New York State Department of Environmental Conservation
625 Broadway • Albany, New York 12233

Feasibility Study Report

Chemical Sales Corporation OU#1
Town of Gates, New York
Site # 8-28-086

Work Assignment # D-004439-11

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Report Prepared By:

Malcolm Pirnie, Inc.

43 British American Blvd.
Latham, New York 12110
518-782-2100

0266368

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1. Introduction

This Feasibility Study Report has been developed to evaluate remedial measure alternatives for contaminants in soil and groundwater at the Chemical Sales Corporation Operable Unit 1 (OU#1) (site) in the Town of Gates, New York (Figure 1). This Feasibility Study Report expands on earlier site investigations and feasibility study and describes the screening of potential remedial measures to address soil and groundwater contamination within OU#1. The purpose of this report is to:

- Identify potentially feasible soil and groundwater remedial technologies;
- Screen these technologies based on their feasibility/implementability and cost; and
- Present and evaluate remedial alternatives based on technologies that could be implemented to meet Remedial Action Objectives (RAOs).

The overall goal of these remedies is to reduce the current or potential threat to public health and the environment caused by soil, groundwater, and soil vapor contamination at the site.

1.1. Site History

The site (NYSDEC site number 8-28-086) is located on an approximately 0.85-acre parcel at 190 Lee Road in an urban area in the Town of Gates, Monroe County, New York. The site is landlocked by a larger 6.6-acre parcel. Residential, industrial, and commercial properties are located directly to the west and south of the site. The New York State Barge Canal (the canal) and bike path are located just east and north of the site.

The site is the location of a former commercial operation that conducted chemical storage, warehousing, transferring and sales of hazardous materials from 1976 to approximately 1997. Assorted chemicals, primarily flammable and chlorinated solvents, were purchased in bulk and repackaged into smaller containers for resale. These operations resulted in the release of a number of hazardous wastes, including chlorinated solvents and non-halogenated solvents, some of which migrated in groundwater from the site to surrounding areas, including groundwater east of the canal.

There is contamination present in the site soil, in the shallow unsaturated bedrock, and in groundwater beneath the site. Site contaminants include volatile organic compounds, including chlorinated solvents, some petroleum-related contaminants, as well as some non-halogenated solvents.

In January 2000, the NYSDEC determined that contamination from the Chemical Sales site should be addressed in two operable units. The first Operable Unit (OU#1) includes the area west of the canal, consisting of the Chemical Sales property, contaminated portions of the surrounding property, groundwater west of the canal, and a drainage ditch between the site and the canal. Operable Unit 2 (OU #2) consists of groundwater beneath the off-site area east of OU #1 and the canal. This Feasibility Study focuses on the screening and evaluation of potential remedial alternatives for soil and groundwater for OU#1.

In March 2000, the NYSDEC issued a Record of Decision (ROD) for OU#1 that specified the following remedy:

- Operation of a steam stripping system to recover contaminants from the groundwater, soil and bedrock;
- Installation of approximately 180 steam injection and extraction wells covering approximately two acres of the site and surrounding property;
- Removal of all recovered hazardous wastes for off-site disposal or recycling;
- Removal of approximately 150 cubic yards of contaminated surface soils, including drainage ditch soils between the site and the canal; and
- Long-term groundwater monitoring.

Based on an evaluation of the steam stripping vendor proposal, NYSDEC determined that, due to the high estimated cost for the implementation of a full-scale remediation system, steam stripping was not feasible. This Feasibility Study Report was prepared as a basis for revising the OU#1 ROD.

1.2. Site Geology and Hydrogeology

The following geologic units underlie the site from the surface down: miscellaneous and scattered surface debris (fill); tight to very tight till consisting of poorly sorted silt, sand, clay and gravel; and bedrock. The till contacts a glaciated bedrock surface at approximately 3 to 8 feet below ground surface (bgs). The bedrock, to depths of approximately 175 feet, consists of the Lockport Dolomite and Rochester Shale Formations. The bedrock is divided into the Penfield and DeCew Members of the Lockport Formation, and the Gates Dolomite and Rochester Shale of the Rochester Shale Formation. The thickness of the overburden varies, but in general ranges from two feet to approximately seven feet. The rock units also vary in thickness around the site but, in general, the Lockport Formation is approximately 29 to 39 feet thick, and the Rochester Formation is reported to be approximately 150 feet thick.

The primary hydrogeologic unit identified near the site is an unconfined aquifer present in the Lockport and Upper Rochester Shale Formations. Locally, a perched water table is present in some of the thin overburden soil. At most well and boring locations, the water table was found to be within the bedrock zone. No confining soil unit was identified during the remedial investigation (RI). Groundwater in the bedrock flows through secondary porosity features in the rock including fractures, joints, solution cavities, and bedding planes. Both the Lockport and Rochester Formations have little primary porosity, so groundwater flow is controlled by the distribution and magnitude of these secondary porosities in the rock.

The bedrock groundwater regime in the vicinity of the site is dynamic and is affected by depth, distance from, and stage of the canal. Groundwater monitoring wells were installed in shallow, intermediate, and deep portions of the bedrock aquifer corresponding to depths of approximately 20 to 35 feet bgs, 35 to 65 feet bgs, and 80 to 95 feet bgs, respectively. The shallow bedrock zone appears to have a lower hydraulic conductivity than the intermediate zone. This variation in hydraulic conductivity results in a perched shallow water condition when the canal is lowered in the autumn. This occurs because the more transmissive intermediate zone is well connected with the canal and reacts more rapidly to changes in the canal water level. The canal's influence on the shallow bedrock also appears to generate a flux of water either in or out of the bedrock, depending on the seasonal stage of the canal. The intermediate bedrock zone appears to be hydraulically influenced by the seasonal nature of the canal that results in a steepening of the hydraulic gradient during high water conditions and a flattening of the gradient during low water conditions.

1.3. Applicable Standards, Criteria, and Guidance (SCGs)

6 NYSCRR Part 375 requires that SCGs are identified and that remedial actions conform 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, or location. 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 judgment, is determined to be applicable to the site.

The principle SCGs for the site are listed below:

General:

- 6 NYCRR Part 375 – Environmental Remediation Programs, including the Inactive Hazardous Waste Disposal Site Remedial Program
- 6 NYCRR Part 371 – Identification and Listing of Hazardous Wastes

Soil:

- 6 NYCRR Part 375 – Soil Cleanup Objectives
- 6 NYCRR Part 376 – Land Disposal Restrictions
- NYSDEC Division of Solid and Hazardous Materials TAGM 3028 “Contained-in” Criteria for Environmental Media (8/97)

Water:

- 6 NYCRR Part 700-705, Water Quality Regulations for Surface Water and Groundwater
- NYSDEC Division of Water TOGS 1.1.1 – Ambient Water Quality Standards and Groundwater Effluent Limitations

Air:

- Air Guide 1 – Guidelines for Control of Toxic Ambient Air Contaminants
- 6 NYCRR Part 212 – General Process Emissions Sources
- NYSDOH October 2006 Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York

1.4. Nature and Extent of Contamination

Based on the information collected during the remedial investigation (URS Greiner Consultants, Inc. 2000), chemical compounds of potential concern have been identified in soil and groundwater. Compounds of potential concern were selected based on frequency of detection, range of concentration, and potential for migration. The following are the media which were investigated and a summary of the findings of the investigation.

Individual contaminants of concern in the site media are listed on Table 1.

SOIL

Surface soil impacts have been observed at the site in the vicinity of the small metal shed located approximately 120 feet south of the one story building. Light Non-Aqueous Phase Liquids (LNAPL) has been noted in the drainage ditch east of the one story building. Based on the site history, the solvents toluene, ethylbenzene, and xylene were regularly handled in this area. Run-off from this area, combined with other sources, leads directly into the drainage ditch at the site. During heavy rain events, these contaminants may be carried directly into the canal. The volume of contaminated soil in the drainage ditch is estimated to be less than 150 cubic yards.

Subsurface soil contamination is also predominantly made up of volatile organic constituents. Elevated concentrations of BTEX, chlorinated solvents, and alcohols have been detected in on-site subsurface soil to the top of bedrock. The top of the bedrock ranges from three to eight feet bgs.

6 NYCRR Part 375 contains soil cleanup objectives for individual compounds for various land use categories as well as for the protection of ecological resources and groundwater. The site is zoned as commercial. This feasibility study includes two scenarios for the limits of soil remediation: soil impacted with greater than 10 ppm total VOCs, and soil impacted with greater than 100 ppm total VOCs. Soil impacted with 10 ppm total VOCs includes approximately 11,000 yd^3 of soil and soil impacted with 100 ppm total VOCs includes approximately 7,500 yd^3 of soil. The approximate limits of the soil impacts based on the OU#1 Remedial Investigation are presented in Figure 2.

SURFACE WATER AND SEDIMENTS

During the site investigation a number of NAPL seeps were observed in the wall of the canal to the east of the site. The seeps appear to discharge directly to the surface waters of the canal.

Elevated levels of VOCs were detected in surface water samples and sediment samples collected from the canal however, none of the surface water samples exceeded surface water quality standards. These compounds do not bioaccumulate in fish and wildlife. The threat from these compounds is related to their continuing release from the site. By eliminating the sources of contamination at the site and cutting off the continued migration of chemicals into the canal, the contamination in the canal will likely attenuate.

GROUNDWATER

Many VOCs were present in groundwater samples collected from monitoring wells at the site. VOCs with concentrations greater than NYSDEC groundwater standards include BTEX, chlorinated solvents, and alcohols.

The extent of the groundwater contamination as stated in the OU#1 RI is presented on Figure 3.

Groundwater at the site flows radially to the north and east, primarily toward the canal. Groundwater at the site eventually discharges to, or passes under, the canal and flows away from nearby residential areas. The shallow groundwater beneath Lee Road flows primarily north.

SOIL VAPOR

Although on-site soil vapor samples were not collected in previous environmental investigations, on-site contamination of this medium is likely given the soil and groundwater contamination at the site. By eliminating the sources of contamination at the site and cutting off the continued migration of chemicals downgradient of the site, impacts to soil vapor will likely attenuate.

2. Identification of General Response Actions

This section outlines the Remedial Action Objectives (RAOs) proposed for the final on site (OU-1) remedy, and the standards, criteria, and guidance to be considered in addressing the RAOs. General response actions (GRAs) are medium-specific actions that could be taken to address the RAOs.

2.1. Remedial Action Objectives

For the purposes of this feasibility study, and based on the results of previous site investigations, the RAOs for the site are:

- Eliminate, to the extent practicable, exposures to volatile organic compounds in ton-site soil, groundwater, and soil vapor;
- Eliminate, to the extent practicable, off-site migration of groundwater that does not attain NYSDEC Class GA Ambient Water Quality Criteria;
- Eliminate, to the extent practicable, the migration of volatile organic compounds and NAPL to the canal;
- Eliminate, to the extent practicable, exceedances of applicable environmental quality standards related to releases of contaminants to the waters of the state; and
- Eliminate, to the extent practicable, the exposure of fish and wildlife to levels of volatile organic compounds greater than SCGs.
- Eliminate, to the extent practable, migration of LNAPL and DNAPL, if present.

2.2. General Response Actions for Soil

NYSDEC Program Policy DER-15: *Presumptive /Proven Remedial Technologies*, provides generally accepted presumptive remedies for various site media which comply with 6 NYCRR section 375-1.8. The purpose of the presumptive remedy approach is to streamline the remedy selection process by providing remedies which have been proven to be both feasible and cost-effective for specific site types and/or contaminants. Presumptive remedies for VOC contaminated site media are presented in Section 4 of the DER#15 Guidance document. Presumptive soil remedies include:

- Soil Vapor Extraction (SVE);
- Thermal Desorption;
- Incineration;

- Bioremediation (Petroleum Hydrocarbons) ; and
- Excavation/Off-site Disposal.

In accordance with DER#10, Section 4.2(a)3 the use of presumptive remedies streamlines the remedy selection process by eliminating the need to screen the selected technologies and to proceed directly to the evaluation of the presumptive alternatives. However, due to the presence of groundwater impacts in the area of the soil contamination, in-situ thermal treatment of soil contamination was also included in the evaluation of groundwater alternatives since this technology is capable of treating both soil and groundwater.

2.3. General Response Actions for Groundwater

In accordance with DER#10, Section 4.2(a)3 general response actions (GRAs) have been identified for groundwater which may be effective remedies for the remediation of groundwater at site. The GRAs identified include:

- **No Action** - A no action response, required by the DER for the Feasibility Study (FS) process, provides a baseline for comparison with other alternatives.
- **Institutional Controls** - Institutional controls are applied when active remedial measures do not achieve cleanup limits. Current and potential human exposures are reduced by limiting public access to site contaminants. Institutional controls such as environmental easements can also apply through an extended remediation period, or to sites where cleanups are completed up to feasible levels but still leave residual contamination greater than background levels.
- **Monitored Natural Attenuation (MNA)**- MNA, also known as intrinsic remediation, bioattenuation, or intrinsic bioremediation, refers specifically to the use of natural processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, as part of overall site remediation. MNA is a non-engineered remedial technique, which involves the degradation of the VOCs in the groundwater by naturally occurring processes (i.e., biodegradation). Such degradation is monitored over time under a long-term monitoring program
- **In-situ Treatment**- In-situ treatment for groundwater uses various technologies including biological, thermal, and reactive materials. In-situ treatment is effective in treating source areas of contamination but can be prohibitively expensive for treatment of large areas of groundwater contamination
- **Removal Measures-** Removal measures provide for the removal of contaminants or contaminated materials from their existing location for treatment (on-site or off-site) or disposal. Groundwater extraction systems are typically used to remove groundwater and are combined with various ex-situ treatment technologies including UV oxidation, air stripping, and granular activated carbon. The effluent treated water is often returned to the subsurface through injection wells, released to surface water bodies, or released to the local Publicly-Owned Treatment Works (POTW).
- **Containment/Barrier** - Containment for groundwater includes remedial measures that contain or isolate contaminants on-site. Containment prevents migration of

contaminants from the site and attempts to prevent direct human and ecological exposure to contaminated media. Examples of containment technologies are grout slurry walls, sheet piling, hydraulic control by pumping, and reactive barriers. Containment technologies are often combined with other treatment technologies to remove contamination.

3. Identification and Selection of Remedial Technologies

3.1. Identification of Soil Treatment Technologies

In accordance with DER-15 the following presumptive remedies have been identified for screening for the treatment of soil contamination at the site:

- Soil Vapor Extraction (SVE);
- Thermal Desorption;
- Incineration; and
- Excavation/Off-site Disposal

Two of the presumptive remedies are not applicable to the site due to the nature of the site soil, the wide array of site contaminants, and the quantity of soil to be treated.

  - The site soil is not compatible with SVE due to the tight and dense nature of the till. SVE could be potentially conducted in ex-situ piles; however there is not sufficient space on the property to contain the piles.
  - Incineration of the contaminated soil is not feasible due to the large quantity of soil to be treated.

Thermal Desorption and Excavation/Off-site disposal will be the alternatives evaluated for the treatment of soil at the site. Additionally a No Further Action (NFA) alternative including demolition of site buildings, capping of the site with asphalt, and the implementation of institutional controls will be evaluated as a baseline for cost comparison.

3.2. Identification of Groundwater Treatment Technologies

Based on the GRAs for groundwater at the site the following treatment technologies have been identified for evaluation including:

- No Further Action (NFA);
- Monitored Natural Attenuation (MNA);
- In-situ Treatment;
  - Biodegradation/ Bioenhancement
  - In-situ Chemical Oxidation
  - In-situ Thermal (ERH)

- Groundwater Extraction and Treatment;
  - Air Stripping
  - Ultraviolet Oxidation
- Containment/Barrier Technologies;
  - Zero Valent Iron
  - Electrically Induced Redox Barrier.

