal.	This regulation will be applicable to alternatives which utilize an off–site disposal/treatment method for hazardous wastes.
	RCRA (40 CFR 263) Transporter Requirements for Off–Site Disposal	To be determined	Standards for transporters of hazardous waste materials.	This regulation will be applicable to alternatives which utilize an off–site disposal/treatment method for hazardous wastes.
	RCRA (40 CFR 264 and 265) Requirements for Hazardous Waste Treatment Facility Design and Operating Standards for Treatment and Disposal Systems	To be determined	Outlines specifications and standards for design, operation, closure and monitoring of performance for hazardous waste storage, treatment and disposal facilities.	Potential ARARs for alternatives which utilize a surface impoundment, waste pile, landfill, land treatment, incineration or miscellaneous treatment units for on–site storage/disposal/treatment of hazardous wastes.
	RCRA (40 CFR 264.10–264.18) Subpart B – General Facility Standards	To be determined	General requirements regarding waste analysis, security, training, inspections, and location applicable to a facility which stores, treats or disposes of hazardous wastes (a TSDF facility).	This regulation may be applicable to a remedial action conducted at Site 13, if it meets the definition of a TSDF.
	RCRA (40 CFR 264.30–264.37) Subpart C – Preparedness and Prevention	To be determined	Requirements applicable to the design and operation, equipment, and communications associated with a TSDF facility, and to arrangements with local response departments.	This regulation may be applicable to a remedial action conducted at Site 13, if it meets the definition of a TSDF.
	RCRA (40 CFR 264.50–264.56) Subpart D – Contingency Plan and Emergency Procedures	To be determined	Emergency planning procedures applicable to a TSDF facility.	This regulation may be applicable to a remedial action conducted at Site 13, if it meets the definition of a TSDF.

TABLE A-4(continued)
FEDERAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Treatment/ Disposal (cont.)	RCRA (40 CFR 264) Subpart F Ground Water Protection	To be determined	Ground water monitoring/corrective action requirements; dictates adherence to MCLs and establishes points of compliance.	Potential ARARs for alternatives which involve placement of hazardous wastes within solid waste management units, including surface impoundments, waste piles, and land treatment units.
	RCRA (40 CFR 264) Subpart G Closure/Post Closure Requirements	To be determined	Establishes requirements for the closure and long-term management of a hazardous disposal facility.	Applicable to the closure of any hazardous waste management facility.
	RCRA (40 CFR 264) Subpart I Use and Management of Containers	To be determined	Outlines use and management standards applicable to owners and operators of all hazardous waste facilities that store containers of hazardous waste.	Potential ARARs for remedial actions which require storage of hazardous waste in containers.
	RCRA (40 CFR 264) Subpart L Waste Piles	To be determined	Regulates owners and operators of facilities that store or treat hazardous waste in piles.	Potential ARARs for remedial alternatives which utilize a waste pile for on-site storage/treatment of hazardous waste.
	RCRA (40 CFR 264) Subpart O Incinerator Restrictions	To be determined	Outlines specifications and standards for incinerating hazardous waste.	Potential ARARs for alternatives which utilize incineration for on-site treatment of hazardous wastes.
	RCRA (40 CFR 265) Subpart Q - Chemical, Physical and Biological Treatment	To be determined	General operating, waste analysis and trial test, inspection and closure requirements for facilities which treat hazardous waste by chemical, physical or biological methods in other than tanks, surface impoundments and land treatment facilities.	Remedial alternatives which utilize chemical, physical and biological treatment methods as described to treat hazardous wastes will meet these requirements.

TABLE A-4(continued)
FEDERAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Off-site Treatment/ Disposal (cont.)	RCRA (40 CFR 264.600-264.999) Subpart X - Miscellaneous Units	To be determined	Environmental performance standards, monitoring requirements and post-closure care requirements applicable to miscellaneous units (not otherwise defined in the RCRA regulations) used to treat, store or dispose of hazardous waste.	Potential ARARs for remedial actions involving hazardous waste treatment, storage or disposal in units not otherwise covered under RCRA regulations.
	RCRA (40 CFR 268) Land Disposal Restrictions	To be determined	Identifies hazardous wastes that are restricted from land disposal and sets treatment standards for restricted wastes.	This regulation will be applicable to alternatives which utilize land disposal of hazardous wastes.
	Hazardous Materials Transportation Act (49 CFR 170, 171) Rules for Transportation of Hazardous Materials	To be determined	Procedures for packaging, labelling, manifesting, and off-site transport of hazardous materials.	This regulation will be applicable to alternatives which include off-site transport of hazardous materials.
	Toxic Substances Control Act (15 USC. Sect. 2601) Subpart D - Storage and Disposal Requirements for PCBs	To be determined	Establishes requirements for the storage, landfilling, and incineration of PCBs.	This regulation may be applicable or relevant and appropriate to alternatives which involve handling of PCB-contaminated materials.
	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To be determined	Describes the recommended approach for remediating Superfund sites with PCB contamination.	This guidance will be considered in the evaluation of treatment/disposal actions.
Containment	Guidance on Remedial Actions for Superfund Sites with PCB Contamination (OSWER Directive 9355.4-01)	To be determined	Describes the recommended approach for remediating Superfund sites with PCB contamination.	This guidance will be considered in the evaluation of containment actions.
Discharge	Safe Drinking Water Act (40 CFR 144 and 146) Underground Injection Control Requirements	To be determined	Establishes the general requirements, technical criteria and standards for underground injection wells.	This regulation will be applicable to alternatives in which treated water is discharged back to the ground water.
	Clean Water Act (40 CFR 122-125) National Pollutant Discharge Elimination System (NPDES) Permit Requirements	To be determined	Permits contain applicable effluent standards (i.e., technology-based and/or water quality-based), monitoring requirements, and standards and special conditions for discharge.	This regulation will be applicable to alternatives in which treated water is discharged to surface waters or back to the ground water.

TABLE A-4(continued)
FEDERAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Discharge (cont.)	Clean Water Act (40 CFR 403) Discharge to Publicly- Owned Treatment Works (POTW)	To be determined	A national pretreatment program designed to protect municipal wastewater treatment plants and the environment from damage that may occur when hazardous, toxic or other non-domestic wastes are discharged into a sewer system.	This regulation is applicable to alternatives in which waters are discharged to a POTW.
Venting/ Discharges to Air	Clean Air Act (40 CFR 50) National Ambient Air Quality Standards (NAAQS)- Particulates	To be determined	Establishes maximum concentrations for particulates and fugitive dust emissions.	ARARs for alternatives involving treatment methods which impact ambient air (i.e. incineration, soil venting, etc.).
	Clean Air Act, Section 5 171 through 178, 42 USC §§ 7471-7478 (Requirements for Non-Attainment Areas)	To be determined	RI has adopted State Implementation Plan (SIP) requirements approved and enforcable by EPA which meet the New Source Review (NSR) requirement of the CAA. These provisions require that new or modified major sources of VOCs defined as a source which has the potential to emit 50 tpy install equipment to meet Lowest Available Emissions Rate (LAER), which is set on a case-by-case basis and is either the most stringent emissions limitation contained in any SIP for that category or source or the most stringent emissions limitation which is achieved for the source. NSR requirements apply to non-attainment pollutants, which are VOCs and NO_x in RI.	Monitoring will be conducted to determine if the requirements of this standard are applicable or relevant and appropriate based on the emissions levels and on the need to be protective of human health and the environment.
	Clean Air Act, Section 5 160 through 169A - Prevention of Significant Deterioration Provisions	To be determined	RI has adopted SIP requirements approved and enforceable by EPA which meet the Prevention of Significant Deterioration (PSD) requirements of the CAA. These provisions require that new or modified major sources of VOCs, defined as a source which has the potential to emit 25 tons/year, install equipment to meet Best Available Control Technology (BACT). PSD requirements apply to attainment pollutants, which are SO2, CO, lead and particulates in Rhode Island.	Monitoring will be conducted to determine if the requirements of this standard are applicable or relevant and appropriate based on the emissions levels.

TABLE A-4(continued)
FEDERAL ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharges to Air (cont.)	Clean Air Act (40 CFR 61) National Emissions Standards for Hazardous Pollutants (NESHAPS)	To be determined	Establishes emissions limitations for hazardous air pollutants, and sets forth regulated sources of those pollutants.	Potential ARARs for alternatives using treatments (i.e., incineration, etc.) which result in emissions to the air.
	RCRA 40 CFR 265.375 Subpart P - Thermal Treatment	To be determined	Establishes requirements for air emissions from thermal treatment units.	Remedial actions which involve thermal treatment units, as defined in 40 CFR 265.370, will meet these standards.
	RCRA 40 CFR 264.1030 - 264.1036 Subpart AA - Air Emission Standards for Process Vents	To be determined	Establishes standards for air emissions from process vents associated with distillation, fractionation, thin film evaporation, column extraction or air steam stripping operations that treat RCRA substances and have total organic concentrations of 10 ppm or greater.	If these technologies are utilized and the threshold organic concentration is met, air emissions will comply with the standards.
	RCRA 40 CFR 264.1050 - 264.1065 Subpart BB - Air Emission Standards for Equipment Leaks	To be determined	Establishes standards for air emissions for equipment that contains or contacts RCRA wastes with organic concentrations of at least 10% by weight.	If such concentrated wastes are treated, the equipment used will meet these standards.
	EPA Technical Guidance Document: Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0.28)	To Be Considered	Guidance regarding the control of air emissions from air strippers used at Superfund sites for ground water treatment. Distinguishes between attainment and non-attainment areas for ozone.	These guidelines will be considered if air stripping is used as a ground water treatment alternative.

TABLE A-5
STATE ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
On-site/ Off-site Disposal/ Treatment	RI Hazardous Waste Management Act of 1978 (RIGL 23-19.1 et seq.) • Hazardous Waste Management Rules and Regulations	To be determined	Rules and regulations for hazardous waste generation, transportation, treatment, storage, and disposal.	These rules will be applicable for alternatives which involve the on- or off-site management of hazardous wastes.
	• Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (Site Remediation Regulations)	To be determined	Rules and regulations for the investigation and remediation of releases of hazardous materials.	These rules will be applicable to the design and operation of remedial systems.
	RI Hazardous Substance Community Right to Know Act (RIGL, Title 23, Chapter 24.4) Public Right-to-Know Requirements	To be determined	Establishes rules for the public's right-to-know concerning hazardous waste storage and transportation.	These rules will be applicable for alternatives which involve the on- or off-site management of hazardous wastes.
	RI Refuse Disposal Law Rules and Regulation for Solid Waste Management Facilities	To be determined	Rules and regulations for solid waste management facilities.	ARARs for alternatives involving the on-site storage and disposal of solid wastes.
Discharge	RI Water Pollution Control Act • RI Water Quality Regulations for Water Pollution Control (RIGL 46-12 et seq.) RI Water Quality Standards	To be determined	Establishes general requirements and effluent limits for discharge to area waters.	This regulation will be applicable to alternatives in which treated water is discharged to area surface water or ground water.
	• Regulations for the RI Pollutant Discharge Elimination Systems (RIGL 46-12 et seq.)	To be determined	Permits contain applicable effluent standards (i.e., technology-based and/or water quality-based), monitoring requirements, and standards and special conditions for discharge.	This regulation will be applicable to alternatives in which treated water is discharged to area surface water or ground water.

TABLE A–5(continued)
STATE ACTION–SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 – DISPOSAL AREA NORTHWEST OF BUILDINGS W–3, W–4 AND T–1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Discharge (cont.)	RI Water Pollution Control Act			
	• RI Pretreatment Regulations (RIGL 46–12 et seq.)	To be determined	Covers pollutants in wastewaters which can have detrimental effects on POTW processes. Sets specified limitations, pretreatment and monitoring requirements for discharges to POTWs based on federal regulations.	Remedial actions which include discharge to a POTW will meet all required discharge limitations.
	• RI Underground Injection Control Regulations (RIGL 46–12 et seq.)	To be determined	Establishes the general requirements, technical criteria and standards for underground injection wells.	This regulation will be applicable to alternatives in which treated water is discharged back to the ground water via injection.
	• RI Ground Water Protection Act (RIGL, Title 46, Chapter 13.1) Protection of Ground Water	To be determined	Establishes ground water classifications and maximum contaminant levels for each classification.	Potential ARARs for alternatives involving the treatment of contaminated ground water.
Venting/ Discharge to Air	RI Clean Air Act (RIGL, Title 23, Chapter 23) General Air Quality and Air Emissions Requirements	To be determined	Sets emissions limitations for particulates and visible air contaminants.	ARARs for alternatives involving remedial actions which impact ambient air.
	RI Clean Air Act (RIGL, Title 23, Chapter 23) General Air Quality and Air Emissions Requirements • RI Air Pollution Control Regulations, RI Dept. of Health, Div. of Air Pollution Control, effective 8/2/67, most recently amended 5/20/91			
	– Regulation No. 1 – Visible Emissions	To be determined	No air contaminant emissions will be allowed for more than 3 minutes in any one hour which are greater than or equal to 20% opacity.	Air emissions from remedial actions will meet emission levels in regulation.

TABLE A-5(continued)
STATE ACTION-SPECIFIC ARARs AND TBCs
FEASIBILITY STUDY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
NCBC DAVISVILLE

AUTHORITY/ ACTION	REQUIREMENT	STATUS	SYNOPSIS	ACTION TAKEN TO MEET ARAR
Venting/ Discharge to Air (cont.)	RI Clean Air Act (cont.) • RI Air Pollution Control Regulations, (cont.)			
	– Regulation No. 5 – Fugitive Dust	To be determined	Requires that reasonable precaution be taken to prevent particulate matter from becoming airborne.	On-site remedial actions will use good industrial practices to prevent particulate matter from becoming airborne.
	– Regulation No. 7 – Emissions Detrimental to Person or Property	To be determined	Prohibits emissions of contaminants which may be injurious to human, plant or animal life or cause damage to property or which reasonably interferes with the enjoyment of life and property.	All emissions will meet this requirement or gas treatment will be required.
	– Regulation No. 9 – Approval to Construct, Install, Modify or Operate	To be determined	Establishes guidelines for the construction, installation, modification or operation of potential air emission units. Establishes permissible emission rates for some contaminants.	Technologies involving construction, installation, modification or operation of air emission units will meet these requirements.
	– Regulation No. 15 – Control of Organic Solvent Emissions	To be determined	Limits the amount of organic solvents emitted to the atmosphere.	If emissions exceed limits in this regulation, emission controls will be designed and implemented to meet these requirements.
	– Regulation No. 17 – Odors	To be determined	Prohibits the release of objectionable odors across property lines.	No remedial action or air emissions will emit objectionable odors beyond the facility boundary, as practicable.
	– Regulation No. 22 – Air Toxics	To be determined	Prohibits the emission of specified contaminants at rates which would result in ground level concentrations greater than acceptable ambient levels or acceptable ambient levels with LAER, as set in the regulation.	If air emissions contain regulated substances, air emissions control equipment will be used as necessary to meet these standards.

APPENDIX B

APPENDIX B

CALCULATION OF PRELIMINARY RISK-BASED REMEDIATION GOALS

Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals), Interim (USEPA, 1991a) provides guidance on the development of risk-based preliminary remediation goals (PRGs). One of the initial steps in development of PRGs is the identification of the most appropriate future land use for the site so that the appropriate exposure pathways, parameters and equations can be used to calculate PRGs. At Site 13, based on the Comprehensive Base Reuse Plan, the most appropriate future land use is for economic/industrial development. Therefore, exposures to surface soils and ground water, evaluated under the Human Health Risk Assessment for the future commercial/industrial use exposure scenario, will guide the development of PRGs.

According to the OSWER directive "Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions" (USEPA, 1991b), action is generally warranted at a site when the cumulative non-carcinogenic Hazard Index (HI) exceeds 1 based on reasonable maximum exposure (RME) assumptions. Therefore, the cumulative risks associated with a given medium under future commercial/industrial use were evaluated to determine if any medium poses a cumulative cancer risk greater than 10^{-4} or HI greater than 1. At Site 13, exposure to ground water results in a cumulative carcinogenic risk of 4×10^{-4} and the non-cancer RME HI is 10. Cumulative risks associated with exposure to surface soils were 1×10^{-3} (cancer risk) or less than 1 (non-cancer HI). Therefore, the development of PRGs was evaluated with respect to ground water and surface soil exposures.

As described in the National Contingency Plan [40 CFR 300.430(e)(2)(i)(A)(2)], "The 10^{-6} risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available...". As summarized in Table B-1, those soil and ground water constituents which contributed an individual RME cancer risk of greater than 1×10^{-6} to the overall cancer risk estimate, or an individual RME hazard quotient of greater than one to the total hazard index for noncarcinogenic risks, were identified and then evaluated to determine if there were any for which an ARAR/TBC was not available. For those constituents

without an associated ARAR/TBC, a risk-based preliminary remediation goal (PRG) was calculated, based on a future commercial/industrial use scenario. As shown in Tables B-2 and B-3, the calculations for soil and ground water, respectively, incorporate commercial/industrial worker exposures as an adult. Under this scenario, exposure is assumed to occur through incidental ingestion of surface soil, dermal contact with surface soil, and ingestion of ground water. The exposure parameters for the soil and ground water calculations are taken directly from the risk assessment portion of the Phase II RI.

It should be noted that for a number of sites at NCBC (i.e., Sites 9, 10, 11, and 13), the data for benzo(b)fluoranthene (B(b)F) and benzo(k)fluoranthene (B(k)F) in soil were provided by the laboratory in two different ways; namely as B(b)F and B(k)F separately and as B(b)F and B(k)F combined (see the summary statistics tables within the Human Health Risk Assessment, TRC, 1993b). In order to avoid carrying through this artifact of data analysis/reporting into the exposure and risk estimates, exposure point concentrations (EPCs) were estimated for B(b)F and B(k)F combined using both sets of data. In doing so, the values reported separately for B(b)F and B(k)F were summed and treated as detected if one or both chemicals were reported as detected. Thus, the estimated "detected" concentrations (and therefore EPCs) for B(b)F and B(k)F combined may exceed those for B(b)F and B(k)F individually, and/or B(b)F and B(k)F combined as reported by the laboratory. Another result is that cancer risks above 1×10^{-6} may have been estimated for B(b)F and B(k)F "combined" even though no single detection of B(b)F, B(k)F, and/or B(b)F and B(k)F combined exceeded the risk-based preliminary remediation goal (PRG). This is the case for Site 13, where the risk associated with the two compounds combined exceeds 1×10^{-6}, however neither compound was detected at a level exceeding the PRG.

References

USEPA, 1991a. Risk Assessment Guidance for Superfund: Volume I - Human Health Evaluation Manual (Part B, Development of Risk-Based Preliminary Remediation Goals), Interim. EPA/540/R-92/003, December 1991.

USEPA, 1991b. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30, April 1991.

Table B–1

Constituents Considered for the Development of Risk–Based
Preliminary Remediation Goals [a]
Site 13 – Disposal Area Northwest

Constituent	Scenario	Medium	Cancer Risk or Hazard Quotient Elevated?	Soil ARAR or Ground Water MCL Available?	Selected for Development of Risk–Based PRGs?
Beryllium	Commercial	Soil	CR_{RME}	No	**Yes**
Benzo(b/k)flouranthene	Commercial	Soil	CR_{RME}	No	**Y s**
Aroclor–1254	Commercial	Soil	CR_{RME}	Yes	**No**
Aroclor–1260	Commercial	Soil	CR_{RME}	Yes	**No**
Arsenic	Commercial	Ground Water	CR,HQ_{RME}	Yes	No
Beryllium	Commercial	Ground Water	CR	Yes	No
Manganese	Commercial	Ground Water	HQ	No	**Yes**
Bis(2–ethylhexyl)phthalate	Commercial	Ground Water	CR_{RME}	Yes [b]	No

[a] i.e., Constituents associated with individual cancer risks above 1E–06 or hazard quotients above 1 as estimated under the key exposure scenario for each medium (i.e., commercial/industrial for surface soil and for ground water)
[b] Di(2–ethylhexyl)phthalate (synonym)

Table B–2

Cancer–Risk–Based Preliminary Remediation Goals (PRGs) for Constituents in Soil
Assuming Future Commercial/Industrial Land Use
Site 13 – Disposal Area Northwest

Constituent	Oral Slope Factor (SF) $(mg/kd*d)^{-1}$	Oral Relative Absorption Factor (RAF) (––)	Dermal Relative Absorption Factor (RAF) (––)	Soil PRG [a] (mg/kg)
Beryllium	4.3E+00	1	NA	1.3E+00
Benzo(b)fluoranthene	7.3E+00 [b]	1	NA	7.8E–01 [c]
Benzo(k)fluoranthene	7.3E+00 [b]	1	NA	7.8E–01 [c]

a Based on USEPA (1991) guidance and Phase II Human Health Risk Assessment

b Carcinogenic PAHs assigned slope factor for benzo(a) pyrene per EPA Region I guidance

c Corresponds to a PRG for all seven carcinogenic PAHs in soil combined of ~5.5 mg/kg

$$PRG = [TR * AT * BW] / [SF * CF * (IR_s * RAF_o + CR_s * RAF_d) * EF * ED]$$

Where:

TR = Target cancer risk:	1E–06	––
AT = Averaging time:	25550	d
BW = Body weight:	70	kg
SF = Oral cancer slope factor:	CS	Chemical–specific
CF = Conversion factor:	1E–06	kg/mg
IR_s = Soil ingestion rate:	50	mg/d
RAF_o = Oral Relative absorption factor:	CS	Chemical–specific
CR_s = Soil contact rate:	500	mg/d
RAF_d = Dermal Relative absorption factor:	CS	Chemical–specific
EF = Exposure frequency:	250	d/yr
ED = Exposure duration:	25	yr

Table B–3

Non–Cancer–Risk–Based Preliminary Remediation Goals (PRGs)
for Constituents in Ground Water
Assuming Future Commercial/Industrial Use
Site 13 – Disposal Area Northwest

Constituent	Oral Reference Dose (RfD) $(mg/kd*d)^{-1}$	Oral Relative Absorption Factor (RAF) (– –)	Ground Water PRG [a] (mg/l)
Manganese	5.0E–03	1	5.1E–01 [b]

[a] Based on USEPA (1991) guidance and Phase II Human Health Risk Assessment
[b] PRG is within or less than concentrations detected upgradient for all sites (i.e., 0.034 mg/l at 03–MW03 to 2.2 mg/l at 10–MW05).

$PRG = [THI * AT * BW] / [(1/RfD) * IR_w * RAF_o * EF * ED]$

Where:

THI = Target hazard index:	1 – –
AT = Averaging time:	9125 d
BW = Body weight:	70 kg
RfD = Reference dose:	CS Chemical–specific
IR_w = Water ingestion rate:	1 l/d
RAF_o = Oral relative absorption factor:	CS Chemical–specific
EF = Exposure frequency:	250 d/yr
ED = Exposure duration:	25 yr

APPENDIX C

APPENDIX C

EVALUATION OF LEACHING POTENTIAL BASED ON APPLICATION OF LEACHING MODEL

To evaluate the potential for surface and subsurface soil contaminants to leach into the ground water, an infiltration/leaching model was used. USEPA's document entitled Determining Soil Response Action Levels Based on Potential Contaminant Migration to Ground Water: A Compendium of Examples (EPA/540/2-89/057, October 1989) presents various methods which have been used to derive soil cleanup levels based on potential threats to ground water quality.

The Summers model and the "unnamed" model, as described in this USEPA document, were evaluated in terms of applicability to site conditions at Site 13 - Disposal Area Northwest. Both of these three-dimensional models assume that a percentage of rainfall will infiltrate and desorb contaminants from the soil based on equilibrium soil:water partitioning. It is assumed that this contaminated infiltration will mix completely with ground water below the site, resulting in an equilibrium ground water concentration with all contaminants from the infiltration in the final mixture. The Summers model is applicable to a large spill area and is based on a mass balance approach which is applied to the entire area and affected soil volume of the spill. Therefore, it involves a mass balance of the total volume and contaminant concentration of infiltration over the entire area of the site, the total volume and contaminant concentration of ground water flowing into the site area, and the total volume and contaminant concentration of ground water exiting the site.

The unnamed model is a variation of the Summers model in which the mass balance approach is applied to a column of the site, of unit area and of depth equal to the saturated portion of the aquifer. Since subsurface contamination at Site 13 is heterogeneous, characterized by small areas of elevated contamination, rather than consistently contaminated throughout the areal extent of the site, application of the unnamed model was determined to be more appropriate. The unnamed model also provides for the separate estimation of critical saturated and unsaturated soil contaminant levels.

Data Requirements

- Volumetric flow rate of recharge flowing downward through a unit area (based on the infiltration rate of precipitation) (cf/day)
- Volumetric flow rate of ground water in saturated zone in water column through unit width (cf/day)
- Concentration of contaminant in ground water recharge (μg/l)
- Hydraulic conductivity (ft/day)
- Hydraulic gradient (ft/ft)
- Concentration of contaminant adsorbed to the soil in the unsaturated zone (μg/kg)
- Concentration of contaminant in ground water in the saturated zone (μg/l)
- Total organic carbon concentration (mg/mg)

Method Description

In the unnamed model, soil cleanup levels (or maximum allowable soil contaminant levels) are calculated for saturated and unsaturated soils assuming equilibrium between dissolved and adsorbed phases for each contaminant using the following relationship:

$$S_{sat} = (K_d)(C_{sat}) \tag{1}$$

where: S_{sat} = concentration of contaminant adsorbed to the soil in the saturated zone (μg/kg)
K_d = distribution coefficient
C_{sat} = concentration of contaminant in ground water in saturated zone (μg/l)

The K_d is calculated as follows:

$$K_d = (0.63)(F_{oc})(K_{ow}) \tag{2}$$

where: 0.63 = Adjustment factor
F_{oc} = total organic carbon concentration in soil (mg/mg)
K_{ow} = octanol-water partition coefficient

In calculating K_d, it is assumed that the maximum desired contaminant concentration for ground water is equal to an established health-based criteria (i.e., MCLs). Using equation (1), the maximum soil contaminant concentration in the saturated zone may then be calculated.

