FOCUSED
ALTERNATIVES ANALYSIS
AND REMEDIAL PLAN

Sooper Dry Cleaners
Normandy Park Shopping Center
Normandy Park, Washington

Prepared for:

Griffin & Jensen DBA

Normandy Park, Washington

Prepared by:

SCS ENGINEERS

Bellevue, Washington

June 2002

04201036.01

Environmental Consultants

2405 140th Avenue NE
Suite 107
Bellevue, Washington 98005-1877

425 746-4600
FAX 425 746-6747
www.scsengineers.com

SCS ENGINEERS

July 1, 2002
File No. 04201036.01

Mr. Frank Jensen
Griffin & Jensen DBA- Normandy Park Shopping Center
22608 Marine View Drive South
Des Monies, Washington 98198

Subject: **Final Report, Focused Alternative Analysis and Remedial Plan, Sooper Dry Cleaners, Normandy Park Shopping Center**

Dear Mr. Jensen:

Attached please find two copies of the final Focused Alternatives Analysis and Remedial Plan for the former Sooper Dry Cleaners site located at the Normandy Park Shopping Center, Normandy Park, Washington. In addition to the individuals copied below, a copy of the remedial plan will also be submitted to Mr. John Everett of the City of Normandy Park to notify the municipality of the proposed remedial actions.

Thank you for the opportunity to provide our services. If you have any questions, please do not hesitate to call.

Sincerely,

Daniel A. Venchiarutti, P.G.
Project Manager
SCS ENGINEERS

State of Washington
Hydrogeologist
168
Licensed Geologist
Daniel A. Venchiarutti

Gregory D. Helland, P.G.
Project Director
SCS ENGINEERS

cc: Agnes Griffin, Griffin & Jensen DBA
Ken Bloch, Wolfstone Panchot and Bloch
Brad Helland, Washington Department of Ecology

FOCUSED
ALTERNATIVES ANALYSIS
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Sooper Dry Cleaners
Normandy Park Shopping Center
17835 First Avenue South
Normandy Park, Washington 98148

Prepared for:

Griffin & Jensen DBA

22608 Marine View Drive South

Des Moines, Washington

(206) 824 - 9100

Prepared by:

SCS ENGINEERS

2405 140th Avenue NE

Suite 107

Bellevue, Washington

(425) 746-4600

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SECTION 1 INTRODUCTION

This Focused Alternatives Analysis and Remedial Plan was prepared by SCS Engineers for Griffin and Jensen DBA- Normandy Park Shopping Center to evaluate remedial alternatives and develop a cleanup action plan to address tetrachloroethene (PCE) contaminated soils and groundwater at the former Sooper Dry Cleaners site. This document is intended to support the independent cleanup actions that will be implemented at the site under Washington Department of Ecology's Voluntary Cleanup Program (VCP).

The Sooper Dry Cleaners business was formerly located in the Normandy Park Shopping Center at 19935 First Avenue South in Normandy Park, Washington. A series of environmental investigations at the site have reported the presence of PCE contaminated soil and groundwater beneath the western border of the shopping center. The primary point of release has been identified as a former dry well situated immediately behind the dry cleaner tenant space. The conduit formed by the septic line servicing the building is also considered to be a probable secondary source of subsurface contamination.

1.1 PURPOSE AND SCOPE

The purpose of this focused alternatives analysis and remedial plan is to identify applicable remedial technologies to mitigate and/or control the contamination issues identified at the site, detail their advantages and disadvantages for their specific implementation at the Sooper Dry Cleaners site, and recommend the most practical and cost-effective remedy for the site.

The Environmental Site Assessment Report (SCS Engineers, October 2001) prepared for the site included a preliminary remedial evaluation that concluded that aggressive treatment of the contaminated groundwater beneath the property would be impractical to implement, and at best would only provide a marginal benefit. Subsequent discussions with Ecology indicated that a more formal evaluation of the cost/benefit of site remediation alternatives was necessary to support the conclusions of the ESA. It was also indicated that any issuance of a no further action (NFA) determination for soil at the site will be contingent on the development of a groundwater remediation/management plan, which will need to be reviewed and approved by Ecology.

In the following sections of this report, remedial alternatives for both soil and groundwater are screened based on their effectiveness, cost-efficiency and suitability to site-specific conditions. The alternative analysis is then used to develop and support a remedial plan that recommends most appropriate remedies for implementation at the site. Since a passive remedy for groundwater contamination continues to be recommended, the report includes a proposed five-year groundwater monitoring program.

This document specifically includes the following components:

- A feasibility analysis of the remedial alternatives available to address contaminated soils and groundwater at the site. This focused analysis compares the effectiveness of each remedial technology and evaluates the site-specific cost/benefit of their implementation;

- A remedial/management plan identifying the soil and groundwater remedies proposed for implementation at the site. To the extent practical, the groundwater remedy will consider the installation of one or more additional offsite monitoring wells to further evaluate the downgradient extent of the contaminant plume; and
- A five-year groundwater monitoring plan to support the selected groundwater remedy. The proposed program includes both onsite and off-site (downgradient) monitoring points.

1.2 SUMMARY OF SITE CONDITIONS

Environmental investigations at the former Sooper Dry Cleaners indicate that historical releases of dry cleaning solvents have contaminated the subsurface soils and groundwater beneath the Normandy Park Shopping Center with chlorinated solvents, primarily PCE. The PCE contaminated soils present at the site are relatively limited and appear to be primarily associated with an old dry well behind the dry cleaner tenant space. In turn, the old dry well also appears to be the focus for the plume of PCE contaminated groundwater observed beneath the western end of the shopping center. In addition, lower-level PCE groundwater contamination also appears to be associated with several old septic tanks located near the center of the parking area (Figure 1).

1.2.1 Hydrological Setting

Subsurface conditions beneath the subject property are dominated by compact silts that grade into silty fine sands in the vicinity of the water table. Groundwater occurs approximately 40 feet beneath ground surface (bgs) in fine to medium sand with silty zones. Groundwater flow is predominantly to the west-southwest with a hydraulic gradient that ranges from approximately 0.004 to 0.02 ft/ft. Aquifer testing data collected at the site derived hydraulic conductivity values ranging between 5.5×10^{-5} to 2.9×10^{-4} ft/sec. Groundwater elevation data measured at a nested well (MW-5A/B) installed on the site show equal head values in both wells, which are vertically separated by 15 feet. These data indicate that the vertical hydraulic gradient at this location is minimal.

The ground surface hydrologically downgradient (towards the west) of the shopping center forms a broad plateau that abruptly rises over 50 feet above the subject property. As a result, the subject aquifer is situated approximately 115 feet bgs on the properties downgradient of the site. In addition, a distinct, shallow water bearing zone was observed to be perched on a till confining layer at 60 feet bgs in the offsite investigative area (at MW-13) approximately 1,000 feet southwest of the shopping center. Regional groundwater information suggests that the subject aquifer discharges along the Puget Sound shoreline approximately one half-mile further towards the west.

1.2.2 Extent of Subsurface Contamination

PCE Distribution in Soil

The most elevated PCE concentration observed at the subject property (5.1 mg/kg at 5' in MW-7) was encountered in the gravelly fill materials that comprise the upper 13 feet of the former dry well. The next highest soil concentrations were found within the upper horizons of the saturated zone directly beneath (0.85 mg/kg at 45' in MW-7) and immediately downgradient (0.82 mg/kg at 65' in MW-10) of the dry well. The remaining PCE detections in the soil ranged from 0.057 to 0.34 mg/kg. With few exceptions, the detectable contaminant concentrations were present in samples collected from depths of 10 feet or greater. The areal extent of the soil contamination observed at the subject site is illustrated on Figure 1 (see Appendix A).

Further evaluation of the soils data indicates that low, but detectable levels of PCE and several related compounds (TCE and PCA) are also present in the subsurface soils immediately to the west of the dry cleaner tenant space and the former septic tanks. These low level detections were sporadically observed throughout the vadose and saturated zones. No evidence of any non-aqueous phase liquids (NAPL) was observed in either the vadose or saturated zones during the site investigation.

The origins of the PCE contaminated soils observed in the former dry well remain uncertain. The dry well apparently dates from the original construction of the shopping center (late 1950's) and was used to drain storm water that accumulated on the roof over the dry cleaner and adjacent tenant spaces. Possibly, PCE-containing vapors from the dry cleaning machine may have been vented to the roof and accumulated in the rainwater that ultimately discharged into the dry well. In addition, the presence of PCE around the old septic tanks suggests that PCE containing liquids (possibly wash water from the dry cleaning machine) were also historically discharged into the sanitary sewer. No definitive information is available concerning the precise timing of these releases.

Neither PCE, nor any related compounds, were detected in any of the soil samples collected from the hand auger borings (HA-1 through HA-4) installed inside the dry cleaner tenant space. With the exception of Strataprobe boring SP-7, which was located beside the former septic tanks, PCE was not detected in any of the soil samples collected from along the sanitary sewer line. In addition, PCE was not detected in any of the borings installed on the far north and southern ends of the shopping center, or in the offsite monitoring well boring (MW-13) approximately 1,000 feet west-southwest of the subject property.

PCE Distribution in Groundwater

Groundwater PCE concentrations exceeding the 5 ug/L MTCA Method A standard have been detected in 11 of the 13 monitoring wells present on the shopping center. Neither PCE nor any related contaminants were detected in any of the groundwater samples collected downgradient of the shopping center at offsite well MW-13. The areal estimated extent of PCE contaminated groundwater beneath the subject property is illustrated on Figure 2 (see Appendix A).

The highest PCE concentrations (ranging between 2,300 to 8,300 ug/L) at the site were observed in the wells directly within (MW-7) and immediately downgradient (MW-2 and MW-10) of the former dry well. In addition, trichloroethene (TCE) was also reported in two of the onsite monitoring wells (MW-2 and MW-7) above its 5 ug/L MTCA Method A groundwater standard. These latter exceedances all occurred within the main body of PCE contaminated groundwater originating from the area of the dry well.

The most elevated PCE concentrations appear to be restricted to the groundwater flowing through the upper 10 to 20 feet of the saturated zone. This is best demonstrated in MW-8 (screened 90 feet bgs) which consistently reported lower-level PCE exceedances that remained an order of magnitude less that those reported in the shallow zones of the aquifer. Hydrological data (i.e. equal head values at MW-5A and MW-5B) also suggest that vertical gradients within the aquifer are minimal.

Lower PCE concentrations (ranging between 580 to 980 ug/L) were detected in several monitoring wells (MW-3, MW-5A and MW-6) further west-northwest from the former dry cleaner tenant space. Even through these PCE detections did not occur immediately downgradient of the former dry well, is believed that this contamination is originating from this structure. The relative flatness of the water table on the northern end of the shopping center, combined with seasonal fluctuations in the groundwater flow direction, appears to have spread the PCE contaminated groundwater further northwest towards these wells.

PCE groundwater contamination (ranging from 18 to 120 ug/L) was also observed in the vicinity of the old septic tanks and on the southwest corner of the property. The 18 ug/L detection in MW-11, (which is situated near the southwest corner of the property) appears to represent the southern edge of the main plume of PCE groundwater contamination. The 120 ug/L PCE detection in MW-9 may be part of a smaller plume of PCE contaminated groundwater that is originating from the old septic tanks and/or drain field. The lack of PCE or any related compounds in downgradient well MW-12 suggests that this latter plume remains limited in extent.

Due to the proximity of the property line, PCE contaminated groundwater is likely migrating beyond the western border of the shopping center. However, neither PCE nor any related contaminants have been detected in offsite well MW-13, which is situated approximately 1,000 feet directly downgradient of the property. The lack of groundwater contamination in MW-13 suggests that the plume of PCE contaminated groundwater observed beneath the shopping center may not extend to 4th Avenue South (Figure 5). As detailed in the ESA report, the subsurface conditions within the impacted aquifer appear to become increasingly reducing as the hydrological formation transitions from recessional to advance outwash in the areas immediately downgradient of the site. Natural attenuation of chlorinated compounds, including PCE, becomes increasingly favorable under reducing conditions.

1.2.3 Potential Data Gaps

Because extensive site data have been collected from the shopping center property (soil samples from 40 borings and groundwater samples from 12 onsite wells), the subsurface conditions beneath the site are considered to be adequately characterized. The full delineation of the extent of groundwater contamination downgradient of the subject property, however, has been severely constrained by both physical and logistical challenges specific to the site. These constraints largely stem from the local topography (i.e. a 50' cliff along the western property line, and the associated rise in elevation of the downgradient properties above the contaminated aquifer) and the presence of densely spaced residences in the areas west of the site.

It was in recognition of these challenges that a less invasive approach was originally devised for the offsite groundwater investigation. Quantitative groundwater flow modeling, combined with the construction of a single offsite monitoring well (MW-13) on a municipal right of way, was used to evaluate the likely current and future downgradient extent of the contaminant plume. As previously discussed, neither PCE nor any of its breakdown products were detected in MW-13. Although this approach resulted in the installation of a monitoring point downgradient of the site, Ecology has indicated that the downgradient extent of the contaminant plume has not been sufficiently delineated.

1.3 Remedial Action Objectives

The Normandy Park shopping center is a commercially-zoned property that is surrounded by residential developments. The 2001 revisions to Washington's Model Toxics Control Act (MTCA) provides for two categories of contaminated sites, unrestricted land use and industrial land. Under MTCA, the shopping center property is classified for unrestricted land use. Based on the investigation data, PCE, and to a lesser extent, TCE, have been identified as the main contaminants of concern. As a result, the remedial action objectives for the site will focus on unrestricted land use, taking into account site-specific conditions.

Before cleanup levels can be proposed at a site, all potential onsite and downgradient receptors must be identified to determine whether the impacted soils and groundwater presents any unacceptable risks. Potential exposure pathways and resulting remedial action objectives (ROA's) are discussed below.