3.2.1. No Further Action

An NFA alternative for groundwater including monitoring and the application of institutional controls will be considered further. This alternative will serve as a baseline for comparison with the other groundwater remedial alternatives considered for the site.

3.2.2. Monitored Natural Attenuation (MNA)

MNA, also known as intrinsic remediation, bioattenuation, or intrinsic bioremediation, refers specifically to the use of natural processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, as part of overall site remediation. MNA is a non-engineered remedial technique, which involves the degradation of the VOCs in the groundwater by naturally occurring processes (i.e., biodegradation). Such degradation is monitored over time under a long-term monitoring program.

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 the natural processes of contaminant degradation will reduce contaminant concentrations to less than 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 the eventual attainment of RAOs.

The RAOs for the site cannot be met by MNA alone. MNA will not be considered further as a primary remedial alternative for the site.

3.2.3. In-Situ Treatment

3.2.3.1. Biodegradation/Enhanced Biodegradation

Biodegradation, or bioremediation, is the controlled management of microbial processes in the subsurface. Enhanced bioremediation is accomplished through the addition of organic carbon source, nutrients (including phosphate, nitrate, and potassium), electron acceptors, and/or microbial cultures to stimulate degradation. This differs from monitoring of bioremediation processes under MNA by being an active, designed, and managed process. Therefore, bioremediation can often be enhanced through biostimulation (substrates injected in-situ to promote microbial activity) or bioaugmentation (increasing of bioremediation by adding microbial cultures). Biostimulation is used to set the proper conditions for increased microbial activity and may be all that is needed for satisfactory remediation. Biostimulation is often focused in areas where microbial populations are marginal and/or under conditions that are insufficient to support practical biodegradation rates. Common carbon sources for anaerobic sites include lactic acid, sodium benzoate, methane, and yeast extract.

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

Enhanced bioremediation is 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, enhanced bioremediation can be much less expensive than chemical or physical treatment technologies.

Advantages of biodegradation and/or enhanced biodegradation typically include:

- It can effectively reduce CVOC concentrations under the right conditions;
- CVOCs are degraded in-situ; and
- It is generally less expensive than other remedial technologies.

Disadvantages of biodegradation and/or enhanced biodegradation typically include:

- High levels of contamination can kill the organisms needed for remediation
- Depending on soil type, degree of heterogeneity, and groundwater depth, this technology may be cost prohibitive;
- Bioaugmentation may be necessary if microbial populations are shown to be insufficient;
- When adding nutrients, befouling of any injection or extraction 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); and

- Enhanced bioremediation is limited at how quickly target compounds are degraded. This alternative can take a significantly longer time to remediate an area compared to physical or chemical treatment technologies.

The array of contaminants at the site is not compatible with bioremediation because different contaminants would require conflicting methods of treatment (anaerobic vs. aerobic). Bioremediation will not be considered further as a remedial alternative for the site.

3.2.3.2. In-Situ Chemical Oxidation

In-situ chemical oxidation (ISCO) has been used since the early 1990s to treat environmental contaminants in groundwater, soil, and sediment. Many of these projects have focused on the treatment of chlorinated solvents (e.g., TCE and PCE), although several projects have also used the process to treat petroleum compounds [(i.e., benzene, toluene, ethylbenzene, and xylene (BTEX) and methyl tertiary-butyl ether (MTBE)] and semi-volatile organic compounds such as polycyclic aromatic hydrocarbons (PAHs) and pesticides.

ISCO is defined as the delivery and distribution of oxidants and other amendments into the subsurface to transform contaminants of concern into innocuous end products such as carbon dioxide (CO_2), water, and inorganic compounds. The most common oxidants utilized for ISCO are hydrogen peroxide (Fenton's reagent), potassium and sodium permanganate, and sodium persulfate. Injection locations can be either permanently installed wells or temporary injection points installed using direct-push methods. When oxidants come in contact with contaminants they are broken down into non-toxic components. However, contact between the oxidant and contaminant required to facilitate the reaction is the most important technical limitation of this technology, as it can be difficult to accomplish.

Accordingly, this remedial approach generally includes several injections over time accompanied by groundwater sampling and analysis. Numerous injections are typically required to remediate the treatment area. Given this, and depending on the final contaminant concentration desired, the overall costs are typically medium to high relative to other technologies. Since the reaction with the contaminant and the chemical oxidant generally occurs over a relatively short period, treatment can be more rapid than other in-situ technologies. This technology does not generate large volumes of residual waste material that must be treated and/or disposed.

ISCO can be used to treat localized source areas and dissolved-phase plumes since it is capable of treating high concentrations of contaminants by adding more oxidants. ISCO typically becomes prohibitively expensive for large areas requiring treatment to low concentration endpoints.

Advantages of ISCO typically include:

- Relatively short remediation times in areas where groundwater flow does not introduce additional contaminants with time (typically one to two years);
- Limited long-term O&M costs in such settings;
- Treats both dissolved and sorbed contaminants concurrently;
- Treats compounds that are not readily biodegradable; and
- Breakdown of contaminants without the generation of potentially more toxic degradation products.

Disadvantages of ISCO include:

- Its application to areas with only the highest contaminant concentrations is typically most cost effective;
- The need to inject large volumes of oxidant (especially in areas where groundwater flow introduces additional contaminants over a long period of time from up gradient directions);
- The need for multiple injections;
- The difficulty of contacting oxidants with groundwater contaminants intended for destruction when injecting into low permeability or heterogeneous formations;
- Health and safety issues pertaining to field personnel associated with the handling and injection of oxidants and reagents; and
- Relatively high costs per volume treated.
- Naturally occurring carbon sources increase the oxidant demand in the treatment zone. The presence of carbonates can also add to the oxidant demand for certain ISCO chemicals.

3.2.4. Groundwater Extraction and Hydraulic Containment

Groundwater extraction, also referred to as “pump and treat”, would involve the removal of contaminant-containing groundwater through the use of pumping wells. The extracted water would be treated and returned to the subsurface, a surface water body, or sewer system. Groundwater pumping systems can also be used to prevent dissolved phase plume migration.

Site characteristics, such as hydraulic conductivity, will determine the range of groundwater extraction remedial options possible. Chemical properties of the site and dissolved-phase plume need to be evaluated to characterize transport of the contaminant and evaluate the feasibility of groundwater pumping. To determine if groundwater extraction is appropriate for a site, the following information is needed:

- History of the contamination event;

- Properties of the subsurface including aquifer characteristics which would affect groundwater recovery rates and radius of influence; and
- The biological and chemical contaminant characteristics including the nature and extent of the contamination and any natural attenuation.

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 goal;
- Residual saturation of the contaminant in the soil or rock pores cannot be removed effectively by groundwater pumping. Contaminants tend to be sorbed in the soil or rock matrix. Groundwater pumping is generally not applicable as a remedial technology for contaminants with high residual saturation, contaminants with high sorption capabilities, and homogeneous aquifers with hydraulic conductivity less than 10^{-5} centimeters per second (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 spent carbon and the handling of other treatment residual and wastes; and
- 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 installation.

Extracted groundwater is generally treated by granular activated carbon (GAC), air stripping, or ultraviolet (UV) oxidation. The contaminants at the site are most compatible with UV oxidation due to the more soluble compounds including alcohols and ketones, which are difficult to remove with air stripping. Granular activated carbon could be used to polish the effluent water prior to discharge. During UV oxidation organic compounds are destroyed by UV light and an oxidizing compound (usually hydrogen peroxide). Following air stripping treatment, the water would be discharged to a sanitary sewer or surface water body in accordance with SPDES permit requirements or re-injected into the subsurface.

Groundwater extraction and treatment with UV oxidation and GAC is compatible with site conditions and may be an effective remedy. This technology will be considered further for analysis.

3.2.5. In-Situ Thermal Treatment

In-situ thermal remediation technologies remove contaminants by introducing heat to the subsurface, thereby increasing the volatility and mobility of the VOCs in the soil and groundwater. The VOCs liberated from the soil and groundwater are collected through a vapor extraction well network and are subsequently treated through granular activated carbon or thermal oxidation. Common in-situ approaches include electrical conductive heating, electrical resistance heating, steam enhanced extraction, and radio frequency heating.

In-situ thermal methods can treat sub-surface soil, groundwater, and, potentially, bedrock. In-situ technologies that are potentially feasible for remediating contaminated soil and groundwater at the site include thermal conductive heating (TCH) and electrical resistance heating (ERH). Organic compounds volatilize and are collected in a vapor recovery and treatment system. Electrical conductive or resistance heating wells are installed in a grid pattern across the treatment area. Vapor extraction wells would be installed into the unsaturated zone within and surrounding the treatment area to collect the vapors. Thermal remediation is an aggressive corrective measure that has been shown at various sites to be capable of achieving removal efficiencies greater than 99 percent (Beyke and Fleming, 2005).

In-situ thermal treatments are most-applicable where large volumes of source area soil and groundwater need to be treated or where other constraints limit the feasibility of excavating soils. In-situ thermal remediation is one of a small handful of practicable options for treatment of low permeability soils and bedrock.

Most types of in-situ thermal remediation have the following advantages:

- Effective in all soil types and fractured bedrock;
- Unaffected by heterogeneous materials;
- Effective both above and below the water table;
- Relatively fast treatment times, typically less than one year;
- Usually no need to directly contact the contaminants in the soil;
- Does not require excavation;
- Usually offers guaranteed fixed pricing to reach cleanup goal;
- Often has ancillary benefits outside of the treatment zone such as increasing the rate of natural biodegradation; and
- Captures vapors in the subsurface and treats them before discharging to the atmosphere.

The main disadvantages of thermal remediation are the need for multiple heater and extraction wells and for collection and treatment structures for the VOCs liberated from the subsurface. TCH heater wells consist of steel casing equipped with a single electrically-powered heating element. Heater wells, which can be operated at temperatures of up to 1600°C, are used to heat the subsurface through thermal conduction. To remediate chlorinated VOCs, heater wells are used to bring the formation temperature up to the boiling point of water (100°C). Heating the subsurface to this temperature mobilizes any DNAPL that may be present so that it is vaporized and easily extracted.

For ERH, electrodes are used to apply electrical current to the subsurface. As the current travels through the soils and groundwater the natural resistance of the formation to conduct electricity generates heat. When the subsurface is heated, contaminants are volatilized and captured by the vapor recovery system.

To implement ERH and TCH, electrode and heater wells, respectively, are usually placed in a hexagonal pattern in the remediation area. The ERH electrode wells also serve as vapor recovery wells. As part of TCH remediation, heater wells and vapor recovery wells are located in separate borings. Generally, the electrode and heater wells can be installed using conventional drilling techniques; however, it is sometimes necessary to install electrode, heater, or vapor recovery wells in directional borings to maintain the ability to use roads and buildings during thermal remediation. Temperature monitoring points are installed to confirm the desired remedial sub-surface temperature has been achieved. Surface structures (conduit, piping, and treatment facility) are also required.

In-situ thermal remediation using ERH will be considered as a remedy for both soil and groundwater at the site. Unlike the previously selected remedy for the site which included in-situ thermal remediation by steam injection, ERH relies on electrical resistance heating and does not require contact of fluids (i.e., steam) with the media to be remediated.

3.2.6. Containment/Barrier Technologies

Hydraulic containment features are installed to contain and control the lateral flow of contaminated groundwater, divert uncontaminated groundwater flow, and/or provide a barrier for a groundwater treatment system. Hydraulic containment features include physical walls, such as grout curtains, slurry walls, or sheet pile retaining walls, and permeable reactive barriers (PRBs), which are vertical zones of material that are installed in the subsurface to passively intercept groundwater flow. A physical wall will contain contaminants within a specific area. However, further remediation is often necessary because, unlike a PRB, a physical wall does not treat or destroy the contaminants.

A form of in-situ bioremediation is a biological barrier which acts as a passive control to dissolved phase plume flow when microorganisms break down VOCs that pass by them in groundwater. Biological barriers can be constructed with a variety of materials including mulch and chitin (though inexpensive, mulch and chitin are limited in the depth to which they can be emplaced) and food waste products such as cheese whey. A biological barrier will not be considered further because of the difficulties associated with trenching and/or delivering the barrier material into bedrock.

PRBs are installed in or down gradient of a dissolved phase plume by excavating a trench across the path of a migrating dissolved phase plume and filling it with the appropriate reactive material (such as a mixture of sand and iron particles), or by injecting the reactive material into the ground as a mobile slurry using direct push technology or injection wells. Groundwater flowing passively under a hydraulic gradient through the PRB is treated as the contaminants in the dissolved phase plume are broken down into byproducts or immobilized by precipitation or sorption after reacting with the substrate inside the PRB. Although PRBs are a remedial technology that requires no pumping, the rate of groundwater treatment can be accelerated by groundwater withdrawal or injection in the vicinity of the PRB. Groundwater monitoring systems are typically installed to monitor the effectiveness of a PRB (or other remedial technology) over the long term.

3.2.6.1. Zero-valent Iron PRB

The most common PRB technology utilizes zero-valent iron particles, typically in granular (macro-scale) form, to completely degrade chlorinated VOCs via abiotic reductive dehalogenation. As the iron is oxidized, a chlorine atom is removed from the compound using electrons supplied by the oxidation of iron. As the groundwater containing CVOCs flows through the reactive material, a number of reactions occur that indirectly or directly lead to the reduction of the chlorinated solvents. One mechanism is the reaction of iron filings with oxygen and water, which produces hydroxyl radicals. The hydroxyl radicals in turn oxidize the contaminants. During this process, the chloride in the compound is replaced by hydrogen, resulting in the complete transformation of chlorinated VOCs to byproducts (ethene, ethane, and chloride ions). Since degradation rates using the process are several orders of magnitude greater than under natural conditions, any intermediate degradation byproducts formed during treatment (e.g., VC) are also reduced to byproducts in a properly designed treatment zone. The use of zero-valent iron to treat chlorinated VOCs has been well documented, and is covered under several patents, depending on the installation method.

Advantages of zero-valent iron PRBs typically include:

- The zero-valent iron PRB is a passive method of treatment and long-term operations, maintenance, and monitoring (OM&M) costs will remain low as long as no adjustments need to be made to the barrier;
- Because it is a barrier technology, PRBs can be an effective method of dissolved phase plume control; and
- PRB installation using direct injection technology is not constrained by utilities and is typically a relatively low-impact method for PRB installation.

Disadvantages of zero-valent iron PRBs typically include:

- Emplacement of a PRB using conventional trenching methods can be complicated if underground utilities are present;
- Once emplaced the PRB is expensive to adjust, re-locate or remove;

- Changes in groundwater direction or velocity, though unlikely, can reduce the PRB effectiveness;
- Relatively high capital costs; and
- Infeasible in bedrock.

The use of a zero-valent iron PRB will not be considered further because its application is infeasible in bedrock.

3.2.6.2. Electrically-induced Redox Barrier

Application of this technology involves the insertion of closely spaced permeable electrodes through the dissolved phase plume. A low voltage direct current drives the oxidation of CVOCs. An electrically-induced redox barrier is an effective method for reduction of CVOCs in groundwater.

Advantages of an electrically-induced redox barrier typically include:

- Like other passive technologies electrically induced barrier has low long-term OM&M costs, mostly relating to power usage; and
- The electronic barrier has the potential to control mineral accumulation common on other barriers by periodic reversal of electrode potentials, thereby minimizing potential problems related to decreasing permeability.

Disadvantages of an electrically-induced redox barrier typically include:

- This is a relatively new concept having with only limited field testing (conducted by Environmental Security Technology Certification Program and Colorado State University at F.E. Warren Air Force Base);
- A trench and fill system is the only way to initially emplace the barrier making it impractical in deep aquifers or urban/suburban areas; and
- The barrier needs to equilibrate with the dissolved phase plume for a few months before implementing the charge.

The use of an electrically induced redox barrier will not be considered further due to the heterogeneous nature of the aquifer.

