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FS Report OU2

FEASIBILITY STUDY REPORT

Scobell Chemical Site

(Operable Unit #2, Off-site)

Town of Brighton, New York
Monroe County
Site No. 8-28-076

STATE OF NEW YORK
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SECTION 1 - INTRODUCTION

1.1 General

This Report has been prepared for the Scobell Chemical Site off-site operable unit, New York State Department of Environmental Conservation (NYSDEC) Site Registry No. 8-28-076, and presents the results of the Feasibility Study (FS) performed for the site. This site is a Class 2 inactive hazardous waste site located in the Town of Brighton near the eastern border of the City of Rochester and immediately northwest of the I-490/I-590 interchange ("the can of worms"). The FS has been prepared by the NYSDEC's Division of Environmental Remediation and is based upon the information and data presented in the Remedial Investigation (RI) Report for this site, dated January 1999 (Operable Unit #1) and revised February 2002 (Operable Unit #2).

1.2 Site Description

The site (operable unit #1 - on-site area) is the location of a former chemical operation that conducted chemical storage, warehousing, transferring and sales of hazardous materials. Originally, the site was approximately 2.6 acres in size. In 1988, as a part of the New York State Department of Transportation's (NYSDOT) "can of worms" reconstruction project, an Interim Remedial Measure (IRM) was conducted by NYSDOT. The IRM included demolition of all of the on-site buildings as well as excavation and off-site disposal of contaminated soil and bedrock from over half of the site. The present site is about one (1) acre in size, is capped with approximately twelve (12) inches of clay, and is fenced. The site is located in a highly urbanized area in the Town of Brighton, at the eastern boundary of the City of Rochester. Industrial and commercial properties are located directly to the west of the site. A major Conrail railroad line is directly north, and to the east and south is the I-490 and I-590 highway interchange. The site is presently owned by the New York State Department of Transportation (NYSDOT). Contamination from the site has migrated to the north, north of the railroad tracks (operable unit #2 - off-site operable unit) [see Figure 1-1].

1.3 Site History

The Scobell Chemical Site is the location of a former chemical repackaging company. The former site was operated from the 1920s until 1986. Assorted chemicals were purchased by the company in bulk and repackaged into smaller containers for resale. The site had one main building, two smaller structures and four above ground storage tanks. The amount of and type of the materials handled is unclear but significant subsurface soil contamination has been identified.

In 1986, the NYSDOT condemned the property to construct the "Can of Worms" highway intersection (the intersection of I-590 and I-490). In early 1988, the NYSDOT discovered extensive contamination at the Scobell site including abandoned drums, contaminated structures, and soil and bedrock contamination. Drums and containers containing halogenated volatile organic compounds (VOCs), pesticides/herbicides (including 2,4,5-T) and toluene were found in the warehouse. The site was reported to contain deteriorated containers, discolored soils, and stained asphalt.

In 1988, the NYSDOT conducted an IRM removal action. The cost of the IRM was approximately $4 million and included decontamination and demolition of the structures, removal of containers, drums and above ground storage tanks, and excavation and disposal of contaminated soil and bedrock. Over half of the former footprint of the site was remediated by the IRM and is now a part of the highway interchange. For the remaining portion of the site, only the structures and above ground tanks were removed; no soil remediation was reported other than capping the area with 9-12 inches of clay. A fence was placed around the site. Significant subsurface soil contamination remains under the cap including toluene, trichloroethene, tetrachloroethene, 1,2-dichloroethene, chromium and pesticides (see Tables 1.2 and 1.3).

A seep prevention system was installed by NYSDOT in November 1988, near the end of the IRM. The seep prevention system was installed at the base of the slope, adjacent to the highway ramp, to prevent water from running onto the highway. The seep prevention system consisted of approximately 300 feet of six inch diameter underdrain pipe that ran from the southwest to the northeast at the base of the slope between the site and the highway. When the system was in operation water drained to a 16 cubic foot collection sump (a manhole), located at the base of the slope below the northeast corner of the Scobell site. From the collection sump the water was pumped to a 2000 gallon holding tank, located at the top of the slope in the northeast corner of the site. When the seep prevention system was temporarily shut down in 1994, no water was seeping from the bedrock face. Since the purpose of the seep prevention system (prevent water from running onto the highway) was being accomplished on its own, the system was no longer needed to accomplish its intended goal and its use was discontinued in 1995.

During the demolition of the on-site structures 62 drums of soil/dust, containing site related contamination including low levels of 2,4,5-T (silvex), were generated. At the time the waste was generated it was difficult to find a facility to accept the waste for disposal. As a result, the drums were stored in an on-site storage trailer until they were disposed of at an off-site facility in 1996.

1.4 Summary of Remedial Investigation (OU#1)

1.4.1 Site Characterization

The main source of contamination at this site is most likely the result of spills that occurred, due to past handling practices, over a long period of time. Volatile organic contamination is present at the site as dissolved constituents in the groundwater and apparently as free product which is more dense than water and has/is moving down into the aquifer (dense non-aqueous phase liquid or DNAPL). Some solvents remain in the on-site soil above the water table in the vicinity of the source area. This contamination exists as a residual that did not migrate to the base of the aquifer, but rather bound to individual soil particles as it passed through the unsaturated soil.

The site is underlain by approximately ten feet of overburden consisting of (from the surface down): a silty clay cover (approximately one foot thick - placed as a part of the 1988 IRM), approximately four-five feet of fill and disturbed soil consisting of cinders/brick/glass, up to seven feet of silt and clay with some sand. The bedrock present immediately below the overburden is a Dolostone.

Groundwater at the site was encountered near the bedrock overburden interface. A thin zone of groundwater was found in the overburden and appears to flow to the south, towards the I-590 ramp. The overburden groundwater levels to the north are lower than on-site (following surface elevations which are approximately five feet lower on the north side of the railroad tracks, compared to the surface elevations on-site). As a result, the possibility exists that there is some overburden groundwater which may flow from the northern edge of the site to the north-northeast. Bedrock groundwater elevations are approximately ten feet below the surface of the bedrock on-site and at, or just below the surface of the bedrock north-northeast of the on-site area (MW-4D and MW-5D). Groundwater flow in the bedrock appears to flow to the north-northeast. Slug tests performed during the Site Investigation indicate average hydraulic conductivities at the overburden/bedrock interface of approximately 1.8×10^{-2} centimeters/second (cm/sec), and approximately 8.8×10^{-5} cm/sec in the shallow bedrock.

During the on-site Remedial Investigation (RI) field work a total of 32 small diameter soil borings were advanced, 30 piezometers were installed during the small diameter soil boring program (at all locations except for GP-13 and GP-14), and seven monitoring wells were installed (two overburden and five shallow bedrock). The following environmental samples were collected for chemical analysis: 24 subsurface soil samples, 18 groundwater samples (11 from piezometers and seven from monitoring wells), three surface water samples, three sediment samples, four surface soil samples, two dense non-aqueous phase liquid samples (DNAPL), and four soil gas samples (collected during the vapor extraction pilot study).

The Site Investigation generated enough information, for the site area itself, to develop and screen remedial alternatives as a part of this Feasibility Study (FS). Additional information was needed to define the extent of the contamination downgradient of the site. As a result, the site was divided into two operable units: the on-site operable unit and the off-site operable unit.

1.4.2 Soil Vapor Extraction Pilot Study

During the Site Investigation field work a soil vapor extraction pilot study was performed. During the pilot study air was extracted from the vapor extraction well (SVE-1) at a rate of approximately 39 cubic feet per minute and an average vacuum of 3 inches of mercury. The vacuum response was measured from piezometers around the extraction well at regular intervals during the test. Attachment 1 of the Remedial Investigation Report summarizes the vacuum measurements at each piezometer during the pilot test. The vacuum response measured at the piezometers showed variability throughout the duration of the test. However, the maximum vacuum response in each piezometer was recorded during the first day of vapor extraction. Based on the vacuum response data, an air permeability for the site soils has been estimated to be approximately 9.5 darcy units (or cm^2). This value is typical of soils with moderate permeability.

The relationship between the maximum vacuum response at each piezometer versus distance from the vapor extraction well is linear. Based on this data, the radius of influence for the vapor extraction well has been estimated at approximately 40 feet.

Four air samples were collected during the pilot test for laboratory analyses of VOCs. Three samples were collected prior to carbon treatment and one sample was collected after carbon treatment. A total of 12 VOCs were detected in the air samples. Vinyl chloride was detected at a maximum concentration of 11 ppb after one hour of extraction. The concentration decreased to 0.3 ppb after 120 hours of extraction.

Based on the air sampling data, an estimated 37 pounds of VOCs, or an average of 7.4 pounds per day of VOCs were removed from the soil during the pilot test.

Based on the results of the pilot test, SVE appears to be an effective remedial approach for removing the key VOCs detected in site soils. The following additional conclusions and recommendations can be made from the results of the vapor extraction pilot test:

- Estimated air permeability of the site soils is approximately 9.5 darcys, which is typical of soil with moderate permeability.
- The vacuum radius of influence is approximately 40 feet.
- VOCs in the extracted air stream consisted primarily of toluene, trichloroethene, and *cis*-1,2,-dichloroethylene, with toluene accounting for between 86 percent and 96 percent of the total VOC concentration. These were the primary VOCs detected in site soils and groundwater.
- An average of approximately 7.4 pounds per day of VOCs were removed from the vapor extraction well during the test.

1.5 Summary of Remedial Investigation (OU#2)

1.5.1 Site Characterization

The main source of contamination on-site is most likely the result of spills that occurred, due to past storage and handling practices, over a long period of time. Volatile organic contamination is present at the site as dissolved constituents in the ground water and apparently as free product which is more dense than water and has/is moving down into the aquifer (dense non-aqueous phase liquid or DNAPL). Contamination that is present off-site (operable unit #2) is there mainly because of migration, from the on-site area, of aqueous and non-aqueous phase (NAPL) contamination in the bedrock; to a lesser extent, some contamination has moved off-site in surface water.

The off-site area is underlain by approximately six to eight feet of overburden consisting of silty fine sand with some clay. The bedrock present immediately below the overburden is a Dolostone.

A total of nine new monitoring wells were installed as a part of the OU#2 RI fieldwork: one well was installed across the overburden/bedrock interface (OB-1); four of the wells were installed to monitor the top of the competent bedrock (MW-6S, -7S, -8S, and 9S; installed approximately 5-15 feet into the rock); and four wells were installed to monitor the "deeper" bedrock (MW-6D, -7D, -8D, and 9D; installed approximately 55-65 feet into the rock) Groundwater at the off-site area was encountered near the bedrock overburden interface. A thin zone of groundwater (generally less than 3 ½ feet thick, and non-existent in some areas of the off-site area) was found in the overburden and appears to flow to the north-northeast. Bedrock groundwater elevations are approximately one-three feet below the surface of the bedrock at the off-site operable unit, just north of the railroad tracks. Groundwater flow in the bedrock appears to flow to the northeast. Slug tests were performed on six of the eight new bedrock wells (bedrock wells MW-7D and MW-9D and overburden wells OB-1 could not be slug tested because there was insufficient water in the wells). Of these six wells, the hydraulic conductivities of three of them (MW-6S, MW-7S, and MW-8D) were too low to be effectively estimated by slug tests. Of the three wells where hydraulic conductivity values could be generated, a wide range of hydraulic conductivities were estimated. This is indicative of the heterogeneity of the aquifer's fractured bedrock. The range of hydraulic conductivities is likely representative of the aquifer on the whole. The average hydraulic conductivities ranged from 5.6×10^{-3} cm/sec in MW-8S to 5×10^{-5} cm/sec in MW-9S.

During the Remedial Investigation (RI) field work a total of nine monitoring wells were installed, as discussed in the previous paragraph. The following environmental samples were collected for chemical analysis: 16 groundwater samples, five surface water samples, and one dense non-aqueous phase liquid samples (DNAPL). Also, a seismic reflection survey and a resistivity survey were conducted at both OU#1 and OU#2 to gather information for the potential design and placement of DNAPL recovery wells.

The 2000 Remedial Investigation for OU#2 generated enough information to develop and screen remedial alternatives as a part of this Feasibility Study (FS). However, additional information is needed to define the downgradient extent of the contamination in the bedrock groundwater. As discussed in Section 6.1.6 of the RI Report, potential residential exposure to site related contamination could occur via ingestion of, direct contact with contaminated groundwater, or inhalation of vapors released from contaminated water. However, groundwater in the area is currently not used for drinking water; the area is served with municipal water. Direct contact with groundwater/ inhalation of vapors released from contaminated water could occur if shallow well points are used within the plume for irrigation or other non-potable purposes/ if contaminated groundwater migrated to and under buildings. During the groundwater sampling, performed as a part of both the OU#1 and OU#2 Investigations, groundwater samples were taken from the overburden/bedrock interface along the north and northeast edges of the overburden groundwater plume (the directions where potential off-site exposure could occur). Groundwater samples were taken from geoprobe points GP-29,GP-30, and GP-31, located along the substation access road/driveway, between the substation and the apartment complex to the northwest of OU#2. The results indicated no detections of any site related contamination. Also, an overburden/bedrock interface groundwater sample was taken from the leading edge of the plume at monitoring well OB-1. The results indicated the detection of one site related contaminant (1,2-dichloroethene) at a concentration only slightly above the groundwater standard (detected at 9 ppb vs. standard of 5 ppb). Based on this information, currently there are no completed exposure pathways immediately downgradient of the site. As a result of this, and that the nature and a large part of the extent of the contamination has been characterized, the additional information will be collected at some point in the near future, possibly during the remedial design for the off-site operable unit. Additional downgradient monitoring wells will be installed to help define the downgradient extent of the contamination in the bedrock groundwater. The main purpose for installing additional wells would be to use during the long-term monitoring program once a remedy is implemented at the site.

1.6 Nature and Extent of Contamination

1.6.1 Applicable Standards, Criteria, and Guidance (SCGs)

In order to identify potential exposure pathways, applicable SCGs must be identified. 6 NYCRR Part 375-1.10(c)(1)(i) requires that remedial actions comply with SCGs "unless good cause exists why conformity should be dispensed with." Standards and Criteria are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance. Guidance includes non-promulgated criteria and guidelines that are not legal requirements; however, the site's remedial program should be designed with consideration given to guidance that, based on professional judgement, is determined to be applicable to the site.

SCGs are categorized as chemical specific, location specific, or action specific. These categories are defined as the following:

Chemical Specific:	These are health or risk based numerical values or methodologies which, when applied to site specific conditions, result in the establishment of numerical values for the chemicals of interest. These values establish the acceptable amount or concentration of a chemical that may be found in or

discharged to the environment.

Location Specific: These are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they occur in a specific location.

Action Specific: These are usually technology or activity based requirements or limitations on actions taken with respect to hazardous waste management and site cleanup.

The following lists the principal SCGs that have been identified for the Scobell Chemical site (Table 1.1 lists all of the SCGs for the site):

General - 6 NYCRR Part 375, Inactive Hazardous Waste Disposal Site Remedial Program

Soil - NYSDEC Division of Hazardous Waste Remediation Technical and Administrative Guidance Memorandum (TAGM) 4046, Determination of Soil Cleanup Objectives and Cleanup Levels

- 6 NYCRR Part 371, Identification and Listing of Hazardous Wastes

- 6 NYCRR Part 376 - Land Disposal Restrictions

- NYSDEC Division of Hazardous Substance Regulation TAGM 3028, "Contained in Criteria for Environmental Media" (11/92)

Groundwater - 6NYCRR Part 700-705, Water Quality Regulations for Surface Water and Groundwater

- NYSDEC Division of Water TOGS 1.1.1

- NYSDOH Sanitary Code Part 5.1 (drinking water standards)

Air - Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants

A comprehensive list of all of the potential SCGs for this site is included in Table 1.1 of this report (reproduced from Table 5.1 of the RI Report).

1.6.2 Summary of Nature and Extent of Contaminated Media (On-Site)

Based on the information developed during previous studies and this RI, chemical compounds of potential concern by environmental medium have been identified (see analytical result summaries presented in Tables 1.2 and 1.3). Compounds of potential concern were selected based on frequency of detection, range of concentrations, and potential for migration.

The main source of contamination at this site is most likely the result of spills that occurred, due to past storage and handling practices, over a long period of time. Volatile organic contamination is present at the site as dissolved constituents in the groundwater and apparently as free product which is more dense than water and has/is moving down into the shallow bedrock aquifer (dense non-aqueous phase liquid or DNAPL). Some solvents remain in the on-site soil above the water table in the vicinity of the source area. This contamination exists as a residual that did not migrate to the base of the aquifer, but rather bound to individual soil particles as it passed through the unsaturated soil.

Four surface soil samples were taken from the perimeter of the site, two each from along the western and northern borders of the site. Two pesticides (endrin and heptachlor epoxide) and certain metals (e.g., cadmium, chromium, lead, mercury, and zinc) were detected at elevated concentrations.