Subsequent calculations to derive unsaturated soil maximum contaminant concentrations include the assumption that dissolved contamination in ground water recharge reaches equilibrium with the adsorbed phase on unsaturated soils, and that such recharge is fully diluted into the entire water column upon reaching the water table. Thus the maximum unsaturated soil

contaminant level is established using equation (1) and a dilution equation for calculating C_{sat}, the contaminant concentration in the ground water in the saturated zone which is based on the mass-balance approach, as indicated in Figure C-1.

$$C_{sat} = (C_{unsat})(e)/(e+Q) \tag{3}$$

where: C_{unsat} = contaminant concentration of ground water in recharge (μg/l)
e = volumetric flow rate of recharge flowing downward through a unit area (cf/day)
Q = volumetric flow rate of ground water in the saturated zone throughout the unit (cf/day)

The equilibrium assumption:

$$S_{unsat} = (K_d)(C_{unsat}) \tag{4}$$

and equation (1) combined with equation (3) yields the following relationship. The resultant equation is used to calculate the maximum contaminant concentration for soils in the unsaturated zone.

$$(S_{sat})/(K_d) = (S_{unsat})/(K_d)(e)/(e+Q)$$

and

$$S_{unsat} = (S_{sat})(e + Q)/e \tag{5}$$

where: S_{unsat} = concentration of contaminant adsorbed to the soil in the unsaturated zone (μg/kg)

and the ground water volumetric flow rate through the saturated zone (Q) is estimated from Darcy's Law:

$$Q = (K)\ (i)\ (A) \tag{6}$$

where: K = hydraulic conductivity (ft/day)
i = hydraulic flow gradient (ft/ft)
A = area of flow (unit width x saturated thickness of aquifer) (ft^2)

Site-Specific Application

At Site 13 - Disposal Area Northwest, three Phase II RI soil samples were analyzed for total organic carbon. Detected levels were 11,200 mg/kg, 648 mg/kg, and 674 mg/kg, with an average level of 4,174 mg/kg or 0.4%. Using this value and published octanol-water partition coefficient values, the maximum saturated soil contaminant level was calculated for the Contaminants of Concern identified in the Phase II RI for which an MCL was available. The

contaminants, octanol-water partition coefficients (K_{ow}) values used, calculated K_d values, assumed maximum ground water concentrations in the saturated zone (C_{sat} = MCL) and maximum saturated soil contaminant levels (S_{sat}) are presented in the first 4 columns of Table C-1. The depth of the saturated zone was determined by the depth to ground water for monitoring wells or the depth at which wet soils were first observed for soil borings, as reported in the Phase II RI.

To calculate the maximum acceptable unsaturated soil contaminant levels, the volumetric flow rate of ground water in the saturated zone through the unit area (Q) was calculated. The average linear velocity for the site was estimated to be 0.04 ft/day by averaging the velocity values presented in Table 2-2 of the Detailed Analysis of Alternatives for Site 13. The average saturated thickness, estimated at 13 feet, was calculated by averaging the thickness of the interval from the water table surface to the top of the bedrock layer as measured at the on-site monitoring wells. Therefore, for a unit width of soil,

$$\begin{aligned} Q &= (0.04 \text{ ft/day})\ (13 \text{ ft})\ (1 \text{ ft}) \\ &= 0.52 \text{ cf/d} \end{aligned}$$

To estimated e, the volumetric flow rate of recharge flowing downward through a unit area, the information provided in Section 1.3.2 of the Phase II RI regarding precipitation and infiltration was used. Based on an average annual precipitation of 42.3 inches and 36% infiltration, the annual infiltration is 1.27 ft/yr or 0.0035 ft/day. Therefore, for a unit area of surface,

$$\begin{aligned} e &= (0.0035 \text{ ft/day})\ (1 \text{ ft})\ (1 \text{ ft}) \\ &= 0.0035 \text{ cf/day} \end{aligned}$$

Then S_{unsat} can be calculated using equation (5), where:

$$\begin{aligned} S_{unsat} &= (S_{sat})\ (e + Q)/e \\ &= (S_{sat})\ (0.0035 + 0.52)/0.0035 \\ &= (S_{sat})\ (149.6) \end{aligned}$$

The calculated S_{unsat} values are presented in column 7 of Table C-1. The maximum detected soil contaminant levels in the unsaturated zone and the location of the maximum detected concentration for each contaminant are presented in columns 8 and 9, respectively.

In the unsaturated zone, the PCB concentration in one sample exceeded the calculated maximum allowable level. As shown on Table C-1, the maximum allowable concentration of PCBs in unsaturated soils is 1,500 ppm. Sample S-13-09-00-S had a detected PCB concentration of 4,653 ppm, indicating that PCBs at Site 13 could potentially leach from surface soil and impact ground water. Therefore, the results of the leaching model have been considered in the development of PRGs, as presented in Section 3.1.4.

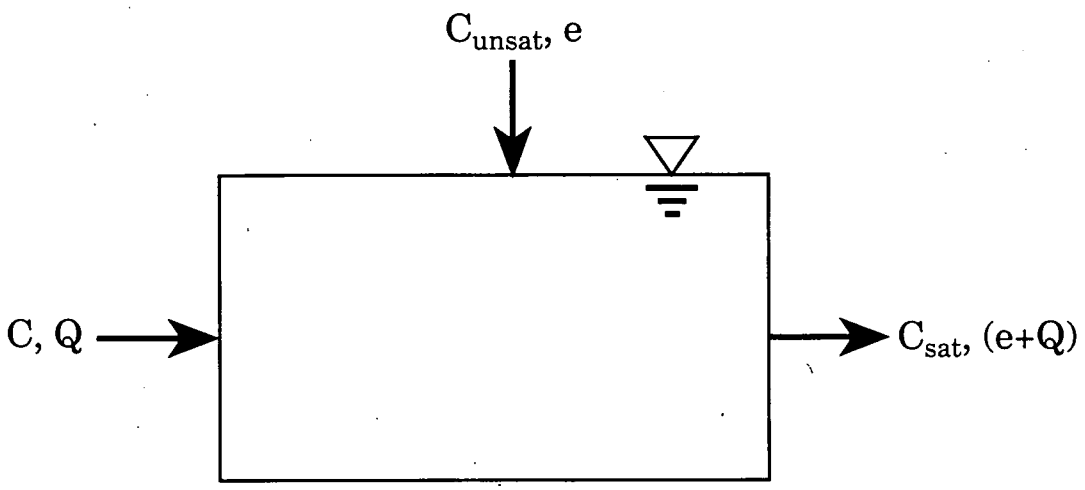
TABLE C-1

Site 13 - Disposal Area Northwest
Comparsion of Soil Contaminant Levels to Modeled Soil Response Action Levels
Using the Unnamed Model (USEPA, EPA/540/2-89/057)

Column:	1	2	3	4	5	6	7	8	9
Constituent	K_{ow}	K_d	C_{sat} (ppm)	S_{sat} (ppm)	Q (cf/d)	e (cf/d)	S_{unsat} (ppm)	Max. Unsaturated Soil Concentration Detected (ppm)	Sample Location
Chloroform	89.1	0.22	0.1	0.02	0.52	0.0035	3.0	0.002	S-13-10-00-S
Toluene	490	1.23	1	1.23	0.52	0.0035	184	0.006	13-B12-02
Xylenes	1000	2.52	10	25.2	0.52	0.0035	3800	0.002	13-B15-01
Bis(2-ethylhexyl)phthalate	2.00E+05	504	0.006	3.02	0.52	0.0035	500	0.15	13-B07-01
Butylbenzylphthalate	6.03E+04	152	0.1	15.2	0.52	0.0035	2300	0.041	13-B07-01
Chrysene	2.45E+05	617	0.0002	0.12	0.52	0.0035	18	0.32	13-SS25
Benzo(a)anthracene	4.07E+05	1027	0.0001	0.10	0.52	0.0035	15	0.15	13-SS17, 13-SS25
Benzo(a)pyrene	9.55E+05	2407	0.0002	0.48	0.52	0.0035	70	0.13	13-SS17, 13-SS22
Benzo(k)fluoranthene	6.92E+06	17434	0.0002	3.50	0.52	0.0035	500	0.74	13-SS22
Chlordane	8.51E+05	2145	0.002	4.30	0.52	0.0035	600	0.9	13-SS20
Endrin	3.98E+05	1003	0.002	2.01	0.52	0.0035	300	0.003	13-SS13
PCBs	8.13E+06	20488	0.0005	10.2	0.52	0.0035	1500	4653	S-13-09-00-S

K_d = 0.63 x 0.004 x K_{ow} where 0.63=adjustment factor and 0.004=average total organic carbon concentration
C_{sat} = Maximum Contaminant Level
S_{sat} = C_{sat} x K_d
Q = Avg linear velocity * unit area
Avg linear velocity = 0.04 ft/d (from Table 8-8 of Phase II RI)
Unit Area = Avg saturated thickness to top of bedrock (13 ft) * unit width (1 ft) = 13 sq ft
Q = 0.04 x 13 = 0.52 cf/d
e = infiltration rate x unit area
Infiltration rate = 15.2 in/yr = 0.0035 ft/d (= recharge at 36% of average annual 42.3 in precipitation)
Unit area = 1 ft by 1 ft = 1 sq ft
e = 0.0035 x 1 = 0.0035 cf/d
S_{unsat} = S_{sat} x (e+Q)/e

FIGURE C-1
MASS BALANCE DERIVATION OF THE INFILTRATION EQUATION



$$(C_{unsat})\,(e) + (C)\,(Q) = (C_{sat})\,(e + Q)$$

$$C_{sat} = [(C_{unsat})\,(e) + (C)\,(Q)] \,/\, (e + Q)$$

Since C = 0, then:

$$C_{sat} = (C_{unsat})\,(e) \,/\, (e + Q)$$

C_{sat}	=	concentration of contaminant in ground water in saturated zone (µg/l)
C	=	initial concentration of contaminant in ground water (assumed zero)
C_{unsat}	=	contaminant concentration of ground water in recharge (µg/l)
e	=	volumetric flow rate of infiltration (cf/day)
Q	=	volumetric flow rate of ground water in the saturated zone throughout the unit (cf/day)

APPENDIX D

APPENDIX D

TECHNOLOGY AND PROCESS OPTION SCREENING

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APPENDIX D

TECHNOLOGY AND PROCESS OPTION SCREENING

Based on the general response actions developed for Site 13, remedial technologies which could potentially meet the remedial action objectives and cleanup criteria are identified and screened. This process is a two-step process in which technologies are initially screened on the basis of technical implementability. For the technologies which pass the initial screening, the process options associated with each technology are screened based on effectiveness, implementability and cost. Representative process options are then chosen based on this screening for inclusion in the comprehensive remedial alternatives developed for the site.

Technology Screening

The intent of the technology screening is to reduce the universe of potentially applicable technology types and process options based on technical implementability. Two factors which may be considered in the evaluation of the technical implementability of a technology are the type of contaminants present at a site and site-specific conditions which may limit the implementability of a technology. Examples of the application of these factors include the screening of a technology because it does not treat the contaminants of concern, or the screening of a technology which cannot be applied to a site due to site-specific subsurface conditions. The technologies or technology process options which do not pass the screening process on the basis of technical implementability are not retained for further consideration.

A combined technology screening was performed for all of the sites addressed within the Initial Screening of Alternatives Report. While PCB-contaminated soil remediation was evaluated within the ISA report, Site 13 ground water was not included in the remedial action development process because the data collected from the Phase I RI did not sufficiently define the nature and extent of ground water contamination. Thus, the development of remedial action objectives was postponed until the completion of the Phase II RI. Similarly, remediation of catch basin sediments was not evaluated in the ISA report. The technology screening presented herein revisits the technology screening, considering the results of the Phase II RI. The Site 13

technology screening is conducted for soil in Table 3-7 of the report, for ground water in Table 3-8, and for sediment in Table 3-9.

The technology screening tables each include brief descriptions of the individual technologies or process options. More detailed descriptions of the technologies are provided in the text which follows this introduction.

The technology screening tables also include comments on the general applicability of the technologies and limiting characteristics which may prevent their application at Site 13. The technology or process option title block is shaded gray only for those technologies which have been screened from further analysis.

For Site 13 soil, the potential remedial technologies presented in Table 3-7 were identified based on the remedial action objectives and consistent with the Superfund program, as outlined in the National Contingency Plan [NCP, 40 CFR 300.430(a)(1)]. The technologies which were identified include no action, site use restrictions, surface controls, capping, excavation and disposal, excavation and treatment, and in situ treatment. None of the identified technologies were screened from further consideration based on technical implementability. However, a number of process options were screened from further consideration, many based on the limited viability of applying the process option to the relatively small volume of soil potentially requiring remediation at Site 13. Process options eliminated from further consideration on this basis included construction of an on-site landfill, stabilization/solidification, on-site incineration, plasma reactor, thermal desorption, and soil washing. Other process options eliminated based on their inability to treat the contaminants of concern or inapplicability to surficial contamination include off-site slagging, mechanical/thermal aeration, acid extraction, landfarming, slurry phase biodegradation, in situ biodegradation, soil venting, radio frequency heating, in situ vitrification, in situ stabilization/solidification, and steam injection/vacuum extraction.

The potential remedial technologies identified for ground water at Site 13 include no action, ground water monitoring, ground water use restrictions, extraction, off-site treatment, organic treatment, inorganic treatment, in situ treatment, and discharge. Two technologies, off-site treatment and in situ treatment, were screened from further consideration. Off-site treatment was screened based on difficulties associated with the technical implementability of off-site ground water treatment at a POTW or at a RCRA facility. In situ treatment was screened based

on the inability of the treatment technologies to treat organics (pentachlorophenol and bis(2-ethylhexyl)phthalate) and inorganics of concern. Ground water process options screened from further consideration based on technical implementability include provision of an alternative water supply, well point ground water extraction, powdered activated carbon treatment, air stripping, steam stripping, filtration, and discharge of treated ground water to the POTW. Due to the lack of potable ground water receptors, provision of an alternate water supply is not technically implementable. Well point ground water extraction could be affected by the siltiness of the subsurface soils. Powdered activated carbon treatment, air stripping, steam stripping, and filtration are screened based on the ground water contaminants which require treatment. For example, air stripping and steam stripping would not be effective in treating semi-volatile or inorganic contaminants, the ground water is not sufficiently contaminated to warrant such a treatment system as powdered activated carbon, and membrane microfiltration and filtration will not provide treatment of dissolved inorganic constituents. Discharge of treated ground water to the POTW is screened on the basis of preliminary evaluations which indicate the POTW will not be amenable to accepting treated ground water from the facility.

For sediments, the potential remedial technologies identified include no action, site use restrictions, flushing, physical sediment removal, disposal and treatment. Two technologies, site use restrictions and flushing, were screened from further consideration. Site use restrictions would offer little overall protection. The technical implementability of flushing would be complicated by the length of piping and presence of numerous catch basins. Under treatment, on-site treatment, off-site treatment and in situ treatment were considered as individual process options. It is assumed that implementation of these treatment options would be tied to implementation of soil treatment options, due to the limited volumes of materials involved (which limit the implementability of the treatment options) and the similar contaminant types for the two media. In situ treatment was the only process option screened from further evaluation based on the limitations of conducting in situ treatment within catch basins and storm drainage piping.

Process Option Screening

Upon identification of those technologies which are technically implementable, the process options are further evaluated to allow the selection of representative process option(s) for each technology type. In the process option screening, the process options are evaluated on the basis of effectiveness, implementability, and cost. Factors considered in the effectiveness evaluation include the effectiveness of the process in handling the estimated areas or volumes of media, its ability in meeting remediation goals, potential impacts to human health and the environment during construction and implementation, and how proven and reliable the process is. Both technical and administrative feasibility are considered in the implementability evaluation, while relative capital and O&M costs are broadly compared in the cost evaluations.

The process option evaluation for soil is presented in Table 3-10 of the report, the evaluation for sediment is presented in Table 3-11, and the evaluation for ground water is presented in Table 3-12. The selected representative process options are indicated with a bullet in these tables.

For soil, each of the process options evaluated under no action and site use restriction process options were retained for further consideration. Under the containment technologies, revegetation and construction of a single-barrier cap were retained for further consideration. The single-barrier cap was selected over the double-barrier cap since it will meet the objectives of limiting direct contact with surface soils, limiting erosion of contaminated surface soils and limiting infiltration through the PCB-contaminated area and is more cost-effective than the double-barrier cap. Of the excavation and treatment technologies, off-site incineration and solvent extraction were selected for further analysis. Of the in situ treatment technologies, fungal degradation was selected over soil flushing because it offers greater potential treatment of PCBs than does soil flushing.

For ground water, both institutional control process options (deed restrictions and ground water monitoring) were selected for further evaluation, while one process option for extraction was selected for further evaluation. Based on the shallow depth to ground water and the low extraction rates achieved during the RI, an interceptor trench was selected for further consideration. For organic ground water treatment, carbon adsorption was selected as offering the best combination of effectiveness, implementability and cost for treating pentachlorophenol

and bis(2-ethylhexyl)phthalate. For inorganic treatment, precipitation was selected as a representative inorganic treatment process option to be used for remedial alternative development. Filtration processes may not be successful in achieving inorganic PRGs alone since inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved rather than suspended (filtered and unfiltered results were comparable). However, filtration will be considered as a potential pretreatment process, since the silty nature of the ground water at Site 13 could interfere with the effectiveness of the treatment process. For ground water discharge, discharge to surface water was selected as a representative discharge option. This option was considered to be more administratively implementable and more economically feasible than discharging to a POTW, and more technically feasible than ground water discharge, based on the difficulty in identifying an area where ground water does not contain manganese above PRG levels.

For sediments, all of the process options which passed the technology screening were retained for further analysis. In general, the process options were tied to the soil treatment process technologies, since the soil treatment technologies would also be effective in treating the sediment contaminants, and the small estimated volume of sediments prohibits the implementation of sediment-only treatment systems.

TECHNOLOGY AND PROCESS OPTION SCREENING

SOIL/WASTE REMEDIAL TECHNOLOGIES

Site Use Restrictions

Site use restrictions are intended to prevent or reduce exposure to on-site contamination. They include actions such as fencing, signage, and restrictive covenants on the property deed to prevent development of the site or use of the ground water of the site. Site use restrictions may also be imposed to reduce required maintenance and to protect the integrity of a remedial alternative. Conditions in the area of the site should be evaluated in the five-year reviews to assess the continuing or future need for site use restrictions. Two types of access restrictions typically used at hazardous waste sites include deed restrictions and fencing.

Deed Restrictions

Deed restrictions are intended to prevent or limit site use and development. Restrictive covenants, written into the property deed, notify any potential purchaser of the site property that the land use must be restricted in order to ensure the integrity of any waste remediation systems, if they exist. Based on the closure of the NCBC facility, deed restrictions could be incorporated into property transfer documents, as required. The effectiveness of deed restrictions depends on state and local laws, continued enforcement, and maintenance.

Fencing

Fencing is used to physically limit access to the site. The most common type of fence used to limit access is a chain-link fence about eight feet high. Signs may be posted to make clear to potential trespassers that there may be a health threat associated with direct exposure to the site. Fencing may also help reduce the required maintenance and protect the integrity of a remediation system.

Surface Controls

Surface control technologies are designed to control and direct site runoff and can be used to minimize the transport of contaminated surface soils from the site. Revegetation of the site was the only process option considered under this technology since the site is flat and would not require regrading to control erosion.

Revegetation is a method used to stabilize surface soils of a site and promote evapotranspiration. Revegetation decreases erosion of the soil by wind and water, reduces sedimentation in stormwater runoff, and contributes to the development of a naturally stable surface. Revegetation can also improve the aesthetics or ecological value of the site. A systematic revegetation plan includes selection of suitable plant species, seedbed preparation, seeding/planting, mulching and/or chemical stabilization, fertilization, and maintenance. Revegetation is used most in combination with containment technologies such as a landfill cap. In such an instance, the root penetration of the revegetation species must be considered to ensure the integrity of any barrier layer within the cap will not be compromised.

At Site 13, revegetation would require enhancement of the site's surface to support vegetative species. In this sense, revegetation could also be considered to be a soil cap (see below).

Capping

Capping is a process used to cover contaminated materials to prevent contact of the contaminated material with the land surface, with infiltrating precipitation, and/or with ground water. Capping is applicable whenever contaminated materials are to be buried or left in place at a site. In general, capping is performed when extensive subsurface contamination at a site precludes excavation and removal of wastes because of potential hazards and/or unrealistic costs.

At Site 13, capping is considered mainly as a means of limiting erosion of surficial contaminants and subsequent impacts to stormwater drainage system sediment quality. There are a variety of designs and capping materials available. The selection of capping materials and a cap design is influenced by specific factors such as local availability, costs of cover materials, desired function of cover materials, the nature of the contaminated materials, local climate and

hydrogeology, and projected future use of the site in question. Two capping types are considered herein: a single-barrier cap and a double-barrier cap.

The main disadvantages of capping are the need for long-term maintenance and uncertain design life. Another disadvantage to capping is the high cost of proper soil and drainage materials in certain areas of the country.

Single-Barrier Cap

A single-barrier cap utilizes a single low-permeability barrier within the cap's design. For Site 13, a relatively simple cap utilizing a synthetic barrier placed over the site, covered by drainage and vegetative layers would prevent the erosion of surficial contaminants and direct exposures to potential human receptors. Limited long-term cap maintenance and institutional controls would be necessary to ensure the long-term effectiveness of the cap.

Double-Barrier Cap

A double-barrier cap utilizes a combined soil and synthetic barrier to minimize infiltration through the cap. As with the single-barrier cap, long-term cap maintenance and institutional controls would be necessary to ensure the long-term effectiveness of the cap.

On-Site Landfill

Construction of an on-site landfill suitable for the disposal of RCRA or TSCA wastes would require the design and construction of the facility in accordance with RCRA or TSCA requirements. Considering the limited volume of contaminated soils which must be remediated and the rigid design and construction requirements associated with the construction of a RCRA or TSCA landfill, this technology was screened from further consideration for Site 13.

Off-Site Landfill

The disposal of contaminated media from a site at an off-site landfill has several advantages as well as disadvantages. Advantages include the lack of long term on-site management, the

rapidity with which this may be implemented, the use of commonly employed excavation and trucking techniques. Disadvantages include the need to properly sample and analyze the waste material for proper characterization necessary to meet landfill requirements, the lack of destruction of the waste material, and the general lack of properly permitted and operating landfills available to accept the waste material. Based on the detected concentration of PCBs in the surface soils, the soils are expected to require disposal at a TSCA-permitted landfill. Based on the TCLP analyses conducted at the site, it is not expected that the soils are RCRA hazardous, although they would require characterization upon removal.

Solidification/Stabilization

Stabilization represents a treatment method that neutralizes hazardous contaminants and improves a waste's physical characteristics. Specifically, stabilization utilizes formulated reagents in combination with the waste to maintain contaminants in their most immobile form. This is achieved by reducing a waste's solubility or chemical reactivity. A wide range of reagents is available for stabilizing both organic and inorganic contaminated wastes. The relatively small volume of soils being remediated at Site 13 limits the viability of employing stabilization as a treatment technology, and therefore, it is screened from further consideration.

Incineration

Incineration involves the thermal destruction of contaminants. High temperature oxidation occurring under controlled conditions degrades contaminants into products that generally include carbon dioxide, water vapor, sulfur dioxide, NO_x, hydrogen chloride gases and ash. Air pollution control equipment is necessary to minimize the discharge of gaseous contaminants into the air. Organics are destroyed in the treatment process. Some metals such as arsenic, mercury, and lead may vaporize during incineration. Other metals typically are not treated and remain in the ash residual. Incineration can be implemented on-site or off-site. Since a substantial treatment volume is typically required for on-site incineration to be a cost-effective alternative, on-site incineration is screened from further consideration for Site 13. Off-site incinerators are not plentiful, and delays in their acceptance of a given wastestream are not uncommon due to their great demand. Some common incinerator types include rotary kiln,

fluidized bed and infrared thermal incinerators. Off-site incineration is retained for further analysis.

Slagging

Slagging is a high temperature process for the treatment of both organic and inorganic wastes. In a two-stage, high-temperature system, carbonaceous fuel is combusted with oxygen-enriched air under fuel-rich conditions in the first stage (burner section) followed by pneumatic injection of the waste into the hot (2,200-2,500 degree C) reducing flame in the second stage (reactor section). The intensive process conditions allow reaction times to be short (less than one-half second) and permit a high waste throughput. Close control of the operating parameters enables extraction of valuable metals and destruction of hazardous organic constituents.

The process temperature inside the reactor section is between 1,400 and 1,850 degrees C. In the high-temperature reducing atmosphere, metals such as zinc, lead, arsenic, and cadmium are vaporized from the waste along with volatile components such as alkali and halide compounds. Less volatile metals such as copper, nickel, and cobalt, if present in sufficient quantities, coalesce as a molten alloy. The remaining components of the waste, including some metal oxides such as those of iron, melt into a molten slag.

The reactor feeds into a slag separator, or horizontal cyclone, where the process gases and volatile compounds are separated from the molten materials. The slag is continuously tapped and solidified on a non-contact, water-cooled, vibrating conveyor. The process gases are drawn from the slag separator through the off-gas system where the vapors are post-combusted with ambient air and condensed as metal oxides, and all remaining H2 and CO are combusted to water vapor and carbon dioxide. The gases are subsequently cooled, and the mixed metal oxide particulate is collected in a pulse-jet baghouse. A clean off-gas is discharged to the atmosphere.

Because off-site slagging is most applicable to hazardous wastes which contain substantial metals concentrations, the levels of metals in the soils at Site 13 are not considered to be significant enough to justify the implementation of this technology. Therefore, the technology is screened from further consideration.

Mechanical/Thermal Aeration

Mechanical/thermal aeration employs vapor pressure or volatility to separate contaminants from the media of interest. In these systems, soils are exposed to large quantities of air which allows the transfer of the volatile component from the liquid to the gaseous phase. To achieve the exposure, mechanical means such as tilling or other rotary operations may be used. Often heat is applied to this system to achieve separations of relatively high vapor pressure organic compounds. The technology is screened from further consideration at Site 13 due to its inability to treat PCBs and inorganic contaminants.

Plasma Reactor

In a plasma reactor, feed material is heated in a molten bath where, under extremely high temperatures, it is detoxified. The melted matrix solidifies, with the inorganics retained in the final solid phase. The residual is a non-leachable, glassy residue which meets TCLP criteria. This technology is relatively innovative, with few vendors offering treatment systems. The small volume of contaminated soils at Site 13 limits the viability of its implementation and therefore, it is screened from further consideration.

Thermal Desorption

Thermal desorption involves the use of a dryer to volatilize water and organic contaminants from the feed material into an inert carrier gas stream. The gas stream is treated to remove dust particles and a portion of the organic contaminants. The gas then passes through heat condensers, where it is cooled. The majority of the gas is reheated and recycled through the treatment system. A small portion is passed through a particulate filter and a carbon adsorption system before discharge. A thermal desorption process offered by Chemical Waste Management, Inc. (the X*TRAX system) is reported to reduce volatile organic concentrations to less than 1 ppm, semivolatile organic concentrations to less than 10 ppm, and PCB concentrations to 2 to 25 ppm (from feed streams of 120 to 6,000 ppm). The feed material must be less than 2 inches in particle size and a minimum of 5,000 cubic yards is necessary for the system to be economically feasible. The small volume of contaminated soils at Site 13 limits the viability of its implementation and therefore, it is screened from further consideration.

