Blaine Mini Mart Site
Blaine, Washington

Focused Feasibility Study Report

Prepared for

Washington State Department of Ecology
Toxics Cleanup Program
300 Desmond Drive
Lacey, Washington

Prepared by

Science Applications International Corporation
18912 North Creek Parkway, Suite 101
Bothell, Washington

August 27, 2010

Table of Contents

Page

Tables

Figures

List of Acronyms

bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, xylenes
CLARC	Cleanup Levels and Risk Calculation
COC	contaminant of concern
CUL	cleanup level
Ecology	Washington State Department of Ecology
EDC	ethylene dichloride (1,2-dichloroethane)
FS	feasibility study
FFS	focused feasibility study
JEM	Johnson and Ettinger model
mg/kg	milligrams per kilogram
MNA	monitored natural attenuation
MTBE	methyl tertiary-butyl ether
MTCA	Model Toxics Control Act
MW	monitoring well
NAPL	non-aqueous phase liquid
O&M	operation and maintenance
ORC	oxygen release compound
PCB	polychlorinated biphenyl
SAIC	Science Applications International Corporation
SB	soil boring
SCR	Site Characterization Report
TEE	terrestrial ecological evaluation
TPH	total petroleum hydrocarbons
UST	underground storage tank
VOC	volatile organic compound
WAC	Washington Administrative Code

This page intentionally left blank.

1.0 Introduction

An environmental investigation is currently under way at the Blaine Mini Mart site, under the direction of the Washington State Department of Ecology (Ecology). A Site Characterization Report (SCR) was completed in July 2010 (SAIC 2010), which summarized soil and groundwater conditions affected by past activities and releases at the Blaine Mini Mart property. This Focused Feasibility Study (FFS) is directed toward evaluating onsite conditions and developing cleanup alternatives for the property.

This FFS Report fulfills the submittal requirements described in section 173-340-350(4) of the Washington Administrative Code (WAC) for documentation of a feasibility study (FS) conducted under the Model Toxics Control Act (MTCA). The purpose of a site characterization and FS is to collect, develop, and evaluate sufficient information to select a cleanup action.

This FFS Report has been prepared by Science Applications International Corporation (SAIC) and is being submitted to Ecology. The Toxics Cleanup Program of Ecology is managing the SCR and FFS through a master agreement with SAIC, under Contract number C0700034, and Work Assignment SAIC045. Funding from the American Reinvestment and Recovery Act became available in early 2010 for additional site characterization efforts and cleanup at the Blaine Mini Mart site. The site assessment took place between March and June 2010. This FFS has been focused in order to expedite the cleanup action and in recognition of the fact that few alternative options are feasible for this site.

1.1 Site Description and History

The Blaine Mini Mart is an active gas station located at 2530 Peace Portal Drive, a rural community inside the city limits of Blaine, Washington (Figure 1). The Blaine property is a one-half acre triangular lot bounded by Peace Portal Drive on the southwest and Bell Road to the west. Vacant land is present between the property and Interstate 5 to the north, and an abandoned former Rocky Mountain Trading Post building is on the east. The property is located within a mixed commercial/residential area and was previously identified as 1828 Peace Portal Drive. The property is entirely covered with asphalt, concrete, or structures and the surface gently slopes toward the southwest and Peace Portal Drive. Dakota Creek is located approximately 1,000 feet south of the property and discharges to Drayton Harbor of Puget Sound, roughly 1,500 feet southwest of the site (Environmental Associates 2005). Shallow groundwater at the site generally flows in a south to southwest direction (see SCR).

The Blaine Mini Mart property was initially developed for residential purposes and included one house and two additional buildings, one of which housed the Blaine Mail and Package center (BEK 1997). In 1955 a 1,161-square foot convenience store, currently the Blaine Mini Mart, and a 1,120-square foot dual-bay storage space replaced the original buildings. Four underground storage tanks (USTs) were removed in 1980 from a tank basin in front of the current Mini Mart, where the fuel dispenser canopy is now located (Environmental Associates 2005). In 2005, during a transition from Texaco to Shell branded gasoline, a new fuel island canopy and four dispenser islands were constructed in the footprint of the previously existing dispenser canopy (Environmental Associates 2005). Ecology UST records indicate four USTs, ranging in size from 10,000 to 29,999 gallons and containing unleaded and leaded gasoline, were permanently closed in June 2007 (Ecology 2010). Currently, three 10,000-gallon USTs, located in a tank pit on the east-central side of the property, store gasoline (regular and premium) and diesel fuel (Northwest Tank 2010). Tank-tightness tests performed in January 2010 certified no leaks or concerns regarding three 10,000-gallon USTs (Northwest Tank 2010). Reportedly a former waste oil tank located on the east side of the Mini Mart was abandoned in-place and filled with sand and clay relatively recently.

1.2 Regulatory and Investigation History

Documents available for review by SAIC do not include information about any initial release conditions, sources of contamination, or the initial time frame of possible petroleum-related releases. The driving factor for performing the initial environmental investigations at the Blaine Mini Mart site is not known.

Two monitoring wells (MW-1 and MW-2) were installed in October 1997 on the northwest and southeast sides of the fuel dispenser canopy (Figure 2). Hydrocarbon odors were observed during installation of MW-2 at 10 feet bgs. Groundwater samples from MW-1 and MW-2 were collected on October 22, 1997. Three previously installed tank pit observations wells (OW-1, OW-2, and OW-3) were also sampled for groundwater. Analytical results indicated groundwater in MW-2 exceeded MTCA Method A cleanup levels (CULs) for benzene, toluene, ethylbenzene, and xylenes (BTEX) and gasoline-range total petroleum hydrocarbons (TPH). Sample OW-1 contained concentrations of benzene and xylene exceeding the MTCA Method A CULs (BEK 1997).

A site characterization conducted in November 2005 included the installation of seven soil borings (B1 through B7) and groundwater sample collection from existing monitoring wells MW-1 and MW-2, and from geoprobe boring B-1. Laboratory analytical results for soil indicated concentrations of benzene, and methyl tertiary-butyl ether (MTBE), and TPH exceeded MTCA Method A CULs in B-1, B-4, B-6, and MW-2. Analysis of groundwater collected from MW-2 indicated BTEX, MTBE, gasoline, diesel, and heavy-oil range TPH exceeded MTCA Method A CULs. Diesel-range and heavy-oil range TPH exceeded Method A CULs in groundwater collected from B-1 (Environmental Associates 2005).