1.3.1 Exposure Pathways

Impacted Soils

The contaminated soils identified at the subject site range in depth from 3 to 65 feet bgs, with most of these scattered PCE detections occurring at depths greater than 10 feet below ground surface. Excepting areas of perimeter landscaping, the entire site is covered with buildings and asphalt pavement. Therefore, direct contact with contaminated soil by the general public is not considered to be a viable exposure pathway. With the exception of the former dry well, the depth of the soil contamination also suggests that construction workers are unlikely to encounter significant exposure to the PCE soils. For similar reasons, volatile emissions from the PCE contaminated soils are not considered to present a significant exposure potential at the site.

While the overall level of soil contamination observed beneath the shopping center was relatively low, the presence of significant amounts of PCE in the shallow groundwater suggests that these impacted soils have leached and may continue to leach contaminants into the groundwater. As previously discussed, there is no evidence of NAPL at the site. Although the groundwater is not currently under beneficial use (i.e. drinking or irrigation water), the underlying aquifer is still be considered to be a potential future source of drinking water. As a result, soil leaching to groundwater remains a possible pathway for future exposure to PCE contamination.

Impacted Groundwater

Groundwater beneath the shopping center occurs at an average depth of approximately 40 feet below ground surface. Since all drinking and landscape irrigation water for the site has historically been provided by the Highline Water District, there is currently no potential for exposure to PCE contaminated groundwater at the subject property.

Because the land surface rises precipitously to the west of the subject property, the impacted aquifer lies over 110 feet below the properties immediately downgradient of the site. In addition, offsite investigations have identified a sizable shallow aquifer and confining layer of impermeable till which overlie the impacted aquifer. As detailed in the ESA report, the lack of PCE or related compounds in downgradient well MW-13 indicates that contaminated groundwater is not currently discharging to Puget Sound. Changes in the lithological condition of the aquifer (i.e. an increasingly reducing environment and higher organic carbon levels) immediately downgradient of the property may be directly attenuating and/or limiting the migration of the PCE contamination.

Consequently, the single potential exposure risk is anticipated to be ingestion of PCE contaminated groundwater by downgradient residents. However, both a detailed water supply records search and field survey of local downgradient residences found no evidence of any current municipal or domestic groundwater use. As a result, none of the local residents appear to currently be at risk from the consumption of PCE contaminated groundwater from the impacted aquifer.

1.3.2 Cleanup Level Goals

Based on the current land use and the most likely future development scenarios (i.e. shopping center or other commercial use), PCE and TCE contamination in the soils and groundwater beneath the site are not anticipated to present an unacceptable risk to potential receptors on the subject property. However, the contaminated soils beneath the site are apparently leaching PCE (and to a lesser extent, TCE) into the surrounding groundwater.

Based on input received from Ecology during the VCP technical review process, the soil cleanup level to be applied at the site will be the current unrestricted land use MTCA Method B standard for protection of groundwater. The Method B protection of groundwater soil standards are 0.053 mg/kg for PCE and 0.033 mg/kg for TCE, based on a 5 µg/L Method A groundwater standard for suspected carcinogenic compounds. These conservative Method B standards are virtually identical to the published MTCA Method A values for these compounds (0.050 mg/kg and 0.030 mg/kg for PCE and TCE, respectively).

Similarly, the Method A MTCA standard is applicable for groundwater at this site. The Method A standard for PCE and TCE in groundwater is 5 µg/L. However, it should be noted that these standards assume that some degree of exposure of contaminated groundwater to humans occurring at a site. To date, there is no evidence of any municipal or domestic groundwater use within a 3,000-foot arc downgradient of the site. Highline Water District records confirmed that all the residences downgradient of the site obtain their domestic water from the municipal provider. As a result, it does not appear that the PCE contaminated groundwater originating from the former dry cleaners currently presents a threat to human health. Conversely, it is apparent that PCE contaminated groundwater from the site has negatively impacted a potential future drinking water source.

SECTION 2 FOCUSED ANALYSIS OF REMEDIAL ALTERNATIVES

2.1 INTRODUCTION

The remedial evaluation provided in the ESA report concluded that aggressive remediation of the soil and groundwater contamination at the site was not practical or justified. The main reasons supporting this initial conclusion included the lack of a well-defined source material to treat, the depth of contamination, the low permeability of the site soils, and the lack of any human or ecological exposure. In addition, contaminant transport simulations suggested that only a marginal benefit in downgradient water quality would be realized even if the entire mass of contamination on the property (both unsaturated and saturated zones) could be effectively removed.

The following sections provide a more formal evaluation of the cost/benefit of possible site cleanup alternatives. As previously discussed, the plume of PCE contaminated groundwater appears to represent the principal long-term environmental issue associated with the subject property.

2.1.1 Alternatives Analysis Process

Under MTCA the selection of remedial alternatives involves evaluating cleanup methods that could be used at a site and then deciding which of those methods will best achieve cleanup standards. Aside from meeting cleanup standards, remedial actions must also comply with applicable state and federal laws, protect human health and the environment, provide for compliance monitoring, and to the extent practical provide a permanent site remedy. When it is not practical to restore a site to the cleanup standards, MTCA allows the use of engineered and land-use controls provided that the remedy remains protective of human health and the environment.

Remedial alternatives for both soil and groundwater are evaluated based on their effectiveness, cost-efficiency and suitability to site-specific conditions. During the initial stage of this process, remedial methods potentially applicable to PCE are prescreened to identify those that are most applicable to the site.

2.1.2 Criteria for Remedy Selection

Remedial alternatives that survive the preliminary analysis are assessed in greater detail using the cleanup evaluation criteria provided in MTCA. WAC 173-340-360 specifies that the following evaluation criteria be used to evaluate and compare cleanup action alternatives:

- Protectiveness to Human Health and the Environment;
- Permanence in Reduction, Mobility or Volume of Hazardous Substances;
- Cost of Implementation;
- Long-term Effectiveness;
- Management of Short-term Risks;
- Technical and Administrative Implementability; and
- Consideration of Public Concerns.

2.2 Applicable Technology Descriptions and Preliminary Screening

The technologies listed below are potentially applicable for the remediation PCE-impacted soils and groundwater:

- Bioremediation through Reductive Chlorination;
- Soil Excavation;
- Soil Vapor Extraction;
- Dual-Phase Extraction;
- Groundwater Pump and Treat;
- *In Situ* Chemical Oxidation;
- Air Sparging with/without Ozone;
- Soil Heating;
- Passive Reactive Wall; and
- Institutional Controls with/without Groundwater Monitoring.

An initial discussion of each of these remedial technologies is provided below.

2.2.1 Bioremediation through Reductive Chlorination

Bioremediation of PCE has the potential to be an effective destructive technology for PCE in groundwater, and to a lesser extent in soil, but only under anaerobic subsurface conditions. This is an *in situ* process that takes advantage of indigenous anaerobic microorganisms that will metabolize PCE to TCE, cis-1,2 DCE, vinyl chloride, and occasionally to ethane. Vinyl chloride is more toxic and mobile than PCE, but can degrade aerobically. Therefore, an aerobic environment is generally required downgradient of the source area to eliminate vinyl chloride.

In certain cases, primarily where the subsurface is marginally anaerobic, the natural breakdown of PCE can be enhanced though the application of reducing agents or electron donors (such as Hydrogen Release Compound – HRC®). Under the proper conditions, these compounds create an elevated chemical oxygen demand and deplete oxygen in the subsurface materials. Often a simple food source (alcohol or carbohydrate) is also provided to promote anaerobic metabolism. However, even enhanced reductive chlorination is only feasible at sites that are already relatively anaerobic.

The advantages of this technology include its *in situ* character, ease of application (even at depth), relatively low cost, and the destruction of PCE and TCE within the application area. Its primary disadvantages are the need for anaerobic background conditions (even with enhanced treatment), the risk associated with the creation of vinyl chloride, and the typically prolonged remediation duration.

Because subsurface conditions at the Sooper Dry Cleaners site are highly aerobic, neither natural nor enhanced bioremediation are anticipated to provide an effective cleanup technology. As a result, this technology will not be considered for further evaluation. However, since subsurface conditions downgradient of the site become increasing anaerobic, these areas may have an increased potential for naturally occurring reductive chlorination.

2.2.2 Soil Excavation

Soil excavation is a proven method for the remediation of PCE contaminated soils, and to a lesser extent PCE contaminated groundwater. This remedial method relies on source removal of the impacted soils, and the associated reduction or elimination of contaminant leaching into the surrounding groundwater. The contaminated soils generated can either be treated onsite or transported off-site to an appropriate treatment/disposal facility.

This alternative has the advantage of providing a permanent removal of PCE soil contamination over a relatively short period of time. In addition, excavation is a source removal technology that can help to reduce groundwater contamination at a site. The primary disadvantages of this technology are the need to disturb a large portion of the site, exposure of buried contaminants, disposal of potentially hazardous soils, and the associated costs and permitting requirements.

Given the relatively low concentrations of PCE in the soils beneath the Sooper Dry Cleaners, soil excavation does not appear to be an appropriate remedial alternative to address the majority of the site contamination. With the exception of the gravel fill in the upper 13 feet of the former dry well, most of the PCE impacted soils occurred at depths greater that 20 feet bgs. However, since limited soil excavation may be appropriate in the area of the former dry well, this technology will be retained for further consideration.

2.2.3 Soil Vapor Extraction

Soil vapor extraction (SVE) is an *in situ* technology that has been effectively used at numerous contaminated sites to treat PCE and TCE impacted soils. SVE removes contaminants from the unsaturated soils by volatilization. A vacuum is applied to the vadose zone via one or more extraction wells, and the PCE containing vapors are typically collected and treated onsite.

SVE is currently the presumptive remedy for soils that have been impacted by volatile organic compounds (VOCs), such as PCE and TCE. Its primary advantages are its small siting footprint, the ability to extract VOCs from beneath undisturbed structures, moderate costs, and a relatively short (6 to 18 month) treatment time. However, the main disadvantage of SVE is its limited effectiveness in treating low permeability (i.e. silty and clayey) and saturated soils. Given that the majority of the unsaturated soils beneath the Sooper Dry Cleaners site are comprised of low permeability silts, SVE is not considered to be a viable remedial alternative.

2.2.4 Dual Phase Extraction

Dual phase extraction technology involves extracting groundwater from a zone of contamination to depress the local water table so that SVE can be effectively applied to the dewatered soils exposed in the saturated zone. This method is implemented under a higher vacuum than standard SVE, and typically uses duel-phase (i.e. combined groundwater and vapor) extraction wells. The two phases are separated at the surface and treated before discharge. Common VOC treatment trains include air stripping and carbon filtration.

This remediation method retains many of the advantages of SVE, and is better suited for use in low permeability and saturated soils. Its disadvantages include difficulty in dealing with water table fluctuations, a complex and labor intensive control system, a prolonged treatment period, and high overall cleanup cost. In addition, the marginal benefit of duel phase extraction would be significantly reduced at the Sooper Dry Cleaners site, where the aquifer permeability would require high groundwater extraction rates to sufficiently depress the water table. Because this technology would require the constant extraction of large volumes of PCE contaminated groundwater (that would require treatment) to be effective, it will not be considered for further evaluation.

How can you have it both ways

2.2.5 Groundwater Pump and Treat

Pump and treat technologies were the first cleanup methods to be broadly applied to sites with contaminated groundwater. Although this technology has many variations, it primarily involves actively extracting groundwater and pumping it to a surface treatment plant. Common treatment trains include air stripping and carbon filtration. Although pump and treat has been demonstrated to be capable of temporarily capturing or containing a contaminant plume, its has proven to be generally ineffective in reaching low cleanup levels. This is principally due to mass transfer limitations common to fine-grained and/or variable soils.

Pump and treat technologies tend to generate large volumes of contaminated groundwater that require treatment, have extremely long treatment periods, and are often prohibitively expensive. Therefore, this technology will not be retained for further consideration.

2.2.6 *In Situ* Chemical Oxidation

In situ chemical oxidation involves injecting a strong oxidant into the subsurface to react with and destroy contaminants directly within the impacted media. Three primary forms of oxidants can be applied with this technology, including Fenton's reagent (hydrogen peroxide with ferrous iron), sodium permanganate ($NaMnO_4$) and ozone. When the process can run to completion, the oxidant chemicals react with PCE, TCE and their intermediate breakdown products (including vinyl chloride) to produce innocuous substances such as carbon dioxide (CO_2), water and inorganic chloride. Where site conditions do not allow for the complete breakdown of harmful intermediate compounds, extraction wells may be required downgradient of the treatment zone. In certain circumstances, unused oxidant may also need to be recovered.

The principal advantage of this technology is the *in situ* destruction of chlorinated solvents and their harmful breakdown products. However, to date *in situ* chemical oxidation has only been used at relatively few sites. Other disadvantages of this technology include the difficulty in distributing oxidant into the subsurface, competition for oxidants from naturally occurring reduced minerals and organic carbon in the formation, the potential to affect subsurface conditions (i.e. lowering pH, raising temperature), and its relatively high cost. In addition, the chemical oxidants are extremely reactive when applied, so that worker safety issues can be a concern. It spite of these challenges, *in situ* chemical oxidation could potentially reduce the PCE groundwater contamination that may be migrating from the site, and will be retained for further considered.

2.2.7 Air Sparging with/without Ozone

Air sparging is primarily a groundwater treatment technology. Injection wells are used to inject a gas (usually ambient air or ozone) into the impacted aquifer to strip VOCs directly from the groundwater and saturated soils. If the injected gas is air, the VOCs are carried to the vadose zone, where they must be collected using SVE and treated before discharge. If ozone gas is used, VOCs are chemically destroyed *in situ* through oxidation and limited or no SVE is required to capture the emissions.

In addition, variants of these standard air sparging technology, such as the UVB treatment system, have recently been developed. The UVB system (also referred to as vacuum vaporization well technology) performs both the air sparging and vapor extraction processes within a single air injection-vapor recovery well. Air and groundwater are circulated through the well to promote contaminant volatization and to establish convection cells within the saturated zone to promote the continued capture of the contaminant plume. As with standard air sparging techniques, the captured vapors often require surface treatment prior to discharge.