3.3. Summary of Selected Alternatives

The following technologies have been selected as remedies for further evaluation.

Soil-

- NFA including capping and institutional controls

- Excavation and off-site disposal
- Excavation and on-site thermal treatment
- In-situ thermal treatment by ERH (in conjunction with groundwater treatment by ERH)

Groundwater-

- No further action including groundwater monitoring and institutional controls
- Groundwater extraction with UV and carbon treatment
- In-situ thermal treatment by ERH

4. Development of Remedial Alternatives

4.1. Evaluation Criteria

The remedial alternatives were evaluated based on the following seven criteria, as outlined DER#10 Section 4.1(e):

- Overall protectiveness of the public health and the environment;
- Compliance with SCGs;
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, and volume;
- Short-term impacts and effectiveness;
- Implementability;
- Cost-effectiveness;

Overall protectiveness of the public health and the environment

This criterion serves as a final check to assess whether each alternative 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 current and potential human exposures are reduced. The analysis includes how each source of contamination is to be eliminated, reduced or controlled for each alternative.

Compliance with SCGs

This evaluation criterion determines how each alternative complies with applicable or relevant and appropriate SCGs, as discussed and identified in Section three. 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)(1) is discussed. If an alternative does not meet the SCGs and a waiver is not appropriate or justifiable, such as alternative should not be considered further.

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 the 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 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 RAOs 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 compounds remaining in environmental media at the site and operating systems necessary for the remedy to remain effective. The factors being evaluated include the permanence of the remedial alternative, magnitude of the remaining potential exposures, adequacy of controls used to manage residual waste, and reliability of controls used to manage residual waste.

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 the site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in the contaminant’s 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 be irreversible, and the type and quantity of treatment residuals that would remain following treatment.

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.

Cost

Cost opinions are prepared and evaluated for each alternative. The cost opinions include capital costs, operation and maintenance costs, and future capital costs. The cost opinions are included in tables 2 and 3.

4.2. Evaluation of Soil Remedial Technology Alternatives

The remedial alternatives for soil are:

- No Further Action
- Soil Capping
- Excavation and Off Site Disposal
- Excavation and On-Site Thermal Treatment
- In-Situ Thermal Treatment

These alternatives are described and evaluated below.

4.2.1. No Further Action

The NFA alternative would consist of the implementation of institutional controls. The institutional controls would include deed restrictions on the property which would reduce the potential for the exposure of sensitive receptors to contaminated soil in the future.

Overall protectiveness of the public health and the environment

This remedy would not meet the RAOs for the site but would provide a relatively limited level of protection to public health and the environment through the use of institutional controls to limit exposure to impacted soil. Contaminated soil would continue to be a source of contamination for groundwater and soil vapor because the contaminated soil would be left in place with this alternative.

Compliance with SCGs

The NFA remedy is not compliant with the SCGs for the site. With this alternative contaminants are left in place and the soil is not remediated.

Long-term effectiveness and permanence

This remedy leaves impacted soil in place and has little long term effectiveness.

Reduction of toxicity, mobility, and volume

Since this alternative does not remediate the contaminated soil, there would be no reduction in the toxicity, mobility, and volume of contaminants.

Short-term impacts and effectiveness

This remedy leaves impacted soil in place and has little short term effectiveness. There is no possibility of additional potential exposures to the public as a result of this remedy.

Implementability

The remedy could be implemented in a timely manner with existing technology, however, there may be administrative or legal barriers to the implementation of this alternative.

Cost

This alternative would require a capital cost $7,000. The total Present value of this alternative is $7,000 which assumes a discount rate of 3.5%.

An opinion of probable cost for Soil Alternative 1 (NFA) is included in Table 2.

4.2.2. Soil Capping

The soil capping alternative would consist of capping approximately 68,000 square feet of exposed soil and vegetated areas at the site, the demolition of the existing building, and the implementation of institutional controls. The approximate limits of the asphalt cap is presented on Figure 4. The institutional controls would include deed restrictions on the property which would reduce the potential for the exposure of sensitive receptors to contaminated soil in the future.

Overall protectiveness of the public health and the environment

This remedy would not meet the RAOs for the site, but would provide some level of protection of public health and the environment through the elimination of the direct contact pathway for soil. Contaminated soil would continue to be a source of contamination for groundwater and soil vapor because the contaminated soil would be left in place with this alternative.

Compliance with SCGs

The remedy is not compliant with the SCGs for the site. With this alternative contaminants are left in place and the soil is not remediated.

Long-term effectiveness and permanence

This remedy leaves impacted soil in place under an asphalt cover. The cover would have to be inspected annually to verify that it remains effective as a barrier between contaminants and receptors.

Reduction of toxicity, mobility, and volume

Since this alternative does not remediate the contaminated soil, there would be no reduction in the toxicity, mobility, and volume of contaminants.

Short-term impacts and effectiveness

There would be a potential for worker and residential exposure due to fugitive emissions including VOCs and particulates during any surface preparation. Exposure would be significantly reduced through the use of dust suppression measures, the implementation of a community air monitoring program, and personal protection equipment. These dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce any increased potential exposure to the public or impacts to the environment during the capping. Another potential concern is the impact that the additional construction traffic would have on the occupants of adjacent commercial properties. However, the use of traffic control measures and planned traffic flow patterns would minimize any impacts caused by the heavy truck traffic during the implementation of the remedy. This alternative could be implemented in approximately one month.

Implementability

The remedy could be implemented in a timely manner with existing technology, however, there may be administrative or legal barriers to the implementation of this alternative.

Cost

This alternative would require a capital cost $330,000 including the first year of O&M. The total Present value of this alternative is $402,000 including a 30-year O&M cost for cap inspections. The cost assumes a discount rate of 3.5%.

An opinion of probable cost for Soil Alternative 2 soil capping is included in Table 2.

4.2.3. Excavation and Disposal with Off Site Thermal Treatment

This alternative would involve the reduction of source contamination in the soil through the excavation of contaminated overburden soil from OU#1. This alternative was evaluated using two scenarios: 1) Excavation of soil impacted with greater than 10 ppm total VOCs; and 2) Excavation of soil impacted with greater than 100 ppm total VOCs. Excavation to 10 ppm total VOCs would involve the excavation of approximately 11,000 yd^3 of soil. Excavation to 100 ppm total VOCs would involve the excavation of approximately 7,500 yd^3 of soil. These proposed cleanup levels were chosen based on the lateral distribution of contaminants in the soil. Figure 2 presents the approximate limits of excavation for both the 10 ppm and 100 ppm areas. It is assumed that, prior to excavation, the on-site building would be demolished and the remaining slab removed. Characterization samples would be collected from the excavated material and confirmation samples would be collected from the sidewalls and bottom of the excavations. Land Disposal Restrictions (LDRs) prevent the landfilling of contaminated material that exceeds certain concentrations or Universal Treatment Standards (UTSs), listed by contaminant. Soils with concentrations that exceed UTSs must be treated prior to being placed in a landfill. It is estimated that this alternative would involve the excavation, transportation, and off-site treatment of approximately 7,000 yd^3 of soil that exceeds the UTSs. The additional estimated 4,000 yd^3 of soil would be transported to an off-site landfill for disposal. Contaminant-free soil for backfilling of the excavations would be trucked to the site from an off-site source.

Overall protectiveness of the public health and the environment

Long-term this alternative would reduce the likelihood of long term exposure to contaminants through the removal of source area contamination and would lead to the reduction of COCs of soil vapors and groundwater.

Compliance with SCGs

This alternative would remove source material contamination at concentrations above the proposed site specific SCGs of 10 ppm and 100 ppm. Action-specific SCGs for this alternative apply to the excavation and handling of site soils, monitoring requirements, and OSHA health and safety requirements. Compliance with these SCGs would be achieved by following a site-specific health and safety plan and the implementation of a storm water pollution prevention plan.

Long-term effectiveness and permanence

COCs at concentrations exceeding the UTSs would be permanently treated, and contaminants at concentrations exceeding the cleanup objectives would be removed from the site, eliminating the need for any future monitoring. Therefore, this alternative would be effective in the long term through the removal of source material.

Reduction of toxicity, mobility, and volume

The volume of contaminated soil at the site would be permanently reduced. Since soil containing COCs at concentrations exceeding UTSs would be treated, the volume of contaminants at concentrations exceeding UTSs would be treated; the volumes of contaminants and the toxicity of the soil would be reduced. Since soil with concentrations less than the UTSs would be placed in a landfill, the mobility of these contaminants would be reduced.

Short-term impacts and effectiveness

There would be a potential for worker and residential exposure due to fugitive emissions including VOCs and particulates during excavation and transportation of contaminated soil. There would also be the potential for the general public to be exposed during the hauling of contaminated soil for off-site treatment and disposal. Exposure would be significantly reduced through the use of dust suppression measures, proper covering of trucks, the implementation of a community air monitoring program, and personal protection equipment. These dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce any increased potential exposure to the public or impacts to the environment during construction. Another potential concern is the impact that the additional construction traffic would have on the occupants of adjacent commercial properties. However, the use of traffic control measures and planned traffic flow patterns would minimize any impacts caused by the heavy truck traffic during the implementation of the remedy. This alternative could be implemented in approximately three to six months and would be effective in the short-term. The remedy would be completed in approximately 6 months to 1 year.

Implementability

Adequate commercial disposal capacity is available for wastes to be treated and disposed off-site. The remedy could be easily implemented using existing excavation technologies. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost

Scenario 3: Excavation to 100 ppm total VOCs

This alternative would require a capital cost of $4.5 Million including the first year of O&M. The 30-year O&M cost for cap inspection has a present value of $90,179 with discount rate of 3.5%. The total present value of this alternative is $4.6 Million.

An opinion of probable cost for Soil Alternative 3 is included in Table 2.

Scenario 3(a): Excavation to 10 ppm total VOCs

This alternative would require a capital cost $5.6 Million including the first year of O&M. The 30-year O&M cost for cap inspection has a present cost of $75,705 with discount rate of 3.5%. The total present value of this alternative is $5.7 Million.

An opinion of probable cost for Soil Alternative 3(a) is included in Table 2.

4.2.4. Excavation and On-Site Treatment by Thermal Desorption

This alternative would involve the reduction of source contamination in the soil through the excavation of contaminated overburden soil from OU#1. This alternative was evaluated using two scenarios: 1) Excavation of soil impacted with greater than 10 ppm total VOCs; and 2) Excavation of soil impacted with greater than 100 ppm total VOCs. Excavation to 10 ppm total VOCs would involve the excavation of approximately 11,000 yd^3 of soil. Excavation to 100 ppm total VOCs would involve the excavation of approximately 7,500 yd^3 of soil. These proposed cleanup levels were chosen based on the lateral distribution of contaminants in the soil. Figure 2 presents the approximate limits of excavation for both the 10 ppm and 100 ppm areas. The excavated soil would be treated on-site in a portable thermal desorption unit. It is assumed, that prior to excavation, the on-site building would be demolished and the remaining slab removed. Confirmation samples would be collected from the sidewalls and bottom of the excavations. Confirmation samples would be collected from the treated soil to determine if the soil can be used as backfill. It is assumed that a 10 percent of the soil will be too contaminated to treat on site or will contain contaminants which are not compatible with the thermal treatment (e.g., metals). This soil would need to be shipped off site for treatment and disposal.

Overall protectiveness of the public health and the environment

This alternative reduces the possibility of exposure to contaminated soils, and the long term would reduce contaminant concentrations in groundwater and soil vapor by reducing the source of contamination. The time to implement the alternative is estimated to be 6 months, and the length of operation of the system is estimated at approximately 1 to 2 years, depending on soil quantity.

Compliance with SCGs

Thermal desorption would significantly reduce the concentrations of a majority of the contaminants of concern at this site, and could meet chemical-specific SCGs for the VOCs in the soil. However, metals would not be effectively treated by this method. Soil with extremely high levels of VOCs would be shipped off site for treatment and disposal.

Long-term effectiveness and permanence

Thermal desorption is successful at permanently reducing the concentrations of VOCs in soil. A stringent confirmation sampling program would be implemented to ensure that the soil which has been treated is acceptable for reuse as backfill.

Reduction of toxicity, mobility, and volume

This alternative would reduce the toxicity, mobility, and volume of contaminated soil at the site by removing the VOCs from the soil.

Short-term impacts and effectiveness

There would be a potential for worker and residential exposure due to fugitive emissions including VOCs and particulates during excavation and treatment of contaminated soil. There would also be the potential for the general public to be exposed during the hauling of contaminated soil for off-site treatment and disposal. Exposure would be significantly reduced through the use of dust suppression measures, proper covering of trucks, the implementation of a community air monitoring program, and personal protection equipment. These dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce any increased potential exposure to the public or impacts to the environment during construction. Another potential concern is the impact that the additional construction traffic would have on the occupants of adjacent commercial properties. However, the use of traffic control measures and planned traffic flow patterns would minimize any impacts caused by the heavy truck traffic during the implementation of the remedy. This alternative could be implemented in approximately three to six months and would be effective in the short-term.

The nearest residences are several hundred feet from the site, along with some commercial properties in the immediate vicinity. Noise during soil handling and treatment operations would need to be monitored and controlled.

Implementability

Thermal desorption is a presumptive remedy which is commonly used with this type of soil contamination. It is anticipated that the necessary specialists and equipment are available to complete the project. Access to adjacent properties will be required for the thermal desorption treatment unit and support areas.

Cost

Scenario 4: Excavation to 100 ppm total VOCs

This alternative would require a capital cost $4.5 Million including the first year of O&M. The 30-year O&M cost for cap inspection has a present cost of $90,179 with discount rate of 3.5%. The total Present value of this alternative is $4.6 Million.

An opinion of probable cost for Soil Alternative 4 is included in Table 2.

Scenario 4(a): Excavation to 10 ppm total VOCs

This alternative would require a capital cost $7.4 Million including the first year of O&M. The 30-year O&M cost for cap inspection has a present cost of $90,179 with discount rate of 3.5%. The total Present value of this alternative is $7.5 Million.

An opinion of probable cost for Soil Alternative 4(a) is included in Table 2.

4.3. Groundwater Remedial Alternatives

The remedial alternatives for groundwater are:

- No Further Action
- Groundwater Extraction with UV Oxidation and Carbon Treatment
- In-Situ Thermal Treatment By Electrical Resistance Heating (ERH)

These alternatives are described and evaluated below.

4.3.1. No Further Action

The NFA alternative for the site groundwater would consist of annual groundwater monitoring of five monitoring wells and the implementation of institutional controls, including deed restrictions on the use of the property and the underlying groundwater. These actions would be in addition to those items listed in the NFA Alternative for soil.

Overall protectiveness of the public health and the environment

This remedy would not meet the RAOs for the site but would provide a relatively limited level of protection to public health and the environment through the use of institutional controls to limit exposure to impacted soil.

Compliance with SCGs

SCGs would not be met through the implementation of the NFA alternative. This alternative does not meet the RAOs for the site.

Long-term effectiveness and permanence

The NFA alternative would provide minimal long term protection of sensitive receptors, as it does not remediate the contaminants in groundwater, but would monitor the nature and extent of the groundwater plume.

Reduction of toxicity, mobility, and volume

The NFA does not directly effect the toxicity, mobility, or volume of contaminants within groundwater at the site. However, over time the concentrations of contaminants may decrease due to natural attenuation.

Short-term impacts and effectiveness

This remedy would not cause additional exposure to the public. This alternative does not actively address groundwater contamination at the site.

Implementability

There may be administrative or legal barriers to the implementation of this alternative.

Cost

Groundwater Scenario 1 (NFA).

This alternative would require a capital cost $8,000. The 30-year O&M cost for groundwater monitoring has a present value of $108,215 with discount rate of 3.5%. The total present value of this alternative is $116,000.

An opinion of probable cost for Groundwater Alternative 1 is included in Table 3.