Subsurface soil contamination appears to be limited to on-site areas and is predominantly made up of volatile organic constituents . A total of 16 on-site subsurface soil samples were taken at eight locations during the RI. These samples were taken to supplement the subsurface soil samples collected in 1988 by NYSDOT . Elevated concentrations of the following contaminants have been found in on-site subsurface soil: trichloroethene (TCE), tetrachloroethene (PCE), 1,2-dichloroethene (1,2-DCE), toluene, xylene, 1,1,1-trichloroethane (1,1,1-TCA), lead, chromium, zinc, and MCPP (a pesticide also known as Mecoprop).

The results of the groundwater samples taken from on-site monitoring points indicated the presence of chloroform, ethylbenzene, xylene, TCE, PCE, toluene, 1,2-DCE, 1,1-DCE, vinyl chloride, and benzene. In addition the following metals were detected at elevated concentrations in the on-site overburden groundwater: cadmium, chromium, lead, and zinc.
Aqueous phase contamination is present in the overburden aquifer while both aqueous and non-aqueous phase (NAPL) contamination is present in the shallow bedrock.

1.6.2.1 Contaminants of Concern (OU#1)

The following contaminants have been found (historically and/or during Site Investigation) at concentrations above SCGs at the Scobell Chemical site:

SURFACE SOIL
endrin
heptachlor epoxide
cadmium
chromium
lead
mercury
zinc

SUBSURFACE SOIL
1,2-dichloroethene (1,2-DCE)

MCPP (pesticide) [seen in one sample during 1988 NYSDOT sampling]
tetrachloroethene (PCE)
toluene
1,1,1-trichloroethane (1,1,1-TCA)
trichloroethene (TCE)
xylene
chromium
lead
zinc

<u>GROUNDWATER</u>
benzene
chloroform
1,1-dichloroethene
1,2-dichloroethene
ethylbenzene
tetrachloroethene
toluene
trichloroethene
vinyl chloride
xylene
cadmium
chromium
lead
zinc

1.6.3 Summary of Nature and Extent of Contaminated Media (Off-Site)

Based on the information developed during previous studies and during the RI, chemical compounds of potential concern by environmental medium have been identified (see analytical result summaries presented in Table 1.2). Compounds of potential concern were selected based on frequency of detection, range of concentrations, and potential for migration. Analytical results confirm the presence of contamination in off-site surface water and groundwater.

The main source of contamination on-site is most likely the result of spills that occurred, due to past storage and handling practices, over a long period of time. Volatile organic contamination is present at the site as dissolved constituents in the ground water and apparently as free product which is more dense than water and has/is moving down into the aquifer (dense non-aqueous phase liquid or DNAPL). Contamination that is present off-site (operable unit #2) is there mainly because of migration, from the on-site area, of aqueous and non-aqueous phase (NAPL) contamination in the bedrock; to a lesser extent, some contamination has moved off-site in surface water.

The results of the groundwater samples taken from off-site monitoring points indicated the presence of elevated concentrations of vinyl chloride, carbon disulfide, dichloroethene, trichloroethene, tetrachloroethene, benzene, toluene, and xylene [see Figure 1-2].

The results of the surface water samples, taken from the retention pond and the outlet from the pond, located to the northeast of the site, indicated the presence of elevated concentrations of dichloroethene and trichloroethene.

1.6.3.1 Contaminants of Concern (OU#2)

Compounds of potential concern were selected based on frequency of detection, range of concentrations, and potential for migration. The following contaminants have been found (historically and/or during Site Investigation) at elevated concentrations at the Scobell Chemical site, operable unit #2:

GROUNDWATER
benzene
carbon disulfide*
1,1-dichloroethene
1,2-dichloroethene*
tetrachloroethene*
toluene*
trichloroethene*
vinyl chloride
xylene*

SURFACE WATER
1,2-dichloroethene*
trichloroethene*

* = contaminant that was detected in 8/98 and/or 11/00 DNAPL samples (collected from MW-3D/MW-4D and MW-3D, respectively)

SECTION 2 - PROJECT GOALS and OBJECTIVES

Goals for the remedial program have been established through the remedy selection process stated in 6 NYCRR Part 375-1.10. The overall remedial goal is to meet all Standards, Criteria and Guidance (SCGs) and be protective of human health and the environment. At a minimum, the remedy selected must eliminate or mitigate all significant threats to public health and/or the environment presented by the hazardous waste disposed at the site through the proper application of scientific and engineering principles.

Based on the results of the Human Exposure Pathway Analysis and the Fish and Wildlife Impact Analysis, presented in the RI Report, the Remedial Action Objectives (RAOs) for this site are:

- Reduce, control, or eliminate, to the extent practicable, the highly contaminated off-site source area, located in the shallow bedrock just north of the railroad tracks.

- Reduce, control, or eliminate, to the extent practicable, the continued migration of contaminated groundwater and dense non-aqueous phase liquid (DNAPL) from the off-site area.

- Reduce, control, or eliminate, to the extent practicable, the continued migration of contaminated groundwater to the surface water drainage system/retention pond, adjacent to the site, at concentrations above surface water standards.

- Eliminate, to the extent practicable, the potential for exposure to contaminated groundwater and/or vapors and/or contaminated surface water.

The ultimate goal of the program will be to reduce contaminant concentrations to levels that are consistent with SCGs (i.e., to reduce contaminant concentrations in the groundwater to below the corresponding groundwater standards/guidance values). Any remedial alternative that will later be presented as the preferred remedial action **must** demonstrate that it will be protective of human health and the environment.

SECTION 3 - DEVELOPMENT OF REMEDIAL ALTERNATIVES

The following section will present remedial alternatives that are meant to address the remedial goals presented in the previous section.

3.1 Presumptive Remedies Directive

The EPA has developed policy and procedures for presumptive remedies at sites where commonly encountered characteristics are present. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA's scientific and engineering evaluation of performance data on technology implementation. The EPA has: evaluated technologies that have been consistently selected at sites using the remedy selection criteria set out in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP); reviewed currently available performance data on the application of these technologies, and; has determined that a particular set of remedies is presumptively the most appropriate for addressing specific types of sites. The objective of the presumptive remedies initiative is to use past experience to speed up the evaluation and selection of remedial options, to ensure consistency in remedy selection, and to reduce the time and cost required to clean up similar types of sites. The presumptive remedies directive eliminates the need for the initial step of identifying and screening a variety of alternatives during the Feasibility Study. The NCP states that "the lead agency shall include an alternatives screening step, <u>when needed</u>, to select a reasonable number of alternatives for detailed analysis." EPA has analyzed feasibility studies for sites with commonly encountered contamination (i.e., sites with VOC-contaminated soil) and found that certain technologies are routinely screened out based on effectiveness, implementability, or excessive costs, consistent with the procedures set forth in the NCP. Accordingly, EPA has determined that, for sites that meet the requirements of the presumptive remedies directives, site-specific identification and screening of alternatives is not necessary.

This FS will use the following presumptive remedy guidance directives: *Presumptive Remedies: Policies and Procedures*, USEPA Directive 9355.0-47FS, September 1993; and *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites*, USEPA Directive 9283.1-12, October 1996.

3.2 Identification of Remedial Technologies for Groundwater

3.2.1 No Action/Groundwater Monitoring

The No Action alternative is included as a procedural requirement and as a baseline to evaluate the other alternatives. Under this alternative, no remedial action would be taken to address contaminated groundwater. Groundwater monitoring would be conducted. It is assumed that: 1)two additional downgradient bedrock well pairs would be installed; and 2) the four new wells, as well as the sixteen existing wells, would be monitored quarterly for the first year followed by annually for up to 30 years.

3.2.2 Natural Attenuation

Natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, are allowed to reduce contaminant concentrations to acceptable levels. Consideration of this option usually requires evaluation of contaminant degradation rates and pathways and predicting contaminant concentrations at downgradient receptor points. The primary objective of this evaluation would be to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long term monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered on a case-by-case basis. In all cases where natural attenuation is being considered, extensive site characterization and monitoring would be required, both before and after any potential implementation of this remedial alternative.

Compared with other remediation technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes.
- It would be less intrusive.
- It may be applied to all or part of a given site, depending on site conditions and cleanup objectives.
- Natural attenuation may be used in conjunction with, or as a follow-up to, other (active) remedial measures.
- Overall cost will likely be lower than active remediation.

Synonyms: Intrinsic Remediation; Bioattenuation; Intrinsic Bioremediation.

Applicability: Target contaminants for natural attenuation are VOCs, SVOCs, and fuel hydrocarbons. Fuel and halogenated VOCs are commonly evaluated for natural attenuation.

Limitations: Factors that may limit applicability and effectiveness include:

- Data used as input parameters for modeling need be collected.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation is not appropriate where imminent site risks are present.

- Contaminants may migrate before they are degraded.
- Institutional controls may be required, and the site may not be available for reuse until contaminant levels are reduced.
- It is not meant to address source areas of relatively high contamination
- There are long term monitoring and associated costs associated with this alternative.
- Longer time frames would be required to achieve remediation objectives, compared to active remediation.

3.2.3 Groundwater Extraction and Treatment

Groundwater pumping systems are used to remove dissolved contaminants from the subsurface as well as to contain contaminated groundwater to prevent its migration.

Synonyms: Pump and treat.

Applicability: Site characteristics, such as hydraulic conductivity, will determine the range of remedial options possible. Chemical properties of the site and plume need to be determined to characterize transport of the contaminant and evaluate the feasibility of groundwater pumping. To determine if groundwater pumping is appropriate for a site, one needs to know the history of the contamination event, the properties of the subsurface, and the biological and chemical contaminant characteristics. Identifying the chemical and physical site characteristics are necessary in designing an effective groundwater pumping strategy.

Surfactant-enhanced recovery may also be used to improve the effectiveness for contaminated sites with light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs).

Limitations: The following factors may limit the applicability and effectiveness of groundwater pumping as part of the remedial process:

- It is possible that a long time may be necessary to achieve the remediation goals.
- Residual saturation of the contaminant in the soil pores/bedrock cannot be removed by groundwater pumping. Contaminants tend to be sorbed in the soil/rock matrix. Groundwater pumping is not applicable to contaminants with high residual saturation, contaminants with high sorption capabilities, and homogeneous aquifers with hydraulic conductivity less than 10^{-5} cm/sec.
- The cost of procuring and operating treatment systems can be high, in the long term. Additional cost may also be attributed to the disposal of spend carbon and the handling of other treatment residuals and wastes.
- Bio-fouling of the extraction wells, and associated treatment stream, is a common problem which can severely affect system performance. The potential for this problem should be evaluated prior to the installation.

The following factors may limit the applicability and effectiveness of surfactant-enhanced recovery:

- Subsurface heterogeneities, as with most groundwater remediation technologies, present challenges to the successful implementation of surfactant-enhanced recovery.
- Potential toxic effects of residual surfactants in the subsurface.
- Migration of contaminants due to the increase solubility achieved with surfactant injection.

There are a number of water treatment options that would be available after the removal of the contaminated groundwater from the subsurface. The EPA directive, entitled *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites*, dated October 1996, has been used to identify the following treatment options for extracted groundwater:

Air Stripping

Air stripping involves the mass transfer of volatile contaminants from water to air. For groundwater remediation, this process is typically conducted in a packed tower. The typical packed tower air stripper includes a spray nozzle at the top of the tower to distribute contaminated water over the packing in the column, a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect decontaminated water. Auxiliary equipment that can be added to the basic air stripper includes an air heater to improve removal efficiencies; automated control systems with sump level switches and safety features, such as differential pressure monitors, high sump level switches, and explosion-proof components; and air emission control and treatment systems, such as activated carbon units, catalytic oxidizers, or thermal oxidizers. Packed tower air strippers are installed either as permanent installations on concrete pads or on a skid or a trailer.

Air strippers can be operated continuously or in a batch mode where the air stripper is intermittently fed from a collection tank. The batch mode ensures consistent air stripper performance and greater energy efficiency than continuously operated units because mixing in the storage tanks eliminates any inconsistencies in feed water composition.

The eventual duration of cleanup using an air stripping system may be tens of years and depends on the capture of the groundwater contamination from the pumping system.

Applicability: Air stripping is used to separate VOCs from water. Henry's law constant is used to determine whether air stripping will be effective. Some examples of compounds that can be successfully separated from water using air stripping include benzene/toluene/ethylbenzene/xylene (BTEX), chloroethane, TCE, DCE, and PCE.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- The potential exists for inorganic (e.g., iron greater than 5 ppm, hardness greater than 800 ppm) or biological fouling of the equipment, requiring pretreatment or periodic column cleaning.
- Most effective for contaminated water with VOC or semivolatile concentrations with a

dimensionless Henry's constant greater than 0.01.

- Consideration should be given to the type and amount of packing used in the tower.
- Process energy costs are high.
- Compounds with low volatility at ambient temperature may require preheating of the groundwater.
- Off-gases may require treatment based on mass emission rate.

Granular Activated Carbon

Liquid phase carbon adsorption is a full-scale technology in which groundwater is pumped through one or more vessels containing activated carbon to which dissolved organic contaminants adsorb. When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be regenerated in place; removed and regenerated at an off-site facility; or removed and disposed. Carbon used for explosives- or metals-contaminated groundwater probably cannot be regenerated and should be removed and properly disposed. Adsorption by activated carbon has a long history of use in treating municipal, industrial, and hazardous wastes.

The two most common reactor configurations for carbon adsorption systems are the fixed bed and the pulsed or moving bed. The fixed-bed configuration is the most widely used for adsorption from liquids. Pretreatment for removal of suspended solids from streams to be treated is an important design consideration. If not removed, suspended solids in a liquid stream may accumulate in the column, causing an increase in pressure drop. When the pressure drop becomes too high, the accumulated solids must be removed, for example, by backwashing. The solids removal process necessitates adsorber downtime and may result in carbon loss and disruption of the mass transfer zone.

The duration of GAC is usually short-term; however, if concentrations are low enough, the duration may be long-term. The duration of operation and maintenance is dependent on the capture of the groundwater contamination from the pumping system.

Applicability: The target contaminant groups for carbon adsorption are hydrocarbons. Liquid phase carbon adsorption is effective for removing contaminants at low concentrations (less than 10 mg/L) from water at nearly any flow rate, and for removing higher concentrations of contaminants from water at low flow rates (typically 0.5 to 1 gpm). Carbon adsorption is particularly effective for polishing water discharges from other remedial technologies to attain regulatory compliance. Carbon adsorption systems can be deployed rapidly, and contaminant removal efficiencies are high. Logistic and economic disadvantages arise from the need to transport and decontaminate spent carbon.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- The presence of multiple contaminants can impact process performance.
- Streams with high suspended solids (> 50 mg/L) and oil and grease (> 10 mg/L) may cause fouling of the carbon and may require frequent treatment. In such cases,

pretreatment is generally required.

- Costs are high if used as the primary treatment on wastestreams with high contaminant concentration levels.
- The quality of the carbon, as well as the operating temperature, will impact process performance.
- Small molecules are not adsorbed well.
- All spent carbon will eventually need to be properly disposed.

Ultraviolet (UV) Oxidation

UV oxidation is a destruction process that oxidizes organic constituents in water by the addition of strong oxidizers and irradiation with UV light. Oxidation of target contaminants is caused by direct reaction with the oxidizers, UV photolysis, and through the action of UV light, in combination with ozone (O_3) and/or hydrogen peroxide (H_2O_2). The main advantage of UV oxidation is that it is a destruction process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted and concentrated in a separate phase. UV oxidation processes can be configured in batch or continuous flow modes, depending on the throughput under consideration.

The UV oxidation process is generally done with low pressure lamps operating at 65 watts of electricity for ozone systems and lamps operating at 15kW to 60kW for hydrogen peroxide systems.

Applicability: Practically any organic contaminant that is reactive with the hydroxyl radical can potentially be treated. A wide variety of organic contaminants are susceptible to destruction by UV/oxidation, including chlorinated hydrocarbons used as industrial solvents and cleaners. Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes.

Limitations: Limitations of UV oxidation include:

- The aqueous stream being treated must provide for good transmission of UV light (high turbidity causes interference).
- Free radical scavengers can inhibit contaminant destruction efficiency.
- The aqueous stream to be treated by UV oxidation should be relatively free of heavy metal ions (less than 10 mg/L) and insoluble oil or grease to minimize the potential for fouling.
- When UV/O_3 is used on certain volatile organics, such as TCA, the contaminants may be volatilized (e.g., "stripped") rather than destroyed. They would then have to be removed from the off-gas by activated carbon adsorption or catalytic oxidation.
- Costs may be higher than competing technologies because of energy requirements.
- Pretreatment of the aqueous stream may be required to minimize ongoing cleaning and maintenance.
- Handling and storage of oxidizers require special safety precautions.

Another component of any groundwater extraction system is a groundwater monitoring program to verify its effectiveness. Monitoring the remedial system with wells and piezometers allows the operator to make continuous adjustments, as necessary, to the system in response to changes in subsurface conditions caused by the remediation.