These sparging technologies have the advantage of being relatively easy to operate and avoiding the generation of contaminated groundwater. However, similar to SVE, this technology works best in high permeability soils and would be expected to provide only limited treatment and/or vapor recovery within the low permeability soils that underlie the Sooper Dry Cleaners site. For this reason, air sparging will not be retained for further consideration. However, ozone sparging would not require an SVE component, and could potentially be used to treat PCE in groundwater. Since they represent similar technologies, ozone sparging will considered further as part of the chemical oxidation alternative.

2.2.8 Soil Heating

Soil heating is an *in situ* remedial technology that utilizes the application of thermal energy to volatize and degrade contaminants in both the vadose and saturated zones. The two main soil heating methods are the ISTD thermal blanket technology (TerraTherm®) and the six-phase soil heating technology (Current Environmental Solutions®). The ISTD thermal blankets consist of high-temperature elements that are deployed immediately over contaminated soils to heat the subsurface media and volatize contaminants. With six-phase soil heating, an array of metallic electrodes are vertically deployed in the contaminated media and an electrical current is applied to volatize the contamination. Vapor recovery (i.e. SVE) and surface treatment of collected vapors is generally required to supplement these technologies.

Because ISTD thermal blankets are only effective on surface or shallow subsurface contamination, this technology would not be appropriate for the relatively deep PCE contaminated soils present at the subject site. Six-phase soil heating elements could potentially be driven into the PCE contaminated soils 40 to 60 feet bgs. However, as previously discussed for other remedial technologies, the low permeability soils beneath the site would likely inhibit the effectiveness of this technology. In addition, only limited performance data are available to reasonably gauge the likely effectiveness of six-phase soil heating under site-specific conditions. For this reasons, soil heating technologies will not be retained for further consideration.

2.2.9 Passive Reactive Wall

A passive reactive wall is a groundwater treatment technology. Typically a trench is excavated into the saturated zone near the downgradient edge of the source of PCE contamination. The trench is filled with reactive materials (usually iron filings) that abiotically catalyze the degradation of the dissolved contaminants. The advantages of this remedial alternative are an ability to degrade PCE and a lack of operation and maintenance costs. The main disadvantages are that this technology does not treat contaminated soils and the installation costs rise precipitously for sites where the zone of groundwater contamination exceeds 20 feet bgs.

Passive reactive walls have been successfully deployed at several PCE and TCE sites in Washington. However, for this technology to be effective, the reactive wall must penetrate through the full thickness of the aquifer and be keyed into the lower confining unit. Given the depth to (> 40 feet) and thickness of (>50 feet) the saturated zone beneath the Sooper Dry Cleaners site, the installation of a passive reactive wall is impractical to implement. This technology is dropped from further consideration.

2.2.10 Institutional Controls with/without Groundwater Monitoring

Institutional controls are engineered and land-use measures that can be deployed at a property to isolate and contain site contaminants. This remedial alternative typically includes the use of impermeable barriers (such as liners or surface pavement) to prevent exposure to the affected media. Similarly, institutional controls are often deployed to minimize the contact of contaminated soils to clean surface or groundwater, and thereby limit the leaching of contaminants to downgradient groundwater. This alternative is commonly used at contaminated sites where more aggressive remedial technologies are infeasible, ineffective or result in appreciable residual contamination that must be managed in place. Institutional controls often include measures (such as rezoning, covenants, and deed restrictions) to limit or prohibit activities that could result in exposure to hazardous substances at a site. Also, some form of compliance monitoring (typically several years of groundwater sampling) is often a necessary component of this alternative.

Institutional controls have been successfully used at many contaminated site, both as a stand-alone alternative or combined with limited treatment technologies. The main advantages of institutional controls are that they can be deployed at sites where aggressive treatment is ineffective and/or impractical, and that when properly implemented these measures will reduce the exposure to site contaminants to acceptable levels. The principal disadvantage is that beyond natural attenuation and dispersion, this alternative does not reduce the mass of contamination. As a consequence, institutional controls must often be maintained over the lifetime of property use.

Because the soil and groundwater contamination beneath the Sooper Dry Cleaners site is unlikely to be completely amenable to aggressive treatments (either removal or destruction technologies) it is anticipated that the majority of the residual PCE will need to be managed using institutional controls. This alternative will be retained for further consideration.

2.3 FINAL ALTERNATIVE COMPARISON

The preliminary screening matrix provided in Table 3 (Appendix B) indicates which alternatives are applicable to soil, groundwater, or both. Table 3 also summarizes the relative effectiveness of each of these technologies for each media and qualitatively compares their implementability and cost. The effectiveness evaluation focuses on the technical ability of the technology to destroy, reduce or otherwise control the contaminants of concern. Implementability is a measure of whether the technology is practical at the site based on logistical and regulatory constraints. Relative costs are provided to allow comparison between technologies with similar effectiveness and implementability.

As summarized on Table 3, three remedial alternatives were retained for further consideration at the Sooper Dry Cleaners site including:

- Soil Excavation;
- *In Situ* Chemical Oxidation; and
- Institutional Controls.

In addition, groundwater monitoring is discussed as a distinct task that would need to be implemented to monitor the effectiveness of the selected remedy regardless of which alternative or combination of alternatives is selected. The requirement for additional downgradient offsite monitoring well(s) to supplement the downgradient well MW-13 is also discussed.

Since the surviving alternatives have differing capacities to mitigate adsorbed and dissolved contaminants, each technology is evaluated separately for their potential effectiveness on the PCE soil and groundwater contamination observed at the subject site. Table 4 (Appendix B) summarizes the advantages and disadvantages of each of these alternatives. Table 5 provides a matrix comparing the three alternatives with respect to the MTCA remedial evaluation criteria.

Quantitative cost estimates for the implementation of each of these alternatives at the subject site are provided in Tables 6 through 8. The estimated costs for completion of a five-year groundwater monitoring program and the installation of two additional offsite groundwater wells are provided in Tables 9 and 10, respectively. It should be noted that the all the costs provided in Tables 6 through 10 are approximate estimates with an uncertainty on the order of +/- 25 percent. In addition, these tables do not include costs for supporting tasks such as the preparation and distribution of downstream notifications (required by Ecology) and the decommissioning of on- and off-site groundwater wells at the conclusion of the monitoring program. For completeness, estimated costs for these ancillary tasks are summarized at the conclusion of the alternative analysis (Section 2.4).

2.3.1 Soil Excavation

The soil excavation alternative could potentially be implemented at the subject property using either of two basic soil removal options. The most aggressive form of this alternative would attempt to physically remove all of the PCE and TCE contaminated soils that exceed MTCA Method A soil standards. Given the areal extent and depth of the PCE soils illustrated on Figure 1, it is estimated that on the order of 14,000 cubic yards of soil would require excavation. Conversely, a less aggressive excavation alternative would focus on the removal of the most highly contaminated and accessible soils. This limited excavation option would remove an estimated 30 to 50 cubic yards of impacted fill from the upper 15 feet of the former dry well. The work zones for the both the widespread and limited excavation alternatives are illustrated on Figure 3.

As detailed in Table 6, the widespread soil excavation option has extremely high contractor and disposal costs (on the order of $2,175,000). Because of the depth of the soil contamination, implementation of this alternative would also necessitate extensive shoring and could possibly threaten to undermine the adjacent building (Figure 3) Due to these impacts and its overall inefficiency, widespread soil excavation is not considered to be an appropriate remedial method.

Limited excavation of the fill material within the former dry well appears to represent a more efficient and easier to implement remedial alternative. In addition to removing the most highly contaminated soils observed at the site, this alternative also provides for the decommissioning of a suspected conduit for the observed PCE contamination. Limited excavation can also be effectively combined with the implementation of institutional controls at the site.

Soil Component

The limited soil excavation alternative would involve the following steps:

- Obtaining utility and city grading permits;
- Clearing the work zone by disconnection of overhead electrical and phone wires;
- Excavating up to 50 cubic yards of PCE impacted gravel fill in the upper 13 to 15 feet of the dry well;
- Stockpiling the excavated materials and conducting further soil characterization, as necessary, to ensure proper offsite disposal;
- Backfilling the dry well with clean materials;
- Repaving the area; and
- Reconnection of the overhead utilities.

Ecology would have to approve the soil removal plan and provide a "contained-in determination" designation for the non-hazardous PCE containing soils removed from the site. Although none of the soil previously analyzed from the dry well designate as dangerous wastes (all < 5mg/kg PCE), if dangerous wastes were encountered during the soil excavation these materials would have to be properly characterized and disposed at a hazardous waste landfill.

Groundwater Component

The implementation of the soil excavation alternative would not provide any direct reduction in the groundwater contamination. All the soil removal activities would occur well above the water table. However, some indirect benefit to groundwater quality would be derived from the removal of source materials in the dry well, and the corresponding reduction in contaminant leaching to the underlying groundwater.

As shown on Table 6, the cost to implement the limited excavation alternative is estimated to be approximately $25,000. This cost estimate assumes that none of the excavated materials will designated as a dangerous waste. Depending on contractor availability and the permit review time, it is anticipated that this alternative could be completed in approximately six to ten weeks.

2.3.2 *In Situ* Chemical Oxidization

The most applicable *in situ* chemical oxidation alternative for the subject property would involve the injection of both Fenton's reagent and sodium permanganate ($NaMnO_4$) into the saturated soils beneath the western end of the shopping center. These oxidants would be applied separately, using two discrete applications several weeks apart. Fenton's reagent would be initially applied in the immediately vicinity of the dry well to attempt partial source control within the soil column. A follow-up application of sodium permanganate would then be made both near the dry well and along the western property border to reduce the dissolved phase. Sodium permanganate has the advantage of providing a longer residence time, and its use could potentially allow for a wider area of treatment.

During the initial application period, Fenton's reagent would be pumped into three injection wells within and immediately downgradient of the dry well. An estimated 9,000 pounds of oxidant would be applied during this period. After allowing several weeks for the initial reaction to subside, approximately 2,000 to 3,000 pounds of sodium permanganate would be pumped into a total of eight injection wells (including the three wells used for the initial Fenton's reagent application). Each application point will require the installation a 2-inch diameter stainless steel injection well to depths ranging to 60 feet bgs. Pumping equipment (such as that licensed by Geo-Cleanse®) would then be used to inject the oxidant into the subsurface. Each application, including the installation of the injection wells, would require approximately two weeks to complete. It should also be noted that depending on the effectiveness of the initial treatment, follow-up applications of oxidant may be necessary to achieve any meaningful improvement to the site.

As detailed in Table 4, the primary advantages of this alternative are that it can breakdown PCE and TCE to simpler compounds, treatment can be completed over a relatively short period (several months), and the duration of post-treatment groundwater monitoring may be reduced. However, this technology will be relatively difficult to implement at the subject site (due to the low permeability soils and a 40+ foot depth to groundwater), and will potentially generate harmful byproducts (vinyl chloride and/or unused oxidant). Due to the latter issue, several rounds of groundwater monitoring will need to be competed at the site during and following the treatment period.

In addition, the likely effectiveness of *in situ* chemical oxidation at the site remains somewhat uncertain since it is not a widely used technology and only limited performance data are currently available to gauge its potential effectiveness under site-specific field conditions. As illustrated on Table 7, the costs involved with a one-time combined Fenton's reagent/sodium permanganate application and the supporting activates are relatively high (on the order of $290,000).

Soil Component

This alternative will not result in any significant treatment of the vadose zone soils. The application of Fenton's reagent into the saturated soils would be anticipated to reduce the PCE contamination in the immediate areas of the dry well. Because hydrogen peroxide is extremely reactive and quickly consumed, it will only treat a limited area. Although sodium permanganate will be injected over a wider area, this treatment will primarily be effective against the dissolved component. Consequently, this technology will not effectively treat PCE contaminated saturated soils beyond the immediately footprint of the dry well. The ultimate effectiveness of these treatments is uncertain since this technology remains highly sensitive to site-specific conditions.

Groundwater Component

In situ chemical oxidation by sodium permanganate would be anticipated to reduce PCE concentrations in the contaminated groundwater in the vicinity of the dry well. Depending on the intensity of the subsurface reaction, some of the excess oxidant may migrate beyond the western property border and provide some additional groundwater treatment downgradient of the site. However, even the most intense application of sodium permanganate would not be expected to reduce the levels of PCE contamination to the point where the aquifer would be suitable for beneficial use. Multiple applications of oxidant would likely be required to achieve any significant contaminant reductions. In addition, groundwater downgradient of the application area would need to be routinely monitored during the treatment period for harmful breakdown products.

The lack of any significant exposure of PCE contaminated groundwater to humans or the environment and the uncertain effectiveness of this technology under site-specific conditions limit the appropriateness of this technology. Further, measures to address the soil contamination in the unsaturated zone would likely still be required to control future leaching to groundwater, as would long-term groundwater monitoring. Accordingly, aggressive groundwater treatment by *in situ* chemical oxidation will not be further considered as an appropriate remedial method for the Sooper Dry Cleaners site.

2.3.3 Institutional Controls

The institutional controls alternative involves implementing of a series of engineered and site-management measures to ensure that the PCE impacted soils and groundwater beneath the site remain isolated from potential human and environmental receptors. Engineering controls being considered for the subject site include the replacement/repair of old sanitary sewer and stormwater lines in the areas of soil contamination, the decommissioning of three out-of service septic tanks, the installation of a surface water drain line along the foot of the exposed hill slope along the western property border, and repairing damaged surface pavement. Site-management controls will likely include deed restrictions on the subject property, as well as the notification of downgradient municipalities and/or property owners that could potentially be impacted by groundwater contaminants migrating offsite.

As detailed on Tables 4 and 5, this alternative can effectively prevent exposure to site contaminants and has a high degree of technical and administrative implementability. Although institutional controls will not directly reduce the volume of the PCE contaminated soil and groundwater beneath the site, their use can be expected to decrease PCE leaching into the groundwater from the vadose zone soils.