A third round of groundwater samples was collected from MW-1 and MW-2 in May 2008. Gasoline-range TPH and BTEX were detected at concentrations exceeding MTCA Method A CULs in groundwater from MW-2 (Whatcom Environmental Services 2008).

As part of an additional site characterization, SAIC installed twenty soil borings (SB-8 through SB-28) and three monitoring wells (MW-3 through MW-5) in March 2010. Analytical results indicated MTCA Method A exceedances of BTEX, TPH-Gas, and TPH-Heavy Oil in ten soil borings (SB-16 through SB-23 and MW-3, and MW-4), primarily along the southwest property line (Figure 2). A secondary area of surface soil contamination (1 to 2 feet below ground surface [bgs]) is present in the northeast corner of the property and exceeded MTCA Method A CULs for TPH-Gas and TPH-Heavy Oil (SB-12, SB-15). Groundwater exceeded MTCA Method A CULs for BTEX, MTBE, TPH-Gas, TPH-Diesel, and 1,2-dichloroethane (EDC or ethylene dichloride) in monitoring wells MW-1 through MW-4 (Figure 3).

1.3 Potential Contaminants of Concern

Investigations identified various contaminants in the soil and groundwater on the Blaine Mini Mart property. Petroleum hydrocarbons occur as widespread contaminants in the subsurface of the property and include gasoline-range and heavy oil-range hydrocarbons in both soil and groundwater, and diesel-range hydrocarbons in groundwater. Contamination is known to extend offsite into the city right-of-way under Peace Portal Drive. With the possible exception of the Blaine Mini Mart retail store building and storage garage (Figure 2), no local residences and/or commercial buildings are located within areas of known contamination. Analytical results are included in the 2010 SCR. Additional information regarding contaminants of concern (COCs) is presented in Section 2.2.

Two areas of contamination are present on the property. The largest area of petroleum hydrocarbon contamination in soil and groundwater is referred to as the western plume. This plume is located under and around the dispenser islands and it extends beyond the southwestern property boundary under Peace Portal Drive. COCs associated with the western plume include the following:

- Benzene
- Toluene
- Ethylbenzene
- Xylenes
- MTBE
- EDC
- Naphthalenes
- TPH-Gas
- TPH-Diesel
- TPH-Heavy Oil

The western plume constitutes a significant source of petroleum hydrocarbons in the subsurface soil, extending to about 20 feet bgs. Petroleum hydrocarbon contamination may have originated from a number of sources, including a historical dispenser island located on the northwest side of the current dispensers and potential gasoline piping. Contamination also appears be transported via groundwater flow southward beyond the property line. An adjacent utility corridor runs parallel to Peace Portal Drive, located a few feet beyond the property line in the street right-of-way. Unconsolidated utility backfill material may create a preferential migration pathway that could serve to transport contamination from the historical fuel dispenser island, southward along the property boundary.

A secondary area of contamination is referred to as the eastern plume and this small area is located on the southern side of the storage garage. Analytical results indicate MTCA Method A CULs were exceeded for petroleum hydrocarbons in soil at depths of 1 foot to more than 4 feet bgs. COCs associated with the eastern plume include the following:

- TPH-Gas
- TPH-Diesel
- TPH-Heavy Oil

Contamination in the vicinity of the eastern plume is suspected to have originated from a former waste oil tank in this vicinity, and possibly also from petroleum surface spills, although no releases are documented for the site.

1.4 Current and Potential Land Uses

The Blaine Mini Mart is an active Shell branded gasoline station and convenience store. The entire property is paved with asphalt or concrete. The property is zoned as commercial, although nearby commercially zoned properties also include residential buildings. Properties on the southwestern side of Peace Portal Drive are, in part, located downgradient from the Blaine Mini Mart and include both residential and commercial zoning. For the sake of cleanup activities, the Blaine property is considered to be available for unrestricted land use purposes. Therefore, it is possible that any type of future development could occur, including residential development and eventually the installation of drinking water wells. The Ecology Well Log Database shows no known water wells currently existing within one-quarter mile of the site.

1.5 Exposure Pathways and Potential Receptors

Exposure pathways are described as the mechanism by which an individual or population is exposed or has the potential to be exposed to hazardous substances at or originating from a site. Contaminated media at the Blaine Mini Mart site primarily includes soil and groundwater, but soil vapor and surface water are also discussed.

1.5.1 Soil

Soil as an environmental medium relates to a number of potential exposure pathways, to other media, and to receptors. These include: soil ingestion or dermal contact, inhalation of dust emissions, soil to vapor to indoor air, and groundwater leaching. A summary of the potential soil exposure pathways at the site is presented in the following table.

Potential Soil Exposure Pathways

Potential Soil Exposure Pathway/Scenario	***Applicability***
Ingestion/Dermal Contact	**Risk to Future Residents and Future Workers.** The entire area of soil impacted by COCs at the site is covered by pavement or buildings. Therefore, the current potential for ingestion or contact has been significantly limited. However, soil contamination is present just below pavement (less than 6 inches deep) and as deep as 20 feet bgs. Potential direct contact or inhalation exposures are possible during future site redeveloped or during utility work, as well as future residential activities such as digging or gardening.
Soil to Dust Emissions (Outdoor Air)	**Risk to Future Residents or Future Workers.** Dust may be generated during construction activities or utility work if soil is excavated and moved, or during future residential activities such as digging or gardening.
Soil to Vapor (Indoor Air)	**Risk to Future Residents.** Soil contaminants may volatilize into outdoor or indoor air, including into residences.
Groundwater Leaching	**Risk to Future Residents or Future Workers.** Contaminants in soil may leach to groundwater (see Section 1.5.2).

1.5.2 Groundwater

Groundwater as an environmental medium relates to a number of potential exposure pathways, to other media, and to receptors. These include: drinking water ingestion or household contact, incidental exposure (construction scenario), groundwater to surface water, and groundwater to vapor and indoor/outdoor air. A summary of the potential groundwater exposure pathways at the site is presented in the following table.