Soil Washing

The soil washing process works on the principle that the majority of contaminants are associated with the fine-grained particles in the soil, and that the coarser-grained fraction is relatively clean. A typical soil washing process involves the separation of coarser-grained soils by creating a slurry and treating the slurry within a hydrocylone. The coarse fraction is washed with a surfactant to remove contaminants and separated from the contaminants within an air flotation tank. The cleaned sand is dewatered and placed back on-site. The fine-grained fraction and contaminant-containing froth from the air flotation unit are dewatered, with the residual sludge requiring off-site disposal. The technology is reported to be effective on heavy metals, semi-volatile organics and PCBs. It is currently a relatively innovative technology, not widely proven in the United States. A minimum of 20,000 cubic yards of soil is necessary for the system to be economically feasible. The small volume of contaminated soils at Site 13 limits the viability of its implementation and therefore, it is screened from further consideration.

Acid Extraction

Soil is treated by being washed in hydrochloric acid to remove inorganic contaminants. The soil is mixed with a hydrochloric acid solution with a pH less than 2. After extraction, the treated soils are rinsed, neutralized, and dewatered. The extractant solution is regenerated, with entrained soil, organics and heavy metals removed. The concentrated metal solution requires off-site treatment or, potentially, metals recovery. While only tested in the laboratory on a limited, bench-scale basis, the projected treatment capacity is 20 tons per hour. Since this technology would not be applicable to the treatment of PCB-contamination, it is screened from further consideration.

Landfarming

Landfarming involves the above-grade treatment of soils using conventional soil management practices to enhance the microbial biodegradation of contaminants. Typically, soils are spread over a lined area with a drainage system installed between the soil and the liner. If volatile organics are being treated, the system is usually enclosed. Spray irrigations provides moisture control and distribution of nutrients and bacteria. Contaminated leachate collected by the

drainage system can be reapplied to the surface. Landfarming has been used for the treatment of pesticides, creosote wastes, and aromatic hydrocarbons. Since this technology would not be applicable to the treatment of PCB-contamination or inorganics, it is screened from further consideration.

Dechlorination

Dechlorination is a process which involves the remediation of soils, sediments or liquid-phase wastes contaminated with chlorinated organic compounds. Various dechlorination processes have been developed. Typically these involve the replacement of chlorine atoms in halogenated compounds with atoms from the dechlorination agent, thereby rendering the original PCB compound a substituted aromatic compound which is no longer a PCB aroclor. Processes which use an alkaline polyethylene glycolate (APEG) reagent have been developed for full-scale application. Target compounds include halogenated semivolatile organics and PCBs. Since this technology is amenable to small quantity applications and is applicable to the treatment of PCBs, it is retained for further consideration.

Slurry Phase Biodegradation

This process is used to remediate soils and sludges contaminated with biodegradable organics in a manner similar to conventional activated sludge treatment. An aqueous slurry of waste material is prepared and environmental conditions are optimized for biodegradation. The slurry is aerated and mixed to allow for bacterial biodegradation of contamination. In some processes, contaminant-specific bacteria are used to effect treatment. Volatilization of VOCs is a potential concern in the system operation. The system can be combined with land treatment. Most applications to date have been for treating sludges containing petroleum and wood preservative organics such as creosote and pentachlorophenol. Since this technology is not applicable to the treatment of PCBs, it is screened f rom further consideration.

Solvent Extraction

This process uses a solvent to extract contaminants from soil or sludge. Many variations of the process are currently being developed by different vendors and are being demonstrated

under the SITE program. Liquified gases, such as propane, or liquid solvents are used to extract the organics from the wastestream. The soils are mixed with the solvent, followed by solvent recovery and soil drying. Vendors claim the process is successful in treating a wide range of organic compounds, including PCBs, wood preservatives, PAHs and other organics. This technology is retained for further consideration.

In Situ Biodegradation

In situ biodegradation is a technique for treating zones of contamination by microbial degradation processes. The basic concept involves altering environmental conditions to enhance microbial catabolism or cometabolism of organic contaminants, resulting in the breakdown and detoxification of those contaminants. This technology has developed rapidly over recent years, and bioreclamation appears to be one of the most promising of the in-situ treatment techniques.

Microbial metabolic activity can be classified into three main categories: aerobic respiration, in which oxygen is required as a terminal electron acceptor; anaerobic respiration, in which sulfate or nitrate serves as a terminal electron acceptor; and fermentation, in which the microorganism rids itself of excess electrons by exuding reduced organic compounds.

The bioreclamation method that has been most developed and is most feasible for in-situ treatment is one which relies on aerobic (oxygen-requiring) microbial processes. This method involves optimizing environmental conditions by providing an oxygen source and nutrients which are delivered to the subsurface through an injection well or infiltration system to enhance microbial activity.

The feasibility of bioreclamation as an in-situ treatment technique is dictated by waste and site characteristics. More specifically, those factors which determine the applicability of a bioreclamation approach are: biodegradability of the organic contaminants, environmental factors which affect microbial activity, and site hydrogeology. Since the technology would not be successful in treating PCB contaminants in surface soils, it is screened from further consideration.

Soil Venting

Soil venting is an in situ process in which a vacuum is applied to soils in the vadose zone. As the vacuum pulls air through the unsaturated soils, contaminants volatilize and are removed in the air stream. The air is then treated with activated carbon or a catalytic converter to remove organics prior to being discharged to the atmosphere. This technology is applicable to the in situ treatment of volatile organic hydrocarbons, including petroleum- and solvent-related contaminants, in the unsaturated zone and is often combined with in situ biodegradation. Since the technology would not be successful in treating PCB contaminants in surface soils, it is screened from further consideration.

Radio Frequency In Situ Heating

This technology involves the heating of soil in situ with radio frequency waves to thermally decompose, vaporize and distill hazardous constituents. Radio frequency energy is transmitted to the ground by inserting electrode tubes vertically into the contaminated soil or be placing an array of electrodes horizontally above the soil surface. As the soil temperature increases, hydrocarbons are volatilized or stripped from the soil by rising steam. Pyrolysis also contributes to the removal of contaminants. A vapor barrier placed over the surface captures the vapors and gases and the gases are further treated by incineration or carbon adsorption. Since the technology is most successful in treating the more volatile organic compounds, it will be screened from further consideration for the treatment of surficial PCB and inorganic contamination.

Fungal Treatment

This biological treatment process utilizes white rot fungi to treat soils in situ. This technology is typically used to treat soil contaminated with creosote-related compounds and currently is being evaluated within the SITE Demonstration Program for its ability to degrade pentachlorophenol (PCP). The treatment process consists of mixing contaminated soils with organic material inoculated with the fungi and wood chips. As the fungi degrade the wood, they also degrade the soil contaminants. Although not well-proven, this technology will be retained for further consideration.

Soil Flushing

Soil flushing is similar to soil washing but it is performed in situ. As the soil washing fluid percolates down through the soil, it chemically reacts with, solubilizes, or emulsifies the contaminants. The solution and entrained contaminants are captured by a network of drains or wells and extracted for further treatment or disposal. It is best applied in highly permeable soils and may be most effective when combined with another in situ process such as chemical oxidation or bioremediation. Four different approaches (surfactant washing, hot water displacement, alkali-polymer-surfactant flooding and metal extraction) may be applicable to contaminants such as PCBs, oils, chlorinated solvents, creosote wastes, and inorganics. (Hazardous Waste Consultant, 1992).

In Situ Vitrification

In situ vitrification represents an innovative technology that electrically melts the waste media, creating an extremely stable glass-like solid. This process can be used to treat soil and sludges contaminated with mixtures of various waste types (i.e., organic, inorganic, and radioactive. In a typical arrangement, four electrodes connected to a utility distribution system are ingested into the soil. As current flows between electrodes, the adjacent soil is heated to 1600-2000°C. Advantages of in-situ vitrification include the potential ability to destroy, remove, or immobilize all contaminant groups and to reduce the volume of waste media being treated. Disadvantages of this process include the need to treat off-gas and the high capital costs associated with this process. The small volume of soils, limited mix of contaminants and surficial nature of contamination at Site 13 limits the viability of this technology; therefore, it is screened from further consideration.

In Situ Solidification/Stabilization

Utilizes the same solidification processes previously described but the solidification occurs in situ. Would not be applicable to surficial contamination, as is present at Site 13. Therefore, it is screened from further consideration.

Steam Injection and Vacuum Extraction

This technology is similar to soil venting but utilizes steam to remove subsurface contaminants. Steam is injected into the subsurface via steam injection wells. The steam heats the subsurface soils, increasing the vapor pressure of the volatile contaminants and thereby increasing the rate at which they can be stripped from the soils. The air and steam are removed via vacuum extraction wells and undergo treatment prior to discharge or reuse within the treatment system. This treatment system treats both volatile organics and semivolatile organics in the subsurface and can be combined with in situ biodegradation. Since this technology does not treat PCBs or inorganics and is not directly applicable to surface soils, it is screened from further consideration.

GROUND WATER REMEDIAL TECHNOLOGIES

Institutional Control

Institutional controls are intended to minimize exposures to contaminated ground water. They include actions such as ground water monitoring, ground water use restrictions and provision of alternate water supplies. If a five-year review is required for a remedial action involving institutional controls, site conditions such as ground water monitoring results, if available, or changes in ground water usage should be reviewed to determine the need for continuing or future site use restrictions.

Ground Water Monitoring

Ground water monitoring provides a means to assess changes in ground water quality and contaminant migration patterns.

Ground Water Use Restrictions

Ground water use restrictions are intended to prevent or reduce exposure to ground water contamination. The use of ground water below or adjacent to the site is usually restricted. Ground water use restrictions may encompass potable use as well as non-potable use of the ground water. At Site 13, potable use would not be anticipated due to the industrial nature of the area, the GB ground water classification, and the easy

access to municipal water supplies. However, non-potable use could be conceivable in association with potential future industrial site use.

Alternate Water Supply

Alternate water supply represents another type of institutional control in restricting ground water usage. Basically, ground water that is contaminated is no longer utilized as a potable water source, and an alternate source is provided. Since ground water is not used for potable water supply in the vicinity of Site 13, this process option is screened from further consideration.

Extraction

Extraction technology provides a means to collect contaminated ground water at a site. Various means of extraction include extraction wells, well points, or interceptor trenches.

Extraction Wells

Extraction wells represent a conventional technology which is frequently used in the removal of contaminated ground water. Stainless steel or PVC well casings and screens are installed within the contaminated ground water, and submersible pumps are typically used to extract water from the well. An array of wells with overlapping radii of influence can be designed to capture an entire plume or to halt contaminant migration. At Site 13, limited extraction rates were sustainable at on-site monitoring wells during the RI.

Well Points

This ground water extraction technology involves the removal of ground water through a group of closely spaced wells connected by a header pipe. The wells are installed by driving a perforated pipe with a pointed cap into the area to be dewatered. Well point systems are best suited for shallow aquifers where extraction is not needed below twenty feet. The suction lifting pump technique commonly employed with well points is effective up to this depth. However, well points are ineffective when high

percentages of silt or clay are present in site soils. Due to the silty nature of soils at Site 13, this technology has been screened from further evaluation.

Interceptor Trench

Interceptor trenches may be employed as a means of collecting ground water through the use of a perforated pipe placed below the natural ground water table. Ground water enters the perforated pipe and flows by gravity to the lowest point in the pipe, where it is pumped to the surface for treatment and/or discharge. This technology is typically limited to areas where the depth to ground water is not so deep that trench construction becomes prohibitively expensive or complicated (bracing, etc.). This technology offers the advantage of a horizontally oriented intake structure which allows collection of ground water within the area of interest. Additionally, trenches are relatively simple to construct and are passive structures with little maintenance required. Based on the shallow depth to ground water at Site 13, this technology is retained for further consideration.

Off-Site Treatment

Off-site treatment utilizes an off-site facility to treat extracted ground water. The contaminated ground water must be transported or conveyed to the treatment facility. Costs associated with conveyance or transportation can be extremely expensive if the distance from the site to the off-site treatment facility is far. Two types of off-site treatment facilities include publicly owned treatment works (POTW) and RCRA treatment facilities.

Off-Site Treatment at a POTW

This technology involves the discharge of aqueous wastes, which can constitute the majority of waste treated during a remedial cleanup effort, from a site to a Publicly Owned Treatment Works (POTW) for off-site treatment. These aqueous wastes can include ground water, leachate, surface water runoff, or other aqueous wastes. A number of criteria must be met when utilizing a POTW. These restrictions, as they apply to CERCLA sites, are detailed in the U.S. EPA's CERCLA Site Discharges to

POTWs: Guidance Manual (U.S. EPA, 1990a). Typically, the wastes are piped to the POTW via an existing sanitary sewer or by constructing a dedicated sewer line. An additional concern of POTWs in accepting a discharge from a CERCLA site is the issue of whether the POTW is then considered a hazardous waste treatment facility. Therefore, the administrative acceptability of discharging water to a POTW may be limited. Based on preliminary indications that the local POTW will not be amenable to accepting contaminated ground water, off-site treatment at a POTW will be screened from further consideration.

Off-Site Treatment at a RCRA Facility

Discharge to a RCRA facility also represents a potential off-site treatment technology for remediating contaminated ground water and other aqueous wastes. The extracted ground water is collected and transported off-site to a licensed RCRA facility for treatment. High extraction rates and the distance to the nearest RCRA treatment facility can greatly limit the cost-effectiveness of this alternative. This technology is screened from further consideration based on the lack of a locally available RCRA treatment facility.

Bioreactor

A bioreactor utilizes biological treatment to remove organic matter from the wastestream through biological degradation.

The most prevalent form of biological treatment is aerobic (i.e., in the presence of oxygen). Aerobic biological treatment can be effective for the treatment of aromatic hydrocarbons, polynuclear aromatic hydrocarbons, and phenols. The wastestream's biological oxygen demand (BOD) can provide an indication of the treatability of the waste by aerobic treatment.

Specialized biological treatment systems are being developed for specific contaminants not treatable under normal aerobic conditions. Such systems utilize contaminant-specific bacteria or special environmental conditions to enhance the biodegradation of the target contaminants. A system being evaluated under the SITE program has successfully utilized microbes to treat

phenol-contaminated water. Therefore, it is retained for further evaluation for ground water organic treatment at Site 13.

Powdered Activated Carbon Treatment

Powdered activated carbon treatment is a treatment process where powdered activated carbon is added to a traditional aerated biological treatment process. Treatment is achieved both through the biological degradation of contaminants and the adsorption of non-degradable contaminants onto the carbon. It is often combined with wet air oxidation (WAO), where the WAO destroys the adsorbed pollutants and biomass while regenerating the carbon for reuse in the treatment system. WAO is a chemical treatment process which utilizes high temperatures (347-608° F) and pressures (300-3000 psig) to oxidize dissolved or suspended contaminants in aqueous waste streams. Generally, WAO is applicable for treating certain organic-containing media that are too toxic for biological remediation and too dilute to incinerate economically (Surprenant, 1988). Pressure, temperature, and time are controlled to achieve desired reductions in contaminant levels. The powdered activated carbon/WAO treatment process is most suitable for wastestreams such as leachates with a wide variety of contaminants. Based on the relatively low ground water organic contaminant levels, this alternative is screened from further consideration for Site 13.

Air Stripping

Air stripping, a physical treatment method, consists of the mass transfer of a volatile chemical from a liquid phase to air by bringing a flow of air in contact with the liquid. Air strippers come in a variety of configurations, but the basic principle behind their operation is the same for each type.

The most common configuration in ground water treatment is the countercurrent packed tower, in which contaminated water is trickled downward over rings, spheres, or other types of packing material in a stainless steel, fiberglass, or PVC cylinder. Clean air is blown upward through the tower, volatilizing contaminants and exhausting them out the top. Air stripping is effective with contaminants exhibiting high Henry's law constants, which relate equilibrium concentrations of a chemical compound in liquid and gas phases. Removal efficiencies can vary

widely depending on types of contaminant, influent concentrations, stripper design, temperature, and a number of other factors. However, a properly designed and operated air stripper can be expected to achieve greater than 95% removal efficiency for contaminants (Canter, et al., 1986).

Emission controls on the stripping column are often required to collect exhausted contaminants. Although this reduces the simplicity of the system, small carbon adsorption units can be connected to the gaseous outflow to capture contaminants. Environmental effects of exhausted contaminants are probably minimal, since most volatile organic compounds have atmospheric half-lives (time to degrade 50% of the contaminant) on the order of minutes or hours (Cuppitt, 1980).

Based on the relatively low volatility of the organic contaminants of concern within the ground water at Site 13, this alternative is screened from further consideration.

Steam Stripping

Steam stripping differs from air stripping by the injection of steam, as opposed to air, into a tray or packed distillation column in order to remove volatile organic chemicals from waste streams. This type of process option is most effectively applied to aqueous solutions for the removal of volatile organic compounds that are immiscible in water. Steam stripping is more economical and effective than air stripping for treating wastes with high concentrations of volatiles and wastes with contaminants which have a low volatility (Surprenant, 1988). In regard to the specific treatment process, the waste stream enters near the top of the column and then flows by gravity countercurrent to the steam. As the waste stream passes down through the column, volatile compounds within the waste stream are lost to the steam/organic vapor stream rising from the bottom of the column. The concentration of volatile compounds in the waste stream reaches a minimum at the bottom of the column. The overhead vapor is condensed as it exits the column and the condensate is then decanted to achieve water/solvent separation.

Based on the relatively low volatility of the organic contaminants of concern within the ground water at Site 13, this alternative is screened from further consideration.

Carbon Adsorption

One of the most frequently applied technologies for the removal of low concentrations of organics from waste streams is carbon adsorption. The process consists of bringing contaminated ground water in contact with a bed of granular activated carbon (GAC), where contaminants are held by physical and/or chemical forces on the activated surface of the carbon itself. The system is usually configured as one or several columns in series which are filled with activated carbon. Carbon adsorption is effective with a wide variety of organic contaminants, but the performance of the process can be influenced by pH, the adsorptive capacity of the carbon, and temperature. Removal efficiencies of greater than 99% can be expected (Canter, et al., 1986).

Spent activated carbon (carbon which has reached its adsorption capacity) must be regenerated through the application of heat. This usually entails removal of carbon from the unit for regeneration at an off-site incinerator. Operation of units in series prevents shutoff of the entire system during regeneration.

This technology is retained for further consideration at Site 13.

Resin Adsorption

Resin adsorption represents another physical treatment option for the removal of organic contaminants from aqueous waste streams. The operation of resin adsorption is similar to that of carbon adsorption. Specifically, organic molecules contacting the resin surface are held on the surface by physical forces and are subsequently removed during the resin regeneration cycle. Even though the process operation of resin adsorption is similar to carbon adsorption, many aspects of the two technologies differ. For example, the bonding forces in resin adsorption are usually weaker than those encountered in granulated activated carbon adsorption and therefore, resins may be regenerated chemically rather than thermally, as carbon adsorption systems must be regenerated. Resins generally have a lower adsorption capacity than carbon. Resin adsorption is most practical for treatment of colored organic wastes, when material recovery is practical, where selective adsorption is desired, where low leakage rates are required, where carbon regeneration is not practical and where the wastestream contains high levels of dissolved inorganic solids (Berkowitz, et al., 1978). This technology is retained for further consideration.

Ultraviolet (UV) Oxidation

UV oxidation is a chemical process which utilizes an oxidant in combination with ultraviolet radiation to treat specific waste streams containing phenols, cyanides, chlorinated hydrocarbons, organic sulfur compounds, and other rapidly oxidized organics. This process option transforms the contaminants into a less hazardous form. When reactions are carried to completion, halogenated compounds are converted to carbon dioxide, water, and residual halides. Treatment data indicate that destruction of organic contaminants to non-detectable levels is achieved within minutes (Hager, et al., 1987). Since this technology has been proven for the treatment of semivolatile organics, it will be retained for further consideration at Site 13.

Ion Exchange

Ion exchange is a process whereby the toxic ions are removed from the aqueous phase by being exchanged with relatively harmless ions held by the ion exchange material. Ion exchange is a well-established technology for removal of heavy metals and hazardous anions from dilute solutions. Ion exchange can be expected to perform well for these applications when fed wastes of variable composition, provided the system's effluent is continually monitored to determine when the resin bed exhaustion has occurred. However, the reliability of ion exchange is markedly affected by the presence of suspended solids.

Ion exchange systems are commercially available from a number of vendors. The units are relatively compact and are not energy intensive. Although exchange columns can be operated manually or automatically, manual operation is better suited for hazardous waste site applications because of the diversity of wastes encountered. In addition, use of several exchange columns at a site can provide considerable flexibility. Ion exchange, with filtration pretreatment to remove suspended solids, will be retained for further consideration at Site 13.

Precipitation

Precipitation is a physicochemical process whereby some or all of a substance in solution is transformed into a solid phase. It is based on alteration of the chemical equilibrium relationships affecting the solubility of inorganic species. Removal of metals as hydroxides or sulfides is the most common precipitation application in wastewater treatment. Generally, lime

or sodium sulfide is added to the wastewater in a rapid mixing tank along with flocculating agents. The wastewater flows to a flocculating chamber in which adequate mixing and retention time is provided for agglomeration of precipitate particles. Agglomerated particles are separated from the liquid phase by settling in a sedimentation chamber, and/or by other physical processes such as filtration. Precipitation, with filtration pretreatment, will be retained for further evaluation at Site 13.

Membrane Microfiltration

Membrane microfiltration involves the use of an automatic pressure filter in which the filter material has tiny openings (0.10 microns or 1 ten-millionth of a meter) which allow for the filtration of particles normally not separated from the wastestream using standard filtration processes. Membrane microfiltration is most applicable to hazardous waste suspensions, ground water contaminated with heavy metals, landfill leachate and process wastewaters containing uranium (U.S. EPA, 1991). Filtration processes (both filtration and microfiltration) may not be successful in meeting inorganic remediation goals since inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved rather than suspended (filtered and unfiltered results were comparable). For this reason, membrane microfiltration is screened from further consideration.

Filtration

Filtration is a type of physical separation of a solid material based on particle size. As commonly employed in ground water treatment, filtration involves the separation of suspended solids, primarily silt, from the influent stream. Filters generally work on the same principal as a domestic vacuum cleaner whereby particles are intercepted in a fabric. Fabric size, particle size, and density differences each play a role in the proper selection of a filtration device. Inorganic analyses conducted on filtered and unfiltered samples collected using the low flow sampling methodology (which reduced the siltiness of the samples) indicated that the inorganics are probably dissolved rather than suspended (filtered and unfiltered results were comparable).

Therefore, filtration would not be effective as a "stand-alone" treatment, but will be considered as a pretreatment process to improve the efficiency of the treatment technology.

Electrochemical

Electrochemical treatment provides treatment of inorganic contaminants. Contaminated water passes through an electrochemical cell where ferrous ions, hydroxide ions and hydrogen are produced. The ferrous ions act as reducing agents for oxidized heavy metals and also react with the hydroxide ions, forming iron hydroxides and metal hydroxides. The metal hydroxides are removed by adsorption onto the iron hydroxide precipitate that is formed (Hazardous Waste Consultant, 1991). Electrochemical treatment will be retained for further consideration since it is an innovative technology and has been proven effective for inorganic treatment during test operations.

Air Sparging

Air sparging involves the injection of air into special air injection wells. The air then "bubbles" up through the saturated subsurface soils into the unsaturated zone. As the air passes through the contaminated ground water in the saturated zone, it strips volatile organic contaminants from the ground water. The contaminants enter the vapor phase of the unsaturated zone and are then removed using conventional vapor extraction technology. This technology has not been widely proven and its effectiveness in treating contaminated ground water is not well demonstrated. It would not be expected to be effective in the treatment of semivolatile organics or inorganics; therefore, it is screened from further consideration for Site 13.

In Situ Biodegradation

See description for soil treatment technology. Since in situ biodegradation would be ineffective in the treatment of semivolatile organics or inorganics, it is screened from further consideration for Site 13.

Discharge

Following treatment, extracted ground water must be discharged back to the environment. Several options exist for the discharge of ground water, as described below.

Discharge to Ground Water

Treated ground water can be discharged to ground water using recharge basins, infiltration galleries or reinjection wells. The technology selected for recharge is dependent on site-specific considerations such as available space, extent of contamination, and hydrogeology. Ground water recharge systems can provide an added element of hydraulic control to ground water extraction systems. Typically recharge systems can be subject to clogging or other operational problems and must be closely monitored. Compliance with ground water discharge regulations must also be maintained. Since ground water in the vicinity is classified GB, discharge to ground water will be retained for further consideration. However, the presence of manganese at levels exceeding the risk-based PRG throughout the site may complicate the placement of a ground water recharge system.

Discharge to Surface Water

Treated ground water can also be discharged to a surface water body. The nearest surface water body to Site 13 would be Hall Creek, located approximately 1,500 feet northeast of the site. Hall Creek discharges into Frys Pond. Implementation of this alternative would require compliance with NPDES discharge requirements. Discharge to surface water will be retained for further consideration.

Discharge to Sanitary Sewer/POTW

If available nearby, discharge of treated or untreated ground water to a sanitary sewer for subsequent treatment at a Publicly Owned Treatment Works (POTW) is a possible alternative. No sanitary sewers are present in the vicinity of Site 06. Many POTWs have regulations prohibiting discharges of ground water to the treatment system and special approval for such a discharge may be required. The POTW may also require

pretreatment of the wastestream prior to acceptance. An additional concern of POTWs in accepting a discharge from a CERCLA site is the issue of whether the POTW is then considered a hazardous waste treatment facility. The administrative acceptability of discharging water to a POTW may therefore be limited. Based on preliminary indications that the local POTW will not be amenable to accepting aqueous discharges from the site, off-site treatment at a POTW will be screened from further consideration.

CATCH BASIN SEDIMENT REMEDIATION TECHNOLOGIES

Catch basin sediment remediation technologies are generally similar to soil remediation technologies. This evaluation focuses on the means of remediating sediments which are located within catch basins and an active storm water drainage system. Site use restrictions and fencing were previously described within the soil remediation technologies and their descriptions are not repeated here.

Removal

There are basically two means of removing the contaminated sediments from the catch basins and associated piping. These two actions are described below.

Flushing

Flushing is an effective means of removing contaminated sediments from pipes, especially if the piping runs are short or if there are no interruptions within the piping to limit the flushing action. Under this action, water is forced at high pressure through the drainage pipes, entraining underlying sediment as it passes through the piping, and the water/sediment solution is then collected at a downgradient location. At Site 13, implementation of flushing is limited by the frequent pipe breaks located at the catch basins (approximately four connections with other drainage lines and seven catch basins exist between the site and the discharge point), the length of piping run to the discharge location (estimated to be approximately 1,200 feet) and the nature of the discharge point (the drainage discharges directly to a small tributary of Hall Creek).