Soil Component

The main components of the institutional controls alternative would include the following:

- Obtaining utility and city grading permits;
- Replacing two sections (approximately 320 linear feet) of sanitary sewer line behind the main building and in the main parking area;
- Replacing the storm water line (approximately 300 linear feet) that parallels the hill slope behind the main building;
- Installation of a shallow french drain (approximately 250 linear feet) along the foot of the hill slope to collect surface runoff and direct the flow into the storm water system;
- Decommissioning the three old septic tanks (each estimated at 1,000-gallons capacity) located beneath the main parking area; and
- Repaving the entire area immediately behind the main building and disturbed portions of the parking areas.

The engineering measures proposed under the institutional controls alternative are illustrated on Figure 4. Once the site work is completed, a soil management plan will need to be developed to ensure the long-term maintenance of these site controls. As previously discussed, administrative measures (i.e. restricting further use of site groundwater, implementation of the soil management plan and downgradient notifications) will be used to support the engineering controls. Implementation of these institutional control measures will effectively prevent surface receptors from being exposed to impacted soils.

Groundwater Component

As previously discussed, institutional controls will not directly decrease the volume of site contaminants. However, the engineering measures outlined above will isolate the impacted soils from surface water infiltration, thereby reducing the potential for future soil leaching of PCE and TCE into the groundwater. In addition, onsite deed restrictions (i.e. controlling future groundwater use) and off-site notifications (of local municipalities and property owners) will be used to prevent exposure to the impacted groundwater.

As shown on Table 8, the cost to implement the institutional controls alternative outlined above is estimated to be approximately $104,000. Depending on contractor availability and the permit review time, it is anticipated that this alternative would require approximately two to four months to complete.

2.3.4 Groundwater Monitoring

Groundwater monitoring will be a necessary component of each of the remedial alternatives under evaluation. Both the scope and duration of the monitoring program will vary depending on the remedy selected for implementation at the site. As detailed in Table 4, successful completion of an aggressive remediation (such as *in situ* chemical oxidation) could potentially reduce the length of compliance monitoring. However, since such aggressive treatment of the PCE impacted soils and groundwater is not practical at the site, a more extensive groundwater monitoring program will need to be established.

Because both limited soil excavation and institutional controls alternatives will involve the in-place management of contaminated media beneath the site, it is anticipated that a minimum of three to five years of groundwater monitoring will be required to confirm the effectiveness of these site remedies. The monitoring program will focus on confirming that groundwater conditions beneath the site are improving (or have at least stabilized), and that unacceptable levels of PCE are not impacting downgradient receptors or discharging into Puget Sound.

To accomplish these objectives, the selected monitoring program will need to routinely sample both on-site groundwater wells near the center of the contaminant plume, as well as off-site monitoring wells downgradient of the subject property. Based on the existing site data, an optimally-sized monitoring program for the former Sooper Dry Cleaners site would include routine groundwater sampling at eight to 12 on- and offsite well locations. As detailed Section 4 (Groundwater Monitoring Plan), three years of quarterly sampling followed by two years of semiannual sampling are proposed for the site. Groundwater analysis (EPA Method 8260) will be conducted for PCE, TCE and their related breakdown compounds. As shown on Table 9, the estimated cost for implementing this type of groundwater monitoring program at the site is approximately $125,000.

Additional Off-site Groundwater Assessment

As previously discussed, physical and logistical constraints have limited offsite groundwater investigations to the installation of a single downgradient well (MW-13) supported by extensive groundwater modeling. Ecology has indicated that additional offsite assessment is required to better evaluate the downgradient extent of the PCE groundwater contamination. Also, additional offsite monitoring points will be necessary to confirm the effectiveness of any site remedy that involves inplace management of residual contamination.

On May 23, 2002, SCS Engineers met with the City of Normandy Park to discuss whether permission could be obtained to install one or more additional downgradient monitoring wells on city property or easements to supplement the existing offsite well. Based on these discussions, it was determined that Marivista Park (a city administered park approximately 1,000 feet west of the site) was the most workable option for siting any additional off-site groundwater wells. As a result of these discussions, SCS Engineers submitted an application for a right-of-way permit to install up to two groundwater monitoring wells in the south-central portions of the park. Based on discussions with the Normandy Park's planning department through June 2002, it appears that the City will likely grant permission to install the proposed monitoring wells. Additional discussions with City and Marivista Park staff will be necessary to formalize access issues.

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Depending on site conditions, the proposed offsite well(s) will be completed to a maximum depth of 250 feet bgs. Similar to the installation of MW-13, Hydropunch groundwater samples will be collected at 20 foot intervals within the subject aquifer during the drilling operations to optimize the well construction. The well(s) will be constructed consistent with Ecology requirements, and will consist of two-inch diameter PVC casing with a 5-foot long section of factory slotted PVC screen. Each well will require approximately seven to 10 field days to complete.

The proposed locations for the additional offsite monitoring wells are illustrated on Figure 5. As detailed on Table 10, the estimated cost for the installation of two additional offsite groundwater monitoring wells is approximately $123,000.

2.4 ALTERNATIVE SUMMARY AND REMEDY SELECTION

Even though each of the remedial alternatives retained for the final alternative comparison can potentially be applied at the Sooper Dry Cleaners site, their likely effectiveness and implementation costs vary significantly. Both the widespread soil excavation and in situ chemical oxidation alternatives could remove/destroy a portion of the PCE contamination beneath the site, but would likely leave significant contamination inplace (i.e. within the saturated zone for soil excavation and within the unsaturated zone for chemical oxidation) and be too impractical and expensive to effectively implement. Limited soil excavation and institution controls would also leave most of the PCE contamination inplace, but would furthermore reduce contaminant mobility, prevent exposure to surface receptors, and be significantly easier to implement at the site.

As previously discussed, each of the final alternatives will need to be supplemented by additional remedial tasks including: long-term groundwater monitoring, additional off-site well installation, notification of downgradient municipalities and property owners, and final decommissioning of the well field upon termination of the monitoring program. A summary of the estimated costs to complete each of the final cleanup alternatives through the end of the remedial program is provided below.

FINAL ALTERNATIVES - SUMMARY OF ESTIMATED REMEDIAL COSTS[1]

Remedial Alternative	Basic Technology Costs	Supplemental Task Costs	Total Remedial Costs
Soil Excavation	Limited : $ 25,000	Groundwater Monitoring: $ 125,000	$ 25,000[2] to
	Widespread: $ 2,175,000	Additional Well Installations: $ 123,000	$ 2,440,000
In Situ Chemical Oxidation	$ 290,000	Downgradient Notifications: $ 8,000	$ 556,000
Institutional Controls	$ 103,000	GW Well Decommissioning: $ 10,000	$ 370,000

1 Detailed cost estimates for each remedial alternative are provided in Appendix B.
2 Assumes that the limited excavation alternative will only be viable if combined with one of the remaining remedial alternatives.

Based on the results of our remedial alternative evaluation, we recommend that both the limited soil excavation and the institutional controls alternatives be selected for implementation at the Sooper Dry Cleaners site. The combination of these two alternatives will remove the shallowest, most PCE-impacted soils observed at the site, while providing for the secure inplace management of the residual contamination beneath the property. Given that there is no downgradient exposure to site contaminants, these remedial measures are anticipated to remain protective of human health and the environment. The installation of new downgradient monitoring wells combined with a five-year groundwater monitoring program will provide additional assurance that these remedial measures continue to effectively isolate the PCE contamination.

SECTION 3 REMEDIAL PLAN

3.1 SUMMARY OF REMEDIAL CONSIDERATIONS

Remedial goals for any cleanup actions proposed at the Sooper Dry Cleaners site must take into account the lack of existing exposure routes and the technical difficulties associated with the treatment of chlorinated compounds. Based on the current land use and the most likely future development scenarios (i.e. shopping center or other commercial use), the PCE and TCE concentrations observed beneath the site are not anticipated to present an unacceptable risk to potential receptors on the Normandy Park property. Also, given the depth to groundwater beneath the site (40 feet bgs) and at downgradient properties (> 110 feet bgs), exposure to contaminated groundwater is unlikely, given the lack of any domestic or water production wells.

As described in the preceding alternatives analysis, the remediation goals that can be practically achieved at this site will be limited since even the most aggressive remedial technologies will at best remove and/or treat only a portion of the subsurface contamination, while still requiring some degree of long-term onsite management. Similarly, even though PCE contaminated groundwater is likely migrating beyond the downgradient property border, offsite groundwater chemistry and conservatively structured contaminant transport simulations do not suggest any significant exposure to downgradient receptors. Although the historic releases from the site have negatively impacted a potential future source of drinking water, it remains unlikely that even an extremely aggressive remedial program would be able to restore this potential resource to a sufficiently pristine state to allow for its highest and best use. Based on these site constraints, the remedial remedy selected for the site will rely on isolation and long-term in-place management of the majority of the subsurface contamination.

3.1.1 Soil Remediation Levels

As previously discussed, the soil cleanup standard to be applied at the subject property was determined to be the unrestricted land use MTCA Method B standard for protection of groundwater. Consequently, the soil remediation levels assigned to this site will also be defined as the MTCA Method B standard for protection of groundwater (0.053 mg/kg for PCE and 0.033 mg/kg for TCE). check calcs

However, due to the depth and sporadic distribution of the site contamination, it will not be possible to effectively remove and/or treat the majority of the impacted soils beneath the shopping center. As a result, the soil remediation levels set for the site will be met through a combination of source removal (the excavation and decommissioning of the old dry well) and the implementation of institutional controls. The property border will be used to define the standard point of compliance for implementation of these remedial measures.

3.1.2 Groundwater Remediation Levels

Groundwater remediation levels applied at the subject property will be defined by the Method A MTCA groundwater standard (5 µg/L for both PCE and TCE). Given the lack of any exposure to PCE contaminated groundwater, as well as the limitations of available treatment technologies, the groundwater remediation levels for the site will be achieved through the implementation of the same source removal and institutional controls used to mitigate the soil contamination.

These remedial measures will be supported by extensive groundwater monitoring and downgradient notifications to ensure that impacted groundwater remains isolated from both onsite and downgradient receptors. Assuming that the additional groundwater investigations (i.e. the installation of additional offsite monitoring wells) continue to indicate a lack of downgradient exposure, a conditional point of compliance (per MTCA 173-340-720) will be established along the well front (approximately 1,000 feet west of the site) that parallels 4th Avenue South.

3.2 CLEANUP ACTION PLAN

The remedial alternatives selected as most appropriate for implementation at the Sooper Dry Cleaner site combine the following cleanup activities:

- Limited Soil Excavation;
- Institutional Controls;
- Installation of Additional Offsite Groundwater Wells; and
- Groundwater Monitoring.

The scope and rational for each of these remedial tasks are specifically discussed in the preceding alternatives analysis. The details of the cleanup action are reiterated in the remedy descriptions presented below.

3.2.1 Elements for Soil Remedy

The soil remedy proposed for the site involves limited excavation of the contaminated fill within the old dry well immediately behind the dry cleaner tenant space, and the use of engineering and administrative institutional controls across the remainder of the site. Excavation of the upper portions of the dry well will remove the shallowest, most PCE-impacted soils observed at the site, and will allow for the closure of a potential conduit for surface water infiltration. Engineering measures, focusing on repairing and upgrading the stormwater and sanitary sewer systems, will further isolate PCE impacted soils from surface water and reduce contaminant leaching within the vadose zone. Administrative controls, including the implementation of a soil management plan, will ensure that all of the contaminated soils remaining onsite will continue to be properly managed during future site use and/or redevelopment.

The basic elements for the soil remedy will include the following:

- Obtaining utility and city grading permits;
- Excavating and properly disposing of an estimated 50 cubic yards of PCE impacted gravels in the upper 15 feet of the old dry well;
- Backfilling and decommissioning the dry well;
- Replacing two sections (approximately 320 total linear feet) of sanitary sewer line behind the main building and in the main parking area;
- Replacing the storm water line (approximately 300 total linear feet) behind the main building;

Excavation of soil around septic line replacements?

- Installation of a french drain (approximately 250 total linear feet) along the foot of the hill slope that parallels the western property border to collect surface runoff and direct the flow into the storm water system; effluent sampling?
- Decommissioning three old septic tanks (each estimated at 1,000-gallons capacity) located beneath the main parking area;
- Repaving all disturbed areas and repairing any sections of broken pavement present along the western end of the site; and
- Preparation of a soil management plan.

Figures 3 and 4, respectively, illustrate the specific areas on the property where the limited soil excavation and engineering control measures will be implemented. Completion of these control measure will result the following site improvements:

- Removal of the shallowest, most PCE-impacted soils;
- Elimination of conduits for surface water infiltration and utility line leakage in areas of residual soil contamination;
- Overall reduction in contaminants leaching to groundwater in the unsaturated soil column; and
- Further isolation of residual PCE contamination from surface receptors.

Although it is not anticipated that any dangerous waste materials will be encountered during site cleanup, all the excavated soils will be properly characterized to ensure their proper disposal.

3.2.2 Elements for Groundwater Remedy

In addition to the limited source removal measures outlined above, the groundwater remedy will rely on institutional and administrative controls to reduce the offsite migration of PCE contaminated groundwater and prevent any surface exposure to site contaminants. Provided there is no downgradient exposure, this remedy is anticipated to remain protective of human health and the environment. The installation of additional downgradient monitoring wells combined with a long-term groundwater monitoring program will provide assurance that the site remedy is effectively isolating the PCE contamination:

The basic elements for the groundwater remedy will include the following:

- Installation of additional offsite monitoring wells to further evaluate the downgradient extent of the groundwater contamination;
- Implementation of a five-year groundwater monitoring program to evaluate the effectiveness of the site control measures and ensure no downgradient exposure to PCE contaminated groundwater;
- Providing notification to downgradient municipalities and property owners to ensure that PCE contaminated groundwater from the impacted aquifer will not be inappropriately tapped for beneficial use; and
- Long-term maintenance of the engineered surface control measures deployed at the site.