Potential Groundwater Exposure Pathways	
Potential Groundwater Exposure Pathway/Scenario	***Applicability***
Drinking Water Ingestion	**Risk to Future Residents and Workers.** Future residential development could include the installation of drinking water wells on the property or at downgradient locations. Potential exposures could occur during future site redevelopment construction or during underground utility work.
Dermal Contact/Inhalation	**Risk to Future Residents and Workers.** Groundwater is relatively shallow, ranging from approximately 1.5 to 4.6 feet bgs. Therefore, contaminated groundwater may be incidentally encountered by residents (contacted or inhaled during digging) or during redevelopment construction or utility activities.
Groundwater to Surface Water	**Eliminated.** Groundwater from the site is believed to eventually discharge to Dakota Creek (1,000 feet south) and/or Drayton Harbor (1,500 feet southwest). However, petroleum contaminants would attenuate long before groundwater could migrate that distance. Fine-grained site soils would further attenuate and slow the migration of the plume. Therefore, surface water is not a receptor of concern.
Groundwater to Vapor (Indoor Air)	**Risk to Future Residents (Indoor Air).** There is a potential risk due to vapors emanating from contaminated groundwater and intruding into indoor air, affecting building occupants on or near the property. This vapor intrusion risk assumes structures would be built with slab-on-grade construction (ventilated crawl spaces significantly reduce this risk).

2.0 Cleanup Standards

Cleanup standards in MTCA are defined for each hazardous substance present in each environmental medium and for each pathway through which humans and/or the environment may be exposed [WAC 173-340-700(4)]. Each cleanup standard addresses the cleanup levels for hazardous substances, the appropriate point of compliance where these levels must be met, and other applicable regulatory requirements [WAC 173-340-700(3)]. Under MTCA, a point of compliance specific to each medium and exposure pathway must be established, and it marks the regulatory location (such as depth) where cleanup levels shall be attained. Potential exposure pathways and corresponding points of compliance for each impacted medium are discussed below in Section 2.5.

In this report, Method A is the primary cleanup level utilized. However, this is supplemented by two additional means of determining cleanup levels. The soil cleanup levels need to meet not only MTCA human health standards (Method A), but also levels protective of the terrestrial ecological pathway. In Section 2.3, a terrestrial ecological evaluation (TEE) is performed and appropriate soil cleanup levels are applied. In addition, the vapor-intrusion pathway is addressed in Section 2.4, and this yields some groundwater cleanup levels protective of the vapor pathway that are more stringent than Method A.

According to MTCA [WAC 173-340-700(5)(a) and 173-340-704(1)], Method A is appropriate to establish cleanup levels for a site where hazardous substances are relatively few and one or both of the following criteria are met: the site is undergoing a routine cleanup action (Section 2.1), and numerical standards are available through MTCA or other laws for the indicator hazardous substances in the media being cleaned up (Section 2.2). At the Blaine site, the number of hazardous substances is relatively few, being limited to petroleum-related constituents.

2.1 Routine Cleanup Action

In order to determine if the remedial cleanup action (cleanup alternatives listed in this FFS) fulfills the requirements of a “routine cleanup action” as defined in MTCA [WAC 173-340-200], the following three criteria must be met:

- Cleanup standards for each hazardous substance addressed by the cleanup are obvious and undisputed, and allow for an adequate margin of safety for protection of human health and the environment.
- The cleanup action involves an obvious and limited choice among cleanup alternatives and uses an alternative that is reliable, has proven capable of accomplishing cleanup standards, and with which Ecology has experience.
- The cleanup action does not require preparation of an environmental impact statement, and the site qualifies for an exclusion from conducting a simplified or site-specific TEE or if the simplified evaluation can be ended or if TEE cleanup levels are utilized.

These three criteria will be briefly evaluated. The cleanup levels for each hazardous substance are listed in the MTCA regulation or in Ecology’s Cleanup Levels and Risk Calculation

(CLARC) database or can be calculated according to MTCA and other Ecology guidance, and these standards are protective of human health and the environment. The range of cleanup action alternatives evaluated in the FFS involves limited and reliable technologies that have been proven successful at cleaning up numerous sites contaminated with petroleum hydrocarbons. The cleanup action at the site will not require preparation of an environmental impact statement, and the TEE cleanup levels are applied (Section 2.3). Accordingly, the remedial cleanup action at the Blaine site fulfills the requirements of a routine cleanup action under MTCA.

2.2 Numerical Standards

MTCA provides media-specific numerical cleanup levels (Method A table values or Method B standard formula values) for all hazardous substances detected at the site, and all COCs (WAC 173-340-900 and CLARC database), thus fulfilling the requirement of WAC 173-340-704(1)(b). The COCs for the Blaine site are those that exceed MTCA Method A CULs (or Method B for those substances where Method A is not promulgated), which have been used for screening purposes in the SCR (SAIC 2010). Method A soil CULs are not available for the individual polychlorinated biphenyl (PCB) aroclors (Method B CULs are defined for Aroclors 1016 and 1254), although the Method A soil CUL applies to total PCBs. None of the PCB concentrations exceeded any MTCA CULs (aroclors or total PCBs) at the Blaine site and thus are not considered COCs. All other hazardous substances analyzed for at the Blaine site have corresponding Method A soil CULs.

Method A groundwater CULs are not available for most individual PAHs, and Method B CULs are available for some PAHs. In Blaine groundwater sample results, naphthalene and the two methylnaphthalene compounds together exceeded the Method A combined CUL for naphthalenes. None of the other non-carcinogenic PAHs exceeded their Method B CULs, and none of the carcinogenic PAHs were detected in groundwater at the site. The only other chemical tested for in site groundwater that does not have a Method A CUL is dibenzofuran, and the corresponding Method B CUL was not exceeded in any site samples.

Therefore, Method A CULs can be utilized for all soil and groundwater COCs at the Blaine site. The additional cleanup levels determined through the TEE and vapor pathway are discussed below. The resultant full list of cleanup levels for COCs in soil and groundwater at the Blaine site are included in Table 1; underlined values in this table are those applied in this FFS Report. In summary, Method A is appropriate as the primary method to establish cleanup levels for the Blaine site because hazardous substances are relatively few (limited to petroleum constituents), the site is undergoing a routine cleanup action, and/or numerical cleanup standards are available for the indicator hazardous substances in the media being remediated. Method A CULs are supplemented by cleanup levels for soil based on the TEE and by the site-specific groundwater cleanup levels that are protective of indoor air concentrations, as discussed in the following two sections.

2.3 Terrestrial Ecological Evaluation

MTCA requires that a TEE be completed following the release of hazardous substances to soil in order to determine the potential impacts to terrestrial organisms at a site [WAC 173-340-7490], unless certain exclusion criteria are met. MTCA states that one of the following actions be taken:

- Documentation of an exclusion from any further TEE using the criteria in WAC 173-340-7491,
- Completion of a simplified TEE as specified in WAC 173-340-7492, or
- Completion of a site-specific TEE as specified in WAC 173-340-7493.