3.2.4 In-situ Chemical Oxidation

In Situ Chemical Oxidation (ISCO) involves injecting chemical oxidants into soil and/or ground water to oxidize contaminants. This is an emerging technology that can be applied at highly contaminated sites or source areas to reduce contaminant concentrations. This technology, generally, is not cost effective for plumes with low contaminant concentrations. The common oxidants are hydrogen peroxide-based Fenton's reagent, and potassium permanganate. Ozone can also oxidize organic contaminants in situ, but it's not commonly used. Fenton's reagent is produced on site by adding an iron catalyst to hydrogen peroxide solution. A 50 % solution of peroxide is common for this application. A pH adjustment may be needed, as Fenton's reagent is more effective at acidic pH. For permanganate application, a 1 to 5% solution is prepared on site from potassium permanganate crystals that are delivered in bulk to the site.

Synonyms: The acronym ISCO.

Applicability: The highest potential for cost effective application of this technology is at sites contaminated with relatively high concentrations of halogenated volatile organic compounds (VOCs) and dense non-aqueous phase liquid (DNAPL). The chemical oxidation process, however, can be potentially used for halogenated semi volatile organic compounds (SVOCs), non-halogenated VOCs and SVOCs, and ordnance compounds. One advantage ISCO has over some other alternatives is the ability to significantly reduce the time to completion.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- Subsurface heterogeneities can cause non uniform distribution of oxidant.
- Effective porosity of the subsurface may be reduced.
- May need more than one application of oxidant to remediate rebound effects.
- Fenton's reagent may not be used at high alkalinity sites.
- Native organic matter exerts a demand for oxidants, thus increasing costs for chemicals.
- Not cost effective for residual concentrations.

The duration of the ISCO process generally varies from a few days to a few months, depending upon: size of the treatment area, oxidant delivery rates, remediation goal, and aquifer properties.

3.2.5 In-situ Thermal

With this technology, a heat source is introduced into an aquifer to vaporize volatile and semivolatile contaminants. Vaporized components rise to the unsaturated (vadose) zone where they are removed by vacuum extraction and then treated. Hot water or steam-based techniques include Contained Recovery of Oily Waste (CROW), Steam Injection and Vacuum Extraction (SIVE), In Situ Steam-Enhanced Extraction (ISEE), and Steam-Enhanced Recovery Process (SERP).

The process can be used to address contaminant source areas and to retard downward and lateral migration of organic contaminants. The process is applicable to shallow and deep contaminated areas, and readily available mobile equipment can be used.

The total treatment time will vary depending on the size of the contaminated area and the amount of contaminants to be extracted; it can range from a few months to two years.

Synonyms: Steam stripping, hot water/steam flushing.

Applicability: In-situ thermal is appropriate for the recovery of NAPLs from the subsurface, both above and below the water table. It is best applied to concentrated sources of VOCs, although some SVOCs have been successfully recovered using this technology. Because it volatilizes and boils contaminants out of the subsurface, the technology has much higher extraction efficiencies and recovery rates than a traditional pump and treat system.

Limitations: In-situ thermal stripping may be subject to the following limitations:

- Steam systems require a large vapor collection system to ensure that the evaporated contaminants do not condense in the subsurface, possibly contaminating a previously clean area.
- The technology will produce a liquid hazardous waste which must be transported off-site for proper treatment and disposal.
- In-situ thermal/steam systems are not appropriate for compounds with a boiling point greater than approximately 200° C.
- In-situ thermal is considered efficient when addressing source areas; remediation of dissolved phase plumes is not cost-effective.

3.2.6 Enhanced In-situ Bioremediation

Enhanced in-situ bioremediation (EISB) of chlorinated solvents in groundwater involves the input of an organic carbon source, nutrients, electron acceptors, and/or microbial cultures to stimulate degradation. The major biological processes by which chlorinated compounds degrade include anaerobic reductive dechlorination, aerobic cometabolism, and oxidation. Anaerobic reductive dechlorination involves the replacement of chlorine atoms in the chlorinated compound by hydrogen. An electron donor, either hydrogen gas or a precursor organic compound, is necessary for reduction to occur. Aerobic cometabolism involves the fortuitous degradation of chlorinated solvents by enzymes intended to metabolize compounds such as toluene, phenol, or methane. The organisms gain no benefit from the cometabolic degradation and may be harmed.

Direct degradation of some chlorinated solvents can occur in either aerobic or anaerobic environments.

A key factor in the design of EISB systems is the mechanism for delivering amendments and nutrients to the target portion of the groundwater plume. For sites in which treatment of high concentration portions of a plume is the goal, systems with multiple injection and extraction wells may provide semi-closed re-circulation loops in the groundwater which reduce downgradient flow and allow for greater biodegradation of the contaminants.

A variety of amendments may be added to EISB systems. Common carbon sources for anaerobic sites include lactic acid, sodium benzoate, methanol, and yeast extract. Most sites require nutrients as well, including phosphate, nitrate, or potassium.

Applicability: EISB systems are appropriate for sites in which natural biological activity has been confirmed. Anaerobic conditions are generally required for heavily chlorinated compounds including PCE, TCE, 1,1,1-TCA, and DCE. Because naturally occurring bacteria are the primary degradation mechanism, EISB systems can be much less expensive than chemical or physical treatment technologies.

Limitations: EISB systems are susceptible to the following limitations:

- Restrictive regulatory issues may apply if the system includes reinjection of hazardous substances into the groundwater.
- Where the subsurface is heterogeneous, it is very difficult to deliver the amendament/additive throughout every portion of the contaminated zone. Higher permeability zones will be cleaned up much faster because ground water flow rates are greater.
- When adding nutrients, bio-fouling of the injection wells may need to be addressed.
- Not all compounds are equally amenable to biological degradation.
- Some intermediate compounds in the biodegradation pathway are more mobile and/or toxic than their parent compounds (i.e., vinyl chloride is a degradation product of PCE).
- EISB systems are limited to how quickly organisms can degrade the target compounds. These systems can take a significantly longer time to remediate an area compared to some physical or chemical treatment technologies.

3.3 Identification of Remedial Approach for DNAPL

In the EPA document entitled *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites*, there is a discussion on the long-term goals to address the presence of DNAPL. DNAPL is considered as a “principal threat” because it will act as a continuing source of contamination to the groundwater. It is the expectation of the NCP to “use treatment to address the principal threats posed by a site, wherever practicable” (Federal Register, 1990a; Section 300.430(a)(1)(iii)(A)). However, based on program experience, the removal of DNAPL from the subsurface can be very difficult. Therefore, the preferred remedy will need to address DNAPL such that it will reduce the quantity of/control the migration of DNAPL, to the extent practicable. One way to address this situation would be to physically remove DNAPL, to the extent practicable. A DNAPL recovery system could include the installation of low-flow DNAPL recovery wells (installed along areas where bedrock fractures are believed to be present), monitoring the effectiveness of the DNAPL recovery, and adjusting the system in the future to enhance its performance.

This approach will be included in the alternatives to be further evaluated later in this document.

3.4 Summary of Remedial Technologies Identified

The following is a summary of the remedial technologies that have been identified for the Scobell Chemical site, Operable Unit #2:

Remedial Technologies Identified for Groundwater

- No Action/Groundwater Monitoring
- Natural Attenuation
- Groundwater Extraction and Treatment
  - Air Stripping
  - Granular Activated Carbon
  - Ultraviolet Oxidation
- In-situ Chemical Oxidation
- In-situ Thermal
- Enhanced In-situ Bioremediation
- low-flow DNAPL recovery wells, monitoring the effectiveness, future adjustments as needed (shallow bedrock)

SECTION 4 - PRELIMINARY SCREENING OF ALTERNATIVES

The objective of remedial alternatives screening is to narrow the list of potential/viable alternatives that will be evaluated in detail. Screening is used as a tool throughout the alternative selection process to narrow the options being considered. When alternatives are being developed, individual remedial technologies should be screened primarily on their ability to meet medium-specific remedial action objectives, their implementability and their short-term and long-term effectiveness. At this time, cost is not used to guide the initial development and screening of remedial technologies or alternatives. Because the purpose of the screening evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives should be evaluated more generally in this phase than during the detailed analysis.

The **No Action/Groundwater Monitoring** alternative is included, and will be carried through to the detailed analysis of alternatives, as a procedural requirement and as a baseline to evaluate the other alternatives.

Below is a discussion of the alternatives that were eliminated as a part of the preliminary screening, and the basis for their elimination.

4.1 Screening Criteria

The criteria used to evaluate alternatives during the screening of alternatives include short-/long-term effectiveness and implementability, discussed further below.

Short-term effectiveness assesses the impacts of the alternative during the construction and implementation phase. Alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The aspects evaluated include: protection of the community during remedial actions, environmental impacts as a result of remedial actions, time until the remedial response objectives are achieved, and protection of workers during the remedial action. *Long-term Effectiveness* addresses the results of a remedial action in terms of its permanence and quantity/nature of waste or residual remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the waste or residual remaining at the site and the operating system necessary for the remedy to remain effective. The factors being evaluated include the permanence of the remedial alternative, magnitude of the remaining risk, adequacy of controls used to manage residual waste, and the reliability of controls used to manage residual waste.

Implementability addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The evaluation includes: feasibility of construction and operation; the reliability of the technology; the ease of undertaking additional remedial action; monitoring considerations; activities needed to coordinate with other offices or agencies; availability of adequate off-site treatment, storage, and disposal services; availability of equipment; and the availability of services and materials.

4.2 Screening of Alternatives for Groundwater (OU#2)

After reviewing the alternatives identified for groundwater, it became apparent that not all of the alternatives were appropriate for the Scobell site, based on an evaluation against the screening criteria identified above. Below is a summary of the alternative(s) that were eliminated from further consideration, and the basis for elimination.

Natural Attenuation is a remedial approach that allows natural processes to reduce the concentration of contaminants in the groundwater. Due to the high concentrations of contaminants in the aqueous phase, along with the presence of non-aqueous phase liquid, it would not be possible for natural processes to sufficiently reduce contaminant concentrations within a reasonable time frame and/or before the contaminated groundwater had migrated a significant distance from the site. As a result, natural attenuation is eliminated from further consideration in the source area on the basis that it would not provide long-term effectiveness.

4.3 Alternatives to be Evaluated During the Detailed Analysis (OU#2)

The following alternatives have been retained for the Detailed Analysis of Alternatives:

Remedial Alternatives Identified for Groundwater

- No Action/Groundwater Monitoring
- Groundwater Extraction and Treatment
- In-situ Chemical Oxidation
- In-situ Thermal
- Enhanced In-situ Bioremediation
- low-flow DNAPL recovery wells, monitoring the effectiveness, future adjustments as needed (shallow bedrock)

SECTION 5 - DETAILED ANALYSIS OF ALTERNATIVES

5.1 Description of Evaluation Criteria

In Section 5.2, each of the alternatives is analyzed with respect to the criteria outlined in the 6 NYCRR Part 375, which defines the selection process for remedial actions at inactive hazardous waste sites. Each alternative is analyzed with respect to:

1. **Overall Protection of Human Health and the Environment**: This criterion serves as a final check to assess whether each alterative meets the requirements that are protective of human health and the environment. The overall assessment of protection is based on a composite of factors assessed under other evaluation criteria; especially long-term effectiveness and performance, short-term effectiveness, and compliance with SCGs. This evaluation focuses on how a specific alternative achieves protection over time and how site risks are reduced. The analysis includes how each source of contamination is to be eliminated, reduced or controlled for each alternative.

2. **Compliance with SCGs**: This evaluation criterion determines how each alternative complies with applicable or relevant and appropriate SCGs, as discussed and identified in Section 1.7. The actual determination of which requirements are applicable or relevant and appropriate is made by the NYSDEC in consultation with the NYSDOH. If an SCG is not met, the basis for one of the four waivers allowed under 6 NYCRR Part 375-1.10(c)(i) is discussed. If an alternative does not meet the SCGs and a waiver is not appropriate or justifiable, such an alternative should not be considered further.

3. **Short-term Impacts and Effectiveness**: This evaluation criterion assesses the effects of the alternative during the construction and implementation phase. Alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The aspects evaluated include: protection of the community during remedial actions, environmental impacts as a result of remedial actions, time until the remedial response objectives are achieved, and protection of

workers during the remedial action.

4. **Long-term Effectiveness and Permanence**: This evaluation criterion addresses the results of a remedial action in terms of its permanence and quantity/nature of waste or residual remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the waste or residual remaining at the site and operating system necessary for the remedy to remain effective. The factors being evaluated include the permanence of the remedial alternative, magnitude of the remaining risk, adequacy of controls used to manage residual waste, and the reliability of controls used to manage residual waste.

5. **Reduction of Toxicity, Mobility and Volume**: This evaluation criterion assesses the remedial alternative's use of the technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous wastes as their principal element. The NYSDEC's policy is to give preference to alternatives that eliminate any significant threats at as site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in the contaminants mobility, or reduction of the total volume of contaminated media. This evaluation includes: the amount of the hazardous materials that would be destroyed or treated, the degree of expected reduction in toxicity, mobility, or volume measured as a percentage, the degree in which the treatment would irreversible, and the type and quantity of treatment residuals that would remain following treatment.

6. **Implementability**: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The evaluation includes: feasibility of construction and operation; the reliability of the technology; the ease of undertaking additional remedial action; monitoring considerations; activities needed to coordinate with other offices or agencies; availability of adequate off-site treatment, storage, and disposal services; availability of equipment; and the availability of services and materials.

7. **Cost**: Cost estimates are prepared and evaluated for each alternative. The cost estimates include capital costs, operation and maintenance costs, and future capital costs. A cost sensitivity analysis is performed which includes the following factors: the effective life of the remedial action, the O&M costs, the duration of the cleanup, the volume of contaminated material, other design parameters, and the discount rate.

8. **Community Acceptance**: After completion of the FS, a Proposed Remedial Action Plan (PRAP) is prepared and released to the public for comment. Concerns of the community regarding the RI/FS reports the PRAP are evaluated. A "Responsiveness Summary" will be prepared that presents the public comments received and how the Department will address the concerns raised. If the final remedy selected differs significantly from the proposed remedy, notices to the public will be issued describing the differences and reasons for the changes.

5.2 Evaluation of Remedial Alternatives for Groundwater (OU#2)

Note: The cost estimates included for all of the alternatives includes a 20% contingency.

5.2.1 No Action/ Groundwater Monitoring

The no action alternative is evaluated as a procedural requirement and as a basis for comparison. It requires continued monitoring only, allowing the site to remain in an un-remediated state. This alternative would leave the site in its present condition and would not provide any additional protection to human health or the environment. Groundwater monitoring would be conducted. It is assumed that: 1) two additional downgradient bedrock well pairs would be installed; and 2) the four new wells, as well as the thirteen existing off-site wells, would be monitored quarterly for the first year followed by annually for up to 30 years.

Present Worth	$ 229,100
Capital Cost	$ 25,200
Annual O&M	$ 32,000 (1st year)
	$ 9500 (years 2-30)
Time to Implement	NA

Overall Protection of Human Health and the Environment: Although this alternative does not result in any increased short-term risks, it does not comply with chemical-specific SCGs, and is not effective in the long term. This alternative would not be protective of human health or the environment within an acceptable time frame.

Compliance with SCGs: This alternative would not involve any active remediation of groundwater, groundwater standards would not be achieved in the near future, and contaminated groundwater would continue to migrate off-site.

Short-Term Impacts and Effectiveness: Since the only action would be groundwater monitoring, the only short-term impact would be the possibility of exposure of the samplers to the groundwater. Exposure would be significantly reduced through the use of appropriate levels of personal protective equipment and health and safety procedures. It is unlikely that there would be any increased risk to the public or impacts to the environment during the groundwater monitoring.

Long-Term Effectiveness and Permanence: Since no active remediation would take place, this alternative would not be effective in reducing contaminant concentrations in the groundwater in a reasonable time frame.

Reduction of Toxicity, Mobility, and Volume: This alternative would not significantly reduce the toxicity, mobility, or volume of the contamination in groundwater. Natural processes could slowly reduce the contamination, but the time frame would be unacceptable.

Implementability: This alternative would be easily implemented. There would be no activities that would need coordination with other agencies during implementation. This alternative would require sampling of groundwater for an extended period of time (30 years is assumed for cost purposes).

Cost: There would be a capital cost of approximately $20,000 for this alternative, associated with installing two new bedrock monitoring well pairs. The annual O&M cost is $ 32,000 for the first year and$ 9500 thereafter, based on a conservative scenario of sampling 20 wells quarterly for the first year, and then annually for up to 30 years. The present worth value of this alternative is $227,900 using a 5% discount rate over 30 years.

5.2.2 Groundwater Extraction and Treatment (via either Air Stripping, Granular Activated Carbon, or UV/Oxidation)

This alternative would involve the installation of approximately 8 groundwater pumping wells in the off-site area just north of the railroad tracks. It is assumed that four of the wells would be installed to a depth of approximately 35 feet below ground surface (bgs), approximately 25 to 30 feet into the bedrock; the other four would be installed approximately 70 feet bgs. It is estimated that the system would operate at an average withdrawal rate of approximately 25 - 30 gallons per minute for an estimated period of 30 years. Once removed, the groundwater would be treated on site and discharged to either surface water or the sanitary sewers, as necessary and appropriate.