The proposed locations for the additional offsite groundwater monitoring wells are illustrated on Figure 5. The proposed groundwater monitoring plan for the site is detailed in the final section of this document.

3.3 ESTIMATED BUDGET AND TIMELINE FOR SITE REMEDY

As detailed in the summary below, the estimated cost to complete the remedial program recommended for the Sooper Dry Cleaners will be approximately $395,000. With the exception of the five-year groundwater monitoring, the remedial tasks are anticipated to require on the order of six to nine months to complete.

ESTIMATED TIMELINE AND COSTS FOR SITE REMEDY[1]		
Remedial Task	**Estimated Duration**	**Estimated Cost**
Limited Soil Excavation	One to two months.	$ 25,000
Institutional Controls	Two to six months.	$ 104,000
Deed Restrictions and Downgradient Notifications	Two to six weeks.	$ 8,000
Additional Offsite Well Installations	One to two months. seems long	$ 123,000
Groundwater Monitoring Program	Five years. seems high	$ 125,000
Groundwater Well Decommissioning	One week.	$ 10,000
TOTAL ESTIMATED COST		**$ 395,000**

1 Detailed cost estimates for each remedial alternative are provided in Appendix B.

SECTION 4 GROUNDWATER MONITORING PLAN

4.1 INTRODUCTION

This Groundwater Monitoring Plan has been prepared to support of the independent cleanup actions being proposed to address residual tetrachloroethene (PCE) contamination at the Sooper Dry Cleaners site. These remedial actions include limited source removal and institutional control measures to isolate and reduce the groundwater contamination associated with the site. The following plan present a five-year groundwater monitoring program that provides routine sampling of both on- and offsite groundwater wells.

4.1.1 Scope and Purpose

The purpose of the proposed monitoring program will be to document groundwater conditions beneath the shopping center and downgradient proprieties for a five-year period subsequent to the implementation of a remedial remedy at the Sooper Dry Cleaners site. Because the recommended remedy involves onsite management of residual contamination, the monitoring program will focus on confirming that groundwater conditions beneath the site are improving (or have at least stabilized), and that unacceptable levels of PCE or other related contaminants are not impacting downgradient receptors or discharging into Puget Sound.

This document presents the field and analytical procedures to be used to perform the proposed groundwater monitoring. The plan presents up-to-date sampling procedures (e.g. low flow sampling), analytical methods, and data evaluation and quality assurance/quality control (QA/QC) techniques designed to ensure that the monitoring results provide an accurate representation of the groundwater conditions beneath the site. The plan has been prepared to be consistent with existing EPA and Department of Ecology guidance for groundwater monitoring.

4.2 GROUNDWATER MONITORING PROGRAM

As illustrated on Figure 5, a total of 13 groundwater monitoring wells have been installed on the Normandy Park Shopping Center property. One of these wells (MW-9) was decommissioned in August 2001 to allow for necessary repairs to an adjacent underground utility line. In addition, remedial activities planned at the former dry well will require the decommissioning of existing well MW-7 (which is situated within the dry well footprint). As a result, it is anticipated that 11 onsite monitoring wells (MW-1 through MW-6, MW-8 and MW-10 through MW-12) will remain available for long-term groundwater monitoring.

Rising topography and residential land use west of the shopping center has constrained groundwater investigations downgradient of the subject site. Because of these conditions, only a single offsite groundwater monitoring well (MW-13) has been installed, approximately 1,000 feet downgradient of the property. As previously discussed, Ecology has indicated that additional offsite monitoring wells will be required to further evaluate the downgradient extent of the contaminant plume. Toward this end, the groundwater remedy recommended for the site provides for the installation of two additional offsite groundwater monitoring wells (proposed MW-14 and MW-15) which will be situated 700 to

900 feet downgradient of the site in Marivista Park. Assuming that the City of Normandy Park provides right of way access for the additional well installations, three offsite wells will be available for long-term groundwater monitoring

4.2.1 Monitoring Well Network and Sampling Frequency

To provide a comprehensive, cost-effective approach, the proposed groundwater monitoring program will incorporate both quarterly sampling at selected on- and offsite groundwater wells, as well as annual site-wide sampling events. As summarized below, eight groundwater wells (five onsite and three offsite) will be monitored on a quarterly basis. The five onsite wells (MW-2, MW-6, MW-8, MW-10 and MW-11) were selected for quarterly monitoring to provide both areal and vertical coverage within the observed PCE plume and along the western property border. One quarter per year, the six remaining onsite wells (MW-1, MW-3, MW-4, MW-5A, MW-5B and MW-12) will be sampled along with the primary onsite wells to provide a site-wide snapshot of groundwater conditions.

After three full years of quarterly groundwater chemistry data have been obtained for the site, the sampling frequency will be reduced to a semiannual basis for the fourth and fifth years of the monitoring program. Site-wide monitoring will continue to be performed annually during the final two monitoring years. It should also be noted that, depending on the results of the additional offsite well installations and future monitoring, that monitoring points may be added, replaced or otherwise removed from the monitoring network.

PROPOSED MONITORING NETWORK AND SAMPLING FREQUENCY

Monitoring Well	Well Location	Screened Interval (feet bgs)	Monitoring Frequency	
			Quarterly	Annually
MW-2	Onsite: ~20 feet west of dry well.	41-46	✓	
MW-6	Onsite: Northwest property border.	42-47	✓	
MW-8	Onsite: ~ 10 feet west of dry well.	85-90	✓	
MW-10	Onsite: Central-west property border.	63-67	✓	
MW-11	Onsite: Southwest property border.	55-60	✓	
MW-13	Offsite: ~1,000 ft southwest of site.	185-190	✓	
MW-14[1]	Offsite: ~800 feet west of site.	>125	✓	
MW-15[1]	Offsite: ~700 feet west of site.	>125	✓	
MW-1	Onsite: ~20 east of tenant space.	35-40		✓
MW-3	Onsite: ~50 northeast of tenant space.	41-46		✓
MW-4	Onsite: ~100 north of tenant space.	40-45		✓
MW-5A	Onsite: ~60 west of tenant space.	40-45		✓
MW-5B	Onsite: ~60 west of tenant space.	55-60		✓
MW-12	Onsite: South property border.	45-50		✓

1 The final locations and screen internals for these wells will be determined during the additional offsite well installation.

both ?? don't seem nec. deeper?

4.3 GROUNDWATER SAMPLING PROCEDURES

During each quarterly/semi-annual groundwater monitoring event, the depth to the water table will be measured in each of the wells in the monitoring network meter before commencing well purging and groundwater sampling activities. The groundwater elevation will be measures to the nearest 0.01 foot using an electronic water level meter. These data will be used for subsequent calculation of the groundwater flow direction and gradient(s).

Well purging and groundwater sampling will be performed using a submersible Well Wizard™ bladder pump system and low-flow/low-volume well sampling techniques. Low-flow/low-volume methods can be used to overcome many of the limitations created by traditional fixed well volume purging (i.e. purge 3 to 5 well volumes). Low-flow sampling can control sample turbidity and minimize sample chemistry alteration by pumping at very low flow rates from the well screen zone, avoiding disturbance to the water column in the well and minimizing stress on the surrounding formation. By pumping water only from the screen zone and not drawing water from the casing above the screen (if present), the volume of water purged to achieve stable water chemistry can be reduced significantly. Samples obtained in this manner will best reflect the ground-water chemistry at each location beneath the site.

Specific conductance, pH, dissolved oxygen, and groundwater temperature measurements will be taken throughout all well purging activities to ensure the collection of a representative groundwater sample. Field instruments will be calibrated in accordance with manufacturer's guidelines. An accurate record of all sampling activities, field measurements and site observations made during each quarterly monitoring event will be maintained in a field log.

check w/ Ron

All non-disposable equipment that exposed to well water will be cleaned between wells and decontaminated to prevent cross contamination using a three-point wash. The wash will consist of:

- Non-phosphate detergent (such as alconox) and water wash
- Tap water rinse
- Deionized water rinse

A new pair of disposable gloves (latex/nitrile) will be used by all filed staff for sampling each well and discarded after each use

Low flow sampling methods will minimize the volume of purge water that will be generated during each monitoring event. The purge water that is generated will be stored on-site in ~~55-gallon drums~~. Once the analytical results are available, water that does not contain detectable PCE concentrations will be discharged at the site. Water that contains PCE concentrations in excess of regulatory criteria will be retained at the site until proper disposal can be arranged.

all contaminants

Laboratory chain of custody form(s) will be completed for each set of groundwater samples and placed in the shipping cooler for travel with the sample shipment. These forms are provided by the analytical laboratory as a record for tracking samples from the point of collection to the laboratory. Upon transfer of sample possession to subsequent custodians, this form will be signed by the person taking custody of the sample container. As part of the chain of custody procedure, each sample container being delivered will be tracked by the site name, sample number, analytical testing to be performed, and other pertinent information.

Upon receipt of samples at the laboratory, the shipping container seal will be broken and the condition of the samples, including temperature, will be recorded by the receiver. The records will be reviewed in the preparation of the analytical report prepared by the laboratory, and will be considered an integral part of that report.

4.4 Analytical Methods

The groundwater samples collected from the site will be submitted to a Washington Department of Ecology accredited laboratory and analyzed for PCE and related volatile organic compounds (VOCs) using EPA Method 8260 or equivalent.

4.5 Data Evaluation and Reporting

The field and chemical data obtained during each monitoring event will be reviewed to evaluate the impact of the site remedy on the residual PCE groundwater contamination. Our findings will be presented though quarterly (or semiannual) letter reports and annual summary reports.

4.5.1 Quarterly and Semi-Annual Reports

A brief letter report will be prepared for each of the first three quarterly monitoring events (or the first semi-annual event) completed during each monitoring year. The report will present the groundwater sampling results for the quarterly or semi-annual monitoring event, as well as any conclusions or recommendations. These letter reports will be submitted to Ecology within 60 days of each field sampling event.

4.5.2 Annual Reports

An annual groundwater monitoring report will be prepared upon completion of the final quarterly (or semi-annual) sampling event for each monitoring year. The annual report will present the results of the final monitoring event, as well as summarize all earlier rounds of field and chemical data for the monitoring year. These results will be compared against the applicable groundwater standards, guidelines and remedial objectives, and any previous monitoring data. Water table elevation data will be used to calculate the groundwater flow direction and gradient for each monitoring period. "Year-to-year" flow pattern comparisons will be made. The annual reports will be submitted to Ecology within 60 days of the final field sampling event for that calendar year.

4.6 Quality Assurance/Quality Control

The following quality assurance/quality control (QA/QC) measures will be preformed on all the data obtained during the groundwater monitoring at the Sooper Dry Cleaners site. These measures are necessary because the monitoring program provides for analysis for constituents with standards in the low part per billion concentration range.

As previously discussed, a Washington Department of Ecology accredited laboratory will be used for all the sample analyses. The samples will normally be delivered to the laboratory within one day of sample collection. The laboratory will perform all analyses within the appropriate holding times (14 days for EPA Method 8260). The laboratory will perform method-specific QC activities, including surrogate recoveries, matrix spike, duplicates, and blanks. The data will be considered valid if percent recoveries fall between method-specific lower and upper control limits. qualified data

During each individual sampling event, one field duplicate or five percent of the total samples (whichever is greater) will be collected and analyzed using EPA Method 8260. Duplicate samples will be submitted as blind duplicates (i.e. under a separate, unique sample number). The location where the duplicate samples were collected will be recorded in the field logs and documented in the monitoring report. The duplicate samples will be submitted to the same laboratory as the primary samples.

A trip blank will be included with each sample cooler to determine whether cross contamination may have occurred during storage and transport of samples as a result of VOCs possibly diffusing through the septum lids. All trip blanks will be prepared by the contracted laboratory and sent with the empty VOC sample vials. The trip blanks will be analyzed along with the primary groundwater samples using EPA Method 8260.

SECTION 5 CONCLUSIONS AND RECOMMENDATIONS

Remedial alternatives, representing ten disparate cleanup technologies, were evaluated to address residual PCE and TCE contamination at the Sooper Dry Cleaners site. A preliminary screening identified three basic remedial technologies, including soil excavation, *in situ* chemical oxidation and institutional controls, as having the greatest potential for providing a practical and cost-effective site remedy. Further evaluation of the retained remedial alternatives resulted in a recommended site remedy that combines the following cleanup activities:

- Limited Soil Excavation;
- Institutional Controls;
- Installation of Additional Offsite Groundwater Wells; and
- Groundwater Monitoring.

Implementation of these alternatives will remove the shallowest, most PCE-impacted soils observed at the site, while providing for the secure inplace management of the residual contamination beneath the property. Since there is no apparent onsite or downgradient exposure to site contaminants, the recommended site remedy is anticipated to remain protective of human health and the environment. The installation of new downgradient monitoring wells combined with a five-year groundwater monitoring program is also recommended to support the selected cleanup remedy and to provide additional assurance that the remedial measures will continue to effectively isolate the PCE contamination. In addition, this remedy will also need to be supplemented by other supporting tasks including the preparation of a soil management plan, the notification of downgradient municipalities and property owners, and the final decommissioning of the well field upon termination of the monitoring program.

The estimated cost to complete the remedial tasks included in the recommended site remedy is approximately $395,000. With the exception of the five-year groundwater monitoring, the remedial tasks are anticipated to require on the order of six to nine months to complete.

SECTION 6 REFERENCES

1) Dames & Moore. Hydrogeological Study. Final Environmental Impact Statement: Seattle-Tacoma International Airport South Aviation Support Facility, Port of Seattle. Volume 2. September 1992.

2) SCS Engineers. Phase I/II Environmental Site Assessment, Normandy Park Shopping Center, Normandy Park, Washington. April 2000.