A site may be excluded from the requirement for a TEE if any of the four criteria in WAC 173-340-7491(1) are met. However, the Blaine site does not qualify for initial exclusion based on any of these criteria. The site has more than 7 acres of contiguous undeveloped land located within 500 feet (exclusion would be less than 1.5 acres). Also, although the site contamination is currently under pavement, the future potential land uses cannot allow guarantees that pavement will remain and that an institutional control will be set in place to maintain the pavement cover.

A site-specific TEE would be required if any of the four criteria in WAC 173-340-7491(2)(a) apply. None of these criteria, which pertain to the site (contaminated area) and property, are applicable to the Blaine site. As a result, a simplified TEE is required.

An exposure analysis to end the simplified TEE in WAC 173-340-7492(2) does not succeed (per MTCA Table 749-1), and therefore the pertinent values in MTCA Table 749-2 will be required as cleanup levels in this FFS. The only priority contaminant of ecological concern at the Blaine site in Table 749-2 that is more stringent than MTCA Method A soil CULs is diesel-range organics (TPH-diesel). The value for diesel in this table is 460 mg/kg, as compared to the Method A CUL of 2,000 mg/kg. This is assumed to apply to both diesel and heavy oil-range petroleum hydrocarbons. This change to a lower cleanup level for diesel-range organics does not change the area or volume of contamination as initially identified in the SCR (SAIC 2010). Note that the contaminant areas and volumes identified in figures in the SCR are revised in this FFS.

2.4 Groundwater to Indoor Air Modeling

A new draft guidance document from Ecology requires that the vapor pathway be evaluated during site investigations to determine the potential risk of vapor intrusion from the subsurface to current or future building occupants on the contaminated site (Ecology 2009). Ecology expects subsurface media cleanup levels to be protective of indoor air quality. This evaluation of indoor air quality applies whenever volatile hazardous substances (such as gasoline constituents) are present in the subsurface at the site. These conditions apply to the Blaine site, and will be considered because the future unrestricted land use may include potential residential uses. The Ecology guidance provides a means to determine groundwater cleanup levels but not soil cleanup levels protective of vapor intrusion.

Groundwater analytical data may be evaluated to determine if volatile organic compound (VOC) concentrations pose a potentially unacceptable threat to indoor air quality, via vapor intrusion, for current and future site buildings. The first step in the evaluation is to compare site VOC concentrations in groundwater to generic groundwater screening levels protective of the vapor intrusion pathway that were developed by Ecology (2009). If site groundwater VOC concentrations exceed these screening levels, then there is a potential for risk. The VOC chemicals that are to be evaluated in this process include benzene, toluene, ethylbenzene, and xylenes (including m-, o-, and p- isomers of xylene), MTBE, EDC, and naphthalene. The measured concentrations of these hazardous substances for site groundwater samples from the two wells within the contaminant plume (MW-2 and MW-4) were compared to the screening levels. For well MW-2, multiple sampling rounds have been performed, and the minimum and maximum concentrations were presented to evaluate the full range of measured values (Table 2).

Since VOCs are present in groundwater at concentrations exceeding the Ecology screening levels, an estimate of the maximum indoor air concentration, via vapor intrusion, was calculated using the Johnson and Ettinger Model (JEM). According to Ecology (2009), for cases where vapor sampling points are not installed on the site, the acceptable process to evaluate vapor intrusion is to model the pathway from groundwater to soil vapor to indoor air using the standard model of Johnson and Ettinger (1991). Consequently, the JEM was employed in this FFS to estimate the equivalent indoor air concentrations for a residence, based on volatilization from underlying groundwater. The JEM uses a large number of input parameters, including groundwater depth, soil types and depths, groundwater concentration, building dimensions, exposure information, and air exchange rate. The JEM assumes that the house is a slab-on-grade construction (or has a subgrade basement), which maximizes the vapor intrusion conditions. The JEM is not intended for houses with ventilated crawl spaces and is not as useful for locations with a very shallow water table. It is assumed that any future house constructed on the Blaine property will be slab-on-grade construction. The input parameters used for the Blaine site modeling are presented in Appendix A.

In order to evaluate a range of results, the vapor intrusion model was performed using the groundwater concentrations included in Table 2. Following the Ecology guidance, the resulting maximum indoor air concentrations calculated using the JEM were compared to MTCA Method B indoor air CULs (there are no Method A air CULs promulgated). The predicted indoor air concentrations for BTEX exceed the air CULs in one or both wells.

The two-step process described in Ecology's draft guidance for evaluating soil vapor intrusion (Ecology 2009) was used to calculate groundwater concentrations that are protective of the Method B indoor air CULs. For the predicted minimum and maximum groundwater-to-vapor intrusion concentrations, the lower resultant concentration was selected as the potential site-specific cleanup level in order to be more protective. Based on model results, the most protective groundwater cleanup level concentrations were identified from results for well MW-2. This outcome of the model results because a permeable sandy soil, instead of a sandy loam, was present in the shallow subsurface in the area of MW-2.

The resultant calculated site-specific groundwater concentrations were compared to the MTCA Method A groundwater CULs. The lower of these two values for each COC was selected as the final site-specific groundwater cleanup level (listed at the bottom of Table 2) in order to provide the most conservative risk protection in this FFS. A compilation of final cleanup levels applied to the Blaine site is summarized in Table 1.

2.5 Point of Compliance and Extent of Cleanup Actions

The following sections include an evaluation that applies cleanup actions and points of compliance to the various environmental media and exposure pathways. This evaluation will aid in understanding the necessary extent and location of cleanup actions. A *point of compliance* is defined as the point or points where cleanup levels established in accordance with MTCA shall be attained [WAC 173-340-200].

2.5.1 Soil

Soil contamination at the Blaine site extends approximately 500 feet in length for the main plume, reaching off-property under the roadway. Contamination extends vertically to a maximum depth of approximately 20 feet bgs. Because the Blaine Mini Mart property could be redeveloped for residential usage, soil cleanup levels must be protective of unrestricted land use (including future residential use) within the point of compliance. The following four pathway/ media interactions are explained below.

Protection of Direct Contact or Incidental Ingestion

The point of compliance for protection of human exposure via direct dermal contact or incidental ingestion and ecological receptors for soil is defined as being from the surface to a depth of 15 feet bgs throughout the contaminated area [WAC 173-340-740(6)(d)]. All of the identified COCs in site soils have exceeded appropriate cleanup levels at depths of less than 15 feet bgs (see SCR). For the sake of this exposure pathway, remediation of contaminated soil to 15 feet bgs is sufficient.