4.3.2. Groundwater Extraction

A groundwater extraction system would consist of a series of recovery wells piped to an ex-situ treatment system where it would be treated through UV Oxidation and GAC. The treated water could be discharged to a sanitary sewer or surface water in accordance with SPDES permit requirements. The extraction wells would be installed in a pattern perpendicular to groundwater flow to provide hydraulic control of the plume and limit further plume migration toward areas north and east of the site.

As part of a pre-design investigation, an aquifer pumping test would be performed to provide additional information for design of the groundwater extraction system. Analytical sampling performed during the aquifer test would provide additional information for design of a treatment system. After system installation, a comprehensive O&M plan, including routine monitoring and maintenance, as well as annual review procedures, would be developed for the system to ensure proper system performance.

This alternative was evaluated using two scenarios: 1) Treatment of groundwater impacted with greater than 10 ppm total VOCs; and 2) Treatment of groundwater impacted with greater than 100 ppm total VOCs.

Treatment to 10 ppm total VOCs would involve the treatment over an approximate 350,000 ft^2 area. Treatment to 100 ppm total VOCs would involve the treatment over an approximate 120,000 ft^2 area. These proposed cleanup levels were chosen based on the lateral distribution of contaminants in groundwater. Figure 3 presents the approximate limits of treatment for both the 10 ppm and 100 ppm areas. Possible extraction well arrays are presented on Figures 5 and 6.

Overall protectiveness of the public health and the environment

A groundwater extraction and ex-situ treatment system would be effective at minimizing off-site migration of contaminated groundwater by removing contaminant mass and controlling the plume hydraulically. In the long term the system would achieve the RAO by minimizing contaminant mass discharge from the site.

Compliance with SCGs

Groundwater extraction and ex-situ treatment systems typically have difficulty in achieving MCLs for contaminants in source areas. However, groundwater extraction and ex-situ treatment would be effective at decreasing the mass discharge of VOCs downgradient of the site.

Long-term effectiveness and permanence

Long-term operation of groundwater extraction systems typically result in reduced efficiency, caused by factors such as aquifer heterogeneity and adsorptive partitioning of contaminants between the groundwater and aquifer materials. The result is a decrease in contaminant mass removal, also referred to as tailing or asymptotic reduction. Tailing typically limits the ability of the groundwater extraction system to achieve remediation goals for remediation in a reasonable timeframe. Additionally, as less contaminant is removed from the aquifer, the cost-effectiveness of the treatment system per amount of contaminant treated decreases with time. Although potentially less effective than some other remedial technologies, a groundwater extraction system would control the plume migration and volume, thus meeting the RAO for the site.

Reduction of toxicity, mobility, and volume

Initially, groundwater extraction systems are typically effective at controlling plume migration, reducing the plume area, and removing contaminant mass from the aquifer. During initial operation of groundwater extraction systems contaminant mass is most quickly reduced. As operation continues, however, release of contaminants from a residual source such as adsorbed mass can cause tailing of contaminant mass removal. Tailing typically limits the ability of the groundwater extraction system to achieve remediation goals for remediation in a reasonable timeframe without system enhancements via additional remedial technologies. However, the tailing effect will not impact the ability of the groundwater extraction system to limit plume migration. The groundwater extraction system will not affect distal portions of the plume, and portions of the plume downgradient from the wells would continue to migrate toward and under the canal.

Short-term impacts and effectiveness

Groundwater extraction systems are typically effective at controlling migration of the contaminant plume and removing contaminant mass from the aquifer over the short-term. Operation of a groundwater extraction system can typically induce a hydraulic gradient affecting plume migration within days or weeks of system startup. Human exposures to site related contaminants are not expected during the implementation and operation of the groundwater extraction and ex-situ treatment system. Potential exposures to workers, which include contaminated soils and groundwater during well and equipment installation, are readily controlled using work practices and engineering controls. Public exposure to site contaminants and particulates during the installation or wells and excavation for equipment installation would be mitigated through the use of a Community Air Monitoring Program. Dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce increased exposure to the public or impacts to the environment during construction.

Implementability

A groundwater extraction system with ex-situ treatment consists of readily available technologies that are supplied by a number of specialty firms. Therefore, it is anticipated that the necessary equipment, personnel, and materials would be available to meet an appropriate schedule for implementation. As the proposed locations for some of the extraction wells are off-site, an access agreement would be needed. It is assumed that such access agreements can be obtained.

The implementation of a groundwater extraction and ex-situ treatment system would require significant pre-design studies to finalize design of the system. This is due to the inherent complex flow patterns in the bedrock aquifer. Installation of a groundwater extraction system may generate significant amounts of secondary waste, including contaminated soils from drill cuttings and contaminated purge water during well development. Waste generated during implementation and initial operation could be managed using generally accepted methods for off-site disposal and/or treatment.

Operation of a groundwater extraction system over a long time period requires significant O&M. The groundwater extraction system and treatment system must be inspected periodically, with monthly reviews to evaluate overall system performance. Unlike in-situ treatment methods, maintenance of the treatment system must be performed to ensure adequate system performance, including testing and replacement of treated effluent. As an interim measure, it is not anticipated that replacement of system components (except treatment system components and pumps) would be required to continue operation of the system.

Cost

Groundwater Scenario 2: Treatment to 100 ppm total VOCs

This alternative would require a capital cost of $1.4 million including the first year of O&M. The 30-year O&M cost for groundwater monitoring has a present value of $209,662 with discount rate of 3.5%. The total Present value of this alternative is $5.3million.

An opinion of probable cost for Groundwater Alternative 2 is included in Table 3.

Groundwater Scenario 2(a): Treatment to 10 ppm total VOCs

This alternative would require a capital cost $1.5 million including the first year of O&M. The 30-year O&M cost for groundwater monitoring has a present cost of $241,546 with discount rate of 3.5%. The total Present value of this alternative is $6.0 million.

An opinion of probable cost for Groundwater Alternative 2(a) is included in Table 3.

4.3.3. In-Situ Thermal Treatment

Thermal remediation is an aggressive remedial technology that has been shown at various sites to be capable of achieving removal efficiencies greater than 99 percent (Beyke and Fleming, 2005). During electrical resistance heating (ERH), electrodes are used to apply electrical current to the subsurface. As the current travels through the soils and groundwater the natural resistance of the formation to conduct electricity generates heat. When the subsurface is heated, contaminants are volatilized and captured by the vapor recovery system.

To implement ERH, the electrode wells, which also serve as vapor recovery wells, would be placed in a hexagonal pattern in the remediation area. Surface structures (conduit, piping, and treatment facility) would also be required. ERH electrode/extraction wells would be spaced on 15-foot centers throughout the remediation area. The thermal treatment area would include the entire overburden down and into bedrock to approximately 50 feet bgs.

The maximum subsurface temperature during thermal remediation is estimated to be approximately 105°C. Temperature monitoring points are installed to confirm the desired remedial sub-surface temperature has been achieved. After the heating phase is complete the subsurface would slowly cool over a period of approximately one year. During the cooling period, elevated subsurface temperatures would facilitate enhanced biodegradation of residual VOCs in the treatment area. Since thermal remediation can generally achieve up to 99 percent removal efficiencies, it is anticipated that only areas outside the thermal treatment area would require groundwater monitoring to evaluate natural attenuation of VOCs.

Overall protectiveness of the public health and the environment

In the long term this alternative would destroy site-related contaminants in the targeted groundwater, and therefore would be protective of human health and the environment. It would reduce the possibility of exposure to contaminated groundwater by treating it in-situ, thus minimizing it as a continuing source for off-site areas.

Compliance with SCGs

This alternative would comply with the groundwater SCGs. Because it treats and removes the contaminant source, this alternative complies with the preference for permanent remedies in 6 NYCRR 375.

Long-term effectiveness and permanence

This alternative, by removing a significant volume of contamination, would effectively reduce the concentration of contaminants in the subsurface. Any remaining contamination could be addressed through a polishing step of enhanced monitored natural attenuation (this is not part of the alternative evaluated herein). This alternative would be a permanent remedy and would be effective in the long-term.

Reduction of toxicity, mobility, and volume

Because the contaminant sources would be removed under this alterative, there would be a substantial reduction in the volume, toxicity, and mobility of the contamination. In addition, this alternative could serve as an effective, permanent method for remediating the overburden soils without needing to excavate them.

Short-term impacts and effectiveness

Short-term impacts from this alternative involve the need to utilize approximately 2 acres of the Chemical Sales site and surrounding properties. The bulk of the contaminants would be removed in a short period of time under this alternative. Any potential for contaminated vapors migrating to uncontaminated areas or being released to the atmosphere could easily be mitigated through proper design and operation of the system.

Public exposure to site contaminants and particulates during construction would be mitigated through the use of a Community Air Monitoring Program. Dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce exposure to the public or impacts to the environment during construction.

Implementability

Generally, the electrode and heater wells can be installed using conventional drilling techniques; however, it is sometimes necessary to install electrode, heater, or vapor recovery wells in directional borings to maintain the ability to use roads and buildings during thermal remediation. The design of the thermal treatment system can be complicated and difficult; however, the materials for its implementation are readily available and there are no known legal or administrative barriers to implementing this alternative.

Cost

Groundwater Scenario 3: Treatment to 10 ppm total VOCs

This alternative would require a capital cost of $21.3 million including the first year of O&M. There would be no O&M costs with this remedy past year one. The total present value of this alternative is $21.3million.

An opinion of probable cost for Groundwater Alternative 3 is included in Table 2.

Groundwater Scenario 3(a): Treatment to 100 ppm total VOCs

This alternative would require a capital cost of $64.0 million including the first year of O&M. There would be no O&M costs with this remedy past year one. The total present value of this alternative is $64.7 million.

An opinion of probable cost for Groundwater Alternative 3(a) is included in Table 2.

4.4. Comparison of Alternatives

Each of the alternatives could be implemented with readily available equipment and methods. The ranking of the alternatives in order of time to achieve RAOs (from shortest to longest) is as follows (NFA Alternatives not included):

Soil-

1. Soil Alternative 2: Soil Capping 2 Months

2.	Soil Alternative 3: Excavation/Off-Site Disposal(100 ppm)	6 Months
3.	Soil Alternative 3(a): Excavation/Off-Site Disposal (10 ppm)	1 Year
4.	Soil Alternative 4: Excavation/Ex-Situ Thermal (100 ppm)	1 Year
5.	Soil Alternative 4(a): Excavation/ Ex-Situ Thermal (10 ppm)	2 Years

Groundwater-

1.	GW Alternative 3: In-Situ ERH (100 ppm)	1 Year
2.	GW Alternative 3(a): In-Situ ERH (10 ppm)	2.5 Years
3.	GW Alternative 2: Groundwater Extraction (100 ppm)	30 Years
4.	GW Alternative 2(a): Groundwater Extraction (10 ppm)	30 Years

The ranking of each Alternative in order of total present value (from lowest to highest) is as follows:

Soil-

1.	Soil Alternative 1: No Further Action	$7,000
2.	Soil Alternative 2: Soil Capping	$402,000
3.	Soil Alternative 3: Excavation/Off-Site Disposal(100 ppm)	$4.60 Million
4.	Soil Alternative 4: Excavation/Ex-Situ Thermal (100 ppm)	$4.64 Million
5.	Soil Alternative 3(a): Excavation/Off-Site Disposal (10 ppm)	$5.77Million
6.	Soil Alternative 4(a): Excavation/ Ex-Situ Thermal (10 ppm)	$7.53 Million

Groundwater

1.	GW Alternative 1: No Further Action	$116,000
2.	GW Alternative 2: Groundwater Extraction (100 ppm)	$5.34 Million
3.	GW Alternative 2(a): Groundwater Extraction (10 ppm)	$6.06 Million
4.	GW Alternative 3: In-Situ ERH (100 ppm)	$21.3 Million
5.	GW Alternative 3(a): In-Situ ERH (10 ppm)	$63.9 Million

4.5. Remedial Alternative Cost Analysis

A cost analysis was performed comparing the calculated mass of VOCs removed relative to the cost of each alternative for soil and groundwater. The results of the analysis are presented in the table below, which includes an estimated cost per pound of VOCs removed. The calculated costs were based on the mass of VOCs within the 10ppm and 100ppm isocontours for soil and groundwater contamination. Approximately 3,307 pounds of VOCs would be removed through the excavation of soil within the 10 ppm contour, and 3,201 pounds would be removed from the 100 ppm area. For groundwater the calculated mass of VOCs within the 10 ppm and 100 ppm contours is 240 pounds and 202 pounds respectively. The mass of VOCs within the groundwater was based on an estimated secondary porosity of 0.01. Additional data collected for soil and groundwater at the site could be used to further delineate contamination at the site and would allow for additional estimates of cost per pound of VOCs removed for more defined isocontours.

	Soil					
Soil Alternative	Technology	Treatment Zone	Estimated Cost	Cost/Pound VOC Treated	Pounds VOC Treated	Notes:
3	Excavation with off-site disposal	100,000 ug/kg isocontour	$4.6 Million	$1,437	3,201	
3(a)	Excavation with off-site disposal	10,000 ug/kg isocontour	$5.7 Million	$1,724	3,307	
4	Excavation with on-site treatment	100,000 ug/kg isocontour	$4.6 Million	$1,437	3,201	
4(a)	Excavation with on-site treatment	10,000 ug/kg isocontour	$7.5 Million	$2,268	3,307	

	Groundwater					
Groundwater Alternative	Technology	Treatment Zone	Estimated Cost	Cost/Pound VOC Treated**	Pounds VOC Treated	Notes:
2	GW Extraction	100,000 ug/kg isocontour	$5.3 Million	$26,237	202	Containment
2(a)	GW Extraction a	10,000 ug/kg isocontour	$6.0 Million	$25,000	240	Containment
3	In-situ Thermal	100,000 ug/kg isocontour	$21.3 Million	$105,445	202	Treatment
3(a)	In-situ Thermal	10,000 ug/kg isocontour	$63.9 Million	$266,250	240	Treatment