The shallow bedrock under the railroad tracks is a relatively small area, but most likely contains a significant amount of contamination. In order for the off-site remediation to be more effective, it would be necessary to address the contamination under the tracks. Some type of in-situ remedial technology will be necessary since the area is under an active rail line. Possibilities include, but are not limited to surfactant flushing, enhanced in-situ bioremediation, and in-situ chemical oxidation (ISCO). For the purpose of this FS, and to develop cost estimates (added to all "active" remedies included in the detailed analysis of alternatives in this FS), the use of ISCO has been included as the component to address under the tracks (assumed that five wells would be installed along the northern boundary of the on-site area, one to extract groundwater and four to inject the groundwater mixed in a 2% potassium permanganate solution - see Appendix A for cost estimate/assumptions made). However, the final decision on the method of treatment for this area would be deferred until the Remedial Design.

This section discusses groundwater pump and treat as one alternative. Three different "treat" options are potentially applicable for this site including air stripping (volatile organics are partitioned from extracted ground water by aerating or increasing the surface area of the contaminated water exposed to air; aeration methods include packed towers, diffused aeration, tray aeration, and spray aeration), granular activated carbon (water passes through the carbon system and contaminant molecules are removed from the water by adsorption to the carbon), and ultraviolet oxidation (UV oxidation is a destruction process that oxidizes organic contamination in the water by the addition of strong oxidizers and irradiation with UV light). If pump and treat is selected as the recommended remedial alternative, ***treatment via air stripping would be included so that a cost estimate could be developed***. However, if included as a part of the recommended remedial alternative, the final decision on the method of treatment for the extracted groundwater would be deferred until the Remedial Design.

Pump & treat **(Air stripping)**	
Present Worth	$ 2,083,135
Capital Cost	$ 577,860
Annual O&M	$81,600
Time to Implement	approximately 3 months
Estimated Time to Completion	30 years

Pump & Treat **(Granular Activated Carbon)**	
Present Worth	$ 3,420,010
Capital Cost	$ 578,065
Annual O&M	$154,060
Time to Implement	approximately 3 months
Estimated Time to Completion	30 years

Pump & Treat **(Ultraviolet Oxidation)**	
Present Worth	$2,028,725
Capital Cost	$ 676,560
Annual O&M	$68,300
Time to Implement	approximately 3 months
Estimated Time to Completion	30 years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative would reduce the possibility of exposure to contaminated groundwater by controlling/treating it on-site, thus minimizing it as a continuing source for off-site areas. Although it would control the migration of contaminated groundwater to areas further off-site, it would take quite some time to fully address the source area using this alternative; pump and treat alone would not be very successful in addressing the DNAPL contamination present in the source area.

Compliance with SCGs: This alternative would remove and treat contaminated groundwater on-site. Action-specific SCGs for this alternative apply to the excavation and handling of site soils during well installation (monitoring requirements, and OSHA health and safety requirements). Compliance with these SCGs would be achieved by following a site-specific health and safety plan. This treatment system could incorporate an air emission source that would be subject to New York regulations 6 NYCRR 200, 201, and 212, and the New York Air Guide 1, Guidelines for the Control of Toxic Ambient Air Contaminants. Since the air emissions would be treated, as appropriate, these regulatory requirements would be met. The treatment system would also result in a water discharge. This water would either be discharged to surface waters or to the local publicly owned treatment works (POTW). If discharged to surface waters, it would be subject to New York regulations for SPDES discharges; if discharged to the POTW, coordination with the local municipality would be required. Since the water discharge would be treated, these requirements would be met.

6 NYCRR Part 703, Groundwater Quality Standards, would apply to the groundwater. The history of groundwater extraction and treatment shows that overall, time is needed for this technology to lower contaminant concentrations, and that it is difficult to achieve groundwater standards. However, by hydraulically containing the plume the continued migration of contaminants would be controlled, thereby preventing the volume of contaminated groundwater from increasing.

Short-Term Impacts and Effectiveness: There would be a potential for worker exposure during installation of the groundwater extraction wells. This exposure could be significantly reduced through the use of personal protection equipment. Air and water emission controls would prevent worker and resident exposure to airborne and waterborne contaminants. The time to implement the alternative is estimated at 3 months, and the length of operation of the system is estimated at approximately 30 years. However, it is possible that even after 30 years of operation groundwater standards would not be achieved.

Long-Term Effectiveness and Permanence: This alternative would control the migration of the contamination from the off-site area (OU#2). Groundwater concentrations would be expected to decrease with time as a result of the extraction and treatment of the contaminated groundwater, assisted by natural processes. However, this time frame would be very long; 30 years has been used for the purposes of this FS/cost estimate, although it is possible that even after 30 years of operation groundwater standards would not be achieved.

Reduction of Toxicity, Mobility, and Volume: By removing contaminants from the groundwater and treating the removed contaminants, the toxicity and volume of the contaminants in the groundwater in this location would be reduced, relative to the site. Since hydraulically controlling the contaminant plume would mitigate further migration of contaminants in groundwater, the contaminant mobility would be significantly reduced, and an increase in the volume of contaminated groundwater would be avoided. The contaminants would be removed from the environment, concentrated into another media, and disposed of off-site. As a result, relative to the site, the treatment of the contaminated groundwater would be complete without the potential for those contaminants to cause a future threat at the site.

Implementability: The equipment and material needed to install a groundwater extraction and treatment system are commercially available from several vendors. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost: The costs are discussed, for three of the potential treatment options, at the beginning of this section.

5.2.3 **In-Situ Chemical Oxidation** (ISCO)

This alternative would involve the installation of a system to inject chemical oxidants into ground water to oxidize contaminants. This is a technology that can be applied at highly contaminated sites or source areas to reduce contaminant concentrations. It is generally not cost effective for plumes with low contaminant concentrations. The common oxidants are hydrogen peroxide-based Fenton's reagent, and potassium permanganate. Ozone can also oxidize organic contaminants in situ, but it's not commonly used. Fenton's reagent is produced on site by adding an iron catalyst to hydrogen peroxide solution. A pH adjustment may be needed, as Fenton's reagent is more effective at acidic pH. For permanganate application, a 1 to 5% solution is prepared on site from potassium permanganate crystals that are delivered in bulk to the site.

The shallow bedrock under the railroad tracks is a relatively small area, but most likely contains a significant amount of contamination. In order for the off-site remediation to be more effective, it would be necessary to address the contamination under the tracks. Some type of in-situ remedial technology will be necessary since the area is under an active rail line. Possibilities include, but are not limited to surfactant flushing, enhanced in-situ bioremediation, and in-situ chemical oxidation (ISCO). For the purpose of this FS, and to develop cost estimates (added to all "active" remedies included in the detailed analysis of alternatives in this FS), the use of ISCO has been included as the component to address under the tracks (assumed that five wells would be installed along the northern boundary of the on-site area, one to extract groundwater and four to inject the groundwater mixed in a 2% potassium permanganate solution - see Appendix A for cost estimate/assumptions made). However, the final decision on the method of treatment for this area would be deferred until the Remedial Design.

For the purposes of this FS it has been assumed that potassium permanganate would be used as the chemical oxidant. It is assumed that up to 25 additional wells (well locations placed along bedrock fractures based upon results of the geophysical work performed during the OU#2 RI) would be installed to a depth of 35 feet. These wells would be located from just north of the railroad tracks to the area of MW-5S/MW-5D. Approximately five of these wells would be used to extract groundwater, which would be mixed with the potassium permanganate crystals in a 2% solution and then re-introduced to the subsurface through the other 20 newly installed wells. It is assumed that there would be three separate applications of up to 300,000 gallons of solution, each event lasting approximately one month. The total time frame for the three applications/ performance monitoring would be approximately 2 years.

At the completion of the three applications it is assumed that, although the contaminant concentrations would be significantly reduced, there would be some residual contamination remaining in the groundwater at concentrations above groundwater standards. Therefore, during the RD the NYSDEC could also evaluate the need for additional remedial measures and/or property use restrictions to control threats posed by any residual contamination left after the ISCO treatment was completed. For the purposes of this FS it is assumed that a downgradient groundwater pump and treat system (6 wells, 30gpm) would be put in place after the ISCO would have been performed to address the source area. The purpose of this system would be to "contain" the downgradient part of the plume. It is envisioned that the system would be installed closer to the northern extent of the RG&E property (closer to Blossom Road). The groundwater concentrations are much lower in this area, but they are still present above groundwater standards. Installing a groundwater containment system in this area would minimize the potential for residual contamination to continue to migrate from the site. The cost assumption includes ten years of operation for this system. It is also assumed that the groundwater would be monitored for a period of approximately15 years (following the completion of the ISCO source area remediation).

Present Worth	$2,233,780
Capital Cost	$1,959,180
Annual O&M (years 1-10)	$26,700
Annual O&M (years 11-15)	$8,400
Time to Implement	approximately 2 years
Estimated Time to Completion	approximately 15 years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be mitigated with proper controls. This alternative would reduce the possibility of exposure to contaminated groundwater by controlling/treating it on-site, thus greatly reducing the site as a continuing source for off-site areas. This alternative would be successful at treating the contaminated groundwater and the DNAPL that it would come in contact with in the source area. However, due to the nature of the fractured rock system where the contamination is found, delivery to (and thus treatment of) the entire contaminant mass in the rock would be difficult. As a result, it is likely residual contamination would remain in the environment.

Compliance with SCGs: This alternative would involve in-situ treatment of contaminated groundwater. Action-specific SCGs for this alternative apply to the excavation and handling of site soils during well installation (monitoring requirements, and OSHA health and safety requirements). Compliance with these SCGs would be achieved by following a site-specific health and safety plan. This alternative would significantly reduce the groundwater contaminant concentrations in the area of treatment. However, in a fractured bedrock system it would be difficult to expose the entire volume of contaminated groundwater to the injection treatment system. As a result, groundwater concentrations would be reduced, but groundwater SCGs would not be achieved.

The treatment system would also result in reinjection of treated groundwater. Under CERCLA and UIC (underground injection control) regulations, groundwater recirculation can be exempted from permit requirements. However, the reinjection would be subject to NYS SPDES discharge requirements. Since the extracted water would be treated before reinjection, compliance with the discharge permit requirement should be obtainable.

Short-Term Impacts and Effectiveness: There would be a potential for worker exposure during installation of the groundwater extraction wells. This potential could be significantly reduced through the use of personal protection equipment. Air and water emission controls would prevent worker and resident exposure to airborne and waterborne contaminants. The time to implement the alternative is estimated at 2 years, and the length of operation of the system is estimated at approximately 15 years ("polishing" of residuals and monitoring).

Long-Term Effectiveness and Permanence: Groundwater concentrations would be expected to significantly decrease as a result of the treatment of the contaminated groundwater. It is anticipated that the ISCO process would be effective in addressing source areas/areas of high contaminant concentrations (not cost-effective to address large areas with relatively low contaminant levels); by doing so it would significantly decrease the amount of time necessary to restore the groundwater quality to acceptable levels, compared to No Action or Pump and Treat. However, since relatively low level residual contamination would remain in the groundwater it may be many years before groundwater standards are achieved.

One of the main limiting factors with this type of technology is the ability for the injected chemical (in this case $KMNO_4$ solution) to come in contact with the contaminated groundwater in order to be effective. In a fractured bedrock aquifer it can be difficult to insure good mixing so that all/most of the contaminated groundwater is addressed.

Reduction of Toxicity, Mobility, and Volume: This technology would be a permanent treatment of the contamination addressed by this alternative. By treating the groundwater/ DNAPL, the toxicity and volume of the contaminants would be reduced. By addressing the highly contaminated source area the contaminant mobility would be significantly reduced, and an increase in the volume of contaminated groundwater would be avoided. Because there would be residuals, the "polishing" step would address any continuing threat of residuals present after the completion of the ISCO.

Implementability: The equipment and material needed to install and implement the ISCO process are commercially available from several vendors. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost: The costs are discussed at the beginning of this section.

5.2.4 In-Situ Thermal

For discussion purposes, a steam stripping system has been included in the text below. If this alternative is selected as the preferred alternative, the details of the thermal system would be developed during the remedial design and may not necessarily include steam to introduce the heat to the subsurface. Other in-situ thermal technologies include radio frequency heating (uses electromagnetic energy to heat contaminated media) and electrical resistance heating (uses an electrical current to heat contaminated subsurface).

This alternative includes the installation of approximately 80-100 steam injection and groundwater/ vapor extraction wells across the site. The details of the layout/configuration of the wells would be developed later in the process. Often the configuration of a such a system would involve dividing the area into individual grid areas with steam injection points at the perimeter of the grid and the extraction well in the center of the grid. With this type of system there would be more injection wells; for the purposes of this FS assume 64-80 steam injection wells and 16-20 groundwater/ vapor extraction wells. In addition, it is assumed that 20-30 boreholes would be installed in order to monitor subsurface conditions. The wells would be installed approximately 30-40 feet apart along the bedrock fractures (well locations placed along bedrock fractures based upon results of the geophysical work performed during the OU#2 RI); most of the wells would be installed to a depth of approximately 35 feet; some may be installed deeper so that steam could be introduced below the area where the contaminant concentrations are the highest. Steam would be injected at the periphery of, and below, the concentrated source area to heat the subsurface. The IST would heat the subsurface (groundwater and bedrock) to volatilize the contaminants in the bedrock, after which they would be collected by the groundwater/vapor extraction wells. The steam injection would remove contaminants from the groundwater as well as the bedrock matrix, and thus would more fully address the volume of contaminated media in the source area. Contamination would be extracted and collected on-site for off-site disposal.

Steam would be generated on-site and injected into the subsurface. As the bedrock fractures would receive the steam, the surrounding matrix would heat up by thermal conduction. The steam would volatilize the contaminants in the bedrock, after which they would travel from the matrix to the fractures and would be collected by the groundwater/vapor extraction wells. The steam injection would remove contaminants from the groundwater as well as the bedrock matrix, greatly reducing the concentrated source area present in the bedrock just north of the railroad tracks.

The thermal system would operate for approximately 12-18 months, after which a long-term groundwater monitoring program would be initiated; it is assumed monitoring would be conducted for approximately five years. The recovered wastes would be condensed and shipped off-site for disposal. By removing the bulk of the contamination from the bedrock, the migration of contaminated groundwater would be greatly reduced. Due to the difficulty of addressing the entire contaminant source area present in a fractured bedrock system, steam stripping may not completely remediate the system so that groundwater standards are achieved. Therefore, during the RD the NYSDEC could also evaluate the need for additional remedial measures and/or property use restrictions to control threats posed by any residual contamination left after the in-situ thermal treatment was completed. For the purposes of this FS it is assumed that a downgradient groundwater pump and treat system (6 wells, 30gpm) would be put in place after the in-situ thermal would have been performed to address the source area. The cost assumption assumes five years of operation for this system. The purpose of this system would be to "contain" the downgradient part of the plume. It is envisioned that the system would be installed closer to the northern extent of the RG&E property (closer to Blossom Road). The groundwater concentrations are much lower in this area, but they are still present above groundwater standards. Installing a groundwater containment system in this area would minimize the potential for residual contamination to continue to migrate from the site.

The shallow bedrock under the railroad tracks is a relatively small area, but most likely contains a significant amount of contamination. In order for the off-site remediation to be more effective, it would be necessary to address the contamination under the tracks. Some type of in-situ remedial technology would be necessary since the area is under an active rail line. Possibilities include, but are not limited to surfactant flushing, enhanced in-situ bioremediation, and in-situ chemical oxidation (ISCO). For the purpose of this FS, and to develop cost estimates (added to all "active" remedies included in the detailed analysis of alternatives in this FS), the use of ISCO has been included as the component to address under the tracks (assumed that five wells would be installed along the northern boundary of the on-site area, one to extract groundwater and four to inject the groundwater mixed in a 2% potassium permanganate solution - see Appendix A for cost estimate/assumptions made). However, the final decision on the method of treatment for this area would be deferred until the Remedial Design.

Present Worth	$3,599,255
Capital Cost	$3,460,500
Annual O&M (5 years)	$26,700
O&M Present Cost	$138,755
Time to Implement	approximately 6 months
Estimated Time to Completion	18-24 months (+ 5 years P&T/monitoring)

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative would reduce the possibility of exposure to contaminated groundwater by treating it in-situ, thus minimizing it as a continuing source for the migration of contaminated groundwater to off-site areas. It would also address the non-aqueous (DNAPL) contamination present in the bedrock fractures as well as in the rock matrix.

Compliance with SCGs: This alternative would greatly reduce the contaminant concentrations in groundwater, possibly approaching groundwater SCGs in the area of treatment. However, due to the nature and extent of the contamination (both on-site and off-site) it would not be practical to assume that groundwater standards would be achieved over the entire groundwater plume in the near future. Because it treats and removes the contaminant source, this alternative complies with the preference for permanent remedies in 6 NYCRR 375.

Short-Term Impacts and Effectiveness: The bulk of contaminants would be removed in a short period of time under this alternative. It is possible that the volume of recovered product could overwhelm the treatment units, resulting in a release to the environment, including vapor releases. It is also possible that the injected steam could move the contamination around the site or possibly into uncontaminated areas. These short-term risks could be reduced and controlled through a careful design and operation of the system. The time to implement the alternative is estimated at 6 months, and the length of operation of the system is estimated at approximately 12-18 months, with groundwater monitoring for a period of approximately 5 years.