Currently, the entire area of soil impacted by COCs at the site is covered by pavement. This significantly limits the current potential for contact by receptors. Potential direct contact or inhalation exposures at the site include future worker interactions with excavated or exposed soil during construction, such as might occur if the property were redeveloped or during utility work, as well as future residential activities such as digging and gardening. MTCA Method A soil CULs are considered to be protective of all these potential exposure scenarios down to the point of compliance.

Protection of Groundwater

Soil sample exceedances of MTCA Method A CULs at depths above and below the water table are numerous at the site (water table ranges from approximately 1.5 to 4.6 feet bgs). These soil contaminants leach (dissolve) into groundwater and adversely impact water quality in the aquifer. In order to minimize soil contamination from leaching to groundwater, soil concentrations would need to be reduced to levels protective of groundwater quality. Based on fine-grained site soils, it is unlikely that there is a drinking water pathway exposure in this area; however, to consider potential future residential uses, groundwater would need to be protective of leaching from soil. In addition, groundwater and soil may emanate vapors and be a concern for vapor intrusion (see below). Therefore, soils on the site or property would need to be remediated throughout the area and thickness of soil contamination, in order to reduce groundwater concentrations to acceptable levels. MTCA Method A soil CULs are stringent enough that they are expected to provide protection of groundwater (Section 2.5.2). Remediation of contaminated soils from the surface to only 15 feet bgs (as in the previous pathway) would leave some deeper soil contaminants that could continue to leach to the aquifer. Therefore, to protect groundwater, soil remediation will need to consider all contaminated site/property soils with concentrations exceeding MTCA Method A.

The ultimate measure of protection of groundwater will consist of a demonstration that groundwater cleanup levels at the site have been achieved.

Protection from Vapors

Soil contaminants may volatilize into outdoor or indoor air, and soil may form dust emissions during future construction work or residential activities. Similar to direct contact, the point of compliance for soil in terms of dust emissions or outdoor air would be from the surface to 15 feet bgs throughout the contaminated area. However, to be protective of vapor intrusion to indoor air of a future house or other building on or near the property, it is recognized that contaminated soil at depths greater than 15 feet bgs could potentially impact future occupants. The Ecology (2009) guidance excludes a means to calculate soil cleanup levels for vapor protection based on soil concentrations. Thus, a MTCA Method A CUL throughout the site/property without a depth limitation is considered to be generally protective of all pathways and is applied as a cleanup level in this FFS Report. Both soil and groundwater would require remediation to reduce the vapor intrusion risk and ensure future protectiveness of human health.

Protection of Ecological Receptors

As discussed under the TEE section above, impacts to ecological organisms that may visit the Blaine site are being considered. Undeveloped areas near the site make some wildlife exposure possible. Soil remediation to Method A CULs and the Simplified TEE concentrations used as cleanup levels would be protective of any ecological receptors that may visit the site.

2.5.2 Groundwater

Groundwater contamination is evident in monitoring wells on the property. Three pathway/ media interactions are explained below, in addition to the possible presence of non-aqueous phase liquid.

Drinking Water Ingestion/Contact

The site aquifer is not currently used as a drinking water source. Because a future residential scenario, with unrestricted land uses, is applicable to the property or the area downgradient of the property, then the drinking water ingestion pathway is being considered. The application of MTCA Method A groundwater CULs will provide protection for future workers and residents. The standard point of compliance for protection of groundwater is throughout the site. The point of compliance for the Blaine site would consist of long-term attainment of Method A groundwater CULs in each of the existing or new monitoring wells following remediation. It is recognized that downgradient monitoring beyond the property boundary is not being considered as part of this FFS and the future cleanup action (see Section 4).

Groundwater to Surface Water

Groundwater from the site likely eventually discharges to Dakota Creek or Drayton Harbor. Because the distance to the creek is approximately 1,000 feet, and the distance to the harbor is approximately 1,500 feet, any petroleum contaminants would attenuate long before the site groundwater migrated those distances. Petroleum groundwater plumes usually only reach roughly one-tenth of those distances, and the fine-grained nature of the site soils would further attenuate the plume constituents and slow the groundwater migration rate. Therefore, the pathway from groundwater to surface water is not considered in this FFS.

Groundwater to Indoor Air

To evaluate the groundwater to vapor pathway, a quantitative evaluation of the potential vapor intrusion risk to building occupants was performed (Section 2.4). Model results indicate there is a potential incremental risk to building occupants on or near the property from vapors emanating from contaminated groundwater (assuming structures would be built with slab-on-grade construction; houses with ventilated crawl spaces significantly reduce this risk). Vapors can be released from groundwater at any depth.

The application of MTCA Method A groundwater CULs in combination with the site-specific vapor intrusion levels for groundwater will ensure protectiveness of future building occupants. The point of compliance would be long-term attainment of these groundwater cleanup levels in each of the site monitoring wells following remediation.

Non-Aqueous Phase Liquid

MTCA requires that in addition to meeting standard cleanup levels, petroleum hydrocarbon concentrations in groundwater must comply with the limitation on non-aqueous phase liquid (NAPL). Specifically, the cleanup level may not allow a concentration that would result in NAPL being present in or on the groundwater [WAC 173-340-720(7)(d)]. This may be determined by physical observation of groundwater to demonstrate the lack of a film, sheen, discoloration, sludge, or emulsion. For any cleanup action at the site, the groundwater cleanup level for NAPL will be met by consistent attainment of lack of visible observation in the groundwater of all site wells. The only location where NAPL has been identified at the site is at geoprobe boring SB-18 in the sample at 5 feet bgs, where brownish NAPL was identified segregating from the soil material. If NAPL is present in the vicinity of MW-2, it may not be entering the well because the top of the well screen is below the water table.

3.0 Screening of Alternative Components

A "cleanup action alternative" is defined as a treatment technology, containment action, removal action, engineered control, institutional control, or other type of remedial action that, individually or in combination, achieves a cleanup action at a site [WAC 173-340-200]. For purposes of this FFS Report, a "cleanup action component" (or "alternative component") is considered to address a specific media/exposure pathway. The media/exposure pathway cleanup action components are then assembled into cleanup action alternatives (Section 4), which address the cleanup requirements.