** Using a porosity of 0.01.

5. References

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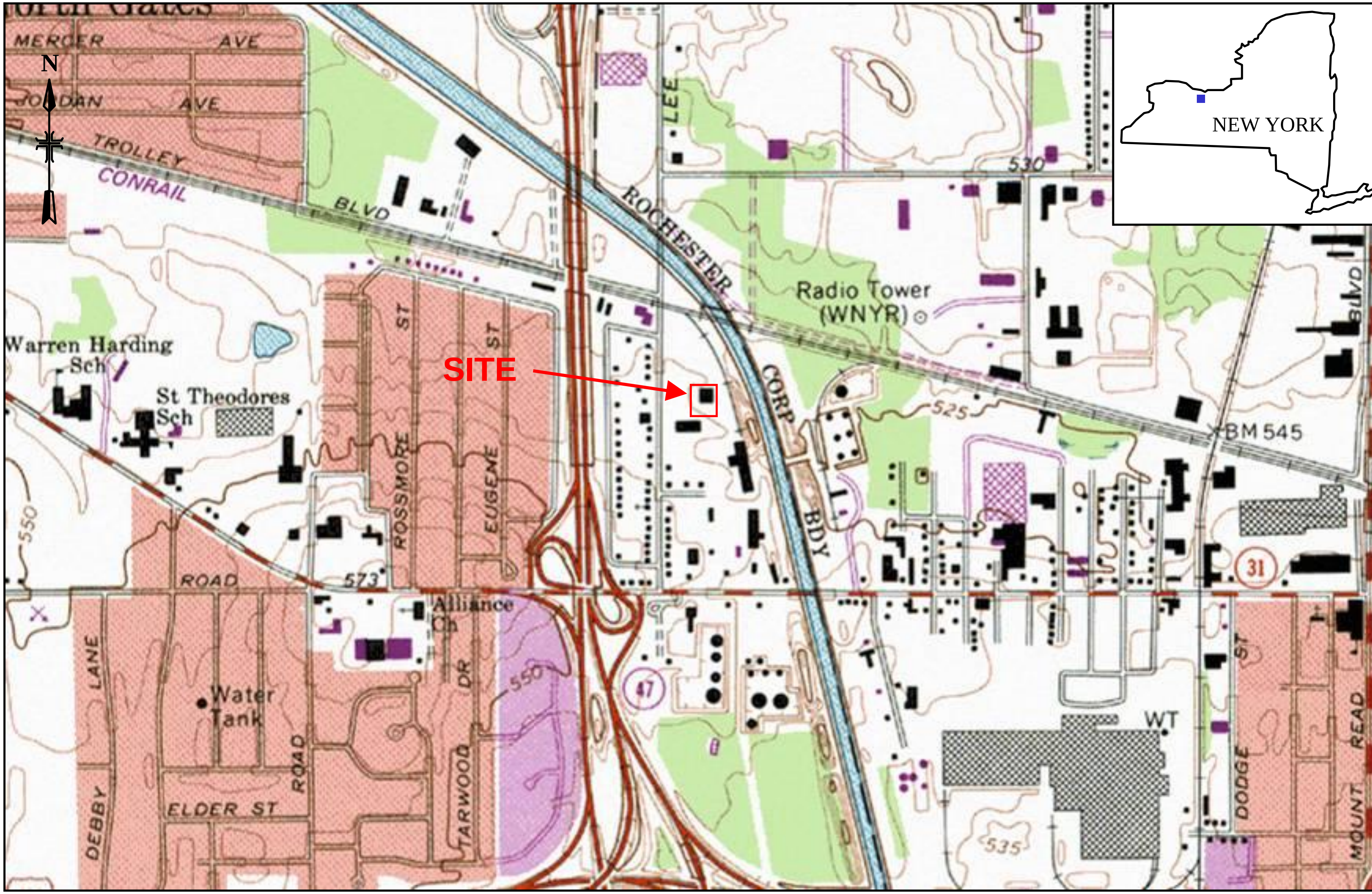
Figures



MAP SOURCE: USGS 7.5 MINUTE TOPOGRAPHIC SERIES, ROCHESTER WEST QUADRANGLE 1971 PHOTOREVISED 1978

APPROXIMATE SCALE IN FEET

0 600 1200 2400

MALCOLM PIRNIE

CHEMICAL SALES OU#1 SITE (HW 8-28-086)
TOWN OF GATES, NEW YORK

SITE LOCATION

FIGURE 1

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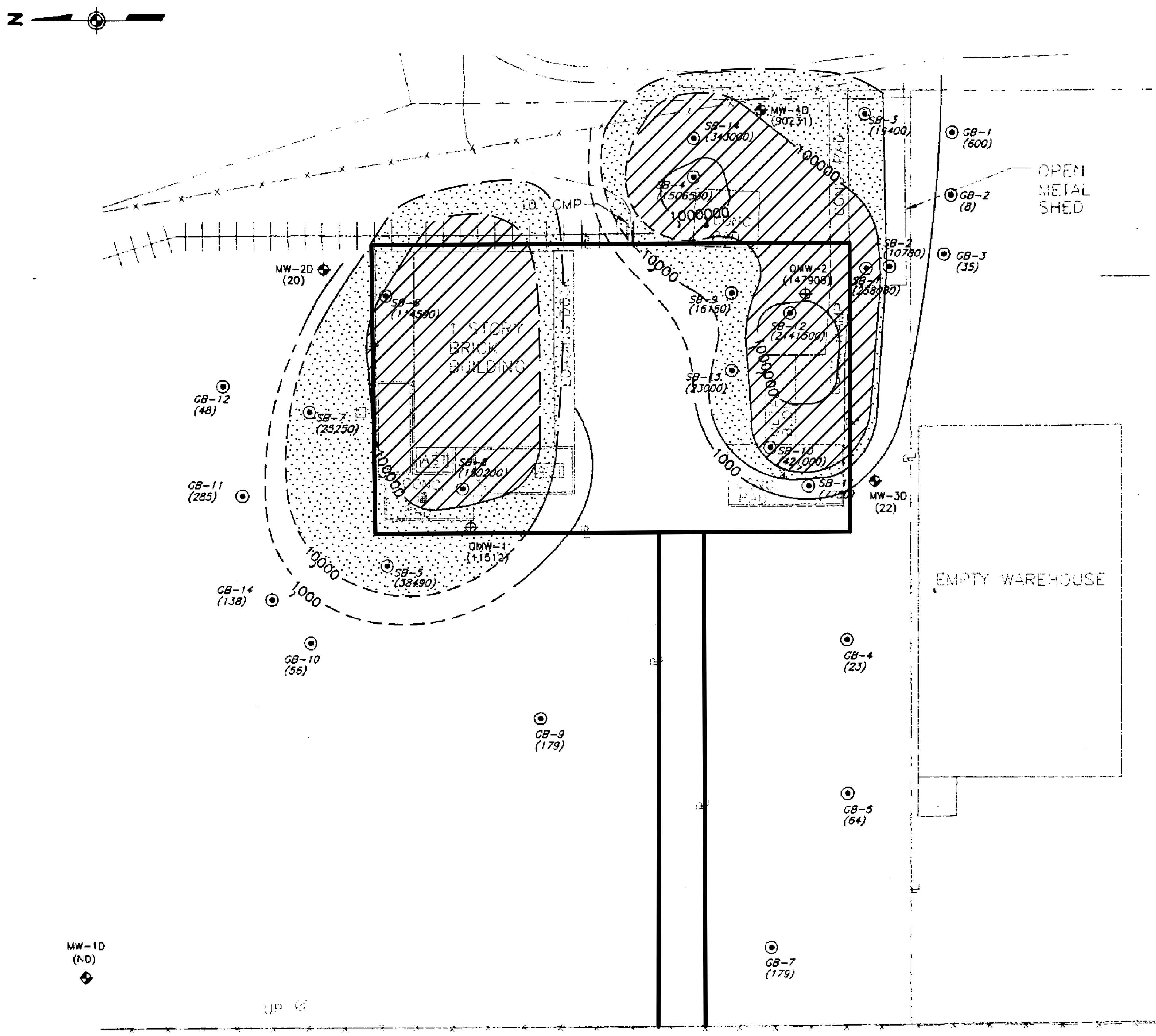


LEGEND:

— ℙ —	PROPERTY LINE
———	SITE PROPERTY LINE
⊙ GB-1	GEOPROBE SOIL BORING LOCATION (SEPTEMBER 1999)
⊙ SB-1	GEOPROBE SOIL BORING LOCATION (AUGUST 1998)
(258080)	TOTAL VOC CONCENTRATION IN µg/kg
⊕ OMW-1	OVERBURDEN MONITORING WELL
MW-1D	BEDROCK MONITORING WELL
—100000—	APPROXIMATE ISOCONCENTRATION CONTOUR IN µg/kg
ND	NOT DETECTED
(hatched)	APPROXIMATE AREA OF EXCAVATION 100 ppm LIMIT
(dotted)	APPROXIMATE AREA OF EXCAVATION 10 ppm LIMIT

MALCOLM PIRNIE

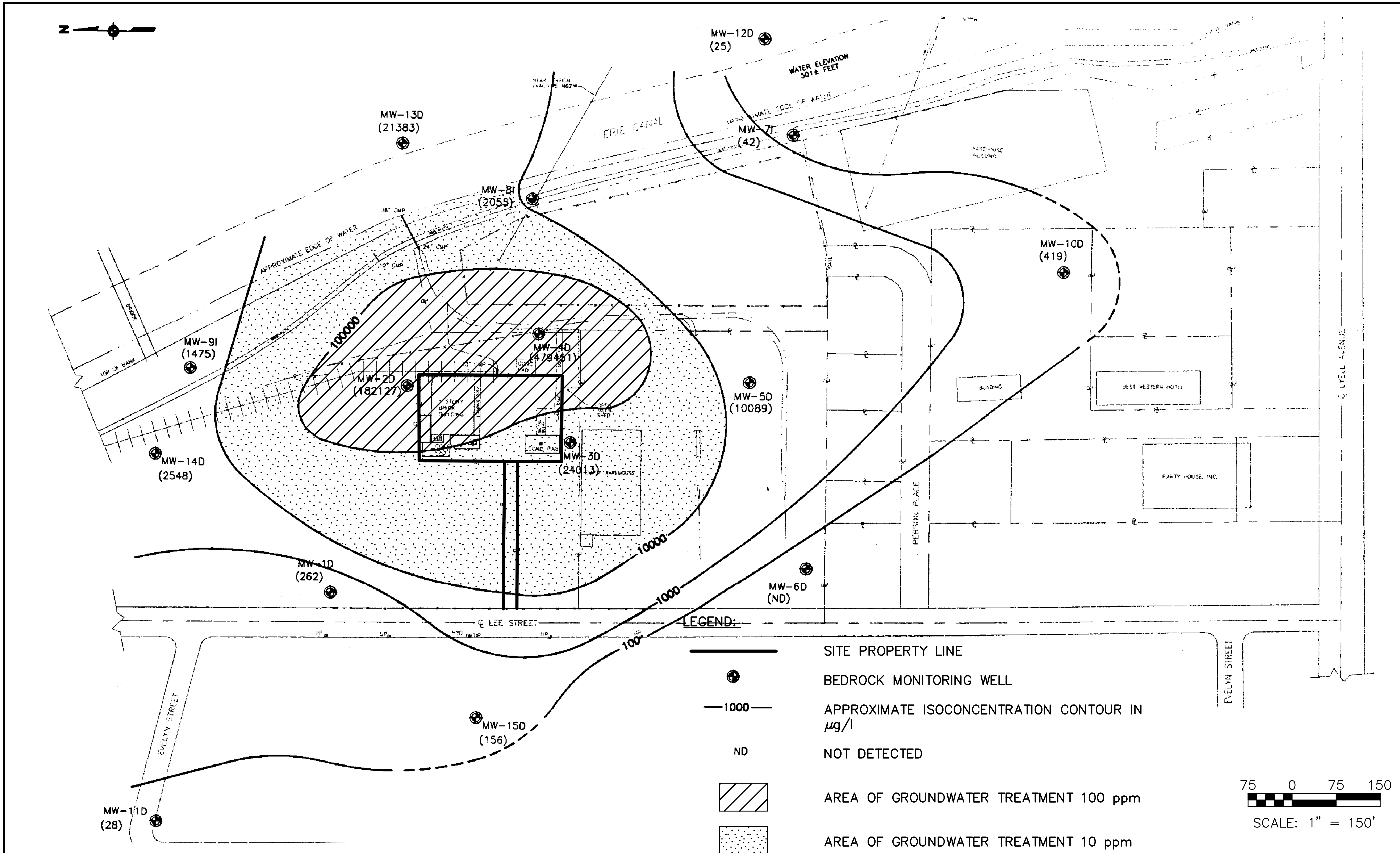
NYSDEC
TOWN OF GATES, NEW YORK
CHEMICAL SALES CORP OU-1
FEASABILITY STUDY REPORT

APPROXIMATE AREAS OF EXCAVATION

SCALE: 1"=60'

MALCOLM PIRNIE, INC.
OCTOBER 2008
FIGURE 2

XREFS: IMAGES: H:\PROJECT\0266368\FILE\DEC Files\4-3.TIF
User: Lewandowski Spec: PIRNIE STANDARD File: H:\PROJECT\0266368\FILE\DEC Files\FIGURES\FIGURE 2.DWG Scale: 1:1 Date: 02/27/2009 Time: 11:24 Layout: Blank



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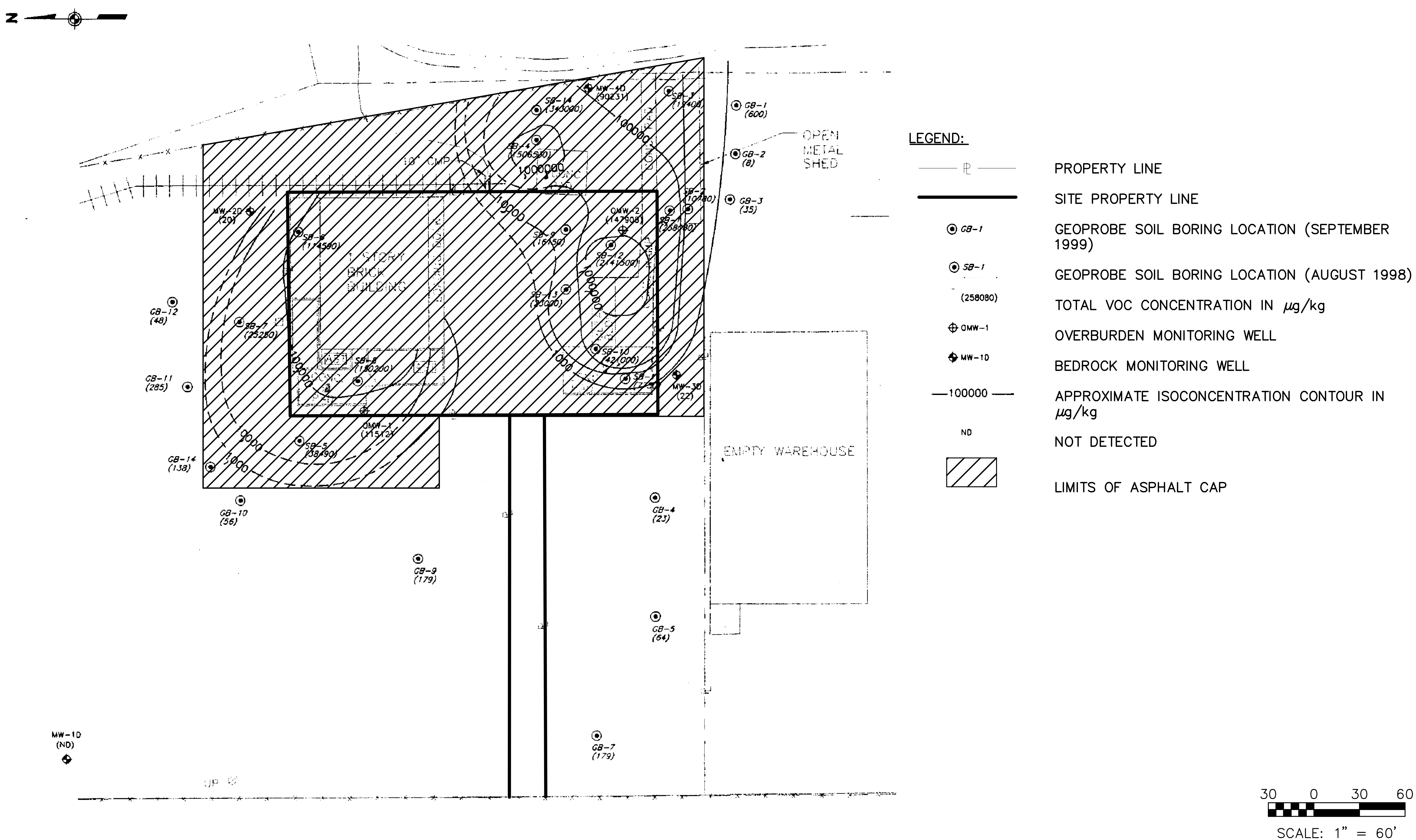
MALCOLM PIRNIE

NYSDEC
TOWN OF GATES, NEW YORK
CHEMICAL SALES CORP OU-1
FEASABILITY STUDY REPORT

APPROXIMATE AREAS OF GROUNDWATER TREATMENT

SCALE: 1"=150'