Physical Removal

Physical removal involves the manual or mechanical removal of sediments from the catch basins. The extracted sediments would then be contained for subsequent treatment or disposal.

Disposal

Disposal options include on-site landfilling or off-site landfilling. As described previously for soils, the limited volume of material requiring landfilling would limit the viability of constructing an on-site landfill. Off-site disposal is retained for further consideration.

On-Site Treatment

On-site treatment would be appropriate if on-site soil treatment is being conducted. The contaminants in the catch basin sediments are similar to the soil contaminants and should successfully be treated by the soil treatment technologies. Therefore, on-site treatment will be retained for further consideration in combination with on-site soil treatment technologies.

Off-Site Treatment

Off-site treatment of catch basin sediments could also be conducted in concert with off-site treatment of soils. Therefore, it is retained for further consideration in combination with off-site soil treatment technologies.

In Situ Treatment

While there are a number of in situ soil treatment technologies, none of them are directly applicable to sediments within catch basins or storm water drainage piping. Therefore, in situ treatment is screened from further consideration with respect to catch basin sediments.

APPENDIX E

APPENDIX E

REMEDIAL COST ESTIMATES

Cost estimates are provided for the following alternatives:

SOIL ALTERNATIVES

Alternative S-2, Deed Restrictions and Fencing

Alternative S-3A, Revegetation

Alternative S-3B, Single-Barrier Cap

Alternative S-4A, Soil Excavation and Disposal (Scenario 1 - Excavation of Inorganic and PCB-Contaminated Soil)

Alternative S-4A, Soil Excavation and Disposal (Scenario 2- Excavation of PCB-Contaminated Soils Only)

Alternative S-4B, Soil Excavation and Off-Site Incineration (Scenario 2)

Alternative S-4C, Soil Excavation and On-Site Solvent Extraction (Scenario 2)

Alternative S-4D, Soil Excavation and In-Situ Fungal Degradation (Scenario 2)

GROUND WATER ALTERNATIVES

Alternative GW-2 , Long-Term Monitoring

Alternative GW-3A, Extraction of Ground Water via Interceptor Trench

Alternative GW-3B, Carbon Adsorption

Alternative GW-3C, Chemical Precipitation

Alternative GW-3D, Discharge to Surface Water

SEDIMENT ALTERNATIVES

No individual cost estimates developed based on low sediment volume and incorporation with soil remediation

ALTERNATIVE S-2
DEED RESTRICTIONS AND FENCING
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Fencing										
- Chain Link , 9 gauge wire, aluminized steel, 6' high	3,100	l. ft.	$13.75	1994	2	1.000	$13.75	$42,625.00		
- Double Swing Gate 6' high, 20' opening	1	each	$905.00	1994	2	1.000	$905.00	$905.00		
- Warning Signs	31	each	$45.50	1994	2	1.000	$45.50	$1,410.50		
Total Fencing Cost										$44,940.50
Direct Capital Cost Subtotal										$44,940.50
CAPITAL COSTS - INDIRECT										
Engineering and Design (10%)					1			$4,494.05		
Legal and Administrative (4%)					1			$1,797.62		
Indirect Capital Cost Total										$6,291.67
TOTAL CAPITAL COSTS										$51,232.17
OPERATION AND MAINTENANCE COSTS										
Site Fence Maintenance	1	each	$500.00	1994	5	1.000	$500.00	$500.00	30	$7,686.00
ANNUAL O & M COST								$500.00		
TOTAL NET PRESENT VALUE OF O & M										$7,686.00
SUBTOTAL COST										$58,918.17
CONTINGENCY (20%)										$11,783.63
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-2										$70,701.80

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-3, OPTION A
REVEGETATION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Soil Cover and Revegetation										
- 12" Topsoil	18,500	cu. yd.	$14.50	1994	5	1.000	$14.50	$268,250.00		
- Seed, Fertilizer, Mulch	500	msf	$45.50	1994	2	1.000	$45.50	$22,750.00		
- Health & Safety (17%)					4			$49,470.00		
Total Soil Cover and Revegetation										$340,470.00
Site Survey	1	lump sum	$5,000.00	1994	2	1.000	$5,000.00	$5,000.00		$5,000.00
Equipment Decontamination										
- Rental of Steam Cleaner	3	months	$425.00	1994	2	1.000	$425.00	$1,275.00		
- Construction of Decon Pit										
Excavate Pit	15	cu. yd.	$3.82	1994	2	1.000	$3.82	$57.30		
Polyethylene Tarpaulin	400	sq. ft.	$0.35	1994	2	1.000	$0.35	$140.00		
- Tanker Truck Rental	3	months	$650.00	1994	5	1.000	$650.00	$1,950.00		
- Disposal (Tanker Truck)	1	each	$1,600.00	1992	11	1.077	$1,723.20	$1,723.20		
Total Equipment Decontamination Cost										$5,145.50
Dust Control										
- Water Tank Sprayer	3	months	$2,075.00	1994	2	1.000	$2,075.00	$6,225.00		$6,225.00
Engineering Mgmt. Mob/Demob										
- 1 Trailer	3	months	$450.00	1994	2	1.000	$450.00	$1,350.00		$1,350.00
Direct Capital Cost Subtotal										$358,190.50
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$35,819.05		
Legal and Administrative (4%)					1			$14,327.62		
Total Indirect Capital Cost										$50,146.67
TOTAL CAPITAL COSTS										$408,337.17

ALTERNATIVE S-3, OPTION A
REVEGETATION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
(continued)

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
OPERATION AND MAINTENANCE COSTS										
Soil Cover O & M										
- Cover Annual Inspection and Repairs	1	each	$1,000.00	1988	7	1.188	$1,188.00	$1,188.00	30	$18,261.94
ANNUAL O&M COST								$1,188.00		
TOTAL NET PRESENT VALUE OF O & M										$18,261.94
SUBTOTAL COST										$426,599.11
CONTINGENCY (20%)										$85,319.82
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-3, OPTION A										$511,918.93

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-3, OPTION B
SINGLE-BARRIER CAP
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Single-Barrier Cap Construction										
- 6" Bedding Layer	9,300	cu. yd.	$14.50	1994	5	1.000	$14.50	$134,850.00		
- Geomembrane	500,000	sq. ft.	$0.68	1994	21	1.000	$0.68	$340,000.00		
- Geonet	500,000	sq. ft.	$0.39	1994	21	1.000	$0.39	$195,000.00		
- 12" Topsoil Layer	18,500	cu. yd.	$14.50	1994	5	1.000	$14.50	$268,250.00		
- Seed, Fertilizer, Mulch	500	msf	$45.50	1994	2	1.000	$45.50	$22,750.00		
- Health & Safety (17%)					4			$163,344.50		
Total Single-Barrier Cap Construction Cost										$1,124,194.50
Site Survey	1	lump sum	$5,000.00	1994	2	1.000	$5,000.00	$5,000.00		$5,000.00
Equipment Decontamination										
- Rental of Steam Cleaner	8	months	$425.00	1994	2	1.000	$425.00	$3,400.00		
- Construction of Decon Pit										
Excavate Pit	15	cu. yd.	$3.82	1994	2	1.000	$3.82	$57.30		
Polyethylene Tarpaulin	400	sq. ft.	$0.35	1994	2	1.000	$0.35	$140.00		
- Tanker Truck Rental	8	months	$650.00	1994	5	1.000	$650.00	$5,200.00		
- Disposal (Tanker Truck)	1	each	$1,600.00	1992	11	1.077	$1,723.20	$1,723.20		
Total Equipment Decontamination Cost										$10,520.50
Dust Control										
- Water Tank Sprayer	8	months	$2,075.00	1994	2	1.000	$2,075.00	$16,600.00		$16,600.00
Engineering Mgmt. Mob/Demob										
- 1 Trailer	8	months	$450.00	1994	2	1.000	$450.00	$3,600.00		$3,600.00
Direct Capital Cost Subtotal										$1,159,915.00
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$115,991.50		
Legal and Administrative (4%)					1			$46,396.60		
Total Indirect Capital Cost										$162,388.10
TOTAL CAPITAL COSTS										$1,322,303.10

ALTERNATIVE S-3, OPTION B
SINGLE-BARRIER CAP
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
(continued)

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
OPERATION AND MAINTENANCE COSTS										
Single-Barrier Cap O & M										
- Cap Annual Inspection and Repairs	1	each	$5,000.00	1988	7	1.188	$5,940.00	$5,940.00	30	$91,309.68
ANNUAL O&M COST								$5,940.00		
TOTAL NET PRESENT VALUE OF O & M										$91,309.68
SUBTOTAL COST										$1,413,612.78
CONTINGENCY (20%)										$282,722.56
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-3, OPTION B										$1,696,335.34

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-4, OPTION A
SOIL EXCAVATION AND DISPOSAL
SCENARIO 1 - EXCAVATION OF INORGANIC AND PCB-CONTAMINATED SOILS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Soil Excavation and Backfill										
- Soil Excavation	900	cu. yd.	$1.52	1994	2	1.000	$1.52	$1,368.00		
- Clean Soil Backfill	900	cu. yd.	$9.75	1994	5	1.000	$9.75	$8,775.00		
Total Soil Excavation and Backfill Cost										$10,143.00
Off-Site Transport and Disposal										
- Non-hazardous Transport and Disposal	500	cu. yd.	$160.00	1994	5	1.000	$160.00	$80,000.00		
- PCB-Contaminated Soil Transport and Disposal	400	cu. yd.	$300.00	1994	5	1.000	$300.00	$120,000.00		
- Health & Safety (17%)					4			$34,000.00		
Total Off-Site Transport and Disposal Cost										$234,000.00
Equipment Decontamination										
- Rental of Steam Cleaner	2	months	$425.00	1994	2	1.000	$425.00	$850.00		
- Construction of Decon Pit										
Excavate Pit	15	cu. yd.	$3.82	1994	2	1.000	$3.82	$57.30		
Polyethylene Tarpaulin	400	sq. ft.	$0.35	1994	2	1.000	$0.35	$140.00		
- Tanker Truck Rental	2	months	$650.00	1994	5	1.000	$650.00	$1,300.00		
- Disposal (Tanker Truck)	1	each	$1,600.00	1992	11	1.077	$1,723.20	$1,723.20		
Total Equipment Decontamination Cost										$4,070.50
Dust Control										
- Water Tank Sprayer	2	months	$2,075.00	1994	2	1.000	$2,075.00	$4,150.00		$4,150.00
Engineering Mgmt. Mob/Demob										
- 1 Trailer	2	months	$450.00	1994	2	1.000	$450.00	$900.00		$900.00
Direct Capital Cost Subtotal										$253,263.50
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$25,326.35		
Legal and Administrative (4%)					1			$10,130.54		
Total Indirect Capital Cost										$35,456.89
TOTAL CAPITAL COSTS										$288,720.39

ALTERNATIVE S-4, OPTION A
SOIL EXCAVATION AND DISPOSAL
SCENARIO 1 - EXCAVATION OF INORGANIC AND PCB-CONTAMINATED SOILS
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
(continued)

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
ANNUAL O&M COST								$0.00		
TOTAL NET PRESENT VALUE OF O & M										$0.00
SUBTOTAL COST										$288,720.39
CONTINGENCY (20%)										$57,744.08
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-4, OPTION A										$346,464.47

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S[illegible]OPTION A
SOIL EXCAVATION AND DISPOSAL
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Soil Excavation and Backfill										
- Soil Excavation	400	cu. yd.	$1.52	1994	2	1.000	$1.52	$608.00		
- Clean Soil Backfill	400	cu. yd.	$9.75	1994	5	1.000	$9.75	$3,900.00		
Total Soil Excavation and Backfill Cost										$4,508.00
Off-Site Transport and Disposal										
- PCB-Contaminated Soil Transport and Disposal	400	cu. yd.	$300.00	1994	5	1.000	$300.00	$120,000.00		
- Health & Safety (17%)					4			$20,400.00		
Total Off-Site Transport and Disposal Cost										$140,400.00
Equipment Decontamination										
- Rental of Steam Cleaner	2	months	$425.00	1994	2	1.000	$425.00	$850.00		
- Construction of Decon Pit										
Excavate Pit	15	cu. yd.	$3.82	1994	2	1.000	$3.82	$57.30		
Polyethylene Tarpaulin	400	sq. ft.	$0.35	1994	2	1.000	$0.35	$140.00		
- Tanker Truck Rental	2	months	$650.00	1994	5	1.000	$650.00	$1,300.00		
- Disposal (Tanker Truck)	1	each	$1,600.00	1992	11	1.077	$1,723.20	$1,723.20		
Total Equipment Decontamination Cost										$4,070.50
Dust Control										
- Water Tank Sprayer	2	months	$2,075.00	1994	2	1.000	$2,075.00	$4,150.00		$4,150.00
Engineering Mgmt. Mob/Demob										
- 1 Trailer	2	months	$450.00	1994	2	1.000	$450.00	$900.00		$900.00
Direct Capital Cost Subtotal										$154,028.50
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$15,402.85		
Legal and Administrative (4%)					1			$6,161.14		
Total Indirect Capital Cost										$21,563.99
TOTAL CAPITAL COSTS										$175,592.49

ALTERNATIVE S-4, OPTION A
SOIL EXCAVATION AND DISPOSAL
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
(continued)

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
ANNUAL O&M COST								$0.00		
TOTAL NET PRESENT VALUE OF O & M										$0.00
SUBTOTAL COST										$175,592.49
CONTINGENCY (20%)										$35,118.50
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-4, OPTION A										$210,710.99

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-4, OPTION B
SOIL EXCAVATION AND OFF-SITE INCINERATION
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Soil Excavation and Backfill										
- Soil Excavation	400	cu. yd.	$1.52	1994	2	1.000	$1.52	$608.00		
- Clean Soil Backfill	400	cu. yd.	$9.75	1994	5	1.000	$9.75	$3,900.00		
Total Soil Excavation and Backfill Cost										$4,508.00
Off-Site Transport and Incineration										
- PCB-Contaminated Soil Transport an Incineration	540	tons	$2,500.00	1994	5	1.000	$2,500.00	$1,350,000.00		
- Health & Safety (17%)					4			$229,500.00		
Total Off-Site Transport and Disposal Cost										$1,579,500.00
Equipment Decontamination										
- Rental of Steam Cleaner	2	months	$425.00	1994	2	1.000	$425.00	$850.00		
- Construction of Decon Pit										
Excavate Pit	15	cu. yd.	$3.82	1994	2	1.000	$3.82	$57.30		
Polyethylene Tarpaulin	400	sq. ft.	$0.35	1994	2	1.000	$0.35	$140.00		
- Tanker Truck Rental	2	months	$650.00	1994	5	1.000	$650.00	$1,300.00		
- Disposal (Tanker Truck)	1	each	$1,600.00	1992	11	1.077	$1,723.20	$1,723.20		
Total Equipment Decontamination Cost										$4,070.50
Dust Control										
- Water Tank Sprayer	2	months	$2,075.00	1994	2	1.000	$2,075.00	$4,150.00		$4,150.00
Engineering Mgmt. Mob/Demob										
- 1 Trailer	2	months	$450.00	1994	2	1.000	$450.00	$900.00		$900.00
Direct Capital Cost Subtotal										$1,593,128.50
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$159,312.85		
Legal and Administrative (4%)					1			$63,725.14		
Total Indirect Capital Cost										$223,037.99
TOTAL CAPITAL COSTS										$1,816,166.49

ALTERNATIVE S-4, OPTION B
SOIL EXCAVATION AND OFF-SITE INCINERATION
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1
(continued)

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
ANNUAL O&M COST								$0.00		
TOTAL NET PRESENT VALUE OF O & M										$0.00
SUBTOTAL COST										$1,816,166.49
CONTINGENCY (20%)										$363,233.30
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-4, OPTION B										$2,179,399.79

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-4, OPTION C
SOIL EXCAVATION AND ON-SITE SOLVENT EXTRACTION
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
On-Site Solvent Extraction	540	tons	$112.12	1993	3	1.031	$115.60	$62,421.69		$62,421.69
Direct Capital Cost Subtotal										$62,421.69
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$6,242.17		
Legal and Administrative (4%)					1			$2,496.87		
Total Indirect Capital Cost										$8,739.04
TOTAL CAPITAL COSTS										$71,160.73
ANNUAL O&M COST								$0.00		
TOTAL NET PRESENT VALUE OF O & M										$0.00
SUBTOTAL COST										$71,160.73
CONTINGENCY (20%)										$14,232.15
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-4, OPTION C										$85,392.87

(1) - Calculated based on 5% interest rate.

ALTERNATIVE S-4, OPTION D
SOIL EXCAVATION AND IN-SITU FUNGAL DEGRADATION
SCENARIO 2 - EXCAVATION OF PCB-CONTAMINATED SOILS ONLY
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
In-Situ Fungal Degradation	400	cu. yd.	$300.00	1993	14	1.031	$309.30	$123,720.00		$123,720.00
Direct Capital Cost Subtotal										$123,720.00
CAPITAL COST - INDIRECT										
Engineering and Design (15%)					1			$18,558.00		
Legal and Administrative (5%)					1			$6,186.00		
Total Indirect Capital Cost										$24,744.00
TOTAL CAPITAL COSTS										$148,464.00
ANNUAL O&M COST								$0.00		
TOTAL NET PRESENT VALUE OF O & M										$0.00
SUBTOTAL COST										$148,464.00
CONTINGENCY (20%)										$29,692.80
TOTAL PRESENT VALUE COST FOR ALTERNATIVE S-4, OPTION D										$178,156.80

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW-2
LONG-TERM GROUND WATER MONITORING
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
TOTAL CAPITAL COSTS										$0.00
OPERATION AND MAINTENANCE COSTS										
Ground Water Monitoring (including trip blanks, field blanks and duplicate samples)										
- Annual Sampling	19	samples	$300.00	1994	5	1.000	$300.00	$5,700.00	30	$87,620.40
- Analysis:										
Full TCL/TAL	19	samples	$1,630.00	1993	10	1.031	$1,680.53	$31,930.07	30	$490,829.04
- Report Preparation	1	each	$10,000.00	1994	5	1.000	$10,000.00	$10,000.00	30	$153,720.00
ANNUAL O&M (1994 $)								$47,630.07		
TOTAL NET PRESENT VALUE OF O & M										$732,169.44
SUBTOTAL COST										$732,169.44
CONTINGENCY (20%)										$146,433.89
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-2										$878,603.32

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW-3, OPTION A
EXTRACTION OF GROUND WATER VIA INTERCEPTOR TRENCH
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Ground Water Extraction Trench										
-Excavation and Backfill	4,400	cu. yd.	$3.59	1994	2	1.000	$3.59	$15,796.00		
-1/2" Crushed Stone	3,200	cu. yd.	$30.00	1994	2	1.000	$30.00	$96,000.00		
-Geotextile Filter Fabric	6,700	sq. yd.	$1.41	1994	2	1.000	$1.41	$9,447.00		
-4" O.D. Slotted HDPE	1,200	l. ft.	$6.95	1994	2	1.000	$6.95	$8,340.00		
-Submersible Pumps	2	each	$196.00	1994	2	1.000	$196.00	$392.00		
-Pre-Cast Concrete Manhole	2	each	$2,584.00	1994	2	1.000	$2,584.00	$5,168.00		
Pipe Trench from Manhole to Treatment Area										
- 1 1/4" O.D. Non-Slotted HDPE Pipe	200	l. ft.	$4.60	1994	2	1.000	$4.60	$920.00		
-Excavation and Backfill	50	cu. yd.	$3.59	1994	2	1.000	$3.59	$179.50		
-Bedding Sand	25	cu. yd.	$16.20	1994	2	1.000	$16.20	$405.00		
Total Ground Water Extraction Trench										$173,868.62
Piezometer Installation										
-16 25-foot Piezometers - 2"	16	each	$2,160.00	1992	6	1.077	$2,326.32	$37,221.12		
Total Piezometer Installation										$37,221.12
Direct Capital Cost Subtotal										$211,089.74
CAPITAL COST - INDIRECT										
Engineering and Design (10 %)					1			$21,108.97		
Legal and Administrative (4%)					1			$8,443.59		
Indirect Capital Cost Subtotal										$29,552.56
TOTAL CAPITAL COSTS										$240,642.30
OPERATION AND MAINTENANCE COSTS										
Piezometer Monitoring	96	hrs	$100.00	1994	5	1.000	$100.00	$9,600.00	30	$147,571.20
ANNUAL O&M (1994 $)								$9,600.00		
TOTAL NET PRESENT VALUE OF O&M										$147,571.20
SUBTOTAL										$388,213.50
CONTINGENCY (20%)										$77,642.70
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-3, OPTION A										$465,856.20

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW-3, OPTION B
CARBON ADSORPTION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Carbon Treatment System										
- Electrical Connections	1	LS.	$10,000.00	1994	5	1.000	$10,000.00	$10,000.00		
- Piping and Controls	1	LS.	$10,000.00	1994	5	1.000	$10,000.00	$10,000.00		
- Equalization Tank	1	LS.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
Total Ground Water Treatment System Cost										$40,000.00
Direct Capital Cost Subtotal										$40,000.00
CAPITAL COST - INDIRECT										
Engineering and Design (15%)					1			$6,000.00		
Legal and Administrative (5%)					1			$2,000.00		
Total Indirect Capital Cost										$8,000.00
TOTAL CAPITAL COSTS										$48,000.00
OPERATION AND MAINTENANCE COSTS										
Carbon Treatment O&M										
- Carbon Supply	14	canisters	$450.00	1991	13	1.110	$499.50	$6,993.00	30	$107,496.40
- Delivery	4	each	$200.00	1991	13	1.110	$222.00	$888.00	30	$13,650.34
- Spent Carbon Disposal	14	drums	$400.00	1991	13	1.110	$444.00	$6,216.00	30	$95,552.35
ANNUAL O&M (1994 $)								$14,097.00		
TOTAL NET PRESENT VALUE OF O&M										$216,699.08
SUBTOTAL										$264,699.08
CONTINGENCY (20%)										$52,939.82
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-3, OPTION B										$317,638.90

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW-3, OPTION C
CHEMICAL PRECIPITATION
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-2 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Precipitation Treatment System										
- Neutralization/Precipitation/ Filtration/Filter Press Unit	1	each	$72,000.00	1987	9	1.219	$87,768.00	$87,768.00		
- Electrical Connections	1	LS.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
- Equalization Tank	1	LS.	$20,000.00	1994	5	1.000	$20,000.00	$20,000.00		
Total Ground Water Treatment System Cost										$127,768.00
Direct Capital Cost Subtotal										$127,768.00
CAPITAL COST - INDIRECT										
Engineering and Design (15%)					1			$19,165.20		
Legal and Administrative (5%)					1			$6,388.40		
Total Indirect Capital Cost										$25,553.60
TOTAL CAPITAL COSTS										$153,321.60
OPERATION AND MAINTENANCE COSTS										
- Precipitation O&M	5256	1000 gal	$8.00	1985	12	1.281	$10.25	$53,863.49	30	$827,989.54
ANNUAL O&M (1994 $)								$53,863.49		
TOTAL NET PRESENT VALUE OF O&M										$827,989.54
SUBTOTAL										$981,311.14
CONTINGENCY (20%)										$196,262.23
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-3, OPTION C										$1,177,573.37

(1) - Calculated based on 5% interest rate.

ALTERNATIVE GW-3, OPTION D
DISCHARGE TO SURFACE WATER
SITE 13 - DISPOSAL AREA NORTHWEST OF BUILDINGS W-3, W-4 AND T-1

Item	Quantity	Units	Unit Price	Basis Year	Reference	Escalation	1994 Unit Costs	1994 Costs	Years (O&M)	(1) Present Value (O&M)
CAPITAL COST - DIRECT										
Piping From Treatment System To Surface Water										
- Trench Excavation & Backfill	2,000 l. ft.		$5.73	1994	2	1.000	$5.73	$11,460.00		
- 2" Diam. PVC in Trench	2,000 l. ft.		$4.60	1994	2	1.000	$4.60	$9,200.00		
- Pipe Bedding (sand)	2,000 l. ft.		$1.32	1994	2	1.000	$1.32	$2,640.00		
Total Piping Cost										$23,300.00
Direct Capital Cost Subtotal										$23,300.00
CAPITAL COST - INDIRECT										
Engineering and Design (10%)					1			$2,330.00		
Legal and Administrative (4%)					1			$932.00		
Total Indirect Capital Cost										$3,262.00
TOTAL CAPITAL COSTS										$26,562.00
OPERATION AND MAINTENANCE COSTS										
Discharge Sampling & Analysis										
- Monthly Sampling	12 samples		$300.00	1994	5	1.000	$300.00	$3,600.00	30	$55,339.20
- Full TCL/TAL	12 samples		$1,630.00	1993	10	1.031	$1,680.53	$20,166.36	30	$309,997.29
ANNUAL O&M (1994 $)								$23,766.36		
TOTAL NET PRESENT VALUE OF O&M										$365,336.49
SUBTOTAL										$391,898.49
CONTINGENCY (20%)										$78,379.70
TOTAL PRESENT VALUE COST FOR ALTERNATIVE GW-3, OPTION D										$470,278.18

(1) - Calculated based on 5% interest rate.

COST REFERENCES

1) Remedial Action Costing Procedures Manual; JRB Associates; October 1987.

2) Means Site Work & Landscape Cost Data; 1994.

3) USEPA, 1993. Resources Conservation Company B.E.S.T.™ Solvent Extraction Technology Applications Analysis Report; June 1993.

4) Compendium of Costs of Remedial Technologies at Hazardous Waste Sites; Environmental Law Institute; October 1987. EPA/600/2-87/08.

5) TRC Environmental Corporation; 1994.

6) Empire Soils Investigations, Inc., Division of Huntingdon; January 1992.

7) Waste Alternatives; December 1988.

8) Gundle Lining Systems; 1994.

9) Technical Resource Document; Treatment Technologies for Metals/Cyanide Containing Wastes, Alliance Technologies Corp.; December 1987.

10) Weston Analytical Laboratory; 1993.

11) DuPont Environmental Treatment Services; 1992.

12) Remedial Action at Waste Disposal Sites; October 1985. EPA/625/6-85/006.

13) WesStates Carbon; 1991.

14) VISITT, Version 2.0. April, 1993.