In this section, alternative components are identified and screened for their applicability in addressing site contamination and achieving remedial objectives (meeting cleanup standards). Furthermore, the screening of these components considers the fact that remediation will be limited to on-property portions of the site, because off-property areas are not safely or logistically accessible for cleanup. The various components have been screened to narrow the list of technologies and other measures that should be considered for more detailed evaluation. MTCA provides for an initial screening step based on the ability of the component to meet the minimum MTCA requirements and also based on its feasibility. According to WAC 173-340-350(8), a cleanup alternative or its components may be screened from further consideration if either of the following conditions applies:

- The component does not meet minimum threshold requirements [WAC 173-340-360(2)(a)], including components in which costs are clearly disproportionate; more specifically:
    - The component is not protective of human health and the environment, or
    - The component does not comply with the cleanup standards, or
    - The component does not comply with applicable state or federal laws, or
    - The component does not provide for compliance monitoring.
- The component is not technically feasible.

MTCA also requires that cleanup alternatives (or their components) meeting threshold requirements also fulfill the following requirements [WAC 173-340-360(2)(b)]:

- Use permanent solutions to the extent practicable,
- Provide for reasonable restoration time frames, and
- Consider public concerns.

Further screening has been performed to select the most appropriate alternative components among those determined to meet the above requirements. This evaluation is based on three criteria: effectiveness, implementability, and relative cost (with cost generally being a secondary consideration). Specifically, these criteria consider the following factors:

- *Effectiveness.* This criterion includes technical effectiveness of the process to achieve the remediation goals (cleanup standards). Performance with respect to the specific chemicals of concern was evaluated, as well as other site-specific factors, such as depth of contamination and chemical complexity.

- *Implementability.* This criterion includes technical and administrative factors that affect the ability to implement the process. This included items such as site constraints, availability of the technology, required expertise to design, install, and operate the component, and probable community concerns and permit issues.
- *Relative cost.* This criterion includes relative capital and operating costs based on engineering judgment. Relative costs were considered to help select components to be carried forward into the analysis of alternatives. Cost alone was not used to reject component types.

The identification and screening evaluation for site cleanup alternative components is presented in Table 3. This table lists components that are retained and the rationale for eliminating components from further consideration. The environmental media considered include pathways related to soil and groundwater. The soil vapor/indoor air pathway is not directly considered because this is addressed through components aimed at remediating soil and groundwater. Surface water is not considered because this pathway has not been identified as being of concern at the site, and it will also be addressed indirectly through soil/groundwater remediation.

The retained alternative components in Table 3 include the following technologies and other measures:

- Deed restriction or soil management plan (institutional controls)
- Groundwater monitoring
- Soil excavation (standard technologies)
- Excavation dewatering
- Biostimulation and bioaugmentation
- Chemical oxidation
- Monitored natural attenuation
- Activated carbon filtration
- Offsite thermal desorption

The following alternative components in Table 6-1 were rejected for the reasons described:

- *No action.* The site has concentrations of petroleum constituents that present risks to future residents and construction workers; taking no action is not protective.
- *Physical access controls.* Although this may be effective in preventing unauthorized individuals from accessing the property, it is not protective in terms of long-term future land use scenarios.
- *Surface cap.* Although a cap would protect some routes of exposure, it is not protective by itself in terms of potential future land use scenarios, and it is difficult to guarantee maintenance.
- *Subsurface vapor barrier.* Although a barrier would protect some routes of exposure, it is not protective by itself in terms of future land use scenarios; it is difficult to implement and maintain; it may be useful protection for future buildings to close the vapor exposure pathway.

- *Soil vapor extraction.* The thin vadose zone at the Blaine site, with heterogeneous and fine-grained soils, would create a small radius of influence and short-circuiting to surface; these factors would render this component ineffective.
- *Deep soil excavation (large-diameter augering).* This technology could be applied to the deep soil at the Blaine site and would result in less dewatering; however, the cost to mobilize and use this separate set of equipment would be too high for the potential gain.
- *Air sparging.* The fine-grained soils at the Blaine site, with a permeability too low for effective sparging, would result in creation of preferential pathways, unreliable distribution, and a small radius of influence; same problems (as above) exist with the soil vapor extraction component.
- *Multi-phase extraction.* The fine-grained soils at the Blaine site, with a permeability too low for effective vapor and groundwater extraction, would result in preferential pathways, and a small radius of influence.

Due to site conditions and other factors, only a limited number of alternative components are retained and available to carry over into the development of alternatives (Section 4). This limits the potential number of alternatives to select from, in order to perform a cleanup at the Blaine property.

4.0 Development of Alternatives

Based on the environmental media requiring cleanup actions and the screening of cleanup action components, remedial action alternatives have been developed that address the presence of contaminants in soil and groundwater at the Blaine site. The following section discusses each alternative with a focus on the rationale for the actions and components that have been selected. The proposed alternatives are analyzed in Section 5 in accordance with evaluation required in MTCA.

Two cleanup action alternatives were developed by assembling appropriate cleanup alternative components from those identified and selected in Section 3. Only a limited number of components were able to be carried forward from the screening process to create these alternatives. Both alternatives include components that are expected to be capable of accomplishing the cleanup levels established for a particular exposure pathway and contaminants as identified in Section 2. Selection of a specific cleanup action component for detailed evaluation in the FS does not preclude later consideration of similar components that are represented by the selected component. Similar cleanup action components that can achieve the same cleanup levels could be re-evaluated for cost effectiveness during the final design phase.

The two alternatives developed for the Blaine site provide cleanup action components capable of protecting the environment and human health as required by MTCA [WAC 173-340-360(2)]. MTCA specifies that each alternative meet the following threshold requirements:

- Protect human health and the environment
- Comply with cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring

For media with contaminants exceeding cleanup levels, identifying the exposure route rather than just the acceptable contaminant levels is important because protectiveness can be achieved by preventing exposures (e.g., by containment or institutional controls) as well as by cleanup. Although MTCA strongly reflects a preference for permanent remedial actions, less permanent solutions may be accepted if controls are put into place to ensure that the solution is protective of human and ecological receptors.

MTCA requires that a feasibility study include at least one “permanent cleanup action alternative” that is used “to serve as a baseline against which other alternatives shall be evaluated for the purpose of determining whether the cleanup action selected is permanent to the maximum extent practicable” [WAC 173-340-350(8)(c)(ii)]. MTCA defines a permanent cleanup action to be one in which the cleanup standards of WAC 173-340-700 through 173-340-760 can be met without any further action being required at the site, with the exception of the disposal of any treatment residue.