MALCOLM PIRNIE, INC.
OCTOBER 2008
FIGURE 3



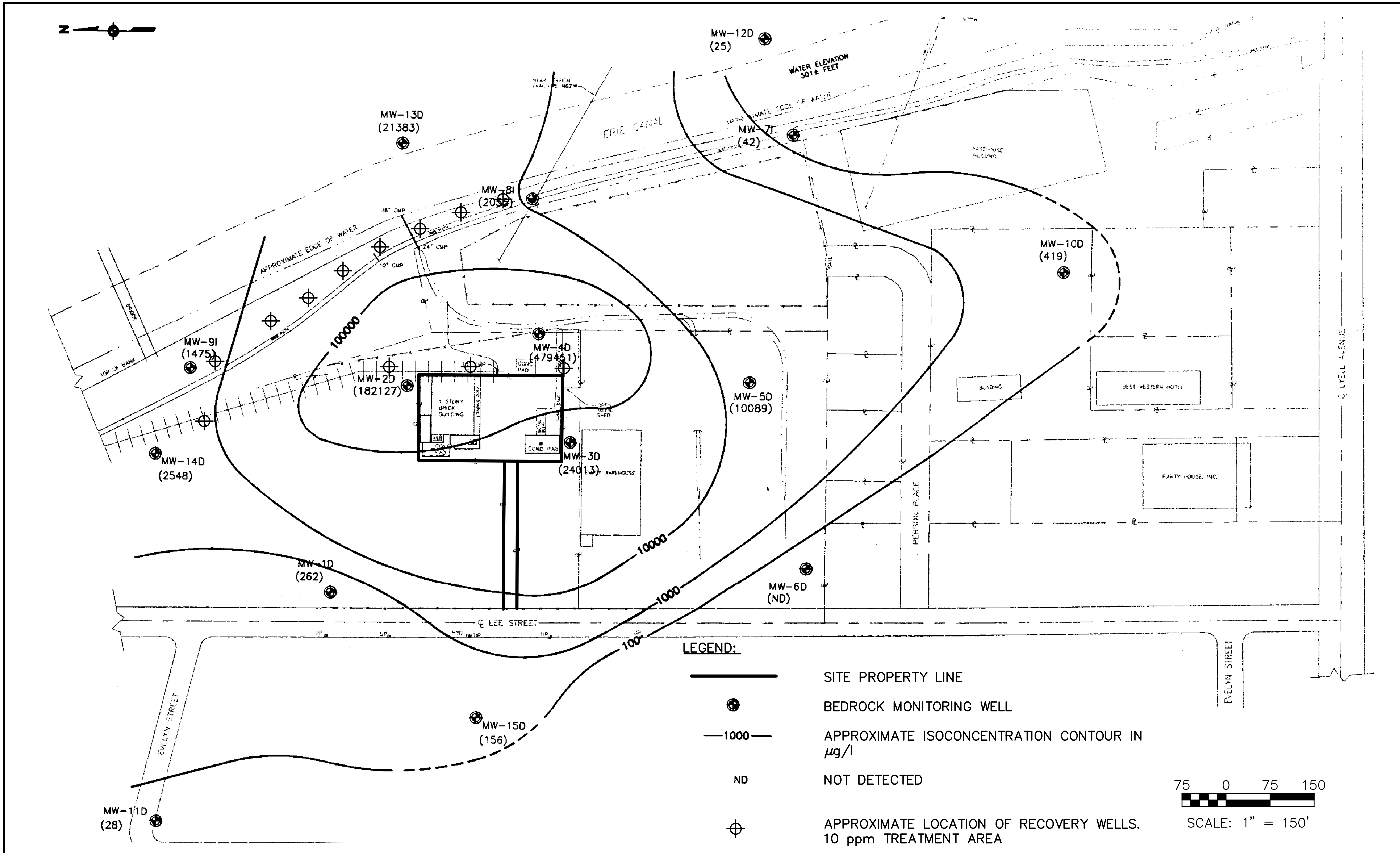
MALCOLM PIRNIE

NYSDEC
TOWN OF GATES, NEW YORK
CHEMICAL SALES CORP OU-1
FEASABILITY STUDY REPORT

APPROXIMATE AREA OF ASPHALT CAP

SCALE: 1"=60'

MALCOLM PIRNIE, INC.
OCTOBER 2008
FIGURE 4

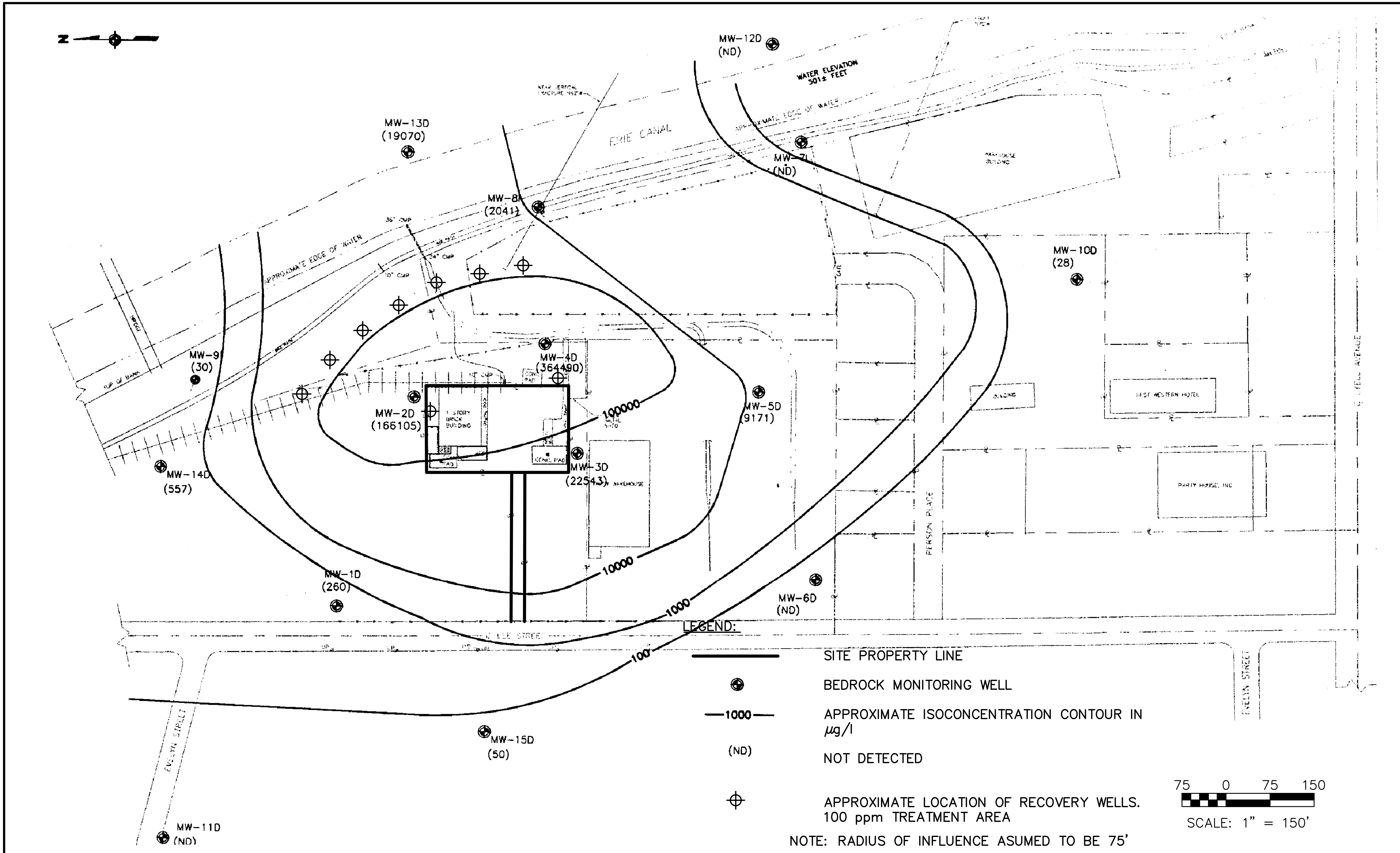


MALCOLM PIRNIE

NYSDEC
TOWN OF GATES, NEW YORK
CHEMICAL SALES CORP OU-1
FEASABILITY STUDY REPORT

RECOVERY WELLS
10 PPM TREATMENT AREA
SCALE: 1"=150'

MALCOLM PIRNIE, INC.
OCTOBER 2008
FIGURE 5



MALCOLM PIRNIE

NYSDEC
TOWN OF GATES, NEW YORK
CHEMICAL SALES CORP OU-1
FEASABILITY STUDY REPORT

RECOVERY WELLS
100 PPM TREATMENT AREA
SCALE: 1"=150'

MALCOLM PIRNIE, INC.
OCTOBER 2008
FIGURE 6

XREFS: IMAGES: H:\PROJECT\0266368\FILE\DEC Files\4-26.TIF
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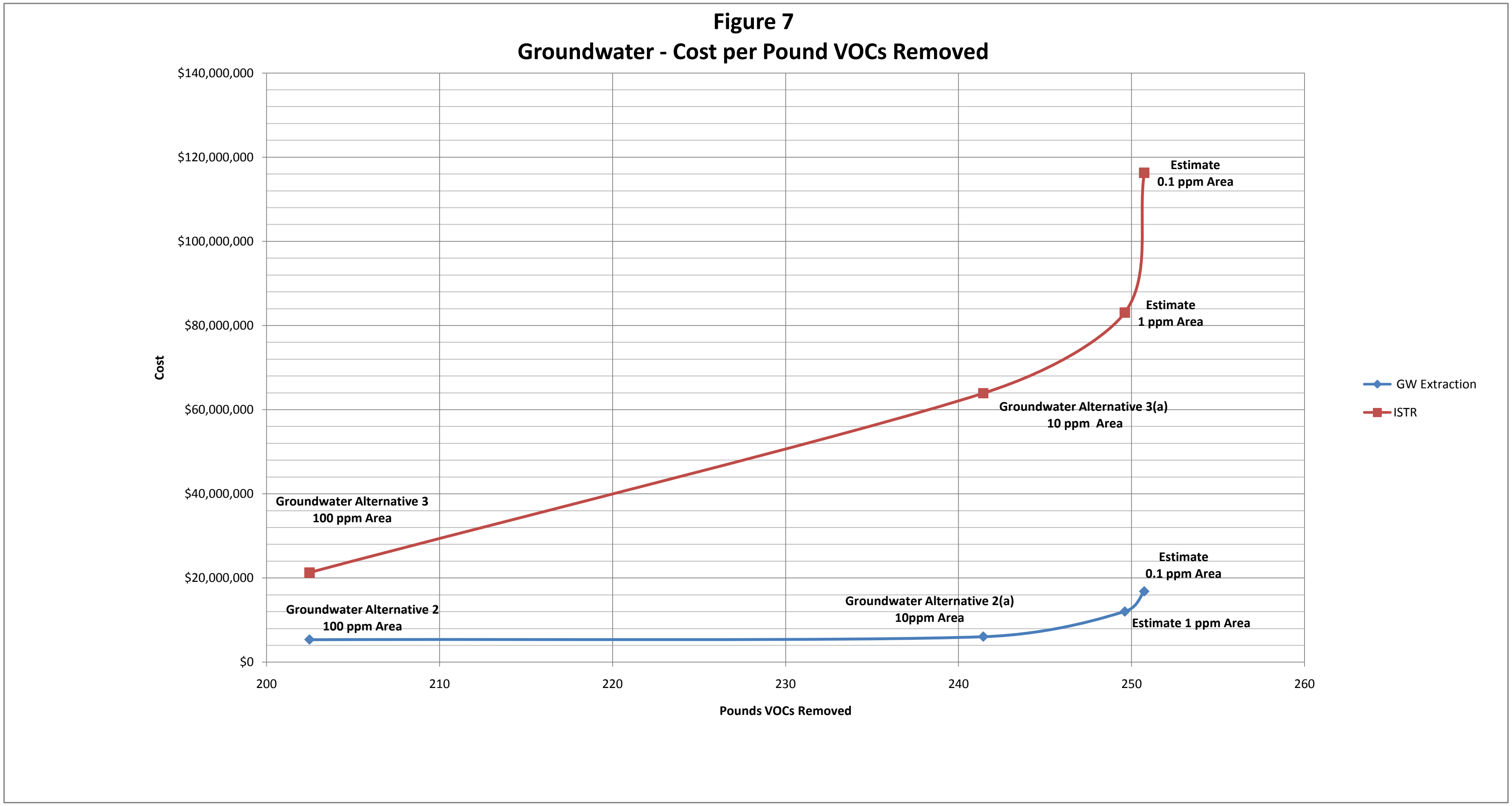
Figure 7
Groundwater - Cost per Pound VOCs Removed
$140,000,000
$120,000,000
$100,000,000
$80,000,000
$60,000,000
$40,000,000
$20,000,000
$0
Cost
200
210
220
230
240
250
260
Pounds VOCs Removed
Estimate
0.1 ppm Area
Estimate
1 ppm Area
Groundwater Alternative 3(a)
10 ppm Area
Groundwater Alternative 3
100 ppm Area
Estimate
0.1 ppm Area
Groundwater Alternative 2(a)
10ppm Area
Estimate 1 ppm Area
Groundwater Alternative 2
100 ppm Area
GW Extraction
ISTR

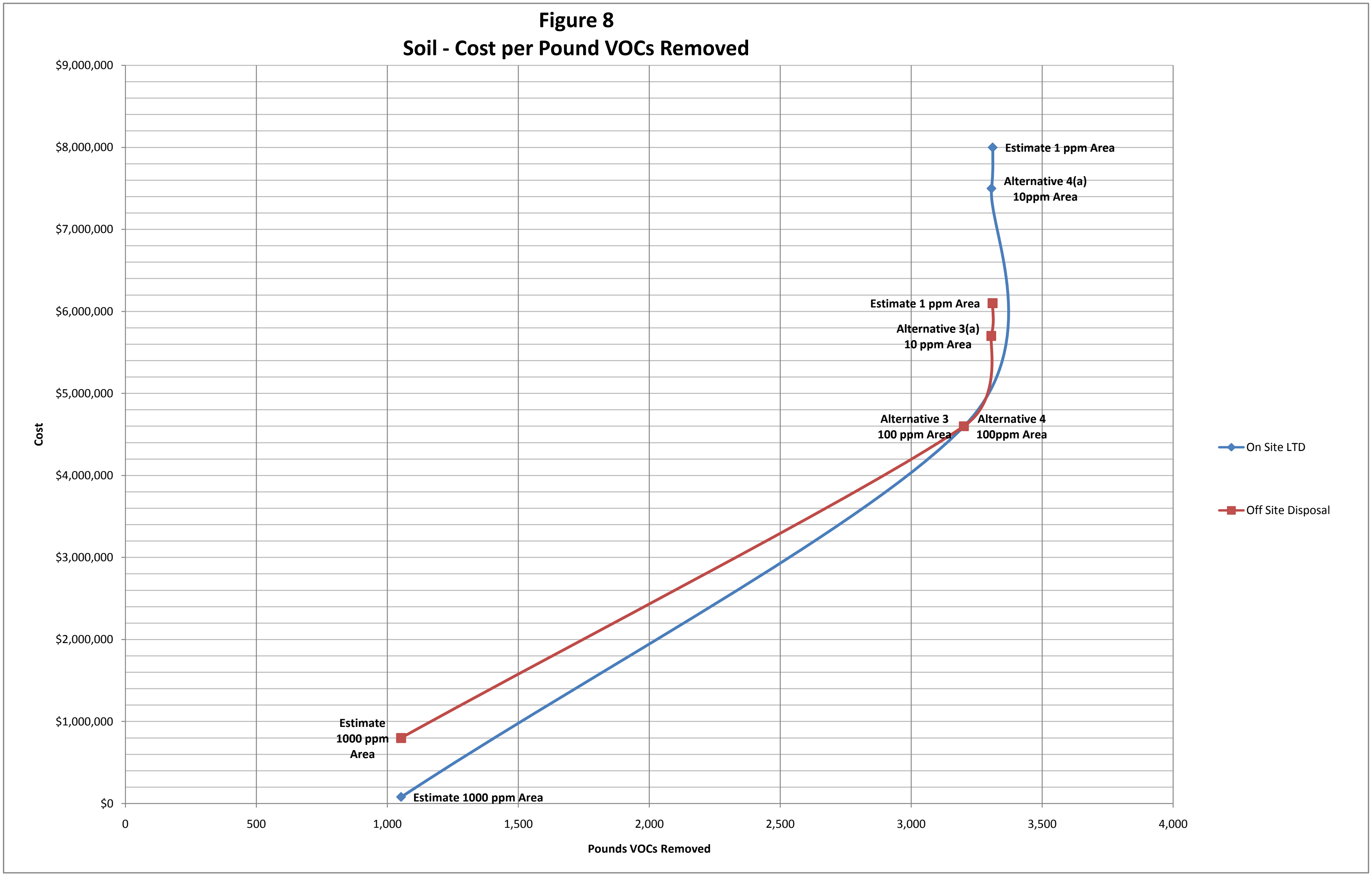
Figure 8
Soil - Cost per Pound VOCs Removed
$9,000,000
$8,000,000
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
Cost
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
Pounds VOCs Removed
Estimate 1 ppm Area
Alternative 4(a) 10ppm Area
Estimate 1 ppm Area
Alternative 3(a) 10 ppm Area
Alternative 3 100 ppm Area
Alternative 4 100ppm Area
Estimate 1000 ppm Area
Estimate 1000 ppm Area
On Site LTD
Off Site Disposal