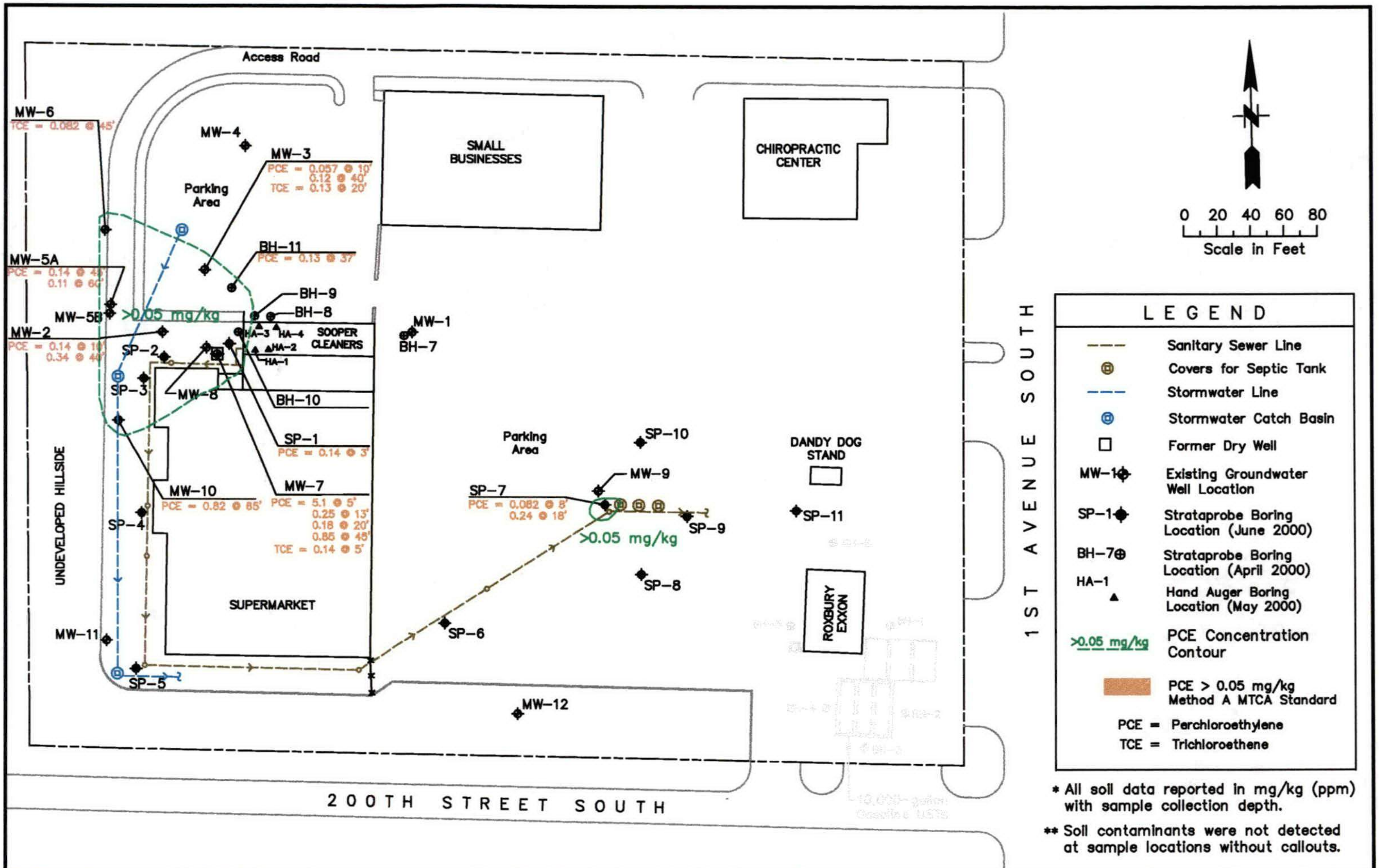
3) SCS Engineers. Voluntary Cleanup Program Application for the Sooper Dry Cleaners Site, Normandy Park shopping Center, Normandy Park, Washington. February 2000.

4) SCS Engineers. Environmental Site Assessment Report, Sooper Dry Cleaners, Normandy Park Shopping Center, Normandy Park, Washington. October 2001.

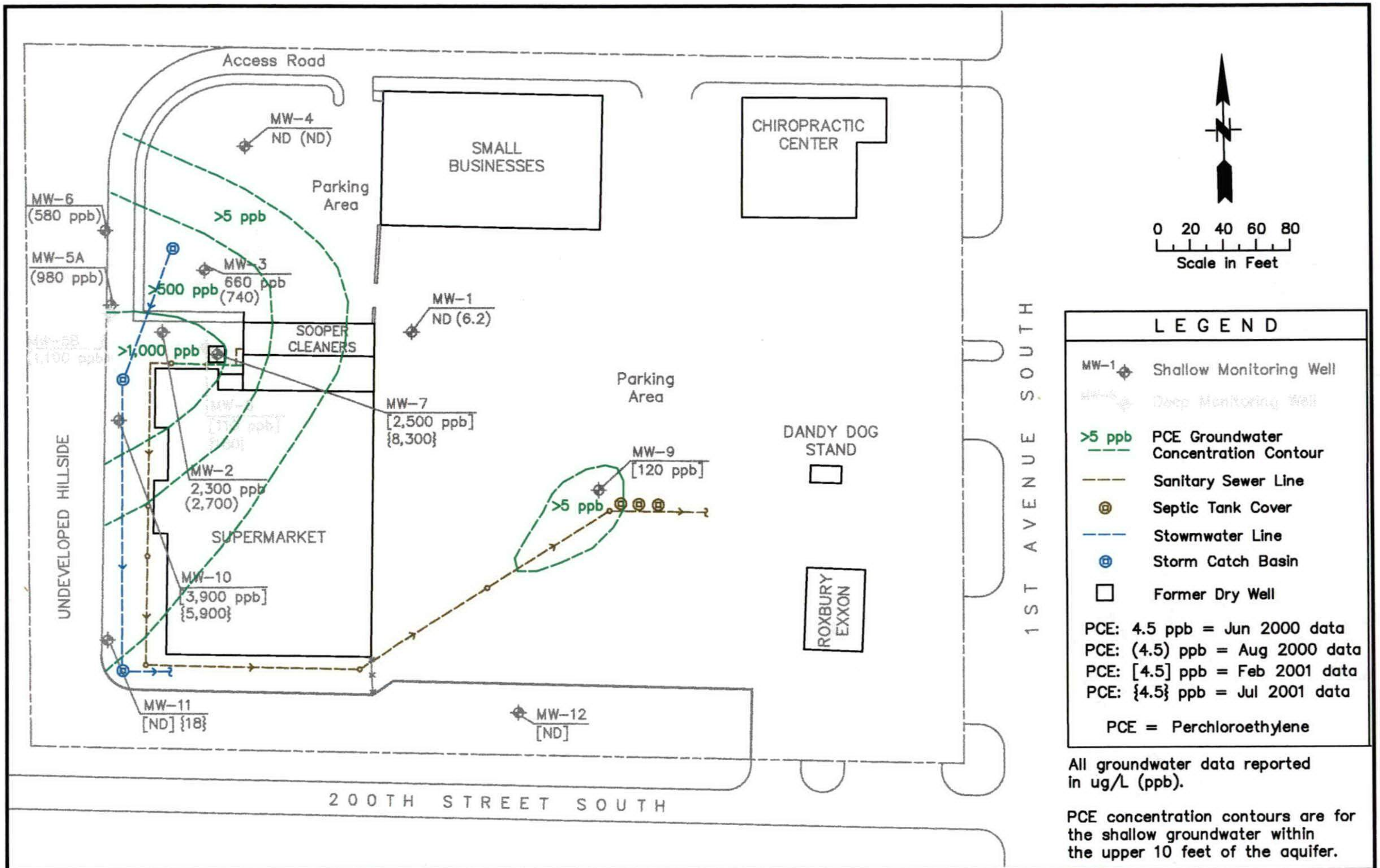
5) Washington State Department of Ecology - Toxics Cleanup Program. The Model Toxics Control Act Cleanup Regulation; Chapter 173-340 WAC. Publication 94-06. Amended February 12, 2001.

APPENDIX A

FIGURES



SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS 2405 140TH AVE NE, SUITE 107, BELLEVUE, WA 98005 (425) 746-4600	PROJECT NO. 04201036.01	DES BY D.V.	ESTIMATED EXTENT OF SOIL CONTAMINATION SOOPER DRY CLEANERS NORMANDY PARK SHOPPING CENTER	DATE MAY 2002
	SCALE AS SHOWN	CHK BY D.V.		FIGURE 1
	CAD FILE Figure 1	APP BY G.H.		

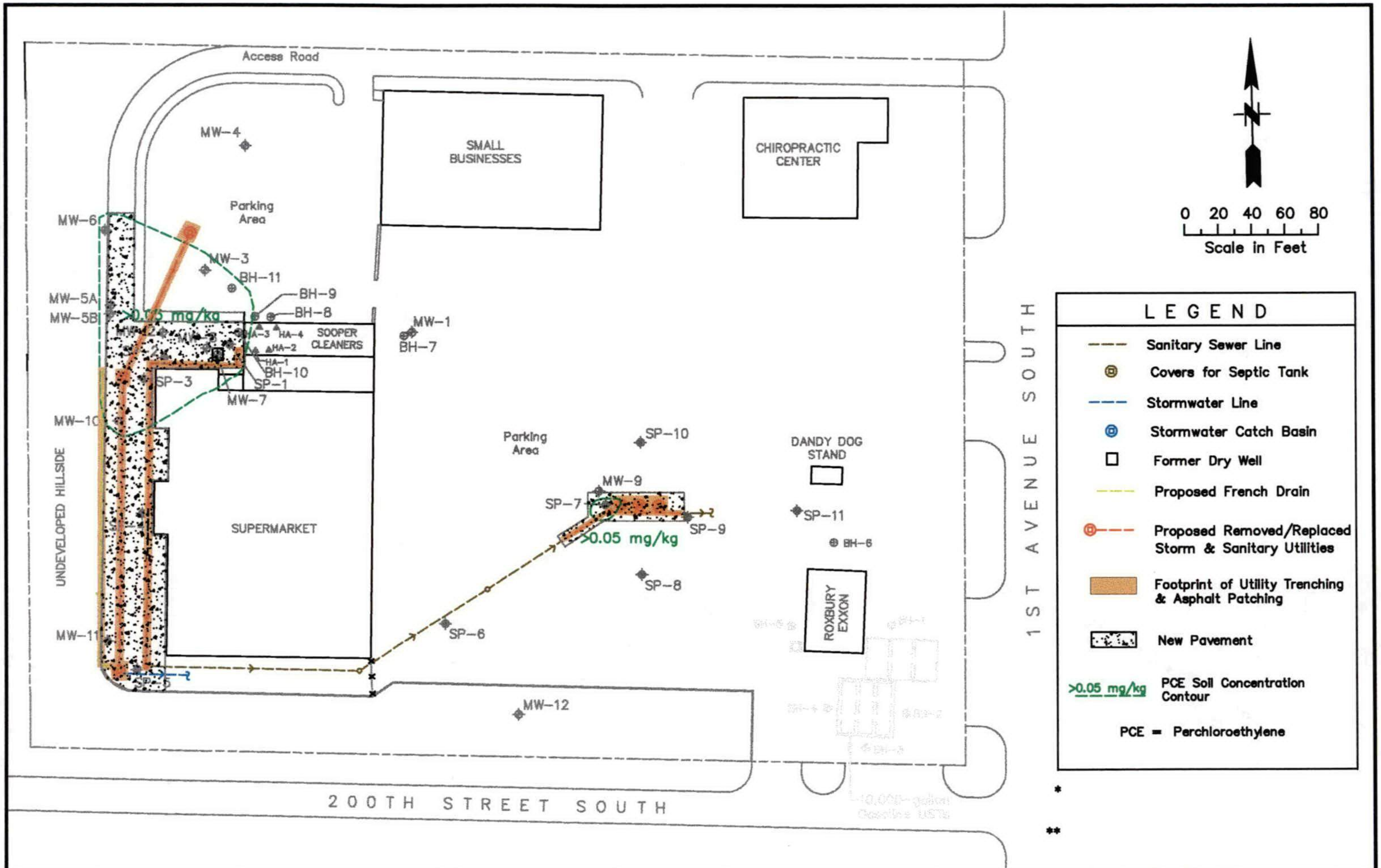


SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS 2405 140TH AVE NE, SUITE 107, BELLEVUE, WA 98005 (425) 746-4600	PROJECT NO. 04201036.01 SCALE AS SHOWN CAD FILE Figure 2	DES BY D.V. CHK BY D.V. APP BY G.H.	ESTIMATED EXTENT OF SHALLOW PCE GROUNDWATER CONTAMINATION SOOPER DRY CLEANERS SITE	DATE MAY 2002 FIGURE 2	