The available data from the SCR are sufficient for development of rational alternatives that address the potential problem at the Blaine site and which form a sound basis for selection of a preferred remedy. However, additional data may need to be collected for certain remedial actions to be implemented. It has been assumed that any additional data needs would be filled during the design or implementation phase for the selected alternative. For the excavation alternative, soil sampling takes place during implementation to direct and confirm the actions.

One of the underlying aspects in developing the remedial alternatives for the Blaine site is that removal or treatment of source material (contaminated soil) will eventually produce a beneficial effect on groundwater quality. The more thoroughly the soil is remediated, the less a cleanup action needs to rely on active or passive groundwater remediation. Passive groundwater cleanup, which relies on naturally occurring processes to degrade hazardous substances, is referred to as monitored natural attenuation (MNA). Natural attenuation may be a relatively slow process, but it can also be supplemented or stimulated by more active measures. Alternatives developed in this FFS are capable of remediating soil to acceptable levels, but with varying restoration time frames for groundwater that may extend significantly into the future. At the Blaine site, off-property soil and groundwater contamination is considered to be generally inaccessible (particularly under Peace Portal Drive), and any impact on this downgradient area is beneficially affected by upgradient on-property cleanup.

The two alternatives that have been developed for this site are summarized in Table 4 and described in detail in the following sections. These two alternatives are generally similar, except that Alternative 1 includes application of a chemical oxidation agent and Alternative 2 does not. The approximate area and depths of soil contamination are shown in Figure 4. This figure lists the estimated depth range of contamination at each boring, including the approximate depth of the base of contamination when it is extrapolated beyond the bottom of the boring. Note that contamination extends beyond the property margin under Peace Portal Drive, although the depths there are unknown. Active remediation of this area under the highway would cause undue traffic concerns, affect subsurface utilities, and likely pose a greater risk to human health and safety. Thus, this area is not being considered for active remediation in this FFS, but will be addressed indirectly via upgradient actions on the property.

4.1 Alternative 1—Soil Removal, ORC Application, and Monitoring

This alternative would reduce and control exposures to contaminants by the following response actions:

- Remove dispenser islands and other structures
- Excavate identified on-property contaminated soil
- Perform offsite thermal desorption of excavated soil
- Apply oxygen release compound (ORC)
- Regrade and restore site
- Initiate environmental monitoring and institutional controls

This remedial alternative would achieve source removal by excavating all identified on-property contaminated soil, as feasible, and transporting it for offsite treatment and disposal. Off-property contamination in soil and groundwater would be addressed through a soil management plan filed with the City of Blaine. Groundwater would be addressed through upgradient (on-property) source removal, by application of ORC, by on-property monitoring, and through natural attenuation. These measures would be required until complete restoration is achieved for soil and groundwater. The areal extent of the remedial actions is displayed in Figure 5. The main features of Alternative 1 are described below.

The goal of this alternative is to prevent direct contact and ingestion exposures to humans and terrestrial receptors, and remove the leaching to groundwater pathway by removing contaminated soil on the property. In addition, although the soil-to-vapor pathway was not modeled in this report, this alternative would significantly reduce the vapor intrusion potential at the site. These objectives would be accomplished by feasible excavation and offsite disposal of all on-property contaminated soil.

4.1.1 Remove Dispenser Islands and Other Structures

Prior to excavation, the dispenser islands and overhead canopy would be removed from the facility. The main (western) soil contaminant plume underlies the footprint of the dispensers and canopy, and soil excavation cannot proceed unless these structures are removed. In addition, the pipelines leading to the dispensers under the contaminant plume will be purged and removed after being disconnected from the underground storage tanks. The asphalt and concrete pavement will also be removed from the area around the western and eastern soil contaminant plumes. This material will be landfilled or recycled. Wells MW-1, MW-2, MW-3, and MW-4 would be decommissioned prior to any removal of structures or material.

4.1.2 Excavate Identified On-Property Contaminated Soil

Figures 4 and 5 outline the approximate contaminant extent and depth for the site, based on data from the SCR and previous site assessment documents. Based on these data, the contaminated soil to be removed from the property totals approximately 2,070 cubic yards (in situ). Soil contamination extending to depths of approximately 20 feet bgs is present in the northern portion of the main western plume. The southern half of this contaminant plume is expected to reach less than 10 feet bgs. Soil in the small eastern plume is anticipated to reach only to depths of about 6 feet bgs.

The area of contaminated soil would be removed using standard excavation and hauling methods. Soil will not be segregated for contaminated versus uncontaminated soil because only minimal volumes of clean overburden soils are anticipated at the site. Soils will be directly loaded into 30-ton truck and trailer units for transport and disposal. The deeper soils will be accessed for removal either from the surface or accessed via a ramp within the excavation pit from the southeast direction. The anticipated sidewall slopes of the excavation are approximately 1:1, but will be adjusted in the field depending on the stability of the material making up the pit walls. To remove all contaminated soil on the property, a vertical or near-vertical excavation face will be needed along the southwestern property edge. Some type of shoring or other support system will be needed along this property boundary to stabilize the sides of the excavation and provide safe working conditions. Stabilization will likely be accomplished in the form of a trench box network. The trench box system would be approximately 10 feet wide, 10 feet deep (average), and 115 feet long, just inside the southwestern property boundary (Figure 5).

It is unlikely that shoring or other support system would be needed in the area of the Mini Mart building, because contaminated soil is not anticipated to extend beyond (northeast of) the location of SB-24. If it is determined in the field that the excavation pit would need to impinge on the slab or footer of this building, a decision will be made by Ecology as to the best path forward. One possible solution would be to install a system of pipe piles under the corner of the slab. Because the requirement for excavation close to the corner of this building cannot be predicted based on current information, these support costs are not directly included in the FFS (although they are likely captured within the contingency costs). Similarly, any support costs for excavation of the small contaminant zone near the storage garage (Figure 5) are not considered in the FFS.

The site information presented in the SCR that defines the contaminated area will be supplemented during excavation activities. This includes collecting soil samples to be analyzed by an onsite mobile laboratory to ensure that all contaminated soil above the cleanup levels is removed, as feasible. Soil will also be field screened for indications of contamination. If field indicators and laboratory analysis indicate that contaminant concentrations remain above MTCA CULs (Table 1), the soil removal would continue until cleanup levels are achieved, as feasible. Soil samples from the sidewalls and bottom of the excavation will be collected at approximately 20-foot lateral intervals to confirm that appropriate cleanup has been achieved.