Tables

MALCOLM PIRNIE

Table 1
Contaminants of Concern Over SCGs
Chemical Sales Corporation, Feasibility Study

Contaminants of Concern	Surface Soil	Subsurface Soil	Ground Water	Surface Water & Sediment
BTEX				
Benzene			x	x
Toluene	x	x	x	x
Ethylbenzene		x	x	x
Xylene		x	x	x
Chloronated Solvents				
Chloroethane		x	x	x
1,1-Dichloroethane	x	x	x	x
1,2-Dichloroethane			x	x
1,2-Dichloroethene	x	x	x	x
1,1-Dichloroethene		x		x
1,2-Dichloropropane			x	
Methylene Chloride	x	x	x	x
Tetrachloroethene	x	x	x	
1,1,1-Trichloroethane	x	x	x	x
Trichloroethene	x	x	x	x
Vinyl chloride		x	x	x
Oxygenated Hydrocarbons				
2-Hexanone		x	x	
2-Butanone (MEK)		x	x	
4-Methyl-2-pentanone (MIBK)		x	x	
Acetone		x	x	x
Ethyl Accetate	x	x	x	
Isopropyl Alcohol		x	x	
n-Butanol	x	x	x	
Methanol	x			

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 1
No Further Action

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 30-Jun-05
Date: 18-Oct-08

Description: Soil Alternative 1 consists of the implementation of institutional controls. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 2-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
SUBTOTAL				$5,000	
Contingency	25%			$1,250	
SUBTOTAL				$6,250	
Project Management	5%			$313	
Remedial Design	8%			$500	
Construction Management	6%			$375	
TOTAL CAPITAL COST				$7,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
			$0.00	$0	Yearly Inspection and reporting
				$0	
SUBTOTAL				$0	
Contingency	25%			$0	
SUBTOTAL				$0	
Project Management	5%			$0	
Technical Support	10%			$0	
TOTAL ANNUAL O&M COST				$0	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$7,000	$7,000	1.00	$7,000	
Annual O&M	2-30	$0	$0	0.00	$0	29 years, 3.5 %
		$7,000			$7,000	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$7,000	

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 2
Capping

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 30-Jun-05
Date: 18-Oct-08

Description: Soil Alternative 2 consists of paving 60,000 square feet of the site with asphalt and the implementation of institutional controls. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 2-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Site Work					
Mobilization	1	LS	$10,000.00	$10,000	
Site Preparation	1	LS	$5,000.00	$5,000	
Asphalt Paving	68,000	Square Feet	$2.50	$170,000	1 inch Asphalt+ 6" base
Fencing	860	Liner Feet	$12.55	$10,793	6' Chain Link Fence, 1 Gate
Demolition of Building	1	lump Sum	$25,000.00	$25,000	
SUBTOTAL				$220,793	
SUBTOTAL				$225,793	
Contingency	25%			$56,448	
SUBTOTAL				$277,241	
Project Management	5%			$13,862	
Remedial Design	8%			$22,179	
Construction Management	6%			$16,634	
TOTAL CAPITAL COST				$330,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Yearly Inspection	1	LS	$3,000.00	$3,000	Yearly Inspection and reporting
SUBTOTAL				$3,000	
Contingency	25%			$750	
SUBTOTAL				$3,750	
Project Management	5%			$188	
Technical Support	10%			$375	
TOTAL ANNUAL O&M COST				$4,000	

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$330,000	$330,000	1.00	$330,000	
Annual O&M	2-30	$4,000	$4,000	18.04	$72,143	29 years, 3.5 %
		$334,000			$402,143	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$402,000	

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 3
Excavation and Off Site Disposal (100 ppm)

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 30-Jun-05
Date: 18-Oct-08

Description: Soil Alternative 3 consists of excavation of contaminated soil and off site disposal. It assumes the excavation of 7,500yd^3 of soil including, 1000yd^3 of non-hazardous soil, and 6,500yd^3 of hazardous soil. Capital costs and O&M costs occur in Year 1. O&M Costs occur in years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Site Work					
Pre-design Investigation	1	lump Sum	$25,000.00	$25,000	
Contractor Mobilization	1	lump sum	$3,500.00	$3,500	
Hazardous soil	9,750	ton	$200.00	$1,950,000	Excavation, trans, disposal
Non hazardous soil	1,500	ton	$74.00	$111,000	Excavation, trans, disposal
Backfill	13,000	ton	$25.00	$325,000	
Site Restoration	50,000	square foot	$2.50	$125,000	1-inch asphalt & base
Fencing	860	Liner Feet	$12.55	$10,793	6' Chain Link Fence, 1 Gate
Decontamination	1	lump Sum	$10,000.00	$10,000	Includes Temporary Decon Pad
Demolition of Building	1	lump Sum	$25,000.00	$25,000	
Water Handling	1	lump Sum	$10,000.00	$10,000	
Dust Control	1	lump sum	$10,000.00	$10,000	
SUBTOTAL				$2,605,293	
Confirmation Sampling					
Excavation Sampling	300	hours	$100.00	$30,000	
Laboratory Analysis	200	samples	$90.00	$18,000	VOC Analysis
Laboratory Analysis	20	samples	$400.00	$8,000	TCLP Analysis
SUBTOTAL				$56,000	
Community Air Monitoring					
Safety Personnel	400	hours	$90.00	$36,000	8 Weeks 10 Hr days
Monitoring Equipment	1	lump sum	$10,000.00	$10,000	
SUBTOTAL				$46,000	
Contingency	25%			$678,073	
SUBTOTAL				$3,390,366	
Project Management	8%			$271,229	
Remedial Design	15%			$508,555	
Construction Management	10%			$339,037	
TOTAL CAPITAL COST				$4,509,000	

Notes: Cost data obtained from 2005 RSMeans Environmental Remediation (ER), Building Construction (BC), or Heavy Construction (HC) Cost Data, vendor quotes, and previous Malcolm Pirnie project experience.

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Yearly Inspection	1	LS	$3,000.00	$3,000	Yearly Inspection and reporting
SUBTOTAL				$3,000	
SUBTOTAL				$3,000	
Contingency	25%			$750	
SUBTOTAL				$3,750	
Project Management	5%			$188	
Technical Support	20%			$750	
TOTAL ANNUAL O&M COST				$5,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$4,509,000	$4,509,000	1.00	$4,509,000	
Annual O&M	2-30	$5,000	$5,000	18.04	$90,179	29 years, 3.5%
		$4,514,000			$4,599,179	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$4,599,000	

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 3(a)
Excavation and Off Site Disposal (10 ppm)

Site:	Chemical Sales Corporation OU-1
Location:	Gates, New York
Phase:	Feasibility Study
Base Year:	2008
Date:	18-Oct-08

Description: Soil Alternative 3(a) consists of excavation of contaminated soil and off site disposal. the Assumes the excavation of 11,500 yd^3 of soil including, 5,000yd^3 of non-hazardous soil, and 6,500yd^3 of hazardous soil. Capital costs costs occur in Year 1. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Site Work					
Pre-design Investigation	1	lump Sum	$30,000.00	$30,000	
Contractor Mobilization	1	lump sum	$3,500.00	$3,500	
Hazardous soil	9,750	ton	$200.00	$1,950,000	Excavation, trans, disposal
Non hazardous soil	7,500	ton	$74.00	$555,000	Excavation, trans, disposal
Backfill	19,000	ton	$25.00	$475,000	
Site Restoration	68,000	square foot	$2.50	$170,000	1-inch asphalt & base
Fencing	860	Liner Feet	$12.55	$10,793	6' Chain Link Fence, 1 Gate
Decontamination	1	lump Sum	$10,000.00	$10,000	Includes Temporary Decon Pad
Demolition of Building	1	lump Sum	$25,000.00	$25,000	
Water Handling	1	lump Sum	$10,000.00	$10,000	
Dust Control	1	lump sum	$10,000.00	$10,000	
SUBTOTAL				$3,249,293	
Confirmation Sampling					
Excavation Sampling	400	hours	$100.00	$40,000	
Laboratory Analysis	330	samples	$90.00	$29,700	VOC Analysis
Laboratory Analysis	35	samples	$400.00	$14,000	TCLP Analysis
SUBTOTAL				$83,700	
Community Air Monitoring					
Safety Personnel	600	hours	$90.00	$54,000	12 Weeks 10 Hr days
Monitoring Equipment	2	lump sum	$15,000.00	$30,000	
SUBTOTAL				$84,000	
Contingency	25%			$855,498	
SUBTOTAL				$4,277,491	
Project Management	8%			$342,199	
Remedial Design	15%			$641,624	
Construction Management	10%			$427,749	
TOTAL CAPITAL COST				$5,689,000	

Notes: Cost data obtained from 2005 RSMeans Environmental Remediation (ER), Building Construction (BC), or Heavy Construction (HC) Cost Data, vendor quotes, and previous Malcolm Pirnie project experience.

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Yearly Inspection	1	LS	$3,000.00	$3,000	Yearly Inspection and reporting
SUBTOTAL				$3,000	
Miscellaneous					
Miscellaneous	0	each	$0.00	$0	
SUBTOTAL				$3,000	
Project Management	5%			$188	
Technical Support	20%			$750	
TOTAL ANNUAL O&M COST				$5,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$5,689,000	$5,689,000	1.00	$5,689,000	
Annual O&M	2-30	$5,000	$5,000	18.04	$90,179	29 years, 3.5%
		$5,694,000			$5,779,179	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$5,779,000	

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 4
Excavation and on-Site Thermal Treatment (100 ppm)

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 30-Jun-05
Date: 18-Oct-08

Description: Soil Alternative 4 consists of excavation of contaminated soil and on site treatment by thermal desorption. It, assumes the excavation of 7,500 yd^3 of soil including, 1000 yd^3 of non-hazardous soil, and 6,500 yd3 of hazardous soil. Capital costs and O&M costs occur in Year 1. O&M Costs Occur in years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Site Work					
Pre-design Investigation	1	lump Sum	$25,000.00	$25,000	
Mobilization	1	lump Sum	$500,000.00	$500,000	
Soil Handling	11250	Ton	$20	$225,000	Includes handling excavated soil and backfill
Off site Disposal	2500	Ton	$200	$500,000	Untreatable Soil for off site treatment and disposal
Backfill Material	20	Ton	$20	$400	Material
Thermal treatment	8,750	Ton	$150.00	$1,312,500	Includes setup and tear down of unit
Site Restoration, capping	50,000	square foot	$2.50	$125,000	1-inch asphalt & base
Fencing	860	Liner Feet	$12.55	$10,793	6' High Chain Link Fence, 1 Gate
Decontamination	1	lump Sum	$10,000.00	$10,000	Includes Temporary Decon Pad
Demolition of Building	1	lump Sum	$25,000.00	$25,000	
Water Handling	1	lump Sum	$10,000.00	$10,000	
Dust Control	1	lump sum	$10,000.00	$10,000	
Confirmation Sampling					
Excavation Sampling	350	hours	$90.00	$31,500	
Laboratory Analysis	300	samples	$95.00	$28,500	VOC Analysis
Laboratory Analysis	30	samples	$400.00	$12,000	TCLP Analysis
Community Air Monitoring					
Safety Personnel	500	hours	$90.00	$45,000	10 Weeks 10 Hr days
Monitoring Equipment	1	months	$10,000.00	$10,000	
SUBTOTAL				$2,885,693	
Contingency	25%			$721,423	
SUBTOTAL				$3,607,116	
Project Management	6%			$216,427	
Remedial Design	12%			$432,854	
Construction Management	8%			$288,569	
TOTAL CAPITAL COST				$4,545,000	

Notes: Cost data obtained from 2005 RSMeans Environmental Remediation (ER), Building Construction (BC), or Heavy Construction (HC) Cost Data, vendor quotes, and previous Malcolm Pirnie project experience.

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Yearly Inspection	1	LS	$3,000.00	$3,000	Yearly Inspection and reporting
SUBTOTAL				$3,000	
Contingency	25%			$750	
SUBTOTAL				$3,750	
Project Management	10%			$375	
Technical Support	20%			$750	
TOTAL ANNUAL O&M COST				$5,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$4,545,000	$4,545,000	1.00	$4,545,000	
Annual O&M	2-30	$10,000	$5,000	18.04	$90,179	29 years, 3.5 %
		$4,555,000			$4,635,179	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$4,635,000	

Table 2
Remedial Alternative Opinion of Probable Cost

Soil Alternative 4(a)
Excavation and on-Site Thermal Treatment (10 ppm)

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 30-Jun-05
Date: 18-Oct-08

Description: Soil Alternative 4(a) consists of excavation of contaminated soil and on site treatment by thermal desorption. It assumes the excavation of 11,500 yd3 of soil including, 5,000 yd3 of non-hazardous soil, and 6,500 yd3 of hazardous soil. Capital costs and O&M costs occur in Year 1. O&M Costs Occur in years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Site Work					
Pre-design Investigation	1	lump Sum	$30,000.00	$30,000	
Mobilization	1	lump Sum	$500,000.00	$500,000	
Soil Handling	21000	Ton	$20	$420,000	Includes excavation and backfill materials
Off site Disposal	2500	Ton	$200	$500,000	Untreatable Soil for off site treatment and disposal
Backfill Material	25	Ton	$20	$500	Material
Thermal treatment	18,500	Ton	$150.00	$2,775,000	Includes setup and tear down of unit
Site Restoration, Capping	68,000	square foot	$2.50	$170,000	1-inch asphalt & base
Fencing	860	Liner Feet	$12.55	$10,793	6' Chain Link Fence, 1 Gate
Decontamination	1	lump Sum	$15,000.00	$15,000	Includes Temporary Decon Pad
Demolition of Building	1	lump Sum	$25,000.00	$25,000	
Water Handling	1	lump Sum	$20,000.00	$20,000	
Dust Control	1	lump sum	$15,000.00	$15,000	
Confirmation Sampling					
Excavation Sampling	525	hours	$90.00	$47,250	
Laboratory Analysis	495	samples	$95.00	$47,025	VOC Analysis
Laboratory Analysis	50	samples	$400.00	$20,000	TCLP Analysis
Community Air Monitoring					
Safety Personnel	800	hours	$90.00	$72,000	12 Weeks 10 Hr days
Monitoring Equipment	3	months	$15,000.00	$45,000	
SUBTOTAL				$4,717,568	
Contingency	25%			$1,179,392	
SUBTOTAL				$5,896,960	
Project Management	6%			$353,818	
Remedial Design	12%			$707,635	
Construction Management	8%			$471,757	
TOTAL CAPITAL COST				$7,430,000	

Notes: Cost data obtained from 2005 RSMeans Environmental Remediation (ER), Building Construction (BC), or Heavy Construction (HC) Cost Data, vendor quotes, and previous Malcolm Pirnie project experience.

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Yearly Inspection	1	LS	$3,000.00	$3,000	Yearly Inspection and reporting
SUBTOTAL				$3,000	
Contingency	25%			$750	
SUBTOTAL				$3,750	
Project Management	10%			$375	
Technical Support	20%			$750	
TOTAL ANNUAL O&M COST				$5,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$7,430,000	$7,430,000	1.00	$7,430,000	
Annual O&M	2-30	$10,000	$5,000	18.04	$90,179	29 years,3.5 %
		$7,440,000			$7,520,179	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$7,520,000	

Table 3
Remedial Alternative Opinion of Probable Cost

Alternative 1
No further action

COST ESTIMATE SUMMARY

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 2008
Date: 18-Oct-08

Description: Groundwater alternative 1 consists of the implementation of institutional controls and groundwater monitoring. Annual O&M costs occur in Years 1-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
SUBTOTAL				$5,000	
Contingency	25%			$1,250	
SUBTOTAL				$6,250	
Project Management	8%			$500	
Remedial Design	15%			$938	
Construction Management	10%			$625	
TOTAL CAPITAL COST				$8,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	16	hours	$80.00	$1,280	Sampling 5 wells annually
Groundwater Laboratory Analysis	7	samples	$70.00	$490	VOC analysis
Reporting	16	hours	$120.00	$1,920	
Purge Water Disposal	2	Drums	$300.00	$600	
SUBTOTAL				$4,290	
Contingency	25%			$1,073	
SUBTOTAL				$5,363	
Project Management	5%			$268	
Technical Support	10%			$536	
TOTAL ANNUAL O&M COST				$6,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$8,000	$8,000	1.00	$8,000	
Annual O&M	2-30	$180,000	$6,000	18.04	$108,215	29 years, 3.5 %
		$188,000			$116,215	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR THIRTY YEARS					$116,000	

Table 3
Remedial Alternative Opinion of Probable Cost

GW Alternative 2
Groundwater Extraction (100 ppm)

COST ESTIMATE SUMMARY

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 2008
Date: 18-Oct-08

Description: Alternative 2 consists of the installation of 9 recovery wells and a monitoring network of 8 monitoring wells. A treatment system utilizing UV Oxidation and carbon filters would be built on site. It, assumes an oporating period of 30 Years. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 2-30

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
Site Work					
Pre-Design Investigation	1	lump sum	$100,000.00	$100,000	
Drilling Mobilization	1	lump sum	$15,000.00	$15,000	
Decon Pad	1	lump sum	$1,500.00	$1,500	
Monitoring Well Drilling	400	linear feet	$52.00	$20,800	8 Monitoring Wells to 50 Feet
Extraction Well Drilling	450	linear feet	$63.00	$28,350	9 Extraction wells to 50 feet
Stick-up Monitoring Well Casing	8	wells	$235.00	$1,880	Monitoring Wells only
Drums	38	Drums	$55.00	$2,090	
Purge Water and Cuttings Disposal	38	Drums	$250.00	$9,500	
Trench for piping	1	lump sum	$4,500.00	$4,500	
Above ground PVC piping	1	lump sum	$7,500.00	$7,500	
Tees, elbows, reducers, and ball valves	1	lump sum	$7,500.00	$7,500	
Well Vaults for extraction Wells	9	Vaults	$2,700.00	$24,300	9 Extraction Wells
Electrical Service Connection	1	lump sum	$60,000.00	$60,000	
Well Pumps	9	pumps	$1,000.00	$9,000	Grunfos SQE
Treatment Shed, UV, Carbon, Controls	1	lump sum	$300,000.00	$300,000	
Well Install. & Development Oversight	340	hours	$90.00	$30,600	20 Hours per well
Drums	30	Drums	$55.00	$1,650	
Purge Water and Cuttings Disposal	35	Drums	$250.00	$8,750	
First year operation and maintenance	1	lump sum	$217,000.00	$217,000	
SUBTOTAL				$854,920	
Contingency	25%			$213,730	
SUBTOTAL				$1,068,650	
Project Management	8%			$85,492	
Remedial Design	15%			$160,298	
Construction Management	10%			$106,865	
TOTAL CAPITAL COST				$1,421,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	250	hours	$80.00	$20,000	14 Wells Quarterly
Groundwater Laboratory Analysis	60	samples	$120.00	$7,200	
SUBTOTAL				$27,200	
System O&M					
Carbon Disposal	3	Lump Sum	$500.00	$1,500	3000 lbs Carbon/yr
Electric Service	1	lump sum	$40,000.00	$15,000	Assumes $0.14 per kWh
Labor	1,000	lump sum	$92.00	$92,000	
Spare Pumps	2	pump	$1,000.00	$2,000	
SUBTOTAL				$111,500	
SUBTOTAL				$138,700	
Contingency	25%			$34,675	
SUBTOTAL				$173,375	
Project Management	5%			$8,669	
Technical Support	20%			$34,675	
TOTAL ANNUAL O&M COST				$217,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$1,421,000	$1,421,000	1.00	$1,421,000	
Annual O&M	2-30	$6,510,000	$217,000	18.04	$3,913,761	30 years, 3.5 %
		$7,931,000			$5,334,761	
TOTAL PRESENT VALUE OF ALTERNATIVE FOR 30 YEARS					$5,335,000	

Table 3
Remedial Alternative Opinion of Probable Cost

GW Alternative 2(a)
Groundwater Extraction (10 ppm)

COST ESTIMATE SUMMARY

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 2008
Date: 18-Oct-08

Description: Alternative 2(a) consists of the installation of 12 recovery wells and a monitoring network of ten monitoring wells. A treatment system utilizing UV Oxidation and carbon filters would be built on site. It, assumes an operating period of 30 Years. Capital costs and first year O&M costs occur in Year 1. Annual O&M costs occur in Years 2-30.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
Site Work					
Pre-Design Investigation	1	lump sum	$110,000.00	$110,000	
Drilling Mobilization	1	lump sum	$15,000.00	$15,000	
Decon Pad	1	lump sum	$1,500.00	$1,500	
Extraction Well Drilling	1,200	linear feet	$23.00	$27,600	12 Extraction Wells to 50 feet
Monitoring Well Drilling	500	linear feet	$62.00	$31,000	10 Monitoring Wells to 50 feet
Stick-up Monitoring Well Casing	10	wells	$235.00	$2,350	
Drums	50	Drums	$55.00	$2,750	
Purge Water and Cuttings Disposal	50	Drums	$250.00	$12,500	
Trench for piping	1	lump sum	$6,000.00	$6,000	
Above ground PVC piping	1	lump sum	$10,000.00	$10,000	
Tees, elbows, reducers, and ball valves	1	lump sum	$10,000.00	$10,000	
Valve Vaults	12	Vaults	$2,700.00	$32,400	12 Vaults
Electrical Service Connection	1	lump sum	$60,000.00	$60,000	
Well Pumps	9	pumps	$1,000.00	$9,000	Grunfos SQE
Treatment Shed, UV, Carbon, Controls	1	lump sum	$300,000.00	$300,000	
Stick-up Injection Well Casing	10	Casing	$235.00	$2,350	10 Monitoring wells
Well Install. & Development Oversight	440	hours	$80.00	$35,200	
Drums	40	Drums	$55.00	$2,200	
Purge Water and Cuttings Disposal	40	Drums	$250.00	$10,000	
First year operation and maintenance	1	lump sum	$250,000.00	$250,000	
SUBTOTAL				$934,850	
Contingency	25%			$233,713	
SUBTOTAL				$1,168,563	
Project Management	8%			$93,485	
Remedial Design	15%			$175,284	
Construction Management	10%			$116,856	
TOTAL CAPITAL COST				$1,554,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Site Monitoring					
Groundwater Sampling	500	hours	$80.00	$40,000	15 Wells Quarterly
Groundwater Laboratory Analysis	70	samples	$120.00	$8,400	
SUBTOTAL				$48,400	
System O&M					
Carbon Disposal	3	Lump Sum	$500.00	$1,500	3000 lbs Carbon/yr
Electric Service	1	lump sum	$40,000.00	$15,000	Assumes $0.14 per kWh
Labor	1,000	lump sum	$92.00	$92,000	
Spare Pumps	3	pump	$1,000.00	$3,000	
SUBTOTAL				$111,500	
SUBTOTAL				$159,900	
Contingency	25%			$39,975	
SUBTOTAL				$199,875	
Project Management	5%			$9,994	
Technical Support	20%			$39,975	
TOTAL ANNUAL O&M COST				$250,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$1,554,000	$1,554,000	1.00	$1,554,000	
Annual O&M	2-30	$7,500,000	$250,000	18.04	$4,508,942	29 years, 3.5 %
		$9,054,000			$6,062,942	

TOTAL PRESENT VALUE OF ALTERNATIVE FOR 30YEARS $6,063,000

Table 3
Remedial Alternative Opinion of Probable Cost

GW Alternative 3
In-Situ Thermal Remediation (100 ppm)

COST ESTIMATE SUMMARY

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 2008
Date: 18-Oct-08

Description: Alternative 3 consists of in-situ thermal treatment of groundwater and soil within the 100 ppm total VOCs contour. Capital costs and O&M costs occur in Year 1.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
Site Work					
Pre-Design Investigation	1	lump sum	$100,000.00	$100,000	
Electrode Materials Mobilization	1	lump sum	$1,390,000	$1,390,000	
Subsurface Installation	1	lump sum	$350,000	$350,000	
Surface Installation and Start-up	1	lump sum	$1,050,000	$1,050,000	
Remediation System Operation	1	lump sum	$2,570,000	$2,570,000	
Demobilization and Contractor Report	1	lump sum	$174,000	$174,000	
Well Installation & Soil Sampling	1	lump sum	$1,451,000	$1,451,000	Assumes $74 Foot
Waste Disposal	200	Ton	$300.00	$60,000	
Electric Utility Connection	1	lump sum	$90,000.00	$90,000	
Electric Energy Usage	1	lump sum	$5,233,000.00	$5,233,000	Assumes $0.14 kWh
First year operation and maintenance	1	lump sum	$326,000.00	$326,000	
SUBTOTAL				$12,799,000	
Contingency	25%			$3,199,750	
SUBTOTAL				$15,998,750	
Project Management	8%			$1,279,900	
Remedial Design	15%			$2,399,813	
Construction Management	10%			$1,599,875	
TOTAL CAPITAL COST				$21,278,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
System Monitoring					
Vapor Sampling and Analysis	100	samples	$241.00	$24,100	
Condensate/Discharge Sampling and Analysis	60	samples	$300.00	$18,000	
Sampling Labor and Operational Checks	1,500	hours	$91.00	$136,500	
Groundwater Laboratory Analysis	250	samples	$120.00	$30,000	VOC analysis
Water/Condensate Disposal	500,000	gallons	$0.01	$5,000	
SUBTOTAL				$208,600	
Miscellaneous					
Contingency	25%			$52,150	
SUBTOTAL				$260,750	
Project Management	5%			$13,038	
Technical Support	20%			$52,150	
TOTAL ANNUAL O&M COST				$326,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$21,278,000	$21,278,000	1.00	$21,278,000	
Annual O&M	2-30	$0	$0	0.00	$0	30 years, 3.5 %
		$21,278,000			$21,278,000	

TOTAL PRESENT VALUE OF ALTERNATIVE FOR 30 YEARS $21,278,000

Table 3
Remedial Alternative Opinion of Probable Cost

GW Alternative 3(a)
In-Situ Thermal Remediation (10 ppm)

COST ESTIMATE SUMMARY

Site: Chemical Sales Corporation OU-1
Location: Gates, New York
Phase: Feasibility Study
Base Year: 2008
Date: 18-Oct-08

Description: Groundwater aAternative 3(a) consists of in-situ thermal treatment of groundwater and soil within the 10 ppm total VOCs contour. Capital costs and O&M costs occur in Year 1.

CAPITAL COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Institutional Controls					
Deed Restriction	1	LS	$5,000.00	$5,000	
Site Work					
Pre-Design Investigation	1	lump sum	$100,000.00	$100,000	
Electrode Materials Mobilization	1	lump sum	$2,780,000	$2,780,000	
Subsurface Installation	1	lump sum	$1,047,000	$1,047,000	
Surface Installation and Start-up	1	lump sum	$3,147,000	$3,147,000	
Remediation System Operation	1	lump sum	$5,140,000	$5,140,000	
Demobilization and Contractor Report	1	lump sum	$522,000	$522,000	
Well Installation & Soil Sampling	1	lump sum	$4,353,000	$4,353,000	Assumes $74 Foot
Waste Disposal	17,000	Ton	$300.00	$5,100,000	
Electric Utility Connection	1	lump sum	$90,000.00	$90,000	
Electric Energy Usage	1	lump sum	$15,699,000.00	$15,699,000	Assumes $0.14 kWh
Condensate Disposal	1	lump sum	$12,000.00	$12,000	
First year operation and maintenance	1	lump sum	$446,000.00	$446,000	
SUBTOTAL				$38,441,000	
Contingency	25%			$9,610,250	
SUBTOTAL				$48,051,250	
Project Management	8%			$3,844,100	
Remedial Design	15%			$7,207,688	
Construction Management	10%			$4,805,125	
TOTAL CAPITAL COST				$63,908,000	

OPERATION & MAINTENANCE COSTS:

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
System Monitoring					
Vapor Sampling and Analysis	300	samples	$241.00	$72,300	
Condensate/Discharge Sampling and Analysis	116	samples	$300.00	$34,800	
Sampling Labor and Operational Checks	1,500	hours	$91.00	$136,500	
Groundwater Laboratory Analysis	350	samples	$120.00	$42,000	VOC analysis
Water/Condensate Disposal	1,000,000	gallons	$0.01	$10,000	
SUBTOTAL				$285,600	
SUBTOTAL				$285,600	
Contingency	25%			$71,400	
SUBTOTAL				$357,000	
Project Management	5%			$17,850	
Technical Support	20%			$71,400	
TOTAL ANNUAL O&M COST				$446,000	

PRESENT VALUE ANALYSIS:

COST TYPE	YEAR	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR	PRESENT VALUE	NOTES
Capital	1	$63,908,000	$63,908,000	1.00	$63,908,000	
Annual O&M	2-3	$0	$0	0.00	$0	29 years, 3.5 %
		$63,908,000			$63,908,000	

TOTAL PRESENT VALUE OF ALTERNATIVE FOR THREE YEARS $63,908,000

Table 4

Combined Soil and Groundwater Alternatives

INCREASING TREATMENT

Remedial Alternatives	Groundwater NFA	Groundwater Extraction	ERH Thermal
Soil NFA	No source removal and minimally protective of sensitive receptors	Source contamination not removed from soil. Groundwater is treated and hydraulic flow is controlled.	NA
Soil Excavation and Off Site Disposal	Source contamination in soil removed and disposed of off-site. Requires importation of fill. No groundwater treatment or hydraulic control.	Source contamination in soil removed and disposed of off-site. Requires importation of fill. Groundwater is treated and hydraulic flow is controlled.	NA
Soil Excavation and On Site Thermal Desorption	Source contamination in soil removed and treated on site. No groundwater treatment or hydraulic control.	Source contamination in soil removed and treated on site. Groundwater is treated and hydraulic flow is controlled.	NA
ERH Thermal	NA	NA	Soil and groundwater contamination are treated, Source contamination destroyed. No hydraulic control.

INCREASING TREATMENT