Long-Term Effectiveness and Permanence: This alternative would significantly reduce the amount of contamination in the subsurface by addressing contamination in the bedrock fractures as well as the contamination in the rock matrix. Any remaining contamination could be addressed through a polishing step of enhanced monitored natural attenuation (possibly through the use of HRC or other compounds). This alternative would be a permanent remedy and would be very effective in the long-term.

Reduction of Toxicity, Mobility, and Volume: Because the contaminant source would be aggressively addressed under this alternative, there would be a substantial reduction in the volume present in the environment. The groundwater/vapor extraction points component of the remedy would also act to reduce the mobility of the contamination.

Implementability: Relative to the other alternatives being considered, the design of a steam stripping system could be complicated and difficult, especially in a fractured rock aquifer. Although it would be difficult, it would be feasible to design such a system. The materials for its implementation are readily available and there are no known legal or administrative barriers to implementing this alternative.

Cost: The costs are discussed at the beginning of this section.

5.2.5 Enhanced In-situ Bioremediation

This alternative would involve the installation of a system to introduce material that would enhance naturally occurring biodegradation processes. Bioremediation is a process that attempts to accelerate the natural biodegradation process by providing such things as nutrients, electron acceptors, competent degrading microorganisms, etc. that may otherwise be limiting the rapid conversion of contamination organics to innocuous end products.

For the purposes of this FS it has been assumed that up to 250 injection wells (approximately 160 well locations in the area immediately north of the railroad tracks, spaced 10 feet apart, placed along bedrock fractures based upon results of the geophysical work performed during the OU#2 RI; approximately 90 well locations placed downgradient of the first area to address breakdown products) would be installed to a depth of 35 feet. These wells would be located from just north of the railroad tracks to the area of MW-5S/MW-5D, with the second group of 90 wells located in the general area of MW-7S/-7D. It is assumed that two applications (injection events) would be performed. The total time frame for the two applications/ performance monitoring would be approximately 2 years. At the completion of the two applications it is assumed there would be residual contamination remaining in the groundwater. Therefore, it is assumed that the groundwater would be monitored for up to 15 years.

The shallow bedrock under the railroad tracks is a relatively small area, but most likely contains a significant amount of contamination. In order for the off-site remediation to be more effective, it would be necessary to address the contamination under the tracks. Some type of in-situ remedial technology will be necessary since the area is under an active rail line. Possibilities include, but are not limited to surfactant flushing, enhanced in-situ bioremediation, and in-situ chemical oxidation (ISCO). For the purpose of this FS, and to develop cost estimates (added to all "active" remedies included in the detailed analysis of alternatives in this FS), the use of ISCO has been included as the component to address under the tracks (assumed that five wells would be installed along the northern boundary of the on-site area, one to extract groundwater and four to inject the groundwater mixed in a 2% potassium permanganate solution - see Appendix A for cost estimate/assumptions made). However, the final decision on the method of treatment for this area would be deferred until the Remedial Design.

Present Worth	$2,497,320
Capital Cost	$2,349,120
Annual O&M	$11,900
Time to Implement	approximately 2 years
Estimated Time to Completion	approximately 15 years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative would reduce the possibility of exposure to contaminated groundwater by treating it on-site. This technology is not as successful with high concentration source areas, so it would not address the goal of minimizing the potential for the migration of DNAPL.

Compliance with SCGs: This alternative would treat contaminated groundwater on-site. Action-specific SCGs for this alternative apply to the excavation and handling of potentially contaminated material during well installation (monitoring requirements, and OSHA health and safety requirements). Compliance with these SCGs would be achieved by following a site-specific health and safety plan. This alternative would reduce contaminant concentrations in the groundwater, but it probably would not achieve groundwater standards.

Short-Term Impacts and Effectiveness: There would be a potential for worker exposure during installation of the injection wells. This exposure potential could be significantly reduced through the use of personal protection equipment. The time to implement the alternative is estimated at 6 months, and the length of operation of the system is estimated at approximately 2 years, with monitoring of groundwater quality for an estimated time frame of 15 years.

Long-Term Effectiveness and Permanence: Groundwater concentrations would be expected to decrease with time as the result of contaminant destruction via biodegradation that would take place. By injecting nutrients, electron acceptors, competent degrading microorganisms, etc. into the subsurface, the resulting enhanced biological degradation would reduce contaminant concentrations. However, due to the high initial contaminant concentrations and the difficulty which could be encountered introducing the injected material to the entire contaminant mass present in the fractured bedrock, it could be many years before contaminant levels in the groundwater approach the standards. During that time there would continue to be contamination at/migrating form the site.

Reduction of Toxicity, Mobility, and Volume: This technology enhances natural degradation that transforms the contaminants into relatively innocuous compounds. By treating the contaminated groundwater the toxicity and volume of the contaminants in the groundwater in this location would be reduced. Over time, the source of contamination in the bedrock would be addressed by biological processes. Treatment of the entire contaminant mass would take quite some time; during that time this alternative would not decrease the mobility of the residual contamination.

Implementability: The equipment and material needed to install/implement this type of system is readily available. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost: The costs are discussed at the beginning of this section.

5.2.6 DNAPL Extraction and Off-site Treatment

Since DNAPL is present in the shallow bedrock physical removal of DNAPL that may be collected in small "pools" could be implemented to address this continuing source of contamination to groundwater. At this site one possible way to address the goal to control migration of DNAPL, possibly in conjunction with some other active remediation, would be to install DNAPL recovery wells in the bedrock. This alternative would include the installation of approximately five DNAPL recovery wells, located along the bedrock fractures north of the railroad tracks. The DNAPL extraction wells would be four inch wells installed approximately 30 feet into bedrock (40 feet below ground surface (bgs)). The wells would be cased/grouted into the top of the competent bedrock with open hole construction in the competent rock. A rough estimate of 1000 gallons of recovered DNAPL, over 5 years, has been included. The recovered DNAPL would be temporarily stored on site until enough accumulates to be sent off-site for incineration. At the end of the estimated five year period, the system would be evaluated and a determination made on whether to continue/ make adjustments to enhance the recovery system, as appropriate.

Present Worth	$150,600
Capital Cost	$84,600
Annual O&M	$66,000
Time to Implement	approximately 2 months
Estimated Time to Completion	5 years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative would act to reduce the potential for the DNAPL to act as a continuing source of contamination to the groundwater, thus reducing the potential for continued off-site migration of contaminants.

Compliance with SCGs: This alternative would address a concentrated source area. Although it would not allow for groundwater SCGs to be achieved on its own, it would help to address a continuing source of contamination to the groundwater. Action-specific SCGs for this alternative apply to the transport and disposal of the DNAPL. Compliance with these SCGs would be achieved by following a site-specific operation and maintenance plan.

Short-Term Impacts and Effectiveness: There would be a potential for worker exposure during installation of the DNAPL extraction wells. This exposure could be significantly reduced through the use of monitoring equipment and personal protection equipment. The time to implement the alternative is estimated at 2 months, and the length of operation of the system is estimated at approximately 5 years.

Long-Term Effectiveness and Permanence: This alternative would partially control/remove the DNAPL from the subsurface. Due to the nature of DNAPL, it would be difficult to completely control/remove it from the bedrock using extraction wells. The amount of contamination moving from the non-aqueous phase to the aqueous phase (dissolved in the groundwater) would be expected to decrease with time as a result of the extraction and treatment of the DNAPL.

Reduction of Toxicity, Mobility, and Volume: By removing concentrated contaminant source areas and treating the removed contaminants, the volume of the contaminants in the in the subsurface in this location would be reduced. Since source control would mitigate further migration of contaminants to the groundwater, the contaminant mobility would be reduced. However, there would be residual DNAPL left behind that would not be captured using this remedial technique. This residual DNAPL, if not addresses by another component of the remedy, would continue to be mobile/act as a source of contamination to the groundwater.

Implementability: The equipment and material needed to install a DNAPL extraction system are commercially available. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost: The costs are discussed at the beginning of this section.

5.3 Comparative Analysis of Alternatives for Groundwater (OU#2)

Overall Protection of Human Health and the Environment: The no action/groundwater monitoring alternative would not be protective of human health or the environment . The pump and treat (P&T), in-situ chemical oxidation (ISCO), in-situ thermal (IST), and the enhanced in-situ bioremediation (EISB) alternatives would all actively address the on-site groundwater contamination and would offer varying degrees of protection to human health and the environment by reducing the volume and the mobility of the contamination. P&T would be protective by controlling the migration of the contamination, but would not be very effective at addressing/removing the concentrated source area from the environment. IST would offer a great deal of protection by addressing the entire volume of bedrock in the treatment area; ISCO would be effective in addressing the contamination it came in contact with, but delivery of this technology to the entire contaminant volume would be difficult/not possible due to the nature of the fractured bedrock system; EISB would not be as effective on a concentrated source area/DNAPL, like what is found at this site, plus it also has the delivery problem mentioned for ISCO. The DNAPL recovery alternative would remove some of the contamination from the environment, and thus would offer some protection to human health and the environment by reducing the volume. However, a significant amount of residual would remain behind if not addressed by another component of the remedy.

Since the P&T and the DNAPL recovery alternatives would be best suited working together, future discussion in this section will combine these two alternatives.

Compliance with SCGs: The no action/groundwater monitoring alternative would not achieve groundwater standards. The P&T alternative, combined with the DNAPL recovery alternative, would actively reduce contaminant concentrations in the groundwater. The length of time for P&T to achieve SCGs would depend, in part, on the success of the DNAPL recovery system. Due to the difficulty in remediating DNAPL, residuals could remain behind for quite some time. As a result, although groundwater concentrations would be reduced, it may not be impossible to achieve groundwater standards. Relatively speaking, it is expected that IST would be the most likely alternative to achieve/approach groundwater standards, followed by ISCO. The contaminant concentrations are too high for EISB to achieve/approach standards in a reasonable amount of time. In addition, the effectiveness of both ISCO and EISB are dependent on the ability for the injected material to come in direct contact with the contaminated groundwater, something that would be difficult in a fractured bedrock aquifer. As a result, based on this factor alone, it would be very difficult for ISCO and EISB to address the entire area of the groundwater plume to be treated.

Short-Term Impacts and Effectiveness: The no action/groundwater monitoring alternative would result in the fewest short-term impacts, as the only action taken would be groundwater monitoring. The P&T alternative would have the potential for short term impacts associated with an air emission source and a water discharge, however air emissions and the water discharge would be treated to prevent worker and resident exposure to contaminants. The DNAPL recovery alternative would involve some short term impacts related to handling of the extracted DNAPL, however, proper execution of health and safety procedures would address these potential impacts. Relative to the ISCO and the EISB alternatives, there would be a potential for worker exposure during installation of the injection wells and the handling of the material to be injected (more so for certain ISCO additives); again, this exposure potential could be significantly reduced through the use of personal protection equipment and proper execution of health and safety procedures. Relatively speaking, IST is the alternative which may pose a greater potential for short term impacts. IST could pose a small risk to nearby residents that the system would remove VOCs too quickly from the site, overwhelming the treatment system. This risk can be controlled through proper design and operation of the technology. For IST, the bulk of the contaminant mass could be removed in a relatively short period of time (estimated at approximately 12-18 months), offering the greatest potential for effectiveness in achieving remedial goals.

The potential to achieve the objectives of the remedy would occur quickest with IST. ISCO and

EISB have similar estimated time frames for their operation, but addressing the residual contamination would take longer after the completion of EISB, compared to ISCO. P&T/DNAPL recovery would take the longest, of the active alternatives, to achieve the objectives.

Long-Term Effectiveness and Permanence: The no action/groundwater monitoring alternative would not provide long term effectiveness. The pump and treat/ DNAPL recovery alternative would remove contaminants with the contaminants captured by the treatment component of these alternatives. The contaminant concentrations associated with this alternative would be expected to decrease over time, but achieving groundwater standards would not be anticipated for a significant length of time, if at all. It is anticipated that the ISCO process would be effective in addressing source areas/areas of high contaminant concentrations (not cost-effective to address large areas with relatively low contaminant levels). One of the main limiting factors with this type of technology is the ability for the injected chemical (in this case $KMNO_4$ solution) to come in contact with the contaminated groundwater in order to be effective. In a fractured bedrock aquifer it can be difficult to insure good mixing so that all/most of the contaminated groundwater is addressed. EISB would not be as effective as ISCO in addressing a concentrated source areas/NAPL; also, the ability for the injected material to come in contact with the contaminated groundwater would be the major factor limiting the alternative's effectiveness. IST would be the most effective alternative at addressing the entire contaminant volume. The steam injection would remove contaminants from the groundwater as well as the bedrock matrix, and thus would more fully address the volume of contaminated media in the source area.

Reduction of Toxicity, Mobility, and Volume: The no action/groundwater monitoring alternative would not actively reduce the volume of contaminants already in the groundwater. The pump and treat/ DNAPL recovery alternative would remove contaminants from the subsurface and treat them, thereby reducing the mobility and slowly reducing the volume of contaminants. As discussed above, due to the difficulty in remediating DNAPL, residuals could remain behind for quite some time. Relative to the ISCO and the EISB alternatives, by treating the groundwater the toxicity of the contaminants in the groundwater in this location would be reduced; by addressing the highly contaminated source area the contaminant mobility would be and a reduction in the contaminant volume would be achieved. Between ISCO and EISB, ISCO would more successfully reduce the contaminant volume. Implementation of the IST alternative would result in the most substantial reduction in the volume, toxicity, and mobility of the contamination.

Implementability: The no action/groundwater monitoring alternative would be the easiest to implement. The pump and treat and the DNAPL recovery alternatives would be straightforward to implement, as the systems are commercially available from several vendors. Although more involved than the P&T alternative, there would be no anticipated administrative or legal barriers to the implementation of the ISCO and EISB alternatives. Finally, although IST would probably have the most complicated design issues to address, it is anticipated these issues could/would be addressed without any significant barrier to this alternative's implementation.

Cost: A summary of the costs are presented in Table 5.1. The costs are the present worth based on a 5% discount rate over the estimated length of the remedial action.

SECTION 6 RECOMMENDED REMEDIAL ALTERNATIVE

The NYSDEC has performed a development and evaluation of remedial alternatives based on the guidance provided in 6 NYCRR Part 375-1.10, *Inactive Hazardous Waste Disposal Site Remedial Program, Remedy Selection.* Based on this analysis, the NYSDEC is recommending: In-situ Thermal as the preferred remedial alternative to address the high levels of contamination present in the bedrock for the off-site operable unit (OU#2). The total present worth of this remedial program is estimated to be approximately $3,599,255 (approximately $3,460,500 in capital costs / $138,755 total present worth of O&M).

Steam injection has been included, in the text below, as the method for introducing the heat source into the subsurface. The details of the thermal system will be developed during the remedial design and may not necessarily include steam to introduce the heat to the subsurface.

Steam will be generated on-site and injected into the subsurface. As the bedrock fractures receive the steam, the surrounding matrix will heat up by thermal conduction. The steam will volatilize the contaminants in the bedrock, after which they will travel from the matrix to the fractures and will be collected by the groundwater/vapor extraction wells. The steam injection will remove contaminants from the groundwater as well as the bedrock matrix, greatly reducing the concentrated source area present in the bedrock just north of the railroad tracks [see Figure 6-1].

It is anticipated that the thermal system will operate for approximately 12-18 months, after which a long-term groundwater monitoring program will be initiated; it is assumed monitoring will be conducted for approximately five years. The recovered wastes will be condensed and shipped off-site for disposal. By removing the bulk of the contamination from the saturated and unsaturated bedrock, the migration of contaminated groundwater will be greatly reduced. Due to the difficulty of addressing the entire contaminant source area present in a fractured bedrock system, IST may not be able to achieve groundwater standards. Therefore, during the RD the NYSDEC could also evaluate the need for additional remedial measures and/or property use restrictions to control threats posed by any residual contamination left after the in-situ thermal treatment has been completed. For the purposes of this FS it is assumed that a small downgradient groundwater pump and treat system (3 wells, 10gpm) will be put in place after the in-situ thermal is performed to address the source area. The cost assumption includes five years of operation for this system. The purpose of this system would be to "contain" the downgradient part of the plume. It is envisioned that the system would be installed closer to the northern extent of the RG&E property (closer to Blossom Road). The groundwater concentrations are much lower in this area, but they are still present above groundwater standards. Installing a groundwater containment system in this area would minimize the potential for residual contamination to continue to migrate from the site.