APPENDIX F

APPENDIX F

GROUND WATER MODELING SUMMARY

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APPENDIX F

GROUND WATER MODELING SUMMARY

1.0 INTRODUCTION/OBJECTIVES

Under Alternative GW-3A - Ground Water Extraction via Interceptor Trench, a system of one or more ground water interceptor trenches was proposed for the capture and extraction of impacted Site 13 ground water from the unconsolidated overburden for treatment and disposal. The Phase I and Phase II RI field investigations revealed that at Site 13 the depth to bedrock is shallow (20 to 25 feet) and the silt content of the unconsolidated overburden aquifer appears to yield low hydraulic conductivity values (K-values) and pumping rates. Due to these circumstances, interceptor trenches were judged to be a more effective means than extraction wells in providing effective capture of the Site 13 ground water and preventing off-site migration of the ground water contaminants. In order to produce a preliminary interceptor trench design for the purposes of option analysis, evaluation, and costing, a ground water flow model was used to: 1) simulate the ground water flow regime at Site 13, and 2) configure an interceptor trench system to provide control and capture of the estimated areal extent of site ground water with contaminant concentrations exceeding ARARs and/or risk-based PRGs. ARARs and/or risk-based PRGs were exceeded in the Phase I and/or Phase II samples from all of the Site 13 shallow and deep monitoring wells except shallow monitoring well 13-MW08S, located at the hydraulically downgradient northeastern margin of the site. Therefore, the area of Site 13 requiring ground water capture, extraction and treatment was assumed to include the entire site except the area immediately surrounding 13-MW08S. In addition, within the estimated area of ground water impacts, it was assumed that the entire saturated interval between the shallow water table and the bedrock underlying Site 13 would require capture and extraction. A description of the modeling procedures, including the model assumptions and the input initial and boundary conditions, is presented in the following sections. Model data sheets are provided following this summary and the associated figures.

2.0 INITIAL MODEL SETUP

FLOWPATH™ Version 3.0 (Waterloo Hydrogeologic Software, 1992), a two-dimensional numerical ground water flow and particle pathlines simulation model, was used to simulate the Site 13 ground water flow regime and to design the proposed ground water interception trench system. The area encompassed by the FLOWPATH™ model grid is shown in Figure F-1. The grid was configured with the principal axes oriented to parallel the primary directions of shallow ground water flow at Site 13. At Site 13, a northwest-trending zone of higher shallow ground water elevation forms a shallow ground water divide extending from the southeast portion of the site to the northwest portion. The shallow ground water elevations measured within the divide area vary only slightly (i.e., less than 0.5 foot), and the areal configuration of the divide may vary with changes in water level and precipitation recharge. The divide reflects Site 13's location midway between Mill and Hall Creeks. Along the western/southwestern flank of the divide, shallow ground water flows generally west-southwestward toward Site 11 and Mill Creek. Along the northern/northeastern flank of the divide, shallow ground water flows generally north-northeastward toward Site 06 and Hall Creek. The model grid is comprised of 33 rows and 33 columns; the variable nodal spacing ranges from 10 to 50 feet. The grid measures 1,500 feet by 1,500 feet, for a total simulation area of 2,250,000 square feet (51.7 acres). The nodal spacing was considered to be optimal to provide coverage of the large modeled area while also allowing flexibility in the development and optimization of the interceptor trench configuration.

A one-layer simulation was used to simulate the Site 13 unconsolidated overburden aquifer. The aquifer was modeled as unconfined, where a portion of the water stored in the aquifer is released by dewatering of the aquifer, and the transmissivity is a product of the hydraulic conductivity (K-value) and the saturated thickness (the hydraulic head minus the elevation of the aquifer bottom at bedrock). The initial input nodal K-value was 2.0 ft/d; this value represents the median K-value determined from the slug tests conducted at the Phase II shallow monitoring wells during the Phase II RI field investigation (Table 4-6, Phase II RI, TRC, 1993). The input aquifer porosity was 0.15 (15 percent); this value represents the average typical value for silty sands determined from 55 field sites (EPRI, 1985). The aquifer bottom was input as 5.5 feet above mean sea level (ft msl), the average bedrock elevation value determined from the logs for the three monitoring well borings where bedrock cores were collected, 13-MW03D, 13-MW07S and 13-MW10D.

A large area was modeled to account for the spatial distribution and potential influence area of the interception trench system; a substantial distance between the system components and the model boundaries must be maintained to limit the influence of boundary effects. The model boundaries were extended outward as far as considered practical when taking into account the areal range of Site 13 water level data points available. As the modeled area of the unconsolidated overburden aquifer is not bounded on any side by an impermeable boundary, constant-head boundaries were placed at the edges of the modeled area to establish flow through the model. The potential constant head boundary effects are considered to be minimal and conservative.

3.0 MODEL CALIBRATION

The ground water flow model was calibrated to steady-state (non-stressed) conditions existing at Site 13 on August 13, 1993. After each model run was conducted, the nodal K-value and/or constant head boundary head values were adjusted as necessary until the model was calibrated to the non-pumping conditions at Site 13 on August 13, 1993. Figure F-2 shows the results of the steady-state calibration for the unconsolidated overburden aquifer at the site. The resulting nodal K-values were kept within the range of K-values determined from the Phase II RI shallow well slug tests (1.0 to 7.5 ft/d).

4.0 REMEDIAL SIMULATIONS

After completing the model calibration, remedial simulations were run to establish the optimal configuration of an interceptor trench system for capturing the unconsolidated overburden ground water flow from areas that were found in the Phase I and Phase II RI field investigations to exhibit contamination above ARARs and/or risk-based PRGs. Due to the presence of the shallow ground water divide at Site 13, it was assumed that two separate trench areas would be required in order to capture the ground water from the entire areal extent of Site 13 with ground water contaminant levels in excess of ARARs and/or risk-based PRGs. One trench would be located just west of monitoring wells 13-MW02, 13-MW09S and 13-MW10S/D and the other would be located just north of monitoring wells 13-MW06S and 13-MW07S.

Preliminary Remedial Simulations - Extraction Wells

Prior to simulating the interceptor trench system, a preliminary evaluation was made whereby a system of ground water extraction wells was simulated to assist in the determination of the optimum locations and extraction rates for the trenches. The resulting ground water hydraulic head distributions and corresponding model-calculated ground water particle pathlines were inspected to ensure that adequate capture was accomplished across the estimated area of ground water to be extracted and treated. Based on the low yields (approximately 0.5 gallon per minute) of the Site 13 monitoring wells during their development, it was determined that a system of eight extraction wells (four located in an east-west line just north of 13-MW06S and 13-MW07S and four located in a north-south line just west of monitoring wells 13-MW02, 13-MW09S and 13-MW10S/D), each extracting at a rate of 0.5 gpm, would provide adequate control and capture of the impacted site ground water.

Final Remedial Simulations - Interceptor Trenches

After completing the preliminary extraction well simulations, numerous interceptor trench remedial simulations were run to determine the optimum combination of number, locations, lengths and extraction rates of trenches to provide hydraulic control and capture equivalent to that produced by the simulated extraction wells. The resulting ground water hydraulic head distributions and corresponding model-calculated ground water particle pathlines were inspected to ensure that adequate capture was accomplished across the estimated area of ground water to be extracted and treated. The capture zones were limited to those portions of the flow regime

where the ground water particles were shown migrating toward and into the trenches for extraction. Based on the results of the preliminary extraction well simulations, it was assumed that each trench would be capable of capturing and extracting the site ground water at a rate of two gpm. The position and length of the trenches were adjusted until capture of the ground water requiring extraction and treatment was shown. In addition, the trench system configuration was adjusted so that neither of the trenches would cross under streets nor lie too close to existing buildings.

5.0 RESULTS OF INTERCEPTOR TRENCH REMEDIAL SIMULATIONS

The evaluation of the interceptor trench simulations determined that two separate 600-foot-long interceptor trenches, each extracting ground water at a rate of two gpm, would be required in order to capture the ground water from the entire estimated areal extent of Site 13 with ground water contaminant levels in excess of ARARs and/or risk-based PRGs. Figure F-3 shows the locations of the two trenches, as well as the hydraulic head distribution resulting from the four gpm total extraction at the trenches. Figure F-4 presents the model-calculated ground water particle pathlines, and shows the extent of capture that the trenches would establish as modeled. Figure 4-4 also shows the locations of the two trenches. The two trenches would be located along the western and northern margins of the site and would be elongated perpendicular to the principal direction of ground water flow in those areas; the western trench would be elongated north-south, and the northern trench would be elongated east-west.

6.0 RECOMMENDED INTERCEPTOR TRENCH SYSTEM DESIGN

Interceptor Trenches

The proposed Site 13 ground water interceptor trenches should be designed to intercept the entire saturated thickness at their locations. Based on the Phase II RI monitoring well logs for 13-MW03D, 13-MW07S and 13-MW10D, it is estimated that the average depth to bedrock in the proposed trench areas is 25 feet below grade. Each trench would therefore be approximately 600 feet long, 25 feet deep and 3 to 4 feet wide, and would be equipped on one end with a precast manhole sump into which the intercepted ground water would flow to be lifted by means of a submersible pump to the surface for treatment. A typical interceptor trench cross-section is provided as Figure 4-5. Within each trench, the drain itself would consist of a 600-foot length of 4-inch O.D. perforated HDPE pipe placed at a slight incline toward the sump end of the trench, to direct drainage flow toward the sump. The placement depth of the drain pipe and sump would depend on the shallowest depth to bedrock at each trench location, expected to be approximately 20 to 25 feet below grade.

At each trench after excavation, a nonwoven geotextile fabric filter should be installed around the trench perimeter to surround the gravel envelope for the pipe drain and inhibit the entrance of fines into the trench. The gravel envelope, consisting of one-half- to three-quarter-inch diameter crushed stone, would then be installed to surround the drainage pipe. At least one foot of compacted gravel should underlie the drainage pipe to establish a gravel bed for the pipe. After installing the drain pipe, additional gravel should be installed and compacted up to a depth of four feet below grade (the approximate maximum seasonal high ground water level); the fabric filter should then be wrapped over the top of the gravel envelope. The remainder of the trench should then be backfilled with excavated soil, compacted and brought to original grade. The trench sump should be fitted with a one-quarter-horsepower sump pump to lift the intercepted ground water to the surface for treatment.

Piezometers

In order to monitor the effectiveness of the interceptor trenches in providing capture of the site ground water, a system of ground water piezometers should be installed surrounding each trench. It is proposed that a total of 16 piezometers, four hydraulically upgradient and four downgradient of each trench, be installed after the trench installation. Figure 4-4 shows the locations of the piezometers relative to the trench locations. The piezometers would be located

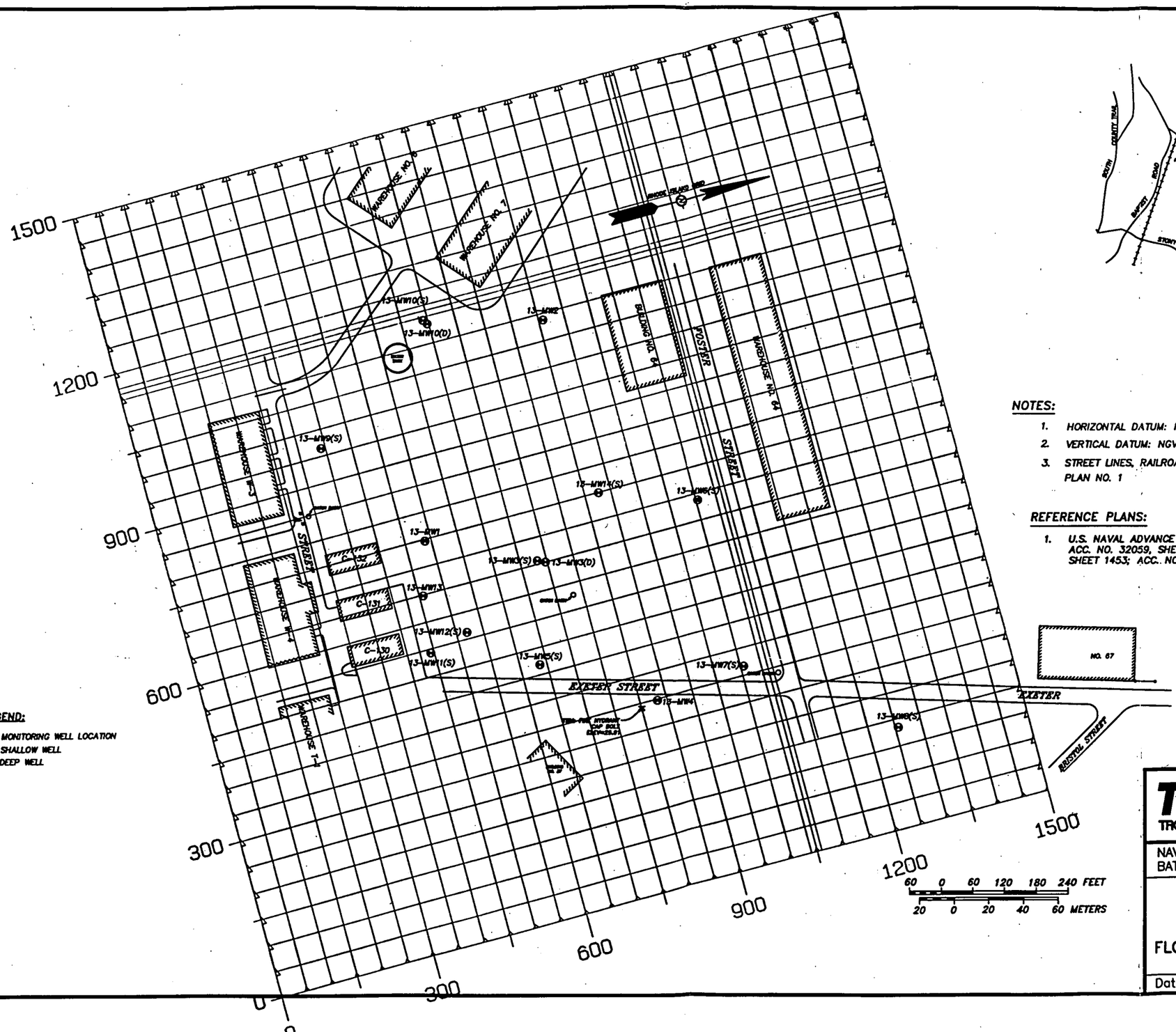
approximately 10 feet from the sides of each trench, and would be spaced every 200 feet along the trench length. Each piezometer would be installed to screen the aquifer from the water table to bedrock, with a total depth of approximately 20 to 25 feet below grade. Each piezometer would be constructed of two-inch I.D. Schedule 40 PVC, with approximately the bottom 20 feet screened with 0.010-inch slotted screen.

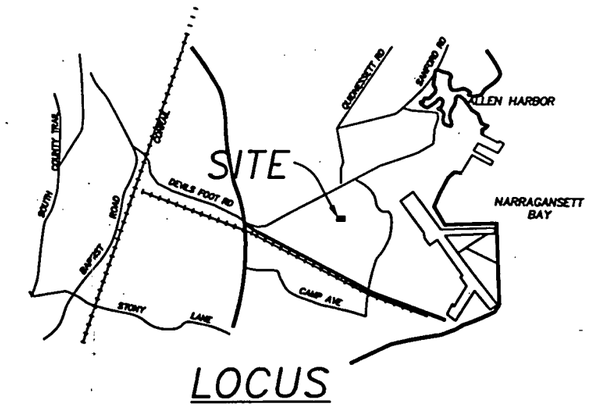
REFERENCES - APPENDIX F

Electric Power Research Institute (EPRI), 1985. A review of field-scale physical solute transport processes in saturated and unsaturated porous media. EPRI EA-4190, Electric Power Research Institute, Palo Alto, California.

TRC Environmental Corporation (TRC), 1993. Phase II Remedial Investigation Report, Naval Construction Battalion Center, Davisville, Rhode Island. Prepared for Northern Division, Naval Facilities Engineering Command, Philadelphia, Pennsylvania. Contract No. N62472-86-C-1282, November 1993.

Waterloo Hydrogeologic Software, 1992. FLOWPATH™ Version 3.0 Steady-State Two-Dimensional Horizontal Aquifer Simulation Model. Waterloo Hydrogeologic Software, Waterloo, Ontario, Canada.





LOCUS

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

LEGEND:

- ⊖ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL

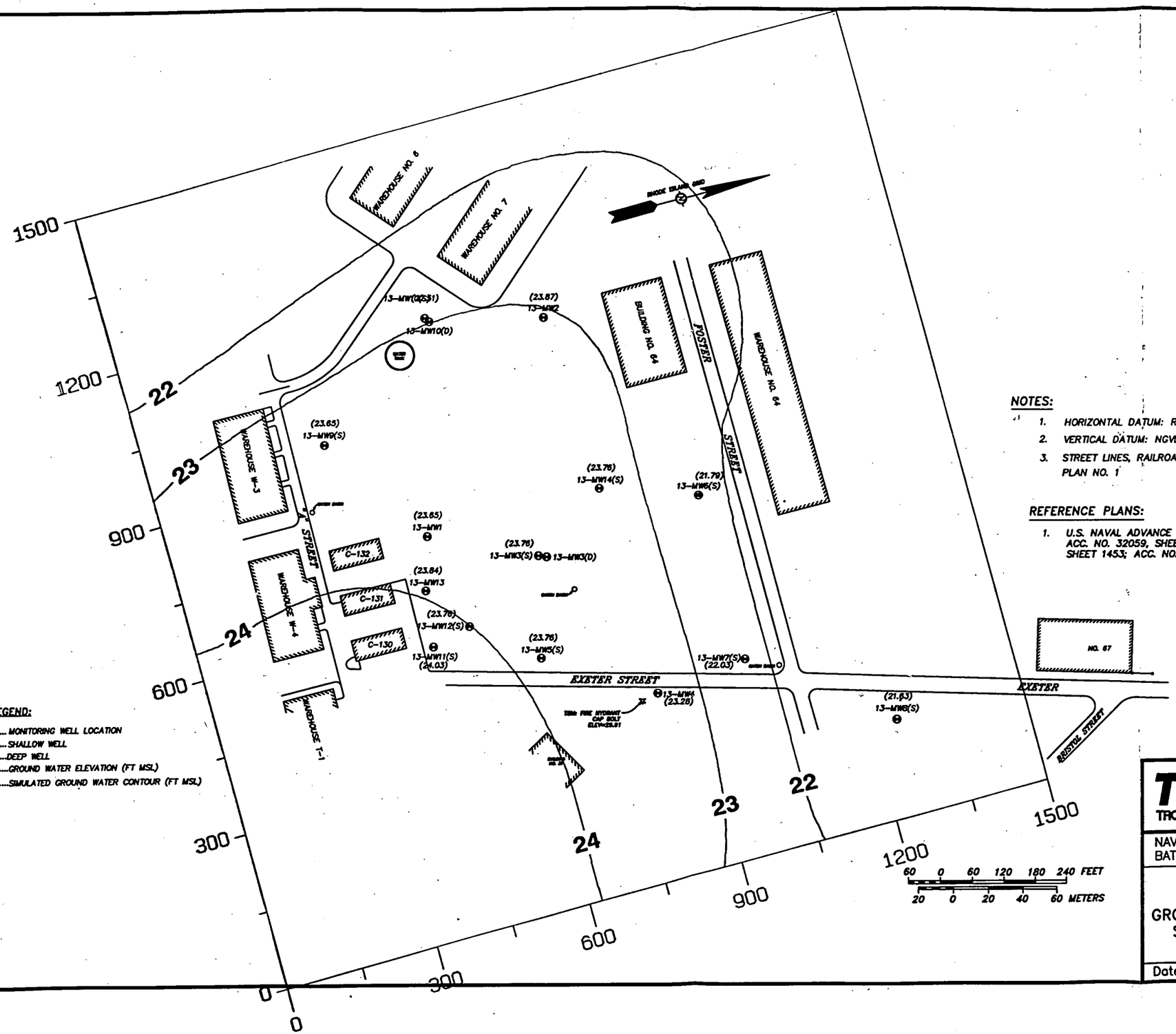
TRC
TRC Environmental Corporation
5 Waterside Crossing
Windsor, CT 06095
(203) 289-8631

NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-1.
SITE 13-DISPOSAL AREA NORTHWEST
FLOWPATH GROUND WATER FLOW MODEL GRID

Date: 4/94 | Project No. 01042-0040

13SW200



LEGEND:

- ⊖ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- (23.65) ..... GROUND WATER ELEVATION (FT MSL)
- 22 ..... SIMULATED GROUND WATER CONTOUR (FT MSL)

NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

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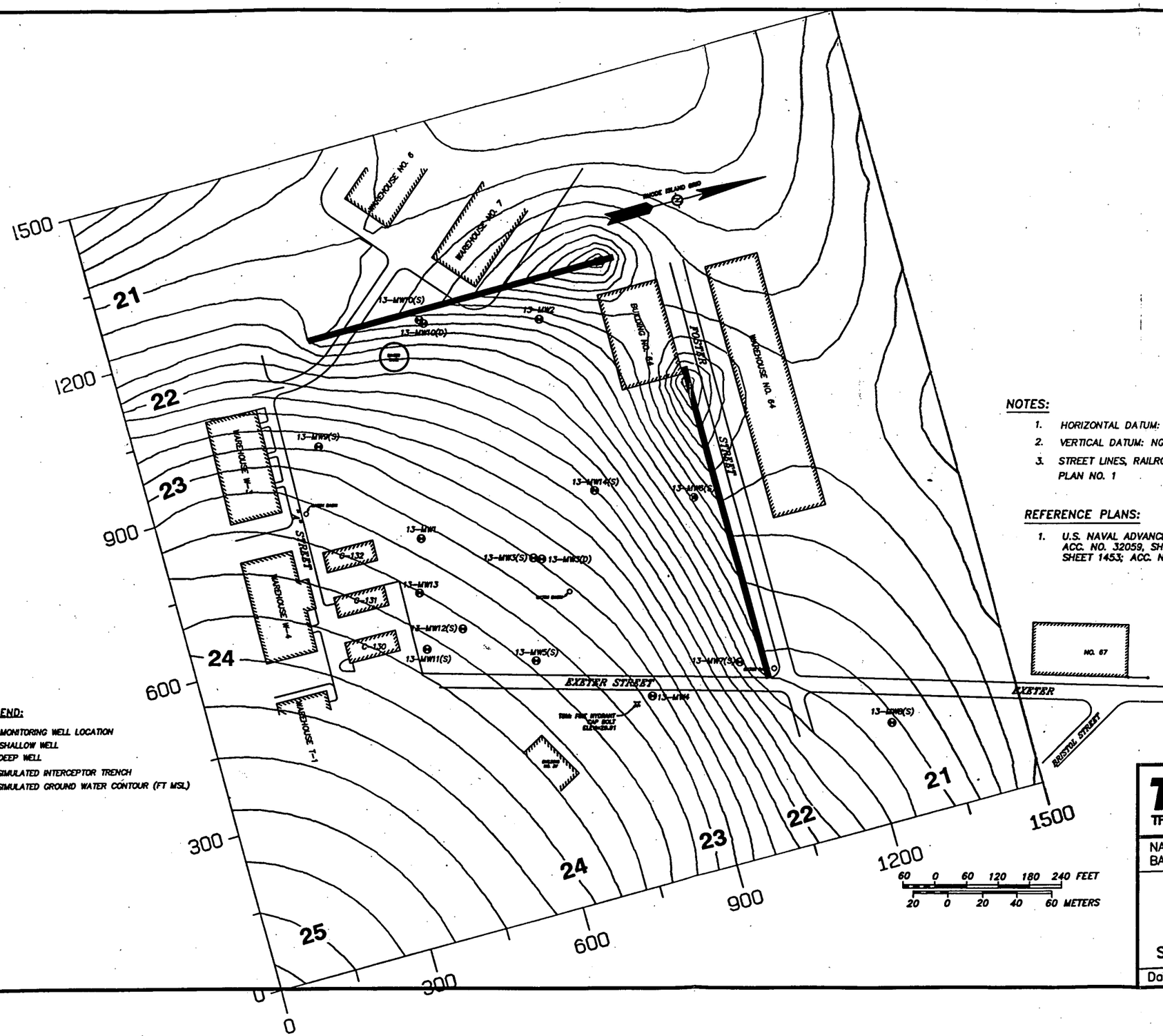
NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-2.
SITE 13-DISPOSAL AREA NORTHWEST
GROUND WATER FLOW MODEL CALIBRATION TO SHALLOW GROUND WATER STEADY-STATE CONDITIONS ON AUGUST 13, 1993

Date: 4/94 | Project No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

LEGEND:

- ⊖ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▬ ..... SIMULATED INTERCEPTOR TRENCH
- —19— ..... SIMULATED GROUND WATER CONTOUR (FT MSL)

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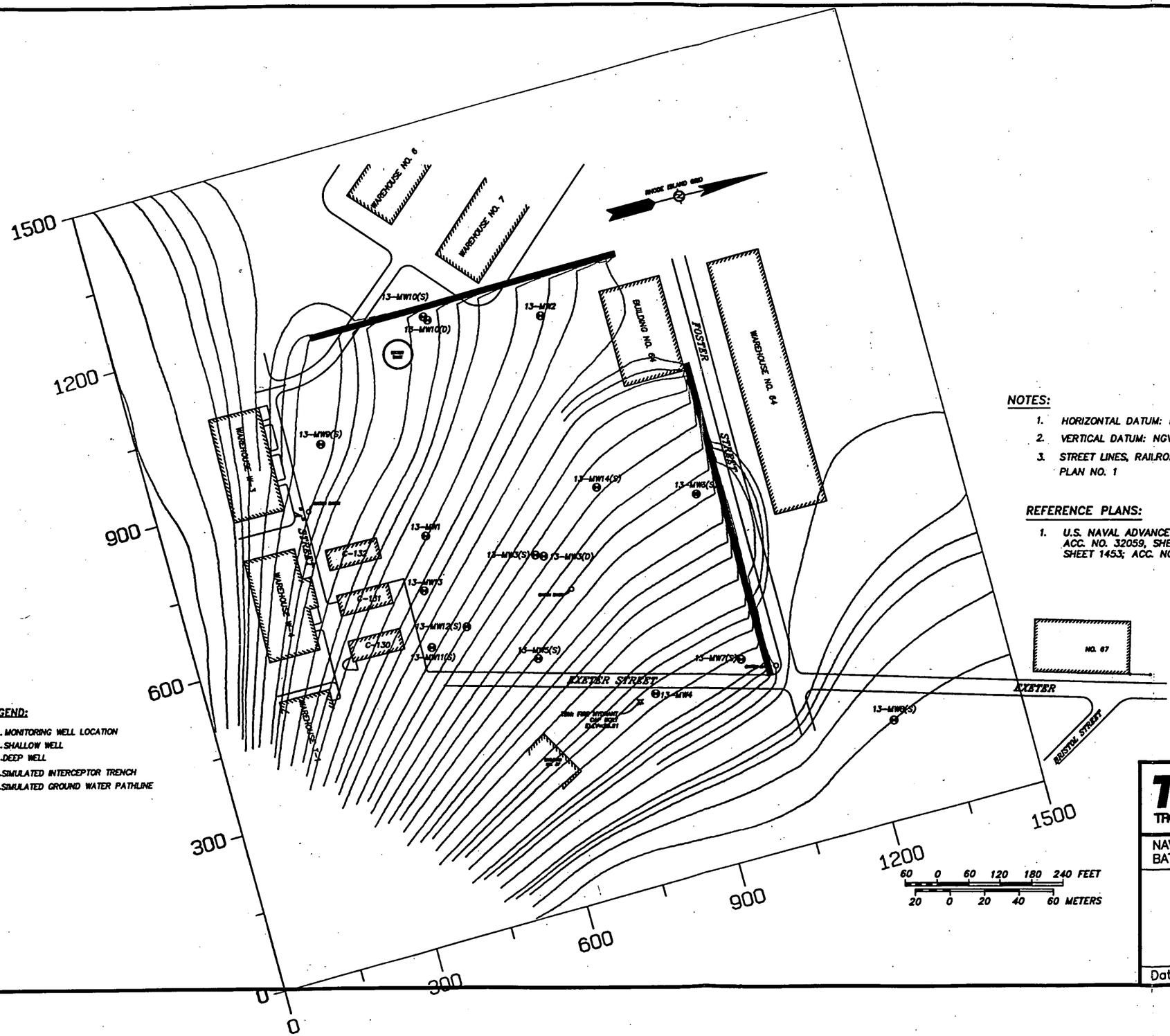
Windsor, CT 06095
(203) 289-8631

NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-3.
SITE 13-DISPOSAL AREA NORTHWEST
SIMULATION RESULTS, PROPOSED
GROUND WATER INTERCEPTOR TRENCHES
SHALLOW GROUND WATER LEVEL CONTOURS

Date: 4/94 | Project No. 01042-0040



NOTES:

1. HORIZONTAL DATUM: RHODE ISLAND GRID, NAD 1927, 1969 ADJUSTMENT.
2. VERTICAL DATUM: NGVD 1929.
3. STREET LINES, RAILROAD TRACKS, ROADS & WATER LINES PROTRACTED FROM REFERENCE PLAN NO. 1

REFERENCE PLANS:

1. U.S. NAVAL ADVANCE BASE DEPOT, DAVISVILLE, R.I., SUB-SURFACE A.B.D., NAVY DEPT. ACC. NO. 32059, SHEET 1273; ACC. NO. 32077, SHEET 1363 & 1363; ACC. NO. 32094, SHEET 1453; ACC. NO. 32112, SHEET NO. 1542.