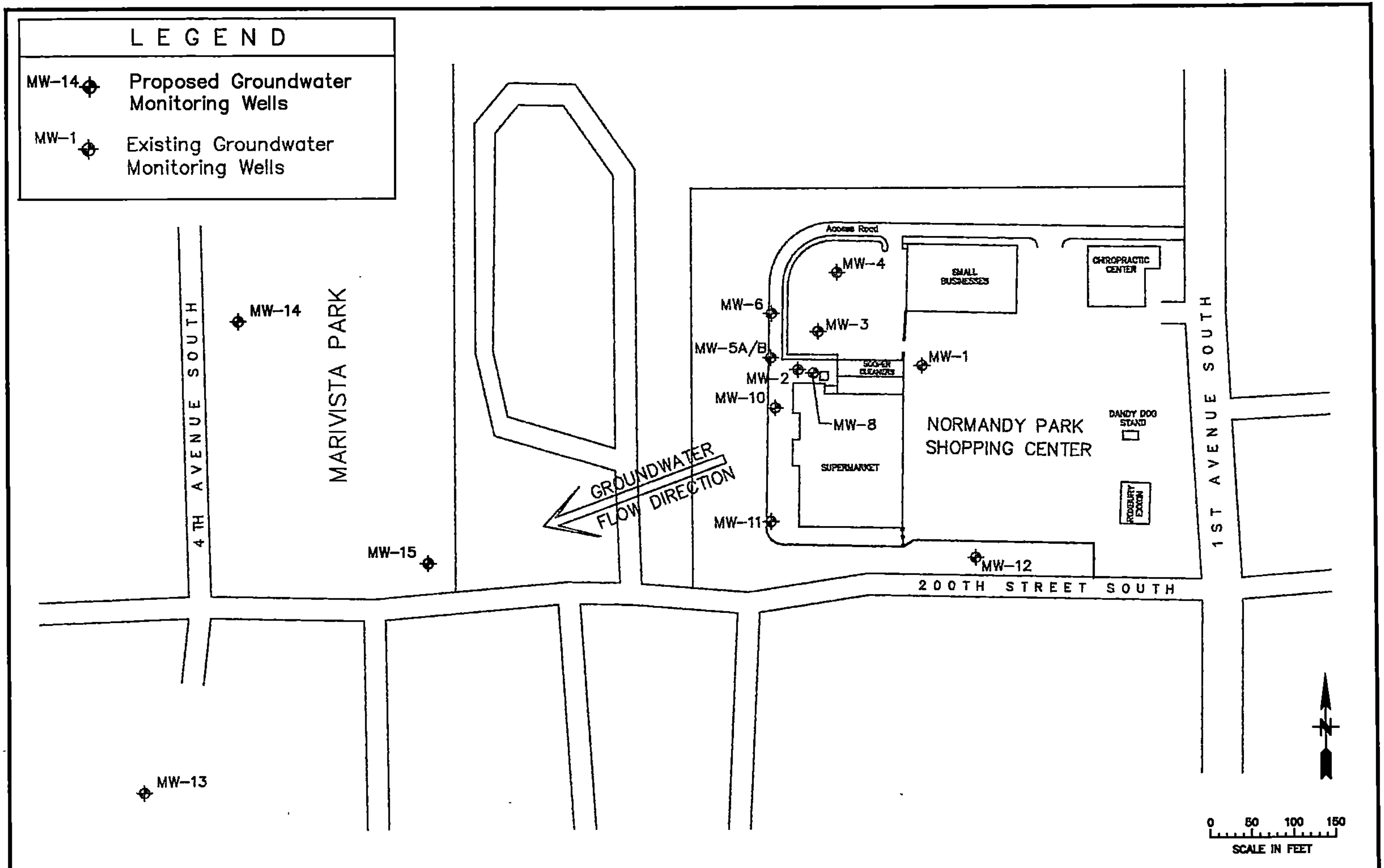
A-3

SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS 2405 140TH AVE NE, SUITE 107, BELLEVUE, WA 98005 (425) 746-4600	PROJECT NO. 04201036.01	DES BY D.V.	SOIL EXCAVATION REMEDIAL ALTERNATIVES	DATE MAY 2002
	SCALE AS SHOWN	CHK BY D.V.	SOOPER DRY CLEANERS	FIGURE 3
	CAD FILE Figure 3	APP BY G.H.	NORMANDY PARK SHOPPING CENTER	

A–4



SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS 2405 140TH AVE NE, SUITE 107, BELLEVUE, WA 98005 (425) 746–4600	PROJECT NO. 04201036.01 SCALE AS SHOWN CAD FILE Figure 4	DES BY D.V. CHK BY D.V. APP BY G.H.	INSTITUATIONAL CONTROLS ALTERNATIVE SOOPER DRY CLEANERS NORMANDY PARK SHOPPING CENTER
			DATE MAY 2002 FIGURE 4



SCS ENGINEERS STEARNS, CONRAD AND SCHMIDT CONSULTING ENGINEERS 2405 140TH AVE NE, SUITE 107, BELLEVUE, WA 98005 (425) 746-4600	PROJECT NO. 04201036.01 SCALE — CAD FILE Figrue 5	DES BY LL CHK BY D.V. APP BY G.H.	LOCATION OF PROPOSED ADDITIONAL GROUNDWATER MONITORING WELLS NORMANDY PARK, WA	DATE JUN 2002 FIGURE 5	

APPENDIX B

TABLES

TABLE 1

Summary of Analytical Data for Halogenated and Aromatic Volatile Organic Compounds in Soil; Sooper Dry Cleaners Site

SAMPLE LOCATION	SAMPLING DATE	EPA METHOD 8021 ANALYTES[1] (µg/kg)						
		PCE	TCE	1,1,2,2-PCA	CB	m,p,o-DCB	Toluene	Xylenes
Phase I/II Strataprobe Boring (April 2000)								
BH-7,4'	04/05/00	ND	ND	ND	ND	ND	ND	ND
BH-8,2'	04/05/00	ND	ND	ND	ND	ND	ND	ND
BH-8,9'	04/05/00	ND	ND	ND	ND	ND	ND	ND
BH-9,2'	04/05/00	ND	ND	ND	ND	ND	ND	ND
BH-9,5'	04/05/00	ND	ND	ND	ND	60,65,160	ND	230
BH-10,2'	04/05/00	ND	ND	4,600	ND	ND	ND	220
BH-10,9'	04/05/00	ND	ND	540	ND	ND	ND	ND
BH-11,11'	04/05/00	ND	ND	ND	ND	ND	ND	ND
BH-11,37'	04/05/00	**130**	ND	ND	ND	ND	ND	ND
Hand Auger Boring (May 2000)								
HA-1,2'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-1,5'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-2,2'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-2,5'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-3,2'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-3,5'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-4,2'	05/26/00	ND	ND	ND	ND	ND	ND	ND
HA-4,5'	05/26/00	ND	ND	ND	ND	ND	ND	ND
Stage I Strataprobe Boring (May 2000)								
SP-1, 3'	05/31/00	**140**	ND	ND	ND	ND	ND	ND
SP-1, 10'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-2,6'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-2,10'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-3,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-4,9'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-5,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-6,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-7,8'	05/31/00	**82**	ND	ND	ND	ND	ND	ND
SP-7,13'	05/31/00	**240**	ND	ND	ND	ND	ND	ND
SP-7,18'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-8,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-9,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-10,6'	05/31/00	ND	ND	ND	ND	ND	ND	ND
SP-11,11'	05/31/00	ND	ND	ND	ND	ND	ND	ND
MTCA Method A Soil Standard		**50**	**30**	**NA**	**NA**	**NA**	**7,000**	**9,000**

Bold Analytical results exceed the new Model Toxics Control Act Method A standard for this compound.
1 Equivalent analytical method (EPA 8260) used for June 2001analyses.
-- Analyte not tested.
PCE Tetrachloroethylene
TCE Trichloroethene
PCA Tetrachloro-ethane
CB Chlorobenzene
DCB Dichlorobenzene
ND Analyte not detected.
NA No MTCA standard has been established for this compound.

TABLE 1 (continued)

Summary of Analytical Data for Halogenated and Aromatic Volatile Organic Compounds in Soil; Sooper Dry Cleaners Site

SAMPLE LOCATION	SAMPLING DATE	EPA METHOD 8021 ANALYTES[1] (µg/kg)						
		PCE	TCE	1,1,2,2-PCA	CB	m,p,o-DCB	Toluene	Xylenes
Stage I Groundwater Well (June 2000)								
MW-1,15'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-1,35'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-2,10'	06/06/00	**140**	ND	ND	ND	ND	ND	ND
MW-2,20'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-2,30'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-2,40'	06/06/00	**340**	ND	ND	ND	ND	ND	ND
MW-3,10'	06/06/00	**57**	ND	ND	ND	ND	ND	ND
MW-3,20'	06/06/00	ND	**130**	ND	ND	ND	130	ND
MW-3,30'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-3,40'	06/06/00	**120**	ND	ND	ND	ND	ND	90
MW-4,15'	06/06/00	ND	ND	ND	ND	ND	ND	ND
MW-4,40'	06/06/00	ND	ND	ND	ND	ND	ND	ND
Stage II Groundwater Well (August 2000)								
MW-5A,35'	08/24/00	ND	ND	ND	ND	ND	ND	ND
MW-5B,45'	08/24/00	**140**	ND	ND	ND	ND	ND	ND
MW-5B,60'	08/24/00	**110**	ND	ND	ND	ND	ND	ND
MW-6,45'	08/24/00	ND	**82**	ND	ND	ND	ND	ND
MW-7,5'	08/24/00	**5,100**	**140**	ND	ND	ND	ND	ND
MW-7,13'	08/24/00	**250**	ND	ND	ND	ND	ND	ND
MW-7,20'	08/24/00	**180**	ND	ND	ND	ND	ND	ND
MW-7,35'	08/24/00	ND	ND	ND	ND	ND	ND	ND
MW-7,45'	08/24/00	**850**	ND	ND	ND	ND	ND	ND
Stage III Groundwater Well (January/February 2001)								
MW-8,55'	01/25/01	ND	ND	ND	ND	ND	ND	ND
MW-8,90'	01/25/01	ND	ND	ND	190	ND	ND	ND
MW-9,34'	01/25/01	ND	ND	ND	210	ND	ND	ND
MW-9,44'	01/25/01	ND	ND	ND	220	ND	ND	ND
MW-10,42.5'	01/25/01	ND	ND	ND	ND	ND	ND	ND
MW-10,65'	01/25/01	**820**	ND	ND	ND	ND	ND	ND
MW-11,25'	02/14/01	ND	ND	ND	ND	ND	ND	ND
MW-11,57.5'	02/14/01	ND	ND	ND	ND	ND	ND	ND
MW-12,25'	02/14/01	ND	ND	ND	ND	ND	ND	ND
MW-12,50'	02/14/01	ND	ND	ND	ND	ND	ND	ND
Stage IV Groundwater Well (June 2001)								
MW-13,140'	06/27/01	ND	ND	ND	ND	–	ND	ND
MTCA Method A Soil Standard		**50**	**30**	**NA**	**NA**	**NA**	**7,000**	**9,000**

Bold Analytical results exceed the new Model Toxics Control Act Method A standard for this compound.
1 Equivalent analytical method (EPA 8260) used for June 2001analyses.
– Analyte not tested.
PCE Tetrachloroethylene
TCE Trichloroethene
PCA Tetrachloro-ethane
CB Chlorobenzene
DCB Dichlorobenzene
ND Analyte not detected.
NA No MTCA standard has been established for this compound.

TABLE 2

Summary of Analytical Data for Halogenated and Aromatic Volatile Organic Compounds in Groundwater; Sooper Dry Cleaners Site

SAMPLE LOCATION	SAMPLING DATE	EPA METHOD 8021 ANALYTES[1] (µg/L)							
		PCE	TCE	cis-1,2 DCE	Chloroform	Toluene	MC	m, p, o-DCB	1,1,2,2-PCA
Phase I/II Strataprobe Boring (April 2000)									
BH-11	04/05/00	**180**	2.5	ND	ND	ND	ND	1,1.5,2.8	13
Stage I Groundwater Well (June 2000)									
MW-1	06/09/00	ND	ND	ND	ND	ND	ND	ND	ND
MW-2	06/09/00	**2,300**	**61**	130	ND	ND	ND	ND	ND
MW-3	06/09/00	**660**	ND	ND	ND	ND	ND	ND	ND
MW-4	06/09/00	ND	ND	ND	ND	ND	ND	ND	ND
Stage II Groundwater Well (August 2000)									
MW-1	08/29/00	**6.2**	ND	ND	ND	ND	ND	ND	ND
MW-2	08/29/00	**2,700**	**90**	ND	ND	ND	ND	ND	ND
MW-3	08/29/00	**740**	ND	ND	ND	ND	ND	ND	ND
MW-4	08/29/00	ND	ND	ND	ND	ND	ND	ND	ND
MW-5A	08/29/00	**980**	ND	ND	ND	ND	ND	ND	ND
MW-5B	08/29/00	**1,100**	2.0	ND	ND	ND	ND	ND	ND
MW-6	08/29/00	**580**	ND	ND	ND	ND	ND	ND	ND
MW-7	08/29/00	**2,500**	ND	ND	ND	ND	ND	ND	ND
Stage III Groundwater Well (January/February 2001)									
MW-8	02/01/01	**110**	ND	ND	ND	4.3	ND	ND	ND
MW-9	02/01/01	**120**	ND	ND	ND	2.7	ND	ND	ND
MW-10	02/01/01	**3,900**	4.4	ND	34	3.3	ND	ND	ND
MW-11	02/20/01	ND	ND	ND	ND	ND	ND	ND	ND
MW-12	02/20/01	ND	ND	ND	ND	ND	ND	ND	ND
Stage IV Groundwater Well (June 2001)									
MW-13,120'	06/27/01	ND	ND	ND	ND	ND	ND	--	ND
MW-13,160'	06/27/01	ND	ND	ND	ND	ND	ND	--	ND
MW-13,180'	06/28/01	ND	ND	ND	ND	ND	ND	--	ND
Stage V Groundwater Well (July 2001)									
MW-7	07/11/01	**8,300**	**85**	65	40	ND	**17**	ND	ND
MW-8	07/11/01	**180**	ND	ND	ND	ND	ND	ND	ND
MW-10	07/11/01	**5,900**	**6.6**	ND	42	ND	ND	ND	ND
MW-11	07/11/01	**18**	ND	ND	ND	ND	ND	ND	ND
MW-13	07/11/01	ND	ND	ND	ND	ND	ND	ND	ND
MTCA Method A GW Standard		**5**	**5**	**NA**	**NA**	**40**	**5**	**NA**	**NA**

Bold Analytical results exceed the Model Toxics Control Act Method A standard for this compound.
1 Equivalent analytical method (EPA 8260) used for June 2001 analyses.
PCE Tetrachloroethene
TCE Trichloroethene
DCE Dichloroethene
MC Methylene Chloride
DCB Dichlorobenzene
PCA Tetrachloro-ethane
ND Analyte not detected.
NA No MTCA standard has been established for this compound.