The shallow bedrock under the railroad tracks (area between on-site and off-site areas) is a relatively small area, but most likely contains a significant amount of contamination. In order for the off-site remediation to be more effective, it will be necessary to address the contamination under the tracks. Some type of in-situ remedial technology will be necessary since the area is under an active rail line. Possibilities include, but are not limited to surfactant flushing, enhanced in-situ bioremediation, and in-situ chemical oxidation (ISCO). Currently, the use of ISCO has been included as the component to address under the tracks; it assumed that five wells will be installed along the northern boundary of the on-site area, one to extract groundwater and four to inject the groundwater mixed in a 2% potassium permanganate solution - see Appendix A for cost estimate/assumptions made. However, the final decision on the method of treatment for this area will be deferred until the Remedial Design. Issues related to the coordination of efforts between the implementation of the remedies for OU#1 and OU#2 will be resolved during the Remedial Design.

Deed restrictions would be pursued for the RG&E property as long as residual contamination remains there. The restrictions to be pursued would be associated with restrictions on subsurface work in areas of contamination as well as restriction on the use of contaminated groundwater. Once the identified treatment area has been addressed long term monitoring would be performed to monitor any residual contamination that may remain in the groundwater.

6.1 Basis For Recommendation (OU#2)

6.1.1 Groundwater

The five alternatives evaluated are No Action/Groundwater Monitoring, Groundwater Extraction & Treatment, In-Situ Chemical Oxidation, In-Situ Thermal, and Enhanced In-Situ Bioremediation. Of these, the No Action/Groundwater Monitoring alternative was rejected because it would leave in place high levels of groundwater contamination/DNAPL that would act as a continuing source of contamination for the groundwater. Groundwater Extraction and Treatment would be effective at containing this area of contaminated groundwater, but it would take a long period of time to significantly reduce the contaminant concentrations in the groundwater. Both In-Situ Chemical Oxidation and Enhanced In-Situ Bioremediation are promising technologies to address the type of contamination present. However, Enhanced In-Situ Bioremediation is not as effective for the high contaminant levels/DNAPL that is present at the site. Also, for both In-Situ Chemical Oxidation and Enhanced In-Situ Bioremediation the conditions present at this site make delivery (to the entire volume to be addressed in the treatment area) of the active remedial components for these alternatives very difficult. Although the cost estimate is higher than those for the other alternatives, and there would be challenges associated with designing an In-Situ Thermal system for this site, this alternative would be more comprehensive in addressing the volume of contamination present in the bedrock, both in the groundwater and the DNAPL present in the bedrock. Specifically, In-Situ Thermal would be more effective in the long term, would have the best chance of achieving the remedial objectives in a reasonable time frame, and would provide better overall protection.

Therefore, In-Situ Thermal is the recommended remedial alternative for the contaminated groundwater.

6.1.2 DNAPL (present in shallow bedrock)

As discussed in Section 3.3, DNAPL is considered as a "principal threat" because it will act as a continuing source of contamination to the groundwater. It is the expectation of the NCP to "use treatment to address the principal threats posed by a site, wherever practicable" (Federal Register, 1990a; Section 300.430(a)(1)(iii)(A)). Since IST would actively address the remediation of DNAPL present in the bedrock, this concern would be addressed by the recommended alternative.

SECTION 7 REFERENCES

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Integrated Water Resources, Inc. web site. Thermal Remediation Technologies/Dynamic Underground Stripping page.
http://www.integratedwater.com/services/dus.html

TABLE 1.1
Standards, Criteria, & Guidance
Scobell Chemical Site - No. 8-28-076

Div./ Agcy.*	Title	Std./ Guid.	Requirements
DAR	Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants	G	▸ control of toxic air contaminants ▸ screening analysis for ambient air impacts ▸ *toxicity classifications* ▸ ambient standards - short term/annual
DAR	6 NYCRR Part 200 (200.6) - General Provisions; 1/29/93	S	▸ prohibits contravention of AAQS or causes air pollution
DAR	6 NYCRR Part 201 - Permits & Certificates; 3/31/93	S	▸ prohibits construction/operation w/o permit/certificate
DAR	6 NYCRR Part 211 (211.1) - General Prohibitions	S	▸ prohibits emissions which are injurious to human, plant, or animal life or causes a nuisance
DAR	6 NYCRR Part 212 - General Process Emission Sources	S	▸ establishes control requirements
DAR	6 NYCRR Part 257 - Air Quality Standards	S	▸ applicable air quality standards
DFW	Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA); 10/94	G	▸ habitat assessments ▸ contaminant impact assessments ▸ ecological effects of remedies ▸ remedial requirements ▸ monitoring ▸ checklist
DFW	Technical guidance for screening contaminated sediments; 7/94	G	▸ sediments screening levels
DER	TAGM HWR-89-4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites; 10/27/89	G	▸ dust suppression during IRM/RA
DER	TAGM HWR-92-4030 Selection of Remedial Actions at Inactive Hazardous Waste Sites; 5/90	G	▸ remedy selection criteria/evaluations
DER	TAGM HWR-92-4042 Interim Remedial Measures; 6/1/92	G	▸ define and track IRMs
DER	TAGM HWR-92-4046 Determination of Soil Cleanup Objectives and Cleanup Levels; 1/24/94	G	▸ soil cleanup goals

DER	TAGM HWR-92-4048 Interim Remedial Measures - Procedures; 12/9/92	G	▸ identifying and implementing IRMs
DER	6 NYCRR Part 375 - Inactive Hazardous Waste Disposal Site Remedial Program; 5/92	S	▸ requirements regarding remedial programs ▸ private party programs, state funded programs, state assistance to municipalities
DOW	Analytical Services Protocols (ASP); 11/91	G	▸ analytical procedures
DOW	TOGS 1.1.2 - Groundwater Effluent Limitations; 8/94	G	▸ guidance for developing effluent limits for groundwater
DOW	TOGS 1.1.1 - Ambient Water Quality Standards & Guidance Values; 10/93	G	▸ compilation of ambient water quality stds. and guidance values
DOW	TOGS 1.2.1 -Industrial SPDES Permit Drafting Strategy for Surface Waters; 4/90	G	▸ guidance for developing effluent and monitoring limits for point source releases to surface water
DOW	TOGS 1.3.8 - New Discharges to Publicly Owned Treatment Works; 10/26/94	G	▸ limits on new or changed discharges to POTWs strict requirements regarding bioaccumulative and persistent substances plus other considerations
DOW	6 NYCRR Part 702-15(a), (b), (c), (d) & (e) -	S	▸ Empowers DEC to Apply and Enforce Guidance where there is no Promulgated Standard
DOW	6 NYCRR Part 700-705 - NYSDEC Water Quality Regulations for Surface Waters and Groundwater; 9/1/91	S	▸ 700 - Definitions, Samples and Tests; 701 - Classifications Surface Waters and Groundwaters; 702 - Derivation and Use of Standards and Guidance Values; 703 - Surface Water and Groundwater Quality Standards and Groundwater Effluent Standards;
DOW	6 NYCRR Part 750-757 - Implementation of NPDES Program in NYS	S	▸ regulations regarding the SPDES program
DRS	6 NYCRR Part 364 - Waste Transporter Permits; 1/12/90	S	▸ regulates collection, transport, and delivery of regulated waste
DSHM	TAGM 3028 "Contained In" Criteria for Environmental Media; 11/92	G	▸ Soil Action Levels
DSHM	6 NYCRR Part 360 - Solid Waste Management Facilities; 10/9/93	S	▸ solid waste management facility requirements landfill closures; C&D landfill requirements; used oil; medical waste; etc.
DSHM	6 NYCRR Part 370 - Hazardous Waste Management System: General; 1/14/95	S	▸ definitions of terms and general standards applicable to Parts 370-374 & 376
DSHM	6 NYCRR Part 371 - Identification and Listing of Hazardous Wastes; 1/14/95	S	▸ haz. waste determinations

DSHM	6 NYCRR Part 372 - Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities; 1/14/95	S	▸ manifest system and recordkeeping, certain management standards
DSHM	6 NYCRR Part 376 - Land Disposal Restrictions - 1/14/95	S	▸ identifies hazardous waste restricted from land disposal
DSHM	6 NYCRR Subpart 373-1 - Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements; 1/14/95	S	▸ hazardous waste permitting requirements: includes substantive requirements
DSHM	6 NYCRR Subpart 373-2 - Final Status Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities; 1/14/95	S	▸ hazardous waste management standards e.g., contingency plan; releases from SWMUs; closure/post-closure; container/management; tank management; surface impoundments; waste piles; landfills; incinerators; etc.
DSHM	6 NYCRR Subpart 373-3 - Interim Status Standards for Owners and Operators of Hazardous Waste Facilities - 1/14/95	S	▸ similar to 373-2
OSHA/ PESH	29 CFR Part 1910.120; Hazardous Waste Operations and Emergency Response	S	▸ health and safety
USEPA	Hydrologic Evaluation of Landfill Performance (HELP) Model Hydrologic Simulation of Solid Wast Disposal Sites	G	▸ cover system performance/hydrology
USEPA	Integrated Risk Information System (IRIS)	G	▸ verified RfDs and cancer slope factors
USEPA	Risk Assessment Guidance for Superfund - Volume 1 - Human Health Evaluation Manual; 12/89	G	▸ human health risk assessments

DAR: Division of Air Resources
DEP: Division of Environmental Permits
DER: Division of Environmental Remediation
DFW: Division of Fish and Wildlife
DOH: Department of Health
DOW: Division of Water
DSHM: Division of Solid and Hazardous Materials
USEPA: US Environmental Protection Agency

TABLE 1.2
Nature and Extent of Contamination (Off-site - *Based upon RI Analytical Data*)

MEDIA	CLASS	CONTAMINANT OF CONCERN	CONCENTRATION RANGE (ppb)	FREQUENCY of Detected Exceedances	SCG (ppb)
Groundwater from Overburden/ Bedrock Interface	Volatile Organic Compounds (VOCs)	1,1-Dichloroethene	ND - 8	1/3	5
		1,2-Dichloroethene	9 - 4200	3/3	5
		Tetrachloroethene	ND - 140	1/3	5
		Trichloroethene	ND - 3500	2/3	5
		Vinyl Chloride	ND - 100	1/3	2
Shallow Bedrock Groundwater	Volatile Organic Compounds (VOCs)	Benzene	ND - 23	2/6	0.7
		Carbon Disulfide	ND - 130	1/6	50
		1,1-Dichloroethene	ND - 330	2/6	5
		1,2-Dichloroethene	ND - 49,000	4/6	5
		Tetrachloroethene	ND - 21,000	3/6	5
		Toluene	ND - 260	2/6	5
		Trichloroethene	ND - 500,000	5/6	5
		Vinyl Chloride	ND - 750	3/6	2
		Xylene (total)	ND - 100	2/4	5
Deep Bedrock Groundwater	Volatile Organic Compounds (VOCs)	Benzene	ND - 180	3/4	0.7
		Carbon Disulfide	ND - 190	2/4	50
		1,2-Dichloroethene	ND - 3300	2/4	5
		Tetrachloroethene	ND - 28	2/4	5
		Toluene	ND - 13	3/4	5
		Trichloroethene	ND - 370	2/4	5
		Vinyl Chloride	ND - 180	1/4	2
		Xylene (total)	ND - 57	3/4	5
Surface Water	Volatile Organic Compounds (VOCs)	1,2-Dichloroethene	4 - 30	4/5	5
		Trichloroethene	ND - 30	3/5	5
DNAPL [MW-3D]	VOCs	Trichloroethene	780,000	1/1	---

ND = Not detected

TABLE 5.1
COST ESTIMATES - SUMMARY

ALTERNATIVE	CAPITAL COST	PRESENT WORTH of O&M	TOTAL PRESENT WORTH
Groundwater			
No Action/ Groundwater Monitoring	$25,200	$203,900	$229,100
Pump & Treat (*Air Stripping*)	$577,860	$1,505,275	$2,083,135
Pump & Treat (*GAC*)	$578,065	$2,841,945	$3,420,010
Pump & Treat (*UV/OX*)	$676,560	$1,352,165	$2,028,725
In-Situ Chemical Oxidation	$1,959,180	$274,600	$2,233,780
In-Situ Thermal	$3,460,500	$138,755	$3,599,255
Enhanced In-Situ Bioremediation	$2,349,120	$148,200	$2,497,320
DNAPL Recovery (bedrock)			
Extraction and Off-site Incineration	$84,600	$66,000	$150,600

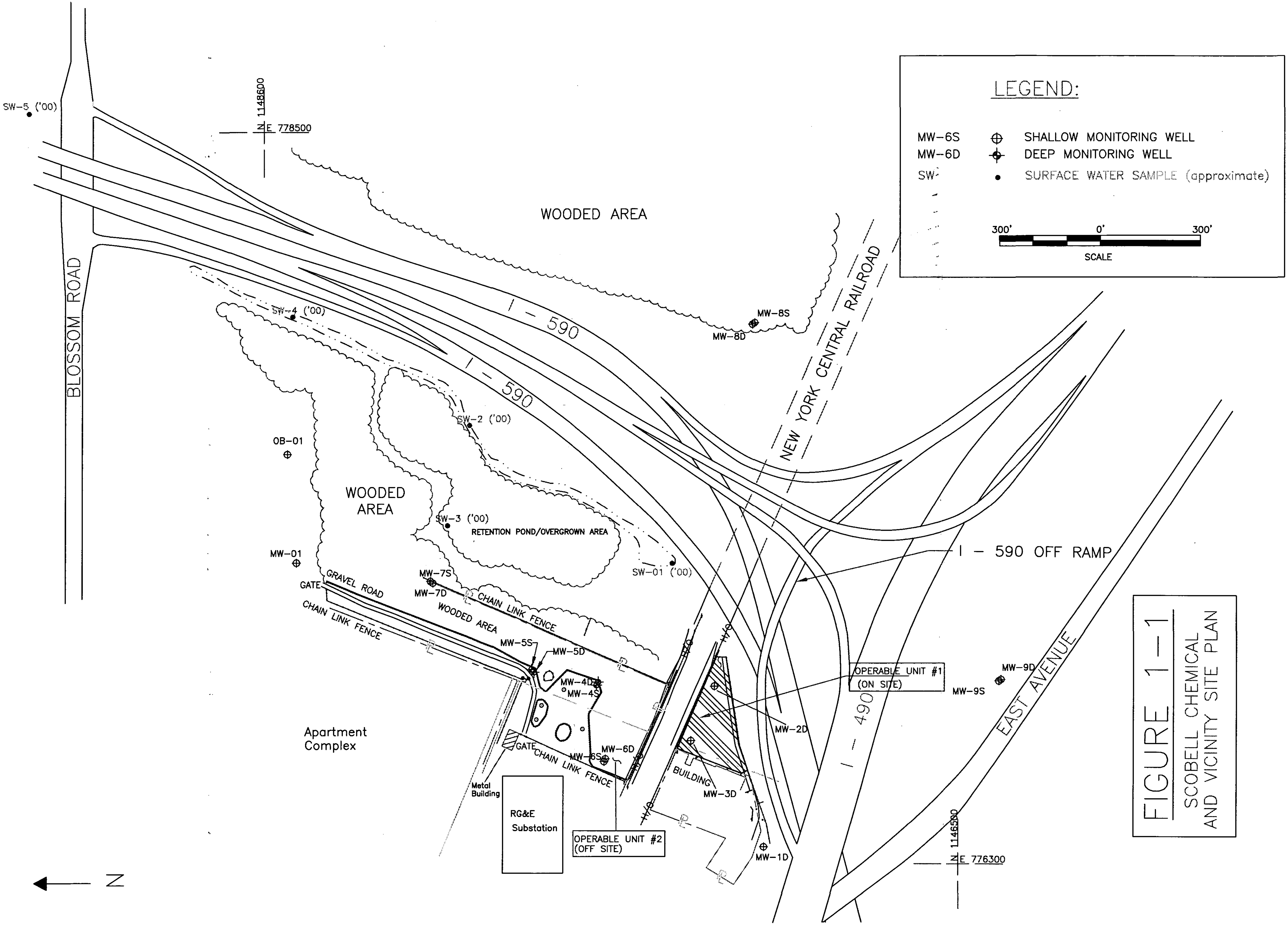
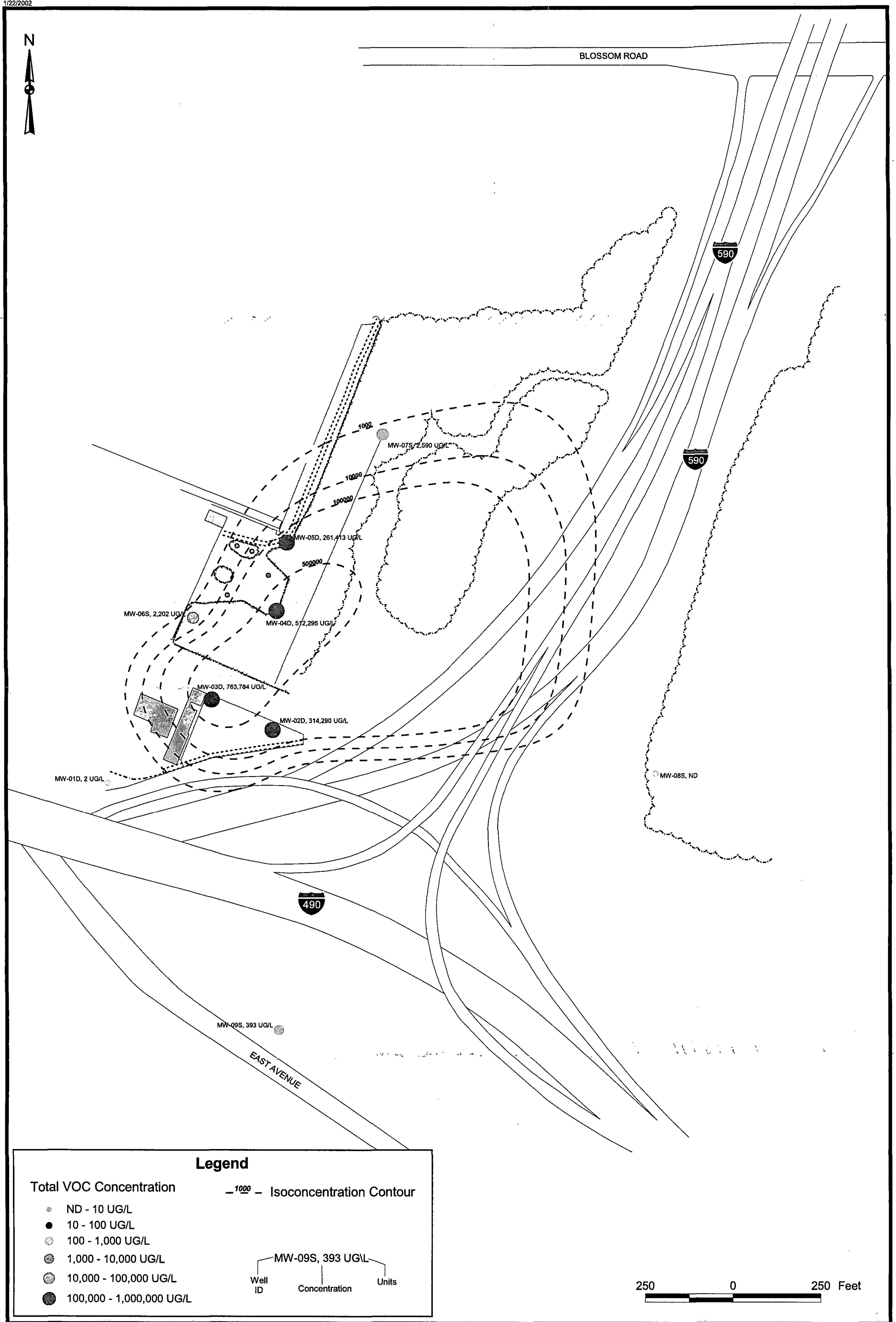