LEGEND:

- ⊖ ..... MONITORING WELL LOCATION
- (S) ..... SHALLOW WELL
- (D) ..... DEEP WELL
- ▬ ..... SIMULATED INTERCEPTOR TRENCH
- ——— ..... SIMULATED GROUND WATER PATHLINE

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NAVAL CONSTRUCTION BATTALION CENTER — DAVISVILLE RHODE ISLAND

FIGURE F-4.
SITE 13-DISPOSAL AREA NORTHWEST
SIMULATION RESULTS, PROPOSED
GROUND WATER INTERCEPTOR TRENCH
INTERCEPTOR TRENCH CAPTURE ZONES

Date: 4/94 | Proj ct No. 01042-0040

13SN200

```
*************************************************************
*                      E C H O P R I N T                    *
*                                                           *
*                       F L O W P A T H                     *
*                         version 3.0                       *
*                                                           *
*  FLOWPATH was written by Thomas Franz and Nilson Guiguer  *
*                                                           *
*************************************************************
*                                                           *
*                    Copyright 1989, 1990                   *
*                             by                            *
*               Waterloo Hydrogeologic Software             *
*                    113-106 Seagram Drive                  *
*                      Waterloo, Ontario                    *
*                       N2L 3B8, Canada                     *
*                                                           *
*                      ph (519) 746-1798                    *
*                                                           *
*************************************************************
```

FLOWPATH logbook for data set : SITE13CA

Unit System : English units [ft/gal/d]

***** GRID PARAMETERS *****

Number of x-grid lines : 33

Number of y-grid lines : 33

Grid coordinates (x-grid lines) [ft] :

1	0.00000E+00
2	5.00000E+01
3	1.00000E+02
4	1.50000E+02
5	2.00000E+02
6	2.50000E+02
7	3.00000E+02
8	3.50000E+02
9	4.00000E+02
10	4.50000E+02
11	5.00000E+02
12	5.50000E+02
13	6.00000E+02
14	6.50000E+02
15	7.00000E+02
16	7.50000E+02
17	8.00000E+02

18	8.50000E+02
19	9.00000E+02
20	9.50000E+02
21	1.00000E+03
22	1.03872E+03
23	1.05000E+03
24	1.05863E+03
25	1.10000E+03
26	1.15000E+03
27	1.20000E+03
28	1.25000E+03
29	1.30000E+03
30	1.35000E+03
31	1.40000E+03
32	1.45000E+03
33	1.50000E+03

Grid coordinates (y-grid lines) [ft] :

1	0.00000E+00
2	5.00000E+01
3	1.00000E+02
4	1.50000E+02
5	2.00000E+02
6	2.50000E+02
7	3.00000E+02
8	3.50000E+02
9	4.00000E+02
10	4.50000E+02
11	5.00000E+02
12	5.50000E+02
13	6.00000E+02
14	6.50000E+02
15	7.00000E+02
16	7.50000E+02
17	8.00000E+02
18	8.50000E+02
19	9.00000E+02
20	9.50000E+02
21	1.00000E+03
22	1.05000E+03
23	1.10000E+03
24	1.15000E+03
25	1.16150E+03
26	1.17146E+03
27	1.20000E+03
28	1.25000E+03
29	1.30000E+03
30	1.35000E+03
31	1.40000E+03
32	1.45000E+03
33	1.50000E+03

***** WELL PARAMETERS *****

Number of wells : 14

No.	i	j	X [ft]	Y [ft]	well discharge [gpd]
1	10	12	4.51327E+02	5.50885E+02	0.00000E+00
2	10	14	4.51327E+02	6.50442E+02	0.00000E+00
3	11	16	5.01106E+02	7.50000E+02	0.00000E+00
4	8	20	3.48451E+02	9.49115E+02	0.00000E+00
5	12	12	5.50885E+02	5.50885E+02	0.00000E+00
6	14	10	6.50442E+02	4.51327E+02	0.00000E+00
7	15	14	7.00221E+02	6.50442E+02	0.00000E+00
8	13	24	6.00664E+02	1.15155E+03	0.00000E+00
9	17	23	7.99779E+02	1.09845E+03	0.00000E+00
10	18	16	8.49558E+02	7.50000E+02	0.00000E+00
11	21	15	9.98894E+02	7.00221E+02	0.00000E+00
12	21	8	9.98894E+02	3.48451E+02	0.00000E+00
13	18	8	8.49558E+02	3.48451E+02	0.00000E+00
14	28	5	1.25111E+03	1.99115E+02	0.00000E+00

***** CONSTRAINED HEAD NODES *****

Number of constant head nodes : 120

No.	i	j	X [ft]	Y [ft]	const. head [ft]
1	33	1	1.50000E+03	0.00000E+00	2.01000E+01
2	32	1	1.45022E+03	0.00000E+00	2.04000E+01
3	31	1	1.40044E+03	0.00000E+00	2.07000E+01
4	30	1	1.35066E+03	0.00000E+00	2.09000E+01
5	29	1	1.30088E+03	0.00000E+00	2.11000E+01
6	28	1	1.25111E+03	0.00000E+00	2.12000E+01
7	27	1	1.20133E+03	0.00000E+00	2.14000E+01
8	26	1	1.15155E+03	0.00000E+00	2.16000E+01
9	25	1	1.09845E+03	0.00000E+00	2.18000E+01
10	23	1	1.04867E+03	0.00000E+00	2.21000E+01
11	21	1	9.98894E+02	0.00000E+00	2.23000E+01
12	20	1	9.49115E+02	0.00000E+00	2.25000E+01
13	19	1	8.99336E+02	0.00000E+00	2.28000E+01
14	18	1	8.49558E+02	0.00000E+00	2.31000E+01
15	17	1	7.99779E+02	0.00000E+00	2.33000E+01
16	16	1	7.50000E+02	0.00000E+00	2.35000E+01
17	15	1	7.00221E+02	0.00000E+00	2.37000E+01
18	14	1	6.50442E+02	0.00000E+00	2.39000E+01
19	13	1	6.00664E+02	0.00000E+00	2.41000E+01
20	12	1	5.50885E+02	0.00000E+00	2.42000E+01
21	11	1	5.01106E+02	0.00000E+00	2.43000E+01
22	10	1	4.51327E+02	0.00000E+00	2.44000E+01
23	9	1	4.01549E+02	0.00000E+00	2.45000E+01
24	8	1	3.48451E+02	0.00000E+00	2.46000E+01
25	7	1	2.98673E+02	0.00000E+00	2.47000E+01
26	6	1	2.48894E+02	0.00000E+00	2.48000E+01
27	5	1	1.99115E+02	0.00000E+00	2.49000E+01
28	4	1	1.49336E+02	0.00000E+00	2.50000E+01
29	3	1	9.95575E+01	0.00000E+00	2.51000E+01
30	2	1	4.97788E+01	0.00000E+00	2.52000E+01
31	1	1	0.00000E+00	0.00000E+00	2.53000E+01

32	1	2	0.00000E+00	4.97788E+01	2.52000E+01
33	1	3	0.00000E+00	9.95575E+01	2.51000E+01
34	1	4	0.00000E+00	1.49336E+02	2.50000E+01
35	1	5	0.00000E+00	1.99115E+02	2.49000E+01
36	1	6	0.00000E+00	2.48894E+02	2.48000E+01
37	1	7	0.00000E+00	2.98673E+02	2.47000E+01
38	1	8	0.00000E+00	3.48451E+02	2.46000E+01
39	1	9	0.00000E+00	4.01549E+02	2.45000E+01
40	1	10	0.00000E+00	4.51327E+02	2.44000E+01
41	1	11	0.00000E+00	5.01106E+02	2.43000E+01
42	1	12	0.00000E+00	5.50885E+02	2.42000E+01
43	1	13	0.00000E+00	6.00664E+02	2.41000E+01
44	1	14	0.00000E+00	6.50442E+02	2.40000E+01
45	1	15	0.00000E+00	7.00221E+02	2.38000E+01
46	1	16	0.00000E+00	7.50000E+02	2.37000E+01
47	1	17	0.00000E+00	7.99779E+02	2.36000E+01
48	1	18	0.00000E+00	8.49558E+02	2.34000E+01
49	1	19	0.00000E+00	8.99336E+02	2.32000E+01
50	1	20	0.00000E+00	9.49115E+02	2.30000E+01
51	1	21	0.00000E+00	9.98894E+02	2.27000E+01
52	1	22	0.00000E+00	1.04867E+03	2.25000E+01
53	1	23	0.00000E+00	1.09845E+03	2.23000E+01
54	1	24	0.00000E+00	1.15155E+03	2.17000E+01
55	1	27	0.00000E+00	1.20133E+03	2.15000E+01
56	1	28	0.00000E+00	1.25111E+03	2.13000E+01
57	1	29	0.00000E+00	1.30088E+03	2.11000E+01
58	1	30	0.00000E+00	1.35066E+03	2.09000E+01
59	1	31	0.00000E+00	1.40044E+03	2.06000E+01
60	1	32	0.00000E+00	1.45022E+03	2.03000E+01
61	1	33	0.00000E+00	1.50000E+03	2.00000E+01
62	2	33	4.97788E+01	1.50000E+03	2.01000E+01
63	3	33	9.95575E+01	1.50000E+03	2.02000E+01
64	4	33	1.49336E+02	1.50000E+03	2.03000E+01
65	5	33	1.99115E+02	1.50000E+03	2.04000E+01
66	6	33	2.48894E+02	1.50000E+03	2.05000E+01
67	7	33	2.98673E+02	1.50000E+03	2.06000E+01
68	8	33	3.48451E+02	1.50000E+03	2.06000E+01
69	9	33	4.01549E+02	1.50000E+03	2.07000E+01
70	10	33	4.51327E+02	1.50000E+03	2.07000E+01
71	11	33	5.01106E+02	1.50000E+03	2.08000E+01
72	12	33	5.50885E+02	1.50000E+03	2.09000E+01
73	13	33	6.00664E+02	1.50000E+03	2.10000E+01
74	14	33	6.50442E+02	1.50000E+03	2.11000E+01
75	15	33	7.00221E+02	1.50000E+03	2.12000E+01
76	16	33	7.50000E+02	1.50000E+03	2.13000E+01
77	17	33	7.99779E+02	1.50000E+03	2.14000E+01
78	18	33	8.49558E+02	1.50000E+03	2.14000E+01
79	19	33	8.99336E+02	1.50000E+03	2.14000E+01
80	20	33	9.49115E+02	1.50000E+03	2.14000E+01
81	21	33	9.98894E+02	1.50000E+03	2.14000E+01
82	23	33	1.04867E+03	1.50000E+03	2.14000E+01
83	25	33	1.09845E+03	1.50000E+03	2.14000E+01
84	26	33	1.15155E+03	1.50000E+03	2.14000E+01
85	27	33	1.20133E+03	1.50000E+03	2.13000E+01
86	28	33	1.25111E+03	1.50000E+03	2.12000E+01
87	29	33	1.30088E+03	1.50000E+03	2.11000E+01
88	30	33	1.35066E+03	1.50000E+03	2.10000E+01
89	31	33	1.40044E+03	1.50000E+03	2.09000E+01
90	32	33	1.45022E+03	1.50000E+03	2.08000E+01
91	33	33	1.50000E+03	1.50000E+03	2.07000E+01

92	33	2	1.50000E+03	4.97788E+01	2.02000E+01
93	33	3	1.50000E+03	9.95575E+01	2.02000E+01
94	33	4	1.50000E+03	1.49336E+02	2.02000E+01
95	33	5	1.50000E+03	1.99115E+02	2.02000E+01
96	33	6	1.50000E+03	2.48894E+02	2.02000E+01
97	33	7	1.50000E+03	2.98673E+02	2.02000E+01
98	33	8	1.50000E+03	3.48451E+02	2.01000E+01
99	33	9	1.50000E+03	4.01549E+02	2.01000E+01
100	33	10	1.50000E+03	4.51327E+02	2.01000E+01
101	33	11	1.50000E+03	5.01106E+02	2.01000E+01
102	33	12	1.50000E+03	5.50885E+02	2.01000E+01
103	33	13	1.50000E+03	6.00664E+02	2.00000E+01
104	33	14	1.50000E+03	6.50442E+02	1.99000E+01
105	33	15	1.50000E+03	7.00221E+02	1.98000E+01
106	33	16	1.50000E+03	7.50000E+02	1.99000E+01
107	33	17	1.50000E+03	7.99779E+02	2.00000E+01
108	33	18	1.50000E+03	8.49558E+02	2.00000E+01
109	33	19	1.50000E+03	8.99336E+02	2.01000E+01
110	33	20	1.50000E+03	9.49115E+02	2.01000E+01
111	33	21	1.50000E+03	9.98894E+02	2.02000E+01
112	33	22	1.50000E+03	1.04867E+03	2.02000E+01
113	33	23	1.50000E+03	1.09845E+03	2.02000E+01
114	33	24	1.50000E+03	1.15155E+03	2.03000E+01
115	33	27	1.50000E+03	1.20133E+03	2.03000E+01
116	33	28	1.50000E+03	1.25111E+03	2.03000E+01
117	33	29	1.50000E+03	1.30088E+03	2.04000E+01
118	33	30	1.50000E+03	1.35066E+03	2.04000E+01
119	33	31	1.50000E+03	1.40044E+03	2.04000E+01
120	33	32	1.50000E+03	1.45022E+03	2.06000E+01

***** SPECIFIED FLUX NODES *****

Number of flux nodes : 0

***** SURFACE WATER BODIES *****

Number of surface water body nodes : 0

***** AQUIFER PROPERTIES *****

Number of different material properties : 6

No.	Kxx [ft/d]	Kyy [ft/d]	Porosity [-]	
1	2.00000E+00	2.00000E+00	1.50000E-01	(default)
2	5.00000E+00	5.00000E+00	1.50000E-01	
3	7.50000E+00	7.50000E+00	1.50000E-01	
4	1.00000E+00	1.00000E+00	1.50000E-01	
5	1.50000E+00	1.50000E+00	1.50000E-01	
6	2.50000E+00	2.50000E+00	1.50000E-01	

********** DISTRIBUTION OF AQUIFER MATERIAL PROPERTIES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
33	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
32	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
31	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
30	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
29	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
28	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
27	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
21	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
20	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	2	2	2	6	6	6	6	1	1	1	1	1	1	1	1	1
18	6	6	6	6	6	6	6	1	1	1	1	1	1	1	1	1
17	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
14	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
13	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
12	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
11	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
10	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
9	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
8	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
7	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
6	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
5	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
4	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
3	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
2	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
1	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3

***** AQUIFER TYPE *****

Unconfined aquifer

***** AQUIFER BOTTOM ELEVATIONS *****

Number of different aquifer bottom elevations : 1

No.	aquifer bottom elevation [ft]
1	5.50000E+00 (default)

********** DISTRIBUTION OF AQUIFER BOTTOM ELEVATIONS **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33

***** AREAL RECHARGE *****

Number of different infiltration/evapotranspiration rates : 1

No.	infiltration [L/T]	evapotranspiration [L/T]	effective recharge [L/T]	
1	5.00000E-04	0.00000E+00	5.00000E-04	(default)

********** DISTRIBUTION OF AREAL IN/OUT-FLUXES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	

33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33

***** PATHLINE & PARTICLE TRACKING DATA *****

Number of forward particles : 0

Number of reverse particles : 0

Particles released at wells :

Well-No.	Particles released
1	0
2	0
3	0
4	0
5	0
6	0
7	0

8	0
9	0
10	0
11	0
12	0
13	0
14	0

********** HYDRAULIC HEAD DISTRIBUTION **********

	1	2	3	4	5	6
33	2.0000E+01	2.0100E+01	2.0200E+01	2.0300E+01	2.0400E+01	2.0500E+01
32	2.0300E+01	2.0396E+01	2.0485E+01	2.0572E+01	2.0656E+01	2.0736E+01
31	2.0600E+01	2.0677E+01	2.0751E+01	2.0824E+01	2.0895E+01	2.0961E+01
30	2.0900E+01	2.0939E+01	2.0997E+01	2.1059E+01	2.1119E+01	2.1173E+01
29	2.1100E+01	2.1161E+01	2.1220E+01	2.1275E+01	2.1329E+01	2.1368E+01
28	2.1300E+01	2.1368E+01	2.1428E+01	2.1473E+01	2.1536E+01	2.1640E+01
27	2.1500E+01	2.1562E+01	2.1634E+01	2.1740E+01	2.1855E+01	2.2013E+01
26	2.1612E+01	2.1709E+01	2.1804E+01	2.1964E+01	2.2087E+01	2.2220E+01
25	2.1660E+01	2.1791E+01	2.1895E+01	2.2041E+01	2.2164E+01	2.2291E+01
24	2.1700E+01	2.1885E+01	2.1996E+01	2.2130E+01	2.2250E+01	2.2370E+01
23	2.2300E+01	2.2308E+01	2.2389E+01	2.2494E+01	2.2597E+01	2.2696E+01
22	2.2500E+01	2.2611E+01	2.2715E+01	2.2815E+01	2.2906E+01	2.2989E+01
21	2.2700E+01	2.2879E+01	2.3003E+01	2.3102E+01	2.3184E+01	2.3251E+01
20	2.3000E+01	2.3159E+01	2.3277E+01	2.3367E+01	2.3436E+01	2.3488E+01
[illegible]	2.3200E+01	2.3355E+01	2.3462E+01	2.3540E+01	2.3598E+01	2.3639E+01
[illegible]	2.3400E+01	2.3499E+01	2.3581E+01	2.3645E+01	2.3693E+01	2.3727E+01
17	2.3600E+01	2.3645E+01	2.3702E+01	2.3752E+01	2.3790E+01	2.3815E+01
16	2.3700E+01	2.3764E+01	2.3817E+01	2.3857E+01	2.3886E+01	2.3904E+01
15	2.3800E+01	2.3881E+01	2.3928E+01	2.3961E+01	2.3981E+01	2.3991E+01
14	2.4000E+01	2.4015E+01	2.4041E+01	2.4062E+01	2.4074E+01	2.4076E+01
13	2.4100E+01	2.4125E+01	2.4145E+01	2.4158E+01	2.4163E+01	2.4158E+01
12	2.4200E+01	2.4226E+01	2.4243E+01	2.4250E+01	2.4248E+01	2.4237E+01
11	2.4300E+01	2.4324E+01	2.4336E+01	2.4338E+01	2.4330E+01	2.4312E+01
10	2.4400E+01	2.4419E+01	2.4426E+01	2.4422E+01	2.4408E+01	2.4384E+01
9	2.4500E+01	2.4513E+01	2.4513E+01	2.4503E+01	2.4482E+01	2.4452E+01
8	2.4600E+01	2.4605E+01	2.4599E+01	2.4581E+01	2.4553E+01	2.4516E+01
7	2.4700E+01	2.4697E+01	2.4682E+01	2.4656E+01	2.4620E+01	2.4576E+01
6	2.4800E+01	2.4787E+01	2.4762E+01	2.4727E+01	2.4683E+01	2.4631E+01
5	2.4900E+01	2.4876E+01	2.4840E+01	2.4795E+01	2.4741E+01	2.4680E+01
4	2.5000E+01	2.4962E+01	2.4914E+01	2.4857E+01	2.4793E+01	2.4723E+01
3	2.5100E+01	2.5046E+01	2.4983E+01	2.4914E+01	2.4838E+01	2.4759E+01
2	2.5200E+01	2.5127E+01	2.5046E+01	2.4962E+01	2.4875E+01	2.4785E+01
1	2.5300E+01	2.5200E+01	2.5100E+01	2.5000E+01	2.4900E+01	2.4800E+01

	1	2	3	4	5	6
	7	8	9	10	11	12
33	2.0600E+01	2.0600E+01	2.0700E+01	2.0700E+01	2.0800E+01	2.0900E+01
32	2.0807E+01	2.0851E+01	2.0910E+01	2.0952E+01	2.1021E+01	2.1088E+01
[illegible]	2.1020E+01	2.1068E+01	2.1119E+01	2.1156E+01	2.1224E+01	2.1343E+01
30	2.1226E+01	2.1263E+01	2.1323E+01	2.1427E+01	2.1544E+01	2.1697E+01
29	2.1430E+01	2.1533E+01	2.1648E+01	2.1797E+01	2.1918E+01	2.2034E+01
28	2.1755E+01	2.1906E+01	2.2029E+01	2.2148E+01	2.2252E+01	2.2344E+01

27	2.2138E+01	2.2259E+01	2.2368E+01	2.2468E+01	2.2556E+01	2.2628E+01
26	2.2337E+01	2.2446E+01	2.2546E+01	2.2637E+01	2.2718E+01	2.2780E+01
25	2.2404E+01	2.2509E+01	2.2605E+01	2.2694E+01	2.2773E+01	2.2832E+01
24	2.2479E+01	2.2580E+01	2.2673E+01	2.2758E+01	2.2836E+01	2.2891E+01
23	2.2786E+01	2.2869E+01	2.2945E+01	2.3019E+01	2.3099E+01	2.3135E+01
22	2.3061E+01	2.3125E+01	2.3181E+01	2.3236E+01	2.3287E+01	2.3297E+01
21	2.3306E+01	2.3350E+01	2.3381E+01	2.3399E+01	2.3400E+01	2.3392E+01
20	2.3526E+01	2.3549E+01	2.3557E+01	2.3544E+01	2.3507E+01	2.3483E+01
19	2.3665E+01	2.3676E+01	2.3671E+01	2.3649E+01	2.3605E+01	2.3567E+01
18	2.3746E+01	2.3751E+01	2.3742E+01	2.3718E+01	2.3682E+01	2.3641E+01
17	2.3827E+01	2.3827E+01	2.3813E+01	2.3788E+01	2.3752E+01	2.3708E+01
16	2.3909E+01	2.3902E+01	2.3885E+01	2.3856E+01	2.3817E+01	2.3769E+01
15	2.3989E+01	2.3977E+01	2.3954E+01	2.3921E+01	2.3878E+01	2.3826E+01
14	2.4068E+01	2.4050E+01	2.4021E+01	2.3983E+01	2.3936E+01	2.3879E+01
13	2.4144E+01	2.4119E+01	2.4086E+01	2.4043E+01	2.3990E+01	2.3929E+01
12	2.4216E+01	2.4186E+01	2.4147E+01	2.4098E+01	2.4041E+01	2.3975E+01
11	2.4285E+01	2.4249E+01	2.4204E+01	2.4151E+01	2.4088E+01	2.4017E+01
10	2.4351E+01	2.4309E+01	2.4258E+01	2.4199E+01	2.4131E+01	2.4055E+01
9	2.4412E+01	2.4364E+01	2.4308E+01	2.4243E+01	2.4170E+01	2.4089E+01
8	2.4470E+01	2.4416E+01	2.4353E+01	2.4283E+01	2.4205E+01	2.4118E+01
7	2.4523E+01	2.4462E+01	2.4394E+01	2.4318E+01	2.4234E+01	2.4142E+01
6	2.4571E+01	2.4504E+01	2.4429E+01	2.4348E+01	2.4259E+01	2.4161E+01
5	2.4613E+01	2.4539E+01	2.4459E+01	2.4372E+01	2.4278E+01	2.4176E+01
4	2.4648E+01	2.4568E+01	2.4482E+01	2.4390E+01	2.4292E+01	2.4185E+01
3	2.4676E+01	2.4589E+01	2.4498E+01	2.4402E+01	2.4301E+01	2.4191E+01
2	2.4694E+01	2.4600E+01	2.4504E+01	2.4406E+01	2.4304E+01	2.4196E+01
1	2.4700E+01	2.4600E+01	2.4500E+01	2.4400E+01	2.4300E+01	2.4200E+01