Because of the iterative nature of the excavation and sampling scheme described above, and the anticipated distribution irregularity of contaminated soil, it is difficult to accurately estimate the final depths and volumes of soil requiring excavation. Due to irregular distribution of subsurface contaminants, some material may be missed or may be too difficult to follow (e.g., stringers extending under a building).

Occupational Safety and Health Administration Level C personal protective equipment may be needed for some portion of the work, depending on measured vapor concentrations and atmospheric conditions. Vapor suppression foam and perhaps other engineered controls would be applied where necessary to minimize the volatilization of hazardous substances and reduce nuisance odors. This might be needed in the portion of the excavation pit where it is not being actively worked, in the area of significant contamination near MW-2 and SB-18 and possibly near MW-4 and SB-23.

The historical depths to the water table at the site have ranged from 1.5 to 4.6 feet bgs. In the early autumn, when excavation is likely to take place, water depths at the site are expected to be approximately 4 feet bgs. Excavation activities performed at depths below the water table will require dewatering. The saturated soil material at the site is fine-grained and appears to yield only small quantities of water (wells go dry during purging). Thus, dewatering the excavation pit is not expected to produce large amounts of water. Extracted water would be stored in one or more tanks on site, where the water would be retained for an adequate amount of time for solids to settle. After settling, water would be pumped through a sand filter for particulate removal and through granular activated carbon for volatile contaminant removal, and then discharged to the city sanitary sewer. Permission for temporary discharge of this treated water will be requested from the City of Blaine. Coordination with the City of Blaine and with Ecology will take place to obtain any other permits and approval for excavation/grading, shoring, traffic control, and pedestrian access, as necessary.

4.1.3 Offsite Thermal Desorption of Excavated Soil

Implementation of the remedial actions of Alternative 1 would result in excavation and offsite disposal of contaminated soil that is classified as nonhazardous petroleum-contaminated waste. The soil will be transported by truck to the Cemex facility in Everett, Washington, where the soil will undergo thermal desorption and then be reused.

The highway transportation route from the site to the Cemex facility is 85 miles. Due to about 25-percent expansion of soil during excavation and loading, the estimated total volume of site soil to be transported is approximately 2,590 cubic yards, with a total weight of about 3,230 tons. Using a 30-ton haul truck with trailer would entail about 108 round trips to transport soil.

4.1.4 ORC Application

After completion of excavation, the pit will be backfilled (Section 4.1.5). Depending on final design decisions, the southwestern margin of the excavation pit will be packed with ORC (Figure 5). This oxidizing material will be added to this portion of the excavation to act as a single time-release treatment of the downgradient aquifer. The ORC will be placed so that a greater amount of the compound is located at depths adjacent to the saturated smear zone, where concentrations are greatest. Some ORC will be placed above the dry-season water table, so that as groundwater rises during the wet season the ORC becomes activated.

The addition of ORC to contaminated groundwater accelerates the natural biodegradation process by increasing the oxygen levels in the groundwater. ORC will continue to release oxygen for a period of time to promote the microbial aerobic degradation of petroleum constituents in the contaminant plume under Peace Portal Drive. The saturated lithology for the site is fine-grained, and ORC injection into onsite wells would most likely have minimal effect on the groundwater, as the distribution would be very limited. However, introducing ORC during excavation activities would increase the volume of groundwater affected and ensure a more even distribution of compound across the area of exposed contamination on the downgradient face. The ORC will be placed into the excavation with backfilled quarry spalls or washed rock in order to assure that surrounding permeability is high, thus allowing the ORC to release and distribute oxygen into the adjacent downgradient aquifer. This application is expected to reduce the overall restoration time frame of downgradient portions of the aquifer, under the roadway. In costing for this FFS, it was calculated that 8,000 pounds of ORC would be needed, based on the estimated volume of contaminated downgradient saturated soil at an application rate of 0.2 percent.

4.1.5 Regrade and Restore Site

In areas where excavation is performed, backfilling and regrading would be required. The excavation pit would be backfilled with material compatible with construction of a future commercial structure or a residence on the property. Structural fill will consist of quarry spalls such as pit run shale and will be compacted 2 to 5 percent. The site will be repaved according to its preexisting condition or according to plans with the property owner. About a 6-inch layer of crushed base rock will be used below the asphalt or concrete. Backfill type, compaction, and pavement near the street right-of-way would be performed according to city directives. All excavated areas would be restored to approximate pre-remediation surface elevations.

4.1.6 Environmental Monitoring and Institutional Controls

Under MTCA, compliance monitoring is required for all cleanup actions (WAC 173-340-410). Three categories of compliance monitoring are defined under MTCA:

- Protection monitoring to confirm that human health and the environment are protected during construction and operation of the cleanup action.
- Performance monitoring to confirm that the cleanup action has attained cleanup standards or remedial objectives.
- Confirmational monitoring to confirm the long-term effectiveness of the cleanup action after remedial objectives have been attained. Cleanup actions consisting of onsite disposal, isolation, or containment will require long-term monitoring until the residual hazardous substance no longer exceeds cleanup levels.

Protection monitoring would take place during remediation primarily using air monitoring in the breathing zone. Performance monitoring would take place during remediation as discussed above to determine that soil has been removed to cleanup levels, as feasible.

Confirmational monitoring would include a groundwater sampling program to monitor water quality and to evaluate the natural attenuation process. This program would monitor for trends in contaminant concentrations, confirm that attenuation is taking place, determine the potential for off-property migration, and determine whether cleanup standards are met.

Components of groundwater monitoring include a number of actions that apply to monitoring for COCs. Three new groundwater monitoring wells would be installed following the remedial action. This is to replace those wells that will be removed during remediation. One new well would be located upgradient and two new wells would be placed on the downgradient side of the property along Peace Portal Drive. Groundwater would be sampled from all site wells to determine if water quality improves or degrades over time. For costing purposes, the following laboratory analyses were assumed for four rounds (one year) of groundwater sampling: NWTPH-Gx and NWTPH-Dx (with cleanup); BTEX, MTBE, EDC, and EDB (Method 8260); and PAHs (Method 8270 SIM).

The time estimated to reach cleanup levels in groundwater (and soil), under both natural attenuation conditions and through the use of ORC, is difficult or impossible to determine with the available limited information. The only well with a significant time period of measured and detected concentrations is MW-2. Concentrations for key hazardous substances for four rounds of sampling, extending over 12½ years, are presented in Table 5. Although concentrations do not