FIGURE 1-1
SCOBELL CHEMICAL AND VICINITY SITE PLAN

L:\35688.00\db\gis\chemical.apr TOTAL VOCs (INTERMEDIATE)
1/22/2002



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TOTAL VOC CONCENTRATIONS - SHALLOW BEDROCK AQUIFER
(NOVEMBER 2000)

Figure 1-2

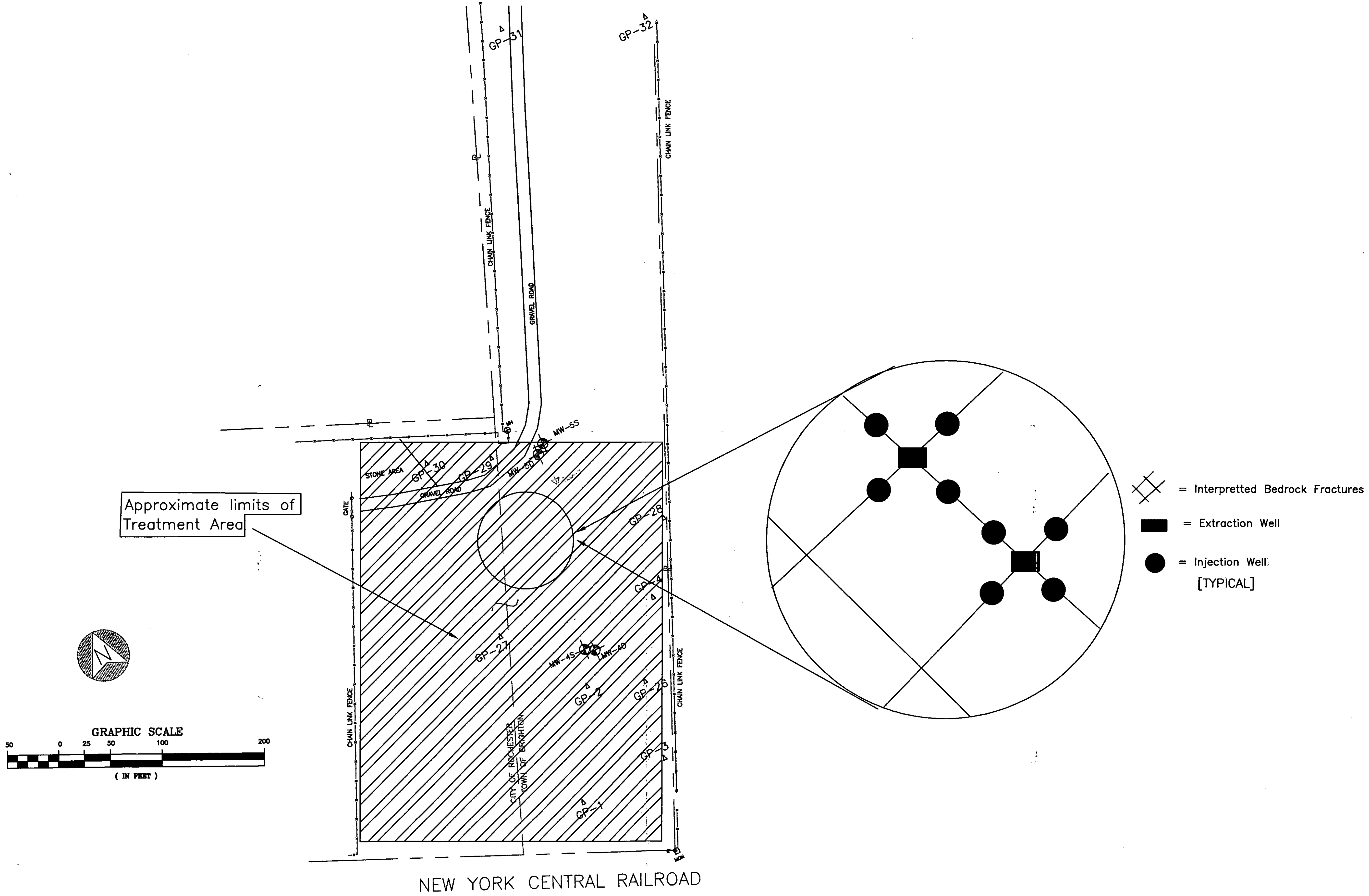

Figure 6-1 – Conceptual Plan

Appendix A

Cost Estimates for Remedial Alternatives

Summary - Groundwater Remedial Alternatives

No Action / Groundwater Monitoring

Capital Cost:	$25,200	(includes 20% contingency)
PW of O&M:	$203,900	(includes 20% contingency)
Total	**$229,100**	

GW Pump - Air Stripping Treatment

[with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$502,860	(includes 20% contingency)
	75,000	(Design Engineering, part of Capital Costs)
PW of O&M:	1,505,275	(includes 20% contingency)
Total	**$2,083,135**	

GW Pump - Granular Activated Carbon Treatment

[with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$518,065	(includes 20% contingency)
	60,000	(Design Engineering, part of Capital Costs)
PW of O&M:	2,841,945	(includes 20% contingency)
Total	**$3,420,010**	

GW Pump - UV Oxidation Treatment

[with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$586,560	(includes 20% contingency)
	90,000	(Design Engineering)
PW of O&M:	$1,352,165	(includes 20% contingency)
Total	**$2,028,725**	

In-Situ Chemical Oxidation

[(1) with post-source remediation residual containment via pump & treat]
[(2) with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$1,809,180	(includes 20% contingency)
	$150,000	(Design Engineering, part of Capital Costs)
PW of O&M:	$274,600	(includes 20% contingency)
Total	**$2,233,780**	

In-Situ Thermal

[(1) with post-source remediation residual containment via pump & treat]
[(2) with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$3,100,500	(includes 20% contingency)
	$360,000	[includes ~$210,000 for pilot study](Design Engineering, part of Capital Costs)
PW of O&M:	$138,755	(includes 20% contingency)
Total	**$3,599,255**	

Enhanced In-Situ Bioremediation

[with in-situ treatment of area under the railroad tracks - ISCO is used to generate a cost estimate, but the final sub-track "flushing technique to be determined in RD]

Capital Costs:	$2,229,120	(includes 20% contingency)
	$120,000	(Design Engineering, part of Capital Costs)
PW of O&M:	$148,200	(includes 20% contingency)
Total	**$2,497,320**	

DNAPL Extraction and Off-site Treatment

Capital Costs:	$64,600	(includes 20% contingency)
	$20,000	(Design Engineering, part of Capital Costs)
PW of O&M:	$66,000	(includes 20% contingency)
Total	**$150,600**	

Remedial Alternatives for Groundwater - Cost Calculations

No Action / Groundwater Monitoring

Assume:

- Install two additional downgradient bedrock well pairs
- groundwater samples collected from 17 monitoring wells, plus 3 QA/QC samples, and analyzed for VOCs/metals
- analytical costs of $300/sample
- quarterly sampling for 1st year / annual sampling for 30 years
- 30 hrs labor / sampling event @ $50/hr
- Annual Summary report @ $2,000/

Capital Costs

	# of Units	Unit Cost	Total
Mobilization	1	$1000	$1,000
Well Installation (6 1/4" Augering / 5 7/8" rock coring/ 2" SS well installation / 4" locking cover & pad / disposal of wastes generated / decon & development)	2 deep bedrock 2 shallow bedrock	LS	$20,000
		Subtotal	**$21,000**

Annual O&M		# of Units	Unit Cost ($)	Total ($)
First year	Analytical Costs	80	300	$24,000
	Labor Costs	4	1,000	6,000
	Reporting	1	2,000	2,000
				$32,,000
Years 2-30	Analytical Costs	20	300	$6,000
	Labor Costs	1	1,500	1,500
	Reporting	1	2,000	2,000
				9,500

30 Year Present Worth

- 32,000 (P/A, 1, 5%) = 32,000 (.9524) = $30,475
- 9,500 (P/A, 29, 5%) = 9,500 (15.411) = 146,400
  146,400 (P/F, 1, 5%) = 146,400 (.9524) = 139,430

30,475 + 139,430 = **$169,905**

GW Pump & Treat
Groundwater Extraction Portion

Assume:	Installation of 8 pumping wells:	- 4 installed to a depth of approximately 35' bgs - 4 installed to a depth of approximately 70' bgs
Assume:	Installation of 4" stainless steel wells	
Assume:	Overburden thickness of 10'	
Assume:	Approximately 2400 linear feet of piping needed	

Capital Costs

	# of Units	Unit Cost	Total *(reference)*
Mobilization	1	$5,000	$5,000
Well Installation (6 1/4" Augering / 5 7/8" rock coring/ 4" SS well installation / 6" locking cover & pad / disposal of wastes generated / decon & development)	1	LS	$65,000
Piping (2" S.S.)	2400 LF	$25/LF	$60,000 ***(Means-Assemblies/ Cost Book)***
Pipe Trenching	2400 FL	$10/FL	$24,000
100 gallon plastic sump with fittings	1	$3,000	$3,000 ***(Means - Assemblies Cost Book [air stripping])***
4" Submersible pump, w/level controls	8	$2000	$16,000 ***(Haight Farm FS)*** ***(Means-Unit Cost Book, p.8-29)***
		Subtotal	**$173,000**

GW Treatment - Air Stripping

Assume: Treatment for recovered GW designed to treat ~25-30 GPM.

Capital Costs

	Units	Unit Cost	Total *(reference)*
Mobilization	1	$10,000	$10,000
6"Structural Slab	240 SF	$5/sf	$1200
Misc. Fitting / Joints	1	$3,200	$3,200
Install Air Stripping Tower (Assume: 3' Diameter/20' tower)	1	$8,000	$8,000 ***(Means-Assemblies Cost Book)***
Packing for Tower	150 CF	$10/CF	$1,500 ***(Means-Assemblies)***
Electrical Controls for stripper	1	$11,000	$11,000 ***(Means-Assemblies)***
3' Diameter Tower Blower	1	$2,800	$2,800 ***(Means-Assemblies)***
50 GPM, 3HP, Centrifigal Pump	1	$3,350	$3,350
Vapor Phase Carbon Installation	1	$5,000	$5,000
System Start-up Labor Costs	1	$15,000	$15,000 ***(Haight Farm FS)***
		Subtotal	**$58,050**

Total Capital costs (pumping wells + treatment system) = $173,000 + $58,050 = **$231,050**

Air Stripping (cont.)

Annual O & M

	Units	Unit Cost	Total
Replacement parts, supplies, materials Electricity/phone service	1 1	$3,000 $10,000	3,000 ***(Haight)*** 10,000 ***(Haight)***
Carbon Canisters (Vapor Phase) (Replacement/Regeneration)	8	$3,000	$24,000
Air Emissions Sampling	8	$350	$2,800
Water Emissions Sampling (influent/effluent - quarterly)	8	$350	$2,800
Weekly inspection / maintenance (assume 10 hrs/week)	520	$75/hr	$39,000
		Subtotal	**$81,600**

Assumed: 30 years of operation

Present Worth of O&M

(81,600) (P/A, 30, 5%) = (81,600) (15.3725) = $1,254,396

with 20% contingency = **$ 1,505,275**

GW Treatment - GAC

Assume: Treatment for recovered GW @ 30 GPM

Capital Costs

	Units	Unit Cost	Total *(reference)*
Mobilization	1	$20,000	$20,000
8"Structural Slab on grade	1000 SF	$6/SF	6,000
Dual Bed, 50 gpm series, 1760 Lb. Carbon fill each	1	$17,000	$17,000 ***(Means-Assemblies)***
Carbon	3520 lb	$1/lb	$3,520
Prefilter/Post-filter Housing & Cartridge, to 30 GPM	2	$1,000	$2,000 ***(Means Assemblies)***
30 GPM transfer pump with motor, valves & piping	2	$1,100	$2,200 ***(Means Assemblies)***
Labor, Startup	1	$20,000	$20,000
		Subtotal	$70,720

Total Capital costs (pumping wells + treatment system) = $173,000 + $70,720 = **243,720**

GW Treatment - GAC (cont)

Annual O&M

	Units	Unit Cost	Total *(reference)*
Regenerate Carbon	150,313 lbs (see carbon usage estimate)	$.83/lb	$124,760 ***(Means)***
Water Emissions Sampling (influent/effluent - quarterly)	8	$350	$2,800
Replacement Parts/Supplies	1	$1,500	$1,500
Electricity/Phone Service		$7,000	$7,000
Monthly inspection / maintenance (assume 20 hrs/month)	240	$75/hr	$18,000
		Subtotal	$154,060

Assumed: 30 years of operation

Present Worth of O&M

(154,060) (P/A, 30, 5%) = (154,060) (15.3725) = $2,368,287

With 20% contingency = **$ 2,841,945**

GAC - Carbon Usage Estimate

- 30 gpm flow
- Estimate (conservative) of influent concentrations based on groundwater samples from:
  - MW-4D
  - MW-5D

PCE ≅ (14.25 mg/L) (30 gallons/min) 9 3.785 (liter/gallon) = 1618 mg PCE/min
TCE ≅ (345 mg/l) (30) (3.785) = 39,175 mg TCE/min
cis-1,2-DCE≅ (25 mg/l) (30) (3.785) = 2840 mg 1,2 DCE/min

Daily Contaminant Loadings

PCE = (1618mg/min) (60 min/hr) (24 hr/day) = 2,329,920 mg/day

TCE = (39,175) (60) (24) = 56,412,000 mg/day

cis-1,2-DCE = (2840) (60) (24) = 4,089,600 mg/day

Daily Consumption of Carbon - From Isotherms

PCE = (2,329,920 mg/day PCE/150 mg PCE/g carbon) = 15,532 g carbon/day

TCE = (56,412,000/500 mg TCE/g. carbon) = 112,824 g carbon/day

cis-1,2-DCE: (4,089,600/70 mg DCE/g carbon) = 58,422 g carbon/day
Total = 186,778 g carbon/day = 186.8 kg/day

(186.8 kg/day) (1 lb/.4536 kg) (365 days/yr) = **150,313 lbs carbon/yr**.