	7	8	9	10	11	12
	13	14	15	16	17	18
33	2.1000E+01	2.1100E+01	2.1200E+01	2.1300E+01	2.1400E+01	2.1400E+01
32	2.1180E+01	2.1328E+01	2.1474E+01	2.1572E+01	2.1639E+01	2.1662E+01
31	2.1475E+01	2.1633E+01	2.1751E+01	2.1832E+01	2.1882E+01	2.1901E+01
30	2.1821E+01	2.1933E+01	2.2021E+01	2.2080E+01	2.2113E+01	2.2121E+01
29	2.2133E+01	2.2216E+01	2.2277E+01	2.2315E+01	2.2330E+01	2.2322E+01
28	2.2420E+01	2.2478E+01	2.2517E+01	2.2534E+01	2.2530E+01	2.2505E+01
27	2.2683E+01	2.2720E+01	2.2738E+01	2.2737E+01	2.2714E+01	2.2670E+01
26	2.2823E+01	2.2849E+01	2.2856E+01	2.2844E+01	2.2812E+01	2.2756E+01
25	2.2871E+01	2.2892E+01	2.2896E+01	2.2881E+01	2.2845E+01	2.2785E+01
24	2.2925E+01	2.2942E+01	2.2942E+01	2.2923E+01	2.2883E+01	2.2818E+01
23	2.3149E+01	2.3146E+01	2.3128E+01	2.3095E+01	2.3042E+01	2.2950E+01
22	2.3293E+01	2.3275E+01	2.3246E+01	2.3206E+01	2.3156E+01	2.3060E+01
21	2.3375E+01	2.3348E+01	2.3311E+01	2.3266E+01	2.3214E+01	2.3125E+01
20	2.3454E+01	2.3417E+01	2.3372E+01	2.3318E+01	2.3259E+01	2.3164E+01
19	2.3528E+01	2.3482E+01	2.3428E+01	2.3364E+01	2.3286E+01	2.3174E+01
18	2.3595E+01	2.3542E+01	2.3481E+01	2.3412E+01	2.3333E+01	2.3209E+01
17	2.3657E+01	2.3598E+01	2.3531E+01	2.3456E+01	2.3372E+01	2.3236E+01
16	2.3713E+01	2.3649E+01	2.3577E+01	2.3495E+01	2.3405E+01	2.3256E+01
15	2.3766E+01	2.3696E+01	2.3618E+01	2.3531E+01	2.3435E+01	2.3274E+01
14	2.3814E+01	2.3740E+01	2.3657E+01	2.3564E+01	2.3462E+01	2.3291E+01
13	2.3859E+01	2.3780E+01	2.3692E+01	2.3594E+01	2.3486E+01	2.3308E+01
12	2.3900E+01	2.3816E+01	2.3723E+01	2.3621E+01	2.3509E+01	2.3324E+01
11	2.3937E+01	2.3849E+01	2.3751E+01	2.3645E+01	2.3528E+01	2.3339E+01
10	2.3970E+01	2.3877E+01	2.3775E+01	2.3665E+01	2.3545E+01	2.3351E+01
9	2.3999E+01	2.3901E+01	2.3795E+01	2.3681E+01	2.3558E+01	2.3360E+01
8	2.4023E+01	2.3921E+01	2.3810E+01	2.3692E+01	2.3566E+01	2.3365E+01
7	2.4042E+01	2.3935E+01	2.3819E+01	2.3697E+01	2.3568E+01	2.3364E+01
6	2.4056E+01	2.3943E+01	2.3822E+01	2.3695E+01	2.3562E+01	2.3356E+01

5	2.4065E+01	2.3945E+01	2.3817E+01	2.3684E+01	2.3547E+01	2.3339E+01
4	2.4068E+01	2.3940E+01	2.3804E+01	2.3662E+01	2.3520E+01	2.3310E+01
3	2.4070E+01	2.3930E+01	2.3781E+01	2.3627E+01	2.3476E+01	2.3263E+01
2	2.4074E+01	2.3917E+01	2.3747E+01	2.3574E+01	2.3408E+01	2.3194E+01
1	2.4100E+01	2.3900E+01	2.3700E+01	2.3500E+01	2.3300E+01	2.3100E+01
	13	14	15	16	17	18
	19	20	21	22	23	24
33	2.1400E+01	2.1400E+01	2.1400E+01	2.1438E+01	2.1400E+01	2.1430E+01
32	2.1665E+01	2.1659E+01	2.1646E+01	2.1634E+01	2.1628E+01	2.1623E+01
31	2.1899E+01	2.1881E+01	2.1852E+01	2.1820E+01	2.1809E+01	2.1800E+01
30	2.2107E+01	2.2076E+01	2.2030E+01	2.1983E+01	2.1968E+01	2.1955E+01
29	2.2294E+01	2.2247E+01	2.2184E+01	2.2124E+01	2.2104E+01	2.2089E+01
28	2.2460E+01	2.2397E+01	2.2317E+01	2.2243E+01	2.2220E+01	2.2202E+01
27	2.2607E+01	2.2526E+01	2.2428E+01	2.2342E+01	2.2315E+01	2.2294E+01
26	2.2682E+01	2.2590E+01	2.2483E+01	2.2388E+01	2.2359E+01	2.2336E+01
25	2.2707E+01	2.2611E+01	2.2500E+01	2.2403E+01	2.2373E+01	2.2350E+01
24	2.2735E+01	2.2635E+01	2.2520E+01	2.2421E+01	2.2390E+01	2.2366E+01
23	2.2844E+01	2.2726E+01	2.2593E+01	2.2482E+01	2.2448E+01	2.2421E+01
22	2.2931E+01	2.2794E+01	2.2645E+01	2.2521E+01	2.2483E+01	2.2454E+01
21	2.2988E+01	2.2839E+01	2.2674E+01	2.2535E+01	2.2494E+01	2.2462E+01
20	2.3022E+01	2.2865E+01	2.2681E+01	2.2525E+01	2.2478E+01	2.2443E+01
19	2.3031E+01	2.2877E+01	2.2675E+01	2.2488E+01	2.2436E+01	2.2398E+01
18	2.3035E+01	2.2839E+01	2.2601E+01	2.2398E+01	2.2339E+01	2.2294E+01
17	2.3033E+01	2.2800E+01	2.2524E+01	2.2272E+01	2.2188E+01	2.2120E+01
16	2.3031E+01	2.2772E+01	2.2471E+01	2.2201E+01	2.2115E+01	2.2047E+01
15	2.3032E+01	2.2755E+01	2.2438E+01	2.2160E+01	2.2073E+01	2.2004E+01
14	2.3036E+01	2.2746E+01	2.2418E+01	2.2134E+01	2.2046E+01	2.1977E+01
	2.3042E+01	2.2743E+01	2.2406E+01	2.2118E+01	2.2029E+01	2.1959E+01
	2.3050E+01	2.2743E+01	2.2400E+01	2.2108E+01	2.2018E+01	2.1948E+01
11	2.3058E+01	2.2745E+01	2.2398E+01	2.2103E+01	2.2012E+01	2.1942E+01
10	2.3065E+01	2.2748E+01	2.2397E+01	2.2100E+01	2.2009E+01	2.1938E+01
9	2.3070E+01	2.2749E+01	2.2397E+01	2.2099E+01	2.2008E+01	2.1937E+01
8	2.3071E+01	2.2749E+01	2.2396E+01	2.2098E+01	2.2007E+01	2.1936E+01
7	2.3069E+01	2.2746E+01	2.2393E+01	2.2097E+01	2.2006E+01	2.1936E+01
6	2.3060E+01	2.2738E+01	2.2388E+01	2.2094E+01	2.2005E+01	2.1935E+01
5	2.3043E+01	2.2724E+01	2.2380E+01	2.2091E+01	2.2002E+01	2.1933E+01
4	2.3014E+01	2.2702E+01	2.2367E+01	2.2086E+01	2.2000E+01	2.1932E+01
3	2.2970E+01	2.2666E+01	2.2350E+01	2.2083E+01	2.2000E+01	2.1935E+01
2	2.2901E+01	2.2607E+01	2.2328E+01	2.2092E+01	2.2015E+01	2.1952E+01
1	2.2800E+01	2.2500E+01	2.2300E+01	2.2140E+01	2.2100E+01	2.2014E+01
	19	20	21	22	23	24
	25	26	27	28	29	30
33	2.1400E+01	2.1400E+01	2.1300E+01	2.1200E+01	2.1100E+01	2.1000E+01
32	2.1589E+01	2.1537E+01	2.1446E+01	2.1338E+01	2.1217E+01	2.1085E+01
31	2.1750E+01	2.1672E+01	2.1570E+01	2.1446E+01	2.1304E+01	2.1142E+01
30	2.1889E+01	2.1792E+01	2.1673E+01	2.1533E+01	2.1371E+01	2.1184E+01
29	2.2008E+01	2.1894E+01	2.1759E+01	2.1602E+01	2.1421E+01	2.1214E+01
28	2.2108E+01	2.1977E+01	2.1827E+01	2.1654E+01	2.1458E+01	2.1233E+01
27	2.2187E+01	2.2042E+01	2.1877E+01	2.1691E+01	2.1480E+01	2.1242E+01
26	2.2223E+01	2.2070E+01	2.1897E+01	2.1704E+01	2.1487E+01	2.1242E+01
	2.2235E+01	2.2078E+01	2.1903E+01	2.1707E+01	2.1488E+01	2.1241E+01
	2.2247E+01	2.2088E+01	2.1909E+01	2.1711E+01	2.1489E+01	2.1240E+01
23	2.2289E+01	2.2115E+01	2.1924E+01	2.1715E+01	2.1483E+01	2.1224E+01
22	2.2308E+01	2.2121E+01	2.1919E+01	2.1700E+01	2.1461E+01	2.1197E+01

21	2.2303E+01	2.2102E+01	2.1890E+01	2.1665E+01	2.1421E+01	2.1156E+01
20	2.2269E+01	2.2054E+01	2.1835E+01	2.1606E+01	2.1361E+01	2.1096E+01
19	2.2201E+01	2.1971E+01	2.1749E+01	2.1521E+01	2.1279E+01	2.1018E+01
18	2.2065E+01	2.1840E+01	2.1627E+01	2.1407E+01	2.1171E+01	2.0916E+01
17	2.1901E+01	2.1723E+01	2.1528E+01	2.1317E+01	2.1087E+01	2.0837E+01
16	2.1846E+01	2.1679E+01	2.1492E+01	2.1285E+01	2.1058E+01	2.0809E+01
15	2.1806E+01	2.1644E+01	2.1462E+01	2.1260E+01	2.1037E+01	2.0791E+01
14	2.1778E+01	2.1619E+01	2.1440E+01	2.1243E+01	2.1025E+01	2.0787E+01
13	2.1759E+01	2.1601E+01	2.1425E+01	2.1232E+01	2.1021E+01	2.0792E+01
12	2.1747E+01	2.1590E+01	2.1417E+01	2.1227E+01	2.1022E+01	2.0801E+01
11	2.1740E+01	2.1583E+01	2.1412E+01	2.1226E+01	2.1025E+01	2.0810E+01
10	2.1736E+01	2.1580E+01	2.1411E+01	2.1227E+01	2.1030E+01	2.0819E+01
9	2.1734E+01	2.1579E+01	2.1411E+01	2.1230E+01	2.1036E+01	2.0827E+01
8	2.1734E+01	2.1580E+01	2.1413E+01	2.1234E+01	2.1042E+01	2.0837E+01
7	2.1734E+01	2.1581E+01	2.1416E+01	2.1239E+01	2.1049E+01	2.0848E+01
6	2.1735E+01	2.1583E+01	2.1419E+01	2.1243E+01	2.1056E+01	2.0857E+01
5	2.1736E+01	2.1585E+01	2.1421E+01	2.1247E+01	2.1061E+01	2.0864E+01
4	2.1739E+01	2.1587E+01	2.1423E+01	2.1249E+01	2.1066E+01	2.0870E+01
3	2.1745E+01	2.1591E+01	2.1423E+01	2.1248E+01	2.1070E+01	2.0876E+01
2	2.1762E+01	2.1595E+01	2.1417E+01	2.1239E+01	2.1076E+01	2.0885E+01
1	2.1800E+01	2.1600E+01	2.1400E+01	2.1200E+01	2.1100E+01	2.0900E+01

	25	26	27	28	29	30

	31	32	33
33	2.0900E+01	2.0800E+01	2.0700E+01
32	2.0939E+01	2.0776E+01	2.0600E+01
31	2.0953E+01	2.0721E+01	2.0400E+01
30	2.0966E+01	2.0708E+01	2.0400E+01
29	2.0975E+01	2.0700E+01	2.0400E+01
28	2.0974E+01	2.0672E+01	2.0300E+01
27	2.0972E+01	2.0664E+01	2.0300E+01
26	2.0967E+01	2.0662E+01	2.0377E+01
25	2.0964E+01	2.0657E+01	2.0356E+01
24	2.0960E+01	2.0648E+01	2.0300E+01
23	2.0934E+01	2.0602E+01	2.0200E+01
22	2.0904E+01	2.0574E+01	2.0200E+01
21	2.0863E+01	2.0542E+01	2.0200E+01
20	2.0805E+01	2.0481E+01	2.0100E+01
19	2.0734E+01	2.0426E+01	2.0100E+01
18	2.0641E+01	2.0341E+01	2.0000E+01
17	2.0567E+01	2.0281E+01	2.0000E+01
16	2.0536E+01	2.0234E+01	1.9900E+01
15	2.0517E+01	2.0200E+01	1.9800E+01
14	2.0523E+01	2.0230E+01	1.9900E+01
13	2.0544E+01	2.0279E+01	2.0000E+01
12	2.0567E+01	2.0326E+01	2.0100E+01
11	2.0582E+01	2.0344E+01	2.0100E+01
10	2.0593E+01	2.0354E+01	2.0100E+01
9	2.0603E+01	2.0362E+01	2.0100E+01
8	2.0616E+01	2.0377E+01	2.0100E+01
7	2.0634E+01	2.0413E+01	2.0200E+01
6	2.0647E+01	2.0427E+01	2.0200E+01
5	2.0654E+01	2.0433E+01	2.0200E+01
4	2.0660E+01	2.0436E+01	2.0200E+01
3	2.0665E+01	2.0437E+01	2.0200E+01
2	2.0674E+01	2.0431E+01	2.0200E+01
1	2.0700E+01	2.0400E+01	2.0100E+01

31 32 33

********** End of logbook **********

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*************************************************************
*                      E C H O P R I N T                    *
*                                                           *
*                       F L O W P A T H                     *
*                         version 3.0                       *
*                                                           *
*  FLOWPATH was written by Thomas Franz and Nilson Guiguer  *
*                                                           *
*************************************************************
*                                                           *
*                    Copyright 1989, 1990                   *
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*                Waterloo Hydrogeologic Software            *
*                     113-106 Seagram Drive                 *
*                       Waterloo, Ontario                   *
*                        N2L 3B8, Canada                    *
*                                                           *
*                       ph (519) 746-1798                   *
*                                                           *
*************************************************************
```

FLOWPATH logbook for data set : SITE13IT

Unit System : English units [ft/gal/d]

***** GRID PARAMETERS *****

Number of x-grid lines : 33

Number of y-grid lines : 33

Grid coordinates (x-grid lines) [ft] :

1	0.00000E+00
2	5.00000E+01
3	1.00000E+02
4	1.50000E+02
5	2.00000E+02
6	2.50000E+02
7	3.00000E+02
8	3.50000E+02
9	4.00000E+02
10	4.50000E+02
11	5.00000E+02
12	5.50000E+02
13	6.00000E+02

14	6.50000E+02
15	7.00000E+02
16	7.50000E+02
17	8.00000E+02
18	8.50000E+02
19	9.00000E+02
20	9.50000E+02
21	1.00000E+03
22	1.03872E+03
23	1.04867E+03
24	1.05863E+03
25	1.10000E+03
26	1.15000E+03
27	1.20000E+03
28	1.25000E+03
29	1.30000E+03
30	1.35000E+03
31	1.40000E+03
32	1.45000E+03
33	1.50000E+03

Grid coordinates (y-grid lines) [ft] :

1	0.00000E+00
2	5.00000E+01
3	1.00000E+02
4	1.50000E+02
5	2.00000E+02
6	2.50000E+02
7	3.00000E+02
8	3.50000E+02
9	4.00000E+02
10	4.50000E+02
11	5.00000E+02
12	5.50000E+02
13	6.00000E+02
14	6.50000E+02
15	7.00000E+02
16	7.50000E+02
17	8.00000E+02
18	8.50000E+02
19	9.00000E+02
20	9.50000E+02
21	1.00000E+03
22	1.05000E+03
23	1.10000E+03
24	1.15000E+03
25	1.16150E+03
26	1.17146E+03
27	1.20000E+03
28	1.25000E+03
29	1.30000E+03
30	1.35000E+03
31	1.40000E+03
32	1.45000E+03
33	1.50000E+03

***** WELL PARAMETERS *****

Number of wells : 16

No.	i	j	X [ft]	Y [ft]	well discharge [gpd]
1	10	12	4.51327E+02	5.50885E+02	0.00000E+00
2	10	14	4.51327E+02	6.50442E+02	0.00000E+00
3	11	16	5.01106E+02	7.50000E+02	0.00000E+00
4	8	20	3.48451E+02	9.49115E+02	0.00000E+00
5	12	12	5.50885E+02	5.50885E+02	0.00000E+00
6	14	10	6.50442E+02	4.51327E+02	0.00000E+00
7	15	14	7.00221E+02	6.50442E+02	0.00000E+00
8	13	24	6.00664E+02	1.15155E+03	0.00000E+00
9	17	23	7.99779E+02	1.09845E+03	0.00000E+00
10	18	16	8.49558E+02	7.50000E+02	0.00000E+00
11	21	15	9.98894E+02	7.00221E+02	0.00000E+00
12	21	8	9.98894E+02	3.48451E+02	0.00000E+00
13	18	8	8.49558E+02	3.48451E+02	0.00000E+00
14	28	5	1.25111E+03	1.99115E+02	0.00000E+00
15	23	19	1.04867E+03	8.99336E+02	-2.88000E+03
16	20	25	9.49115E+02	1.16150E+03	-2.88000E+03

***** CONSTRAINED HEAD NODES *****

umber of constant head nodes : 120

No.	i	j	X [ft]	Y [ft]	const. head [ft]
1	33	1	1.50000E+03	0.00000E+00	2.01000E+01
2	32	1	1.45022E+03	0.00000E+00	2.04000E+01
3	31	1	1.40044E+03	0.00000E+00	2.07000E+01
4	30	1	1.35066E+03	0.00000E+00	2.09000E+01
5	29	1	1.30088E+03	0.00000E+00	2.11000E+01
6	28	1	1.25111E+03	0.00000E+00	2.12000E+01
7	27	1	1.20133E+03	0.00000E+00	2.14000E+01
8	26	1	1.15155E+03	0.00000E+00	2.16000E+01
9	25	1	1.09845E+03	0.00000E+00	2.18000E+01
10	23	1	1.04867E+03	0.00000E+00	2.21000E+01
11	21	1	9.98894E+02	0.00000E+00	2.23000E+01
12	20	1	9.49115E+02	0.00000E+00	2.25000E+01
13	19	1	8.99336E+02	0.00000E+00	2.28000E+01
14	18	1	8.49558E+02	0.00000E+00	2.31000E+01
15	17	1	7.99779E+02	0.00000E+00	2.33000E+01
16	16	1	7.50000E+02	0.00000E+00	2.35000E+01
17	15	1	7.00221E+02	0.00000E+00	2.37000E+01
18	14	1	6.50442E+02	0.00000E+00	2.39000E+01
19	13	1	6.00664E+02	0.00000E+00	2.41000E+01
20	12	1	5.50885E+02	0.00000E+00	2.42000E+01
21	11	1	5.01106E+02	0.00000E+00	2.43000E+01
22	10	1	4.51327E+02	0.00000E+00	2.44000E+01
23	9	1	4.01549E+02	0.00000E+00	2.45000E+01
24	8	1	3.48451E+02	0.00000E+00	2.46000E+01
25	7	1	2.98673E+02	0.00000E+00	2.47000E+01

26	6	1	2.48894E+02	0.00000E+00	2.48000E+01
27	5	1	1.99115E+02	0.00000E+00	2.49000E+01
28	4	1	1.49336E+02	0.00000E+00	2.50000E+01
29	3	1	9.95575E+01	0.00000E+00	2.51000E+01
30	2	1	4.97788E+01	0.00000E+00	2.52000E+01
31	1	1	0.00000E+00	0.00000E+00	2.53000E+01
32	1	2	0.00000E+00	4.97788E+01	2.52000E+01
33	1	3	0.00000E+00	9.95575E+01	2.51000E+01
34	1	4	0.00000E+00	1.49336E+02	2.50000E+01
35	1	5	0.00000E+00	1.99115E+02	2.49000E+01
36	1	6	0.00000E+00	2.48894E+02	2.48000E+01
37	1	7	0.00000E+00	2.98673E+02	2.47000E+01
38	1	8	0.00000E+00	3.48451E+02	2.46000E+01
39	1	9	0.00000E+00	4.01549E+02	2.45000E+01
40	1	10	0.00000E+00	4.51327E+02	2.44000E+01
41	1	11	0.00000E+00	5.01106E+02	2.43000E+01
42	1	12	0.00000E+00	5.50885E+02	2.42000E+01
43	1	13	0.00000E+00	6.00664E+02	2.41000E+01
44	1	14	0.00000E+00	6.50442E+02	2.40000E+01
45	1	15	0.00000E+00	7.00221E+02	2.38000E+01
46	1	16	0.00000E+00	7.50000E+02	2.37000E+01
47	1	17	0.00000E+00	7.99779E+02	2.36000E+01
48	1	18	0.00000E+00	8.49558E+02	2.34000E+01
49	1	19	0.00000E+00	8.99336E+02	2.32000E+01
50	1	20	0.00000E+00	9.49115E+02	2.30000E+01
51	1	21	0.00000E+00	9.98894E+02	2.27000E+01
52	1	22	0.00000E+00	1.04867E+03	2.25000E+01
53	1	23	0.00000E+00	1.09845E+03	2.23000E+01
54	1	24	0.00000E+00	1.15155E+03	2.17000E+01
55	1	27	0.00000E+00	1.20133E+03	2.15000E+01
56	1	28	0.00000E+00	1.25111E+03	2.13000E+01
57	1	29	0.00000E+00	1.30088E+03	2.11000E+01
58	1	30	0.00000E+00	1.35066E+03	2.09000E+01
59	1	31	0.00000E+00	1.40044E+03	2.06000E+01
60	1	32	0.00000E+00	1.45022E+03	2.03000E+01
61	1	33	0.00000E+00	1.50000E+03	2.00000E+01
62	2	33	4.97788E+01	1.50000E+03	2.01000E+01
63	3	33	9.95575E+01	1.50000E+03	2.02000E+01
64	4	33	1.49336E+02	1.50000E+03	2.03000E+01
65	5	33	1.99115E+02	1.50000E+03	2.04000E+01
66	6	33	2.48894E+02	1.50000E+03	2.05000E+01
67	7	33	2.98673E+02	1.50000E+03	2.06000E+01
68	8	33	3.48451E+02	1.50000E+03	2.06000E+01
69	9	33	4.01549E+02	1.50000E+03	2.07000E+01
70	10	33	4.51327E+02	1.50000E+03	2.07000E+01
71	11	33	5.01106E+02	1.50000E+03	2.08000E+01
72	12	33	5.50885E+02	1.50000E+03	2.09000E+01
73	13	33	6.00664E+02	1.50000E+03	2.10000E+01
74	14	33	6.50442E+02	1.50000E+03	2.11000E+01
75	15	33	7.00221E+02	1.50000E+03	2.12000E+01
76	16	33	7.50000E+02	1.50000E+03	2.13000E+01
77	17	33	7.99779E+02	1.50000E+03	2.14000E+01
78	18	33	8.49558E+02	1.50000E+03	2.14000E+01
79	19	33	8.99336E+02	1.50000E+03	2.14000E+01
80	20	33	9.49115E+02	1.50000E+03	2.14000E+01
81	21	33	9.98894E+02	1.50000E+03	2.14000E+01
82	23	33	1.04867E+03	1.50000E+03	2.14000E+01
83	25	33	1.09845E+03	1.50000E+03	2.14000E+01
84	26	33	1.15155E+03	1.50000E+03	2.14000E+01
85	27	33	1.20133E+03	1.50000E+03	2.13000E+01

86	28	33	1.25111E+03	1.50000E+03	2.12000E+01
87	29	33	1.30088E+03	1.50000E+03	2.11000E+01
88	30	33	1.35066E+03	1.50000E+03	2.10000E+01
89	31	33	1.40044E+03	1.50000E+03	2.09000E+01
90	32	33	1.45022E+03	1.50000E+03	2.08000E+01
91	33	33	1.50000E+03	1.50000E+03	2.07000E+01
92	33	2	1.50000E+03	4.97788E+01	2.02000E+01
93	33	3	1.50000E+03	9.95575E+01	2.02000E+01
94	33	4	1.50000E+03	1.49336E+02	2.02000E+01
95	33	5	1.50000E+03	1.99115E+02	2.02000E+01
96	33	6	1.50000E+03	2.48894E+02	2.02000E+01
97	33	7	1.50000E+03	2.98673E+02	2.02000E+01
98	33	8	1.50000E+03	3.48451E+02	2.01000E+01
99	33	9	1.50000E+03	4.01549E+02	2.01000E+01
100	33	10	1.50000E+03	4.51327E+02	2.01000E+01
101	33	11	1.50000E+03	5.01106E+02	2.01000E+01
102	33	12	1.50000E+03	5.50885E+02	2.01000E+01
103	33	13	1.50000E+03	6.00664E+02	2.00000E+01
104	33	14	1.50000E+03	6.50442E+02	1.99000E+01
105	33	15	1.50000E+03	7.00221E+02	1.98000E+01
106	33	16	1.50000E+03	7.50000E+02	1.99000E+01
107	33	17	1.50000E+03	7.99779E+02	2.00000E+01
108	33	18	1.50000E+03	8.49558E+02	2.00000E+01
109	33	19	1.50000E+03	8.99336E+02	2.01000E+01
110	33	20	1.50000E+03	9.49115E+02	2.01000E+01
111	33	21	1.50000E+03	9.98894E+02	2.02000E+01
112	33	22	1.50000E+03	1.04867E+03	2.02000E+01
113	33	23	1.50000E+03	1.09845E+03	2.02000E+01
114	33	24	1.50000E+03	1.15155E+03	2.03000E+01
115	33	27	1.50000E+03	1.20133E+03	2.03000E+01
116	33	28	1.50000E+03	1.25111E+03	2.03000E+01
117	33	29	1.50000E+03	1.30088E+03	2.04000E+01
118	33	30	1.50000E+03	1.35066E+03	2.04000E+01
119	33	31	1.50000E+03	1.40044E+03	2.04000E+01
120	33	32	1.50000E+03	1.45022E+03	2.06000E+01

***** SPECIFIED FLUX NODES *****

Number of flux nodes : 0

***** SURFACE WATER BODIES *****

Number of surface water body nodes : 0

***** AQUIFER PROPERTIES *****

Number of different material properties : 7

No.	Kxx [ft/d]	Kyy [ft/d]	Porosity [-]

1	2.00000E+00	2.00000E+00	1.50000E-01	(default)
2	5.00000E+00	5.00000E+00	1.50000E-01	
3	7.50000E+00	7.50000E+00	1.50000E-01	
4	1.00000E+00	1.00000E+00	1.50000E-01	
5	1.50000E+00	1.50000E+00	1.50000E-01	
6	2.50000E+00	2.50000E+00	1.50000E-01	
7	3.00000E+02	3.00000E+02	2.50000E-01	

********** DISTRIBUTION OF AQUIFER MATERIAL PROPERTIES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
33	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
32	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
31	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
30	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
29	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
28	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
27	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	7	7	7	7	7	7	7	7	7
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
21	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
20	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
19	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
18	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
17	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
16	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
15	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
14	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
13	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
12	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
11	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
10	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
9	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
8	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
7	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
6	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	7	7	7	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	2	2	2	6	6	7	6	1	1	1	1	1	1	1	1	1
18	6	6	6	6	6	7	6	1	1	1	1	1	1	1	1	1
17	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
16	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
15	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
14	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
13	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
12	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
11	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
10	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
9	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
8	6	6	6	6	6	7	6	3	3	3	3	3	3	3	3	3
7	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
6	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
5	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
4	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
3	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
2	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3
1	6	6	6	6	6	6	6	3	3	3	3	3	3	3	3	3

***** AQUIFER TYPE *****

Unconfined aquifer

***** AQUIFER BOTTOM ELEVATIONS *****

Number of different aquifer bottom elevations : 1

No.	aquifer bottom elevation [ft]
1	5.50000E+00 (default)

********** DISTRIBUTION OF AQUIFER BOTTOM ELEVATIONS **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
_	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

***** AREAL RECHARGE *****

Number of different infiltration/evapotranspiration rates : 1

No.	infiltration [L/T]	evapotranspiration [L/T]	effective recharge [L/T]	
1	5.00000E-04	0.00000E+00	5.00000E-04	(default)

********** DISTRIBUTION OF AREAL IN/OUT-FLUXES **********

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
[illegible]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
11	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
10	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33

***** PATHLINE & PARTICLE TRACKING DATA *****

Number of forward particles : 47

No.	x-release	y-release
1	3.31858E+00	5.01106E+02
2	2.65487E+01	5.01106E+02
3	4.97788E+01	5.01106E+02
4	4.97788E+01	4.74558E+02
5	4.97788E+01	4.51327E+02
6	7.63274E+01	4.51327E+02

7	9.95575E+01	4.51327E+02
8	9.95575E+01	4.24779E+02
9	9.95575E+01	4.01549E+02
10	1.26106E+02	4.01549E+02
11	1.49336E+02	4.01549E+02
12	1.49336E+02	3.75000E+02
13	1.49336E+02	3.48451E+02
14	1.75885E+02	3.48451E+02
15	1.99115E+02	3.48451E+02
16	1.99115E+02	3.25221E+02
17	1.99115E+02	2.98673E+02
18	2.25664E+02	2.98673E+02
19	2.48894E+02	2.98673E+02
20	2.48894E+02	2.75442E+02
21	2.48894E+02	2.48894E+02
22	2.75442E+02	2.48894E+02
23	2.98673E+02	2.48894E+02
24	2.98673E+02	2.25664E+02
25	2.98673E+02	1.99115E+02
26	3.25221E+02	1.99115E+02
27	3.48451E+02	1.99115E+02
28	3.48451E+02	1.75885E+02
29	3.48451E+02	1.49336E+02
30	3.75000E+02	1.49336E+02
31	4.01549E+02	1.49336E+02
32	4.01549E+02	1.26106E+02
33	4.01549E+02	9.95575E+01
34	4.24779E+02	9.95575E+01
35	4.51327E+02	9.95575E+01
36	4.51327E+02	7.63274E+01
37	4.51327E+02	4.97788E+01
38	5.01106E+02	3.31858E+00
39	5.01106E+02	4.97788E+01
40	5.01106E+02	2.65487E+01
41	4.74558E+02	4.97788E+01
42	6.30531E+01	4.51327E+02
43	2.15708E+02	9.49115E+02
44	7.99779E+02	8.86062E+02
45	7.99779E+02	9.02655E+02
46	7.99779E+02	2.19027E+02
47	2.58850E+02	9.49115E+02

Number of reverse particles : 0

Particles released at wells :

Well-No.	Particles released
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0

11	0
12	0
13	0
14	0
15	0
16	0

********** HYDRAULIC HEAD DISTRIBUTION **********

	1	2	3	4	5	6
33	2.0000E+01	2.0100E+01	2.0200E+01	2.0300E+01	2.0400E+01	2.0500E+01
32	2.0300E+01	2.0383E+01	2.0458E+01	2.0531E+01	2.0600E+01	2.0664E+01
31	2.0600E+01	2.0651E+01	2.0699E+01	2.0744E+01	2.0785E+01	2.0820E+01
30	2.0900E+01	2.0901E+01	2.0921E+01	2.0942E+01	2.0958E+01	2.0965E+01
29	2.1100E+01	2.1114E+01	2.1124E+01	2.1126E+01	2.1123E+01	2.1099E+01
28	2.1300E+01	2.1311E+01	2.1315E+01	2.1297E+01	2.1291E+01	2.1286E+01
27	2.1500E+01	2.1499E+01	2.1509E+01	2.1530E+01	2.1534E+01	2.1537E+01
26	2.1601E+01	2.1638E+01	2.1662E+01	2.1723E+01	2.1724E+01	2.1696E+01
25	2.1651E+01	2.1717E+01	2.1745E+01	2.1791E+01	2.1789E+01	2.1753E+01
24	2.1700E+01	2.1808E+01	2.1838E+01	2.1869E+01	2.1863E+01	2.1820E+01
23	2.2300E+01	2.2220E+01	2.2209E+01	2.2206E+01	2.2182E+01	2.2124E+01
22	2.2500E+01	2.2519E+01	2.2527E+01	2.2521E+01	2.2491E+01	2.2431E+01
21	2.2700E+01	2.2787E+01	2.2818E+01	2.2816E+01	2.2786E+01	2.2728E+01
20	2.3000E+01	2.3072E+01	2.3101E+01	2.3098E+01	2.3067E+01	2.3012E+01
19	2.3200E+01	2.3272E+01	2.3295E+01	2.3287E+01	2.3254E+01	2.3199E+01
18	2.3400E+01	2.3420E+01	2.3421E+01	2.3404E+01	2.3367E+01	2.3311E+01
17	2.3600E+01	2.3570E+01	2.3552E+01	2.3525E+01	2.3484E+01	2.3427E+01
16	2.3700E+01	2.3694E+01	2.3676E+01	2.3646E+01	2.3602E+01	2.3544E+01
15	2.3800E+01	2.3816E+01	2.3799E+01	2.3765E+01	2.3719E+01	2.3660E+01
14	2.4000E+01	2.3956E+01	2.3922E+01	2.3883E+01	2.3834E+01	2.3773E+01
13	2.4100E+01	2.4071E+01	2.4037E+01	2.3995E+01	2.3945E+01	2.3883E+01
12	2.4200E+01	2.4178E+01	2.4145E+01	2.4103E+01	2.4051E+01	2.3989E+01
11	2.4300E+01	2.4280E+01	2.4248E+01	2.4206E+01	2.4153E+01	2.4091E+01
10	2.4400E+01	2.4380E+01	2.4348E+01	2.4305E+01	2.4251E+01	2.4188E+01
9	2.4500E+01	2.4479E+01	2.4445E+01	2.4401E+01	2.4345E+01	2.4280E+01
8	2.4600E+01	2.4576E+01	2.4540E+01	2.4493E+01	2.4435E+01	2.4368E+01
7	2.4700E+01	2.4672E+01	2.4632E+01	2.4581E+01	2.4520E+01	2.4450E+01
6	2.4800E+01	2.4767E+01	2.4721E+01	2.4666E+01	2.4601E+01	2.4527E+01
5	2.4900E+01	2.4859E+01	2.4808E+01	2.4746E+01	2.4676E+01	2.4598E+01
4	2.5000E+01	2.4950E+01	2.4890E+01	2.4821E+01	2.4745E+01	2.4663E+01
3	2.5100E+01	2.5038E+01	2.4967E+01	2.4890E+01	2.4806E+01	2.4719E+01
2	2.5200E+01	2.5123E+01	2.5038E+01	2.4950E+01	2.4859E+01	2.4765E+01
1	2.5300E+01	2.5200E+01	2.5100E+01	2.5000E+01	2.4900E+01	2.4800E+01

	1	2	3	4	5	6
	7	8	9	10	11	12
33	2.0600E+01	2.0600E+01	2.0700E+01	2.0700E+01	2.0800E+01	2.0900E+01
32	2.0719E+01	2.0747E+01	2.0790E+01	2.0819E+01	2.0874E+01	2.0939E+01
31	2.0846E+01	2.0860E+01	2.0878E+01	2.0892E+01	2.0923E+01	2.0974E+01
30	2.0967E+01	2.0954E+01	2.0953E+01	2.0964E+01	2.0980E+01	2.1003E+01
29	2.1084E+01	2.1069E+01	2.1040E+01	2.1027E+01	2.1012E+01	2.0998E+01
28	2.1250E+01	2.1196E+01	2.1108E+01	2.1050E+01	2.1003E+01	2.0957E+01
27	2.1463E+01	2.1316E+01	2.1107E+01	2.1019E+01	2.0954E+01	2.0884E+01

26	2.1597E+01	2.1393E+01	2.1033E+01	2.0973E+01	2.0911E+01	2.0831E+01
25	2.1649E+01	2.1428E+01	2.0996E+01	2.0957E+01	2.0896E+01	2.0814E+01
24	2.1711E+01	2.1497E+01	2.1125E+01	2.1050E+01	2.0990E+01	2.0909E+01
23	2.2020E+01	2.1862E+01	2.1669E+01	2.1563E+01	2.1528E+01	2.1455E+01
[illegible]	2.2337E+01	2.2211E+01	2.2068E+01	2.1948E+01	2.1892E+01	2.1817E+01
[illegible]	2.2643E+01	2.2531E+01	2.2398E+01	2.2248E+01	2.2123E+01	2.2029E+01
20	2.2932E+01	2.2828E+01	2.2699E+01	2.2532E+01	2.2356E+01	2.2240E+01
19	2.3123E+01	2.3025E+01	2.2906E+01	2.2760E+01	2.2584E+01	2.2441E+01
18	2.3237E+01	2.3144E+01	2.3032E+01	2.2902E+01	2.2758E+01	2.2618E+01
17	2.3354E+01	2.3265E+01	2.3160E+01	2.3041E+01	2.2911E+01	2.2776E+01
16	2.3472E+01	2.3385E+01	2.3286E+01	2.3173E+01	2.3051E+01	2.2921E+01
15	2.3588E+01	2.3504E+01	2.3407E+01	2.3300E+01	2.3182E+01	2.3056E+01
14	2.3702E+01	2.3619E+01	2.3525E+01	2.3420E+01	2.3305E+01	2.3182E+01
13	2.3812E+01	2.3729E+01	2.3637E+01	2.3534E+01	2.3421E+01	2.3300E+01
12	2.3917E+01	2.3835E+01	2.3743E+01	2.3642E+01	2.3530E+01	2.3410E+01
11	2.4018E+01	2.3936E+01	2.3844E+01	2.3743E+01	2.3633E+01	2.3514E+01
10	2.4114E+01	2.4032E+01	2.3940E+01	2.3839E+01	2.3729E+01	2.3610E+01
9	2.4206E+01	2.4122E+01	2.4029E+01	2.3928E+01	2.3818E+01	2.3700E+01
8	2.4291E+01	2.4207E+01	2.4113E+01	2.4011E+01	2.3901E+01	2.3783E+01
7	2.4372E+01	2.4285E+01	2.4191E+01	2.4088E+01	2.3978E+01	2.3859E+01
6	2.4446E+01	2.4358E+01	2.4262E+01	2.4158E+01	2.4047E+01	2.3928E+01
5	2.4514E+01	2.4423E+01	2.4326E+01	2.4222E+01	2.4111E+01	2.3991E+01
4	2.4575E+01	2.4482E+01	2.4383E+01	2.4279E+01	2.4167E+01	2.4048E+01
3	2.4627E+01	2.4532E+01	2.4432E+01	2.4328E+01	2.4218E+01	2.4100E+01
2	2.4669E+01	2.4572E+01	2.4472E+01	2.4369E+01	2.4263E+01	2.4150E+01
1	2.4700E+01	2.4600E+01	2.4500E+01	2.4400E+01	2.4300E+01	2.4200E+01

	7	8	9	10	11	12
	13	14	15	16	17	18
[illegible]	2.1000E+01	2.1100E+01	2.1200E+01	2.1300E+01	2.1400E+01	2.1400E+01
32	2.1007E+01	2.1090E+01	2.1170E+01	2.1235E+01	2.1284E+01	2.1300E+01
31	2.1027E+01	2.1075E+01	2.1114E+01	2.1143E+01	2.1161E+01	2.1168E+01
30	2.1019E+01	2.1028E+01	2.1029E+01	2.1021E+01	2.1008E+01	2.0994E+01
29	2.0977E+01	2.0948E+01	2.0910E+01	2.0862E+01	2.0811E+01	2.0766E+01
28	2.0903E+01	2.0836E+01	2.0756E+01	2.0664E+01	2.0563E+01	2.0468E+01
27	2.0799E+01	2.0695E+01	2.0572E+01	2.0427E+01	2.0264E+01	2.0089E+01
26	2.0730E+01	2.0605E+01	2.0456E+01	2.0281E+01	2.0076E+01	1.9842E+01
25	2.0709E+01	2.0580E+01	2.0425E+01	2.0242E+01	2.0028E+01	1.9780E+01
24	2.0805E+01	2.0676E+01	2.0523E+01	2.0342E+01	2.0130E+01	1.9878E+01
23	2.1354E+01	2.1231E+01	2.1086E+01	2.0920E+01	2.0719E+01	2.0433E+01
22	2.1714E+01	2.1591E+01	2.1453E+01	2.1302E+01	2.1144E+01	2.0872E+01
21	2.1917E+01	2.1790E+01	2.1652E+01	2.1506E+01	2.1360E+01	2.1137E+01
20	2.2116E+01	2.1982E+01	2.1839E+01	2.1688E+01	2.1537E+01	2.1320E+01
19	2.2304E+01	2.2163E+01	2.2013E+01	2.1852E+01	2.1667E+01	2.1415E+01
18	2.2478E+01	2.2333E+01	2.2181E+01	2.2018E+01	2.1842E+01	2.1566E+01
17	2.2637E+01	2.2492E+01	2.2339E+01	2.2177E+01	2.2004E+01	2.1731E+01
16	2.2785E+01	2.2640E+01	2.2488E+01	2.2327E+01	2.2156E+01	2.1883E+01
15	2.2922E+01	2.2779E+01	2.2628E+01	2.2468E+01	2.2298E+01	2.2027E+01
14	2.3050E+01	2.2909E+01	2.2759E+01	2.2600E+01	2.2431E+01	2.2162E+01
13	2.3169E+01	2.3030E+01	2.2881E+01	2.2724E+01	2.2556E+01	2.2290E+01
12	2.3281E+01	2.3143E+01	2.2996E+01	2.2839E+01	2.2673E+01	2.2408E+01
11	2.3386E+01	2.3249E+01	2.3103E+01	2.2947E+01	2.2782E+01	2.2519E+01
10	2.3483E+01	2.3347E+01	2.3202E+01	2.3048E+01	2.2884E+01	2.2623E+01
[illegible]	2.3573E+01	2.3438E+01	2.3294E+01	2.3141E+01	2.2979E+01	2.2721E+01
[illegible]	2.3656E+01	2.3521E+01	2.3378E+01	2.3227E+01	2.3068E+01	2.2815E+01
7	2.3732E+01	2.3597E+01	2.3454E+01	2.3304E+01	2.3148E+01	2.2903E+01
6	2.3801E+01	2.3665E+01	2.3522E+01	2.3373E+01	2.3219E+01	2.2982E+01
5	2.3862E+01	2.3725E+01	2.3580E+01	2.3430E+01	2.3277E+01	2.3047E+01

4	2.3918E+01	2.3777E+01	2.3627E+01	2.3474E+01	2.3320E+01	2.3095E+01
3	2.3970E+01	2.3822E+01	2.3664E+01	2.3502E+01	2.3344E+01	2.3122E+01
2	2.4024E+01	2.3863E+01	2.3689E+01	2.3512E+01	2.3342E+01	2.3124E+01
1	2.4100E+01	2.3900E+01	2.3700E+01	2.3500E+01	2.3300E+01	2.3100E+01

	13	14	15	16	17	18
	19	20	21	22	23	24
33	2.1400E+01	2.1400E+01	2.1400E+01	2.1393E+01	2.1400E+01	2.1393E+01
32	2.1308E+01	2.1315E+01	2.1324E+01	2.1330E+01	2.1332E+01	2.1333E+01
31	2.1174E+01	2.1188E+01	2.1210E+01	2.1228E+01	2.1232E+01	2.1236E+01
30	2.0992E+01	2.1011E+01	2.1053E+01	2.1090E+01	2.1099E+01	2.1107E+01
29	2.0744E+01	2.0767E+01	2.0845E+01	2.0915E+01	2.0932E+01	2.0948E+01
28	2.0403E+01	2.0420E+01	2.0577E+01	2.0707E+01	2.0737E+01	2.0766E+01
27	1.9928E+01	1.9875E+01	2.0245E+01	2.0485E+01	2.0536E+01	2.0582E+01
26	1.9580E+01	1.9337E+01	2.0061E+01	2.0388E+01	2.0450E+01	2.0504E+01
25	1.9493E+01	1.9157E+01	2.0017E+01	2.0366E+01	2.0429E+01	2.0484E+01
24	1.9604E+01	1.9379E+01	2.0035E+01	2.0350E+01	2.0411E+01	2.0464E+01
23	2.0195E+01	2.0078E+01	2.0242E+01	2.0380E+01	2.0412E+01	2.0443E+01
22	2.0600E+01	2.0428E+01	2.0383E+01	2.0396E+01	2.0405E+01	2.0415E+01
21	2.0849E+01	2.0604E+01	2.0408E+01	2.0311E+01	2.0302E+01	2.0299E+01
20	2.1009E+01	2.0682E+01	2.0308E+01	2.0020E+01	1.9978E+01	1.9981E+01
19	2.1095E+01	2.0733E+01	2.0167E+01	1.9397E+01	1.9192E+01	1.9340E+01
18	2.1194E+01	2.0767E+01	2.0209E+01	1.9650E+01	1.9541E+01	1.9601E+01
17	2.1338E+01	2.0894E+01	2.0374E+01	1.9918E+01	1.9832E+01	1.9900E+01
16	2.1487E+01	2.1048E+01	2.0558E+01	2.0149E+01	2.0073E+01	2.0111E+01
15	2.1633E+01	2.1203E+01	2.0734E+01	2.0347E+01	2.0274E+01	2.0293E+01
14	2.1773E+01	2.1350E+01	2.0892E+01	2.0516E+01	2.0445E+01	2.0450E+01
13	2.1903E+01	2.1484E+01	2.1032E+01	2.0661E+01	2.0591E+01	2.0587E+01
12	2.2024E+01	2.1607E+01	2.1156E+01	2.0784E+01	2.0714E+01	2.0705E+01
11	2.2136E+01	2.1719E+01	2.1265E+01	2.0889E+01	2.0818E+01	2.0805E+01
10	2.2242E+01	2.1824E+01	2.1363E+01	2.0976E+01	2.0903E+01	2.0891E+01
9	2.2344E+01	2.1926E+01	2.1456E+01	2.1047E+01	2.0968E+01	2.0961E+01
8	2.2447E+01	2.2038E+01	2.1567E+01	2.1114E+01	2.1010E+01	2.1028E+01
7	2.2550E+01	2.2168E+01	2.1756E+01	2.1431E+01	2.1355E+01	2.1297E+01
6	2.2644E+01	2.2286E+01	2.1911E+01	2.1618E+01	2.1544E+01	2.1472E+01
5	2.2723E+01	2.2382E+01	2.2027E+01	2.1743E+01	2.1669E+01	2.1594E+01
4	2.2782E+01	2.2456E+01	2.2117E+01	2.1840E+01	2.1767E+01	2.1692E+01
3	2.2818E+01	2.2507E+01	2.2188E+01	2.1925E+01	2.1853E+01	2.1780E+01
2	2.2826E+01	2.2529E+01	2.2248E+01	2.2011E+01	2.1944E+01	2.1873E+01
1	2.2800E+01	2.2500E+01	2.2300E+01	2.2126E+01	2.2100E+01	2.1996E+01

	19	20	21	22	23	24
	25	26	27	28	29	30
33	2.1400E+01	2.1400E+01	2.1300E+01	2.1200E+01	2.1100E+01	2.1000E+01
32	2.1335E+01	2.1321E+01	2.1266E+01	2.1191E+01	2.1102E+01	2.0999E+01
31	2.1247E+01	2.1244E+01	2.1212E+01	2.1156E+01	2.1076E+01	2.0973E+01
30	2.1137E+01	2.1154E+01	2.1143E+01	2.1102E+01	2.1033E+01	2.0933E+01
29	2.1008E+01	2.1052E+01	2.1062E+01	2.1037E+01	2.0979E+01	2.0886E+01
28	2.0865E+01	2.0942E+01	2.0974E+01	2.0965E+01	2.0918E+01	2.0833E+01
27	2.0727E+01	2.0834E+01	2.0885E+01	2.0890E+01	2.0854E+01	2.0778E+01
26	2.0663E+01	2.0778E+01	2.0836E+01	2.0847E+01	2.0817E+01	2.0746E+01
25	2.0643E+01	2.0760E+01	2.0819E+01	2.0832E+01	2.0803E+01	2.0734E+01
24	2.0622E+01	2.0738E+01	2.0799E+01	2.0814E+01	2.0788E+01	2.0721E+01
23	2.0554E+01	2.0654E+01	2.0716E+01	2.0738E+01	2.0719E+01	2.0660E+01
22	2.0479E+01	2.0565E+01	2.0629E+01	2.0659E+01	2.0648E+01	2.0598E+01
21	2.0351E+01	2.0453E+01	2.0535E+01	2.0577E+01	2.0576E+01	2.0534E+01

20	2.0136E+01	2.0318E+01	2.0437E+01	2.0496E+01	2.0503E+01	2.0466E+01
19	1.9875E+01	2.0199E+01	2.0355E+01	2.0422E+01	2.0431E+01	2.0396E+01
18	1.9958E+01	2.0199E+01	2.0318E+01	2.0365E+01	2.0362E+01	2.0320E+01
17	2.0130E+01	2.0246E+01	2.0312E+01	2.0332E+01	2.0315E+01	2.0264E+01
[illegible]	2.0236E+01	2.0304E+01	2.0341E+01	2.0344E+01	2.0316E+01	2.0256E+01
[illegible]	2.0351E+01	2.0381E+01	2.0391E+01	2.0377E+01	2.0335E+01	2.0266E+01
14	2.0463E+01	2.0466E+01	2.0454E+01	2.0423E+01	2.0371E+01	2.0295E+01
13	2.0569E+01	2.0552E+01	2.0523E+01	2.0479E+01	2.0418E+01	2.0338E+01
12	2.0667E+01	2.0637E+01	2.0595E+01	2.0540E+01	2.0470E+01	2.0385E+01
11	2.0759E+01	2.0719E+01	2.0669E+01	2.0604E+01	2.0525E+01	2.0433E+01
10	2.0845E+01	2.0801E+01	2.0743E+01	2.0670E+01	2.0582E+01	2.0480E+01
9	2.0931E+01	2.0886E+01	2.0820E+01	2.0738E+01	2.0640E+01	2.0528E+01
8	2.1030E+01	2.0979E+01	2.0902E+01	2.0808E+01	2.0699E+01	2.0578E+01
7	2.1173E+01	2.1086E+01	2.0989E+01	2.0880E+01	2.0760E+01	2.0628E+01
6	2.1302E+01	2.1190E+01	2.1074E+01	2.0951E+01	2.0819E+01	2.0677E+01
5	2.1412E+01	2.1285E+01	2.1155E+01	2.1019E+01	2.0875E+01	2.0722E+01
4	2.1507E+01	2.1371E+01	2.1229E+01	2.1082E+01	2.0929E+01	2.0765E+01
3	2.1595E+01	2.1450E+01	2.1297E+01	2.1139E+01	2.0980E+01	2.0807E+01
2	2.1687E+01	2.1526E+01	2.1355E+01	2.1184E+01	2.1032E+01	2.0851E+01
1	2.1800E+01	2.1600E+01	2.1400E+01	2.1200E+01	2.1100E+01	2.0900E+01
	25	26	27	28	29	30

	31	32	33
33	2.0900E+01	2.0800E+01	2.0700E+01
32	2.0882E+01	2.0747E+01	2.0600E+01
31	2.0840E+01	2.0664E+01	2.0400E+01
30	2.0799E+01	2.0625E+01	2.0400E+01
29	2.0757E+01	2.0591E+01	2.0400E+01
[illegible]	2.0708E+01	2.0538E+01	2.0300E+01
[illegible]	2.0663E+01	2.0506E+01	2.0300E+01
26	2.0636E+01	2.0491E+01	2.0342E+01
25	2.0626E+01	2.0483E+01	2.0331E+01
24	2.0615E+01	2.0472E+01	2.0300E+01
23	2.0559E+01	2.0413E+01	2.0200E+01
22	2.0507E+01	2.0375E+01	2.0200E+01
21	2.0452E+01	2.0336E+01	2.0200E+01
20	2.0390E+01	2.0273E+01	2.0100E+01
19	2.0324E+01	2.0221E+01	2.0100E+01
18	2.0245E+01	2.0142E+01	2.0000E+01
17	2.0186E+01	2.0090E+01	2.0000E+01
16	2.0167E+01	2.0048E+01	1.9900E+01
15	2.0166E+01	2.0023E+01	1.9800E+01
14	2.0194E+01	2.0064E+01	1.9900E+01
13	2.0239E+01	2.0126E+01	2.0000E+01
12	2.0288E+01	2.0186E+01	2.0100E+01
11	2.0329E+01	2.0216E+01	2.0100E+01
10	2.0366E+01	2.0239E+01	2.0100E+01
9	2.0402E+01	2.0261E+01	2.0100E+01
8	2.0442E+01	2.0289E+01	2.0100E+01
7	2.0487E+01	2.0338E+01	2.0200E+01
6	2.0525E+01	2.0365E+01	2.0200E+01
5	2.0558E+01	2.0384E+01	2.0200E+01
4	2.0589E+01	2.0400E+01	2.0200E+01
3	2.0618E+01	2.0413E+01	2.0200E+01
[illegible]	2.0651E+01	2.0420E+01	2.0200E+01
1	2.0700E+01	2.0400E+01	2.0100E+01
	31	32	33

********** End of logbook **********