TABLE 3

Technology Summary and Preliminary Remedial Screening; Sooper Dry Cleaners Site

REMEDIAL ALTERNATIVE OR TECHNOLOGY	PRELIMINARY SCREENING CRITERIA				SCREENING DETERMINATION
	Effectiveness [1]		Implementability [2]	Cost [3]	
	Soil	Groundwater			
Bioremediation through Reductive Chlorination	Low	Low	Low	Low	Rejected because of unfavorable aerobic conditions in the subsurface.
Soil Excavation	High	Low to Medium	High to Low	High	**Retained.** Excavation of the upper portions of the former dry well may be appropriate.
Soil Vapor Extraction	High	NA	Low	Low to Medium	Rejected due to low effectiveness in low permeability soils.
Dual-Phase Extraction	High	High	Low	High	Rejected due to high groundwater recovery and low permeability soils at the site.
Groundwater Pump and Treat	NA	Low	Low	High	Rejected due to high groundwater pumping volumes and because of low effectiveness.
In Situ Chemical Oxidation	Low to Medium	High	Medium	High	**Retained.** This technology may be applicable to partially treat groundwater contamination.
Air Sparging w/wo Ozone	NA	Medium	Low	Medium	Standard air sparging is rejected due to low effectiveness in low permeability soils. Ozone sparging is retained as a chemical oxidation method.
Soil Heating	Medium to High	Low to Medium	Low	High	Rejected due to lack of performance data and inability to recover vapors in low permeability soils.
Passive Reactive Wall	NA	High	Low	High	Rejected because of depth and thickness of saturated zone beneath the site.
Institutional Controls w/wo Groundwater Monitoring	High	Low to Medium	High	Low to Medium	**Retained.** Both institutional controls and groundwater compliance monitoring are proven methods to manage residual contamination.

1 Effectiveness evaluation focuses on the technical ability of the technology to destroy, reduce or otherwise control the contaminants of concern at the site.
2 Implementability is a measure of whether the technology is practical at the site based on logistical and regulatory constraints.
3 Relative costs are provided to allow comparison between technologies with similar effectiveness and implementability.
NA Not Applicable

TABLE 4

Remedial Alternative Advantages and Disadvantages; Sooper Dry Cleaners Site

REMEDIAL ALTERNATIVE [1]	ADVANTAGES	DISADVANTAGES
Soil Excavation	• Permanently removes impacted soils thereby reducing contaminant mobility and leaching of PCE and TCE to groundwater. • Effective on shallow areas or restricted areas of contamination. • Provides a relatively quick remedy. • Can be focused on the removal of "hot spots" such as the old dry well. • Employs readily available equipment and technology.	• Inefficient for removal of deep (>20' bgs) or sporadically impacted soils. Also, inefficient for addressing large areas of low level contamination, or soils beneath structures. • Widespread excavation requires shoring and disturbs site. • Does not directly reduce groundwater contamination. • Generates waste materials that will need to handled, transported and disposed of at an offsite facility. • Expensive to implement over a large area.
In Situ Chemical Oxidation	• Theoretically provides a destructive technology that can reduce the PCE and TCE contaminant volume. • Expected to be most effective in the saturated zone and on dissolved contaminants. • Potentially can expand zone of treatment beyond the property border. • When effective, provides for a relatively quick remedy. • Can potentially reduce the duration of the associated groundwater monitoring program.	• Uncertainty concerning effectiveness due to the limited performance data available for this technology. • Uses highly reactive chemicals that require diligent worker and public safety protection procedures. • Can generate highly toxic vinyl chloride. • Additional performance monitoring will be required over the treatment period. • Injection of reactive chemicals into the subsurface can raise significant permitting issues. • May requires multiple rounds of treatment. • Expensive to implement.
Institutional Controls	• When properly implemented and maintained can be fully protective of human health and the environment. • Prevents exposures to impacted soils and reduces the movement of residual PCE and TCE from soil and into groundwater. • Provides long-term effectiveness with physical and administrative controls. • Moderate cost.	• Requires the replacement of sanitary and storm utilities. • Will result in short-term, but widespread site disturbance. • Represents a non-destructive technology that does not directly reduce soil or groundwater contamination. • This alternative will need to be supplement by an extensive groundwater monitoring program. • Will require on-site deed restrictions and notification of downgradient municipalities and property owners.

1 It is assumed that a groundwater monitoring task will be required as part of each remedial alternative.

TABLE 5

Relative Comparison of MTCA Clean-up Criteria for Selected Remedial Alternatives; Sooper Dry Cleaners Site

MTCA EVALUATION CRITERIA	REMEDIAL ALTERNATIVE [1]		
	Limited Soil Excavation & Offsite Disposal	In Situ Chemical Oxidation of Groundwater	Institutional Controls & In-place Management
Protectiveness to Human Health and the Environment	High	High	High
Permanence in Reduction, Mobility or Volume of Hazardous Substances	Medium	Medium	Low
Cost of Implementation	Low to Medium [2]	High	Medium
Long-term Effectiveness	High	High	Medium
Management of Short-term Risks	Medium to High	Low	High
Technical and Administrative Implementability	High	Low to Medium	High
Consideration of Public Concerns	Medium	Medium	Medium

1 It is assumed that groundwater monitoring will be a necessary task for each of the remedial alternatives.
2 Depending on extent of excavation (hot spot vs. large-scale removal).

TABLE 6: Estimated Costs for Widespread and Limited Soil Excavation Alternatives

Remedial Tasks	Engineering, Permitting & Management Costs	Subcontractor Costs	Laboratory Services & Testing Costs	Other Equipment/ Supplies Costs	Total Cost[1]
Widespread Soil Excavation Option					
Site Preparation, Utility Locating & Permitting	$ 8,000.00	$ 500.00	$ -	$ 3,300.00	$ 11,800.00
Shoring (450' perimeter to 40' bgs)	$ 68,000.00	$ 775,000.00	$ -	$ 1,500.00	$ 844,500.00
Excavation & Backfill (14,000 cy)	$ 13,800.00	$ 227,000.00	$ -	$ 2,000.00	$ 242,800.00
Soil Stockpiling and Characterization	$ 7,800.00	$ 12,000.00	$ 8,300.00	$ 1,200.00	$ 29,300.00
Manifesting, Transportation & Disposal (14,000 cy non-haz)	$ 5,600.00	$ 990,000.00	$ -	$ 1,800.00	$ 997,400.00
Restoration of Disturbed Area (15,000 sq feet)	$ 3,600.00	$ 35,000.00	$ -	$ 1,200.00	$ 39,800.00
Documentation & Cleanup Report	$ 9,000.00	$ -	$ -	$ 400.00	$ 9,400.00
TOTAL COST - WIDESPREAD OPTION	$ 115,800.00	$ 2,039,500.00	$ 8,300.00	$ 11,400.00	**$ 2,175,000.00**
Limited Soil Excavation Option					
Site Preparation, Utility Locating & Permitting	$ 2,100.00	$ 500.00	$ -	$ 800.00	$ 3,400.00
Excavation & Backfill (50 cy)	$ 2,000.00	$ 5,200.00	$ -	$ 1,400.00	$ 8,600.00
Soil Stockpiling and Characterization	$ 600.00	$ 700.00	$ 1,400.00	$ 800.00	$ 3,500.00
Manifesting, Transportion & Disposal (50 cy non-haz)	$ 900.00	$ 4,200.00	$ -	$ 500.00	$ 5,600.00
Restoration of Disturbed Area (100 sq feet)	$ 400.00	$ 600.00	$ -	$ 400.00	$ 1,400.00
Documentation & Cleanup Report	$ 2,200.00	$ -	$ -	$ 300.00	$ 2,500.00
TOTAL COST - LIMITED OPTION	$ 8,200.00	$ 11,200.00	$ 1,400.00	$ 4,200.00	**$ 25,000.00**

1 The estimated costs are solely for completion of the specific remedial alternative, and do not include any additional costs for supplemental tasks (such as long-term groundwater monitoring, additional offsite installations, and decommissioning wells at the conclusion of the monitoring period.

TABLE 7: Estimated Costs for In Situ Chemical Oxidation Alternative

Remedial Tasks	Engineering, Permitting & Management Costs	Subcontractor Costs	Laboratory Services & Testing Costs	Other Equipment/ Supplies Costs	Total Cost [1]
***In Situ* Chemical Oxidation**					
Final Design & Permitting	$ 12,500.00	$ 3,000.00	$ -	$ 500.00	$ 16,000.00
Site Preparation and Utility Locating	$ 2,800.00	$ 800.00	$ -	$ 500.00	$ 4,100.00
3 Injection Well Installations/Fenton's Reagent Injection	$ 9,000.00	$ 98,000.00	$ 2,800.00	$ 3,000.00	$ 112,800.00
5 Injection Well Installations/Permanganate Injection	$ 11,000.00	$ 105,000.00	$ 5,800.00	$ 4,000.00	$ 125,800.00
Treatment Period Compliance Monitoring	$ 6,500.00	$ -	$ 6,200.00	$ 1,600.00	$ 14,300.00
Documentation & Cleanup Report	$ 8,000.00	$ -	$ -	$ 400.00	$ 8,400.00
Decommissioning Injection Points	$ 1,800.00	$ 6,000.00	$ -	$ 800.00	$ 8,600.00
TOTAL COST	$ 51,600.00	$ 212,800.00	$ 14,800.00	$ 10,800.00	**$ 290,000.00**

1 The estimated costs are solely for completion of the specific remedial alternative, and do not include any additional costs for supplemental tasks (such as long-term groundwater monitoring, additional offsite installations, and decommissioning wells at the conclusion of the monitoring period.

TABLE 8: Estimated Costs for Institutional Controls Alternative

Remedial Tasks	Engineering, Permitting & Management Costs	Subcontractor Costs	Laboratory Services & Testing Costs	Other Equipment/ Supplies Costs	Total Cost [1]
Institutional Controls					
Final Design, Utility Locating & Permitting	$ 2,100.00	$ 1,200.00	$ -	$ 1,300.00	$ 4,600.00
Sanitary Sewer Repair/Replacement (320 linear feet)	$ 2,200.00	$ 16,000.00	$ 3,200.00	$ 1,400.00	$ 22,800.00
Stormwater Line Repair/Replacement (300 linear feet)	$ 2,200.00	$ 19,500.00	$ 2,400.00	$ 1,400.00	$ 25,500.00
Installation of French Drain System (300 feet)	$ 1,200.00	$ 5,800.00	$ 1,600.00	$ 400.00	$ 9,000.00
Septic Tank Decommissioning (three 1000-gal tanks)	$ 2,100.00	$ 8,000.00	$ 1,800.00	$ 1,000.00	$ 12,900.00
Asphalt Repavement of Western Alleyway (12,000 sf)	$ 800.00	$ 23,000.00	$ -	$ 200.00	$ 24,000.00
Documentation & Cleanup Report/Soil Management Plan	$ 4,800.00	$ -	$ -	$ 400.00	$ 5,200.00
TOTAL COST	$ 15,400.00	$ 73,500.00	$ 9,000.00	$ 6,100.00	**$ 104,000.00**

1 The estimated costs are solely for completion of the specific remedial alternative, and do not include any additional costs for supplemental tasks (such as long-term groundwater monitoring, additional offsite installations, and decommissioning wells at the conclusion of the monitoring period.

TABLE 9: Estimated Costs for Long-Term Groundwater Monitoring Task

Remedial Tasks	Engineering, Permitting & Management Costs	Subcontractor Costs	Laboratory Services & Testing Costs	Other Equipment/ Supplies Costs	Total Cost
Five-Year Groundwater Monitoring Program					
Year 1 - 4 Quaterly Sampling Events and Reporting	$ 15,600.00	$ -	$ 10,500.00	$ 3,900.00	$ 30,000.00
Year 2 - 4 Quaterly Sampling Events and Reporting	$ 14,900.00	$ -	$ 10,500.00	$ 3,600.00	$ 29,000.00
Year 3 - 4 Quaterly Sampling Events and Reporting	$ 14,900.00	$ -	$ 10,500.00	$ 3,600.00	$ 29,000.00
Year 4 - 2 Semiannual Sampling Events and Reporting	$ 8,600.00	$ -	$ 5,800.00	$ 1,600.00	$ 16,000.00
Year 5 - 2 Semiannual Sampling Events and Reporting	$ 8,600.00	$ -	$ 5,800.00	$ 1,600.00	$ 16,000.00
End of Program Reporting	$ 4,800.00	$ -	$ -	$ 200.00	$ 5,000.00
TOTAL COST	$ 67,400.00	$ -	$ 43,100.00	$ 14,500.00	**$ 125,000.00**

TABLE 10: Estimated Costs for Installation of Two Additional Off-Site Groundwater Monitoring Wells

Remedial Tasks	Engineering, Permitting & Management Costs	Subcontractor Costs	Laboratory Services & Testing Costs	Other Equipment/ Supplies Costs	Total Cost
Additional Off-Site Well Installation					
Access, Utility Locating & Permitting	$ 3,800.00	$ 500.00	$ -	$ 400.00	$ 4,700.00
Mobilization and Well Installations	$ 8,200.00	$ 69,000.00	$ 6,000.00	$ 7,600.00	$ 90,800.00
Well Development, Site Restoration & Demobilzation	$ 4,200.00	$ 5,800.00	$ -	$ 2,100.00	$ 12,100.00
Groundwater Sampling & Analysis	$ 2,400.00	$ -	$ 1,200.00	$ 700.00	$ 4,300.00
Updating the Site Groundwater Flow Model	$ 5,000.00	$ -	$ -	$ 200.00	$ 5,200.00
Documentation & Reporting	$ 5,800.00	$ -	$ -	$ 100.00	$ 5,900.00
TOTAL COST	$ 29,400.00	$ 75,300.00	$ 7,200.00	$ 11,100.00	**$ 123,000.00**