GW Treatment - UV Oxidation

Assume: Ozone treatment system

Capital Costs

	Units	Unit Cost	Total *(reference)*
8" Structural Slab	1000 SF	$6/SF	$6,000
2500 Gallon Holding Tank	1	3,300	3,300
Treatibility Study/ Pilot Plant Study	1	6,000	6,000
Pre-treatment Equipment	1	15,000	15,000
UV Reaction, Capital Equipment	1	$90,000	$90,000 ***(Means-Assemblies p.3-296 line 33-12-0834)***
30 gpm Ozone Assembly & Shakedown	1	$7,500	$7,500 ***(Means-Assemblies p.3-297)***
		Subtotal	$127,800

Total Capital costs (pumping wells + treatment system) = $173,000 + $127,800 = **$300,800**

Annual O&M

	Units	Unit Cost	Total
30 gpm Ozone System Consumables	52 weeks	$275/wk	$14,300 ***(Means Assemblies p.300)***
Ozone system O&M/sampling labor	(10 hrs/wk) 520 hrs	$75	$39,000
Electricity / phone service	1	$20,000	$20,000
		Annual O&M	$73,300

Assumed: 30 years of operation

Present Worth of O&M

(73,300) (P/A, 30, 5%) = (62,000) (15.3725) = $1,126,805

With 20% contingency = $1,352,165

In-Situ Chemical Oxidation

Assume:

- Extraction/injection wells placed approximately every 50-100 feet along the bedrock fractures (interpreted from the geophysical studies performed during the RI) in an area of approximately 2 acres north of the railroad tracks (from the substation fence ~375' east to the DOT fence/ from the base of the RR tracks ~ 275' north to the area of MW-5S/5D)
- wells installed to a depth of 35 feet
- Potassium permanganate ($KMNO_4$) system
- Approximately 25 wells to be installed to an approximate depth of 35 feet; approximately 5 wells would be used to extract groundwater which would be mixed with $KMNO_4$ crystals (approximately 2% solution) and re-injected into the 20 other wells
- Three separate injections of approximately 300,000 gallons of solution to last approximately one month each
- Analytical: Assume 28 (25 groundwater samples per event + 3 QA/QC =28) groundwater samples to be collected each event/ with a total of 10 sampling events included in estimate [baseline, after each of the 3 injections, 6 quarterly events after last injection]
- 15 years of post-remedy monitoring (25 groundwater samples per event + 3 QA/QC =28) on an annual basis
- labor hours associated with each sampling event: 40 hours, $20/hr., multiplier of 3 → $2,400
- $125/ VOC analysis

Capital Costs

	Units	Unit Cost	Total *(reference)*
Install 2" wells (25 wells @ ~ $4000/well [includes decon, disposal of wastes, etc.]; $5000 mob-demob)	1	$105,000	$105,000
cost of chemical for $KMNO_4$ application [see next page for details] per application	3	$275,000	$825,000
site supervision/site engineer (30 days per application/ 8 hr. days/ $30 per hr./ multiplier of 3/ 25% office support for field staff)	3	$27,000	$81,000
Analytical performance monitoring during active remediation (28 samples + labor)	10	$5,900	$59,000
Documentation Reporting	1	$80,000	$80,000
		Subtotal	$1,150,000

with 20% contingency = $ 1,380,000

Annual O&M

	Units	Unit Cost	Total
Annual monitoring of groundwater quality	1	$5,900	$5,900
Annual Reporting	1	$2,500	$ 2,500
		Annual O&M	$8,400

Assumed: 15 years of monitoring

Present Worth of O&M
($8,400) (P/A, 15, 5%) = ($8,400) (10.3797) ~ $87,200
With 20% contingency ~ $105,000

ISCO - $KMNO_4$ calculations/backup

Per Application

- 2% $KMNO_4$ solution
- water = 8.33 lb./gallon
- 300,000 gallons = 2,499,000 lb.
- 2% $KMNO_4$ → (0.02) x 2,499,000 lb. = 49,980 lb. $KMNO_4$
- based on two internet sources [www.baddley.com and www.aquatic-eco.com] approximate price for $KMNO_4$ is $5.50/lb
- 49,980 lb. x $5.50 ~ $275,000

In-Situ Thermal

Assume:

- Injection/extraction wells placed approximately every 30 feet along the bedrock fractures (interpreted from the geophysical studies performed during the RI) in an area of approximately 2 acres north of the railroad tracks (from the substation fence ~375' east to the DOT fence/ from the base of the RR tracks ~ 275' north to the area of MW-5S/5D)
- A total of approximately 30 additional points would be installed for the purpose of monitoring subsurface conditions during the remediation
- A total of approximately 100 injection/extraction wells; assume 80 of the injection/extraction wells installed to a depth of 35 feet; 20 to be installed to approximately 60 feet
- A total of approximately 30 monitoring points (monitor subsurface conditions); assume 20 of the monitoring points installed to a depth of 35 feet; 10 to be installed to approximately 60 feet
- Assume 4 thermocouples installed at different depths in each of the 30 monitoring points
- Assume wells/monitoring points are 8" through overburden/cased @ top of rock and 6" open holes in bedrock
- Analytical: Assume 28 (25 groundwater samples per event + 3 QA/QC =28) groundwater samples to be collected each event/ with a total of 5 sampling events included in estimate [baseline, quarterly for one year during/after implementation]
- For cost estimate, assume 12 months of operation
- 5 years of post-remedy monitoring (25 groundwater samples per event + 3 QA/QC =28) on an annual basis
- labor hours associated with each sampling event: 40 hours, $20/hr., multiplier of 3 → $2,400
- $125/ VOC analysis
- Assume up to 10,000 gallons of DNAPL is recovered

Capital Costs

	Units	Unit Cost	Total *(reference)*
Install wells • 100 wells/points to 35' @ ~ $5500/well [includes decon, disposal of wastes, etc.] • 30 wells/points to 60' @ ~$6500/well [includes decon, disposal of wastes, etc.] • $10,000 mob-demob)	1	$755,000	$755,000
Piping,valves, etc. (~200'/injection-extraction well)	20,000 ft	$20/ft	$400,000
Thermocouples (4/monitoring point)	120	$300	$36,000
Geomembrane (prevent VE short-circuiting)	100,000 ft^2	$0.34/ft^2	$34,000
12000 pph steam boiler (monthly rental) [includes: boiler, feedwater treatment & preheating, steam piping, flow-meters, traps]	12	$10,000	$120,000
Purchase 30 HP, 580 CFM Vapor Extraction blower	8	$17,000	$136,000

Purchase 6000 pph vapor condenser/ cooling tower	1	$90,000	$90,000
extracted water/DNAPL holding tanks	1	$8000	$8,000
treat contaminated groundwater (1 year rental of 30 gpm unit/ 1 year O&M)	1	$250,000	$250,000
DNAPL off-site transportation & disposal (10,000 gallons - bulk)	1	$30,000	$30,000
Utilities, natural gas, eletricity	1	$100,000	$100,000
Site operator (12 months/ 22 days per month/ 8 hr. days/ $30 per hr./ multiplier of 3/ 25% office support for field staff)	1	$237,600	$237,600
Analytical performance monitoring during active remediation (28 samples + labor)	5	$5,900	$29,500
		Subtotal	$2,226,100

with 20% contingency = $2,671,320

<u>Pilot Study During Remedial Design:</u>

- assume the need for a pilot study
- assume pilot study on a 50'x50' area addressing 15' of bedrock thickness (~1390 yd^3)
- assume ~ $150/yd^3

<u>Pilot Study estimate ~ **$210,000**</u>

Annual O&M

	Units	Unit Cost	Total
Annual monitoring of groundwater quality	1	$5,900	$5,900
Annual Reporting	1	$2,500	$ 2,500
		Annual O&M	$8,400

Assumed: 5 years of monitoring

Present Worth of O&M

($8,400) (P/A, 5, 5%) = ($8,400) (4.3295) ~ $36,400

With 20% contingency ~ $43,680

Enhanced In-Situ Bioremediation

Assume:

- Approximately 160 Extraction/injection wells placed approximately every 10 feet along the bedrock fractures (interpreted from the geophysical studies performed during the RI) in an area of approximately 2 acres north of the railroad tracks (from the substation fence ~375' east to the DOT fence/ from the base of the RR tracks ~ 275' north to the area of MW-5S/5D)
- Approximately 90 additional injection wells placed further downgradient (area of MW-7S/-7D) to further address contamination in groundwater plume (i.e., to address generation of breakdown products)
- wells installed to a depth of approximately 35 feet
- For cost purposes, assume HRC/ORC system
- Two separate injections
- Analytical: Assume 28 (25 groundwater samples per event + 3 QA/QC =28) groundwater samples to be collected each event/ with a total of 9 sampling events included in estimate [baseline, quarterly for performance monitoring during the first two years]
- 15 years of post-remedy monitoring (25 groundwater samples per event + 3 QA/QC =28) on an annual basis
- labor hours associated with each sampling event: 40 hours, $20/hr., multiplier of 3 → $2,400
- Approximately $250/ analysis (analyzed for VOCs and bioremediation indicator parameters)

Capital Costs

	Units	Unit Cost	Total *(reference)*
Install 2" wells (250 wells @ ~ $4000/well [includes decon, disposal of wastes, etc.]; $5000 mob-demob)	1	$1,005,000	$1,005,000
cost of chemical for application/ per application	2	$250,000	$500,000 (Abstracts of Remediation Case Studies Volume 5 [EPA 542-R-01-008])
Analytical performance monitoring during active remediation (28 samples + labor)	9	$9,400	$84,600
Documentation Reporting	1	$80,000	$80,000
		Subtotal	$1,669,600

with 20% contingency = $ 2,003,520

Annual O&M

	Units	Unit Cost	Total
Annual monitoring of groundwater quality	1	$9,400	$9,400
Annual Reporting	1	$2,500	$ 2,500
		Annual O&M	$11,900

Assumed: 15 years of monitoring

Present Worth of O&M
($11,900) (P/A, 15, 5%) = ($11,900) (10.3797) ~ $123,500
With 20% contingency ~ $148,200

Post-Source Area Remediation - Residual Containment
GW Pump & Treat
Groundwater Extraction Portion

Assume:	Installation of 6 pumping wells:	- 3 installed to a depth of approximately 35' bgs - 3 installed to a depth of approximately 70' bgs
Assume:	Installation of 4" stainless steel wells	
Assume:	Overburden thickness of 10'	
Assume:	Approximately 1800 linear feet of piping needed	

Capital Costs

	# of Units	Unit Cost	Total *(reference)*
Mobilization	1	$2,000	$2,000
Well Installation (6 1/4" Augering / 5 7/8" rock coring/ 4" SS well installation / 6" locking cover & pad / disposal of wastes generated / decon & development)	1	LS	$50,000
Piping (2" S.S.)	1800 LF	$25/LF	$45,000 ***(Means-Assemblies/ Cost Book*)**
Pipe Trenching	1800 FL	$10/FL	$18,000
200 gallon plastic sump with fittings	1	$3,000	$3,000 ***(Means - Assemblies Cost Book [air stripping])***
4" Submersible pump, w/level controls	6	$2000	$12,000 ***(Haight Farm FS)*** ***(Means-Unit Cost Book, p.8-29)***
		Subtotal	**$130,000**

Residual GW Treatment - GAC

Assume: Treatment for recovered GW @ 30 GPM

Capital Costs

	Units	Unit Cost	Total *(reference)*
Mobilization	1	$10,000	$10,000
8"Structural Slab on grade	500 SF	$6/SF	3,000
1,650 Lb. Fill, stainless steel bed	1	$11,000	$11,000 ***(Means-Assemblies)***
Carbon	1650 lb	$1/lb	$1650
Prefilter/Post-filter Housing & Cartridge, to 40 GPM	1	$1,000	$1,000 ***(Means Assemblies)***
30 GPM transfer pump with motor, valves & piping	1	$3,000	$3,000 ***(Means Assemblies)***
Labor, Startup	1	$10,000	$10,000
		Subtotal	**$39,650**

Total Capital costs (pumping wells + treatment system) = $130,000 + $39,650 = $ 169,650

w/ 20% contingency = $203, 580

Annual O&M

	Units	Unit Cost	Total *(reference)*
Regenerate Carbon	241.5 lbs (see carbon usage estimate)	$.83/lb ***(Means)***	*say $500*
Water Emissions Sampling (influent/effluent - quarterly)	8	$350	$2,800
Replacement Parts/Supplies	1	$3,000	$3,000
Electricity/Phone Service	1	$3,000	$3,000
Monthly inspection / maintenance (assume 10 hrs/month)	120	$75/hr	$9,000
		Subtotal	$18,300

Assumed: 10 years of operation for "follow-up" to ISCO
5 years of operation for "follow-up" to In-situ Thermal

GW P&T "follow-up"to ISCO
Present Worth of O&M

(18,300) (P/A, 10, 5%) = (18,300) (7.7217) = $141,300

With 20% contingency = **$ 169,600**

Total = **$ 203, 580 + $ 169,600 = $ 373,180**

GW P&T "follow-up" In-Situ Thermal
Present Worth of O&M

(18,300) (P/A, 5, 5%) = (18,300) (4.3295) = $79,235

With 20% contingency = **$ 95,075**

Total = **$ 203,580 + $ 95,075 = $298,655**

GAC - Carbon Usage Estimate

- 30 gpm flow
- Estimate (conservative) of influent concentrations based on groundwater samples from:
  - MW-7S
  - MW-7D

TCE ≅ (0.2 mg/l) (30 gal/min) (3.785 liter/gallon) ≅ 22.8 mg TCE/min
cis-1,2-DCE ≅ (0.1 mg/l) (30) (3.785) ≅ 11.4 mg 1,2 DCE/min

Daily Contaminant Loadings

TCE = (22.8 mg/min) (60 min/hr) (24 hr/day) = 32,832 mg/day

cis-1,2-DCE = (11.4) (60) (24) = 16,416 mg/day

Daily Consumption of Carbon - From Isotherms

TCE = (32,832/500 mg TCE/g. carbon) = 66 g carbon/day

cis-1,2-DCE: (16,416/70 mg DCE/g carbon) = 234 g carbon/day
Total = 300 g carbon/day = 0.3 kg/day

(0.3 kg/day) (1 lb/.4536 kg) (365 days/yr) ≅ **241.5 lbs carbon/yr**.

In-Situ Chemical Oxidation

[targeted for the area under the railroad tracks to supplement OU#2 source area alternatives]

Assume:

- Extraction/injection wells placed along the bedrock fractures (interpreted from the geophysical studies performed during the RI) along the northern border of the on-site area
- wells installed to a depth of 35 feet
- Potassium permanganate ($KMNO_4$) system
- Approximately 5 wells to be installed to an approximate depth of 35 feet; one well would be used to extract groundwater which would be mixed with $KMNO_4$ crystals (approximately 2% solution) and re-injected into the four other wells
- Two separate injections of approximately 50,000 gallons of solution to last approximately one month each
- Analytical: Assume the performance monitoring/ long-term monitoring for this system would be covered by the monitoring to be conducted/incorporated into the cost estimate for the main OU#2 remedy.

Capital Costs

	Units	Unit Cost	Total *(reference)*
Install 2" wells (5 wells @ ~ $4000/well [includes decon, disposal of wastes, etc.]; $2000 mob-demob)	1	$22,000	$22,000
cost of chemical for $KMNO_4$ application [see next page for details] per application	2	$46,000	$92,000
site supervision/site engineer (30 days <u>per application</u>/ 8 hr. days/ $30 per hr./ multiplier of 3/ 25% office support for field staff)	2	$27,000	$54,000
Documentation Reporting	1	$20,000	$20,000
		Subtotal	$188,000

with 20% contingency = $ 225,600

ISCO - $KMNO_4$ calculations/backup

Per Application

- 2% $KMNO_4$ solution
- water = 8.33 lb./gallon
- 50,000 gallons = 416,500 lb.
- 2% $KMNO_4$ → (0.02) x 416,500 lb. = 8,330 lb. $KMNO_4$
- based on two internet sources [www.baddley.com and www.aquatic-eco.com] approximate price for $KMNO_4$ is $5.50/lb
- 8330 lb. x $5.50 ~ $46,000

DNAPL Recovery / Treatment - SUMMARY

Capital Costs:	$39,600	(includes 20% contingency)
	$25,000	(Engineering, Including limited 3D Seismic Survey to cite recovery wells)
Present Worth of Annual O&M:	$66,000	(includes 20% contingency)
Total	**$130,600**	

DNAPL Recovery/Treatment

Assume: 4 bedrock recovery wells / 50 feet deep (40' into rock) / 4" Diameter / 5 year operating period/ total of 1,000 gallons in 5 years

Capital Costs

	Units	Unit Cost	Total *(reference)*
Mobilization	1	5,000	5,000
Well Installation	5	3,500	17,500
Submersible pump ("Product Pump" with controls)	4	3,000	12,000 ***(Means-Unit Cost p.8-303)***
Holding Tank	1	2,000	2,000
		Subtotal	**$36,500**

Annual O&M

Assume: 5 year operating period / total of 1,000 gallons recovered =〉Although it won't be uniform, Assume 200 gallons / year for disposal.

Assume: recovered DNAPL sent off-site for incineration

Annual O&M	Units	Unit Cost	Total
Operation / Sampling (quarterly - Labor 20 hrs/quarter)	100 hrs	$75	7,500
DNAPL sample analysis (quarterly)	4	$300	1,200
DNAPL off-site incineration	4 (55 gallon drums)	$1,000	$4,000
		Total Annual O&M	**$12,700**

Present Worth of Annual O&M

(12,700) (P/A, 5, 5%)= (12,700) (4.3295) = **$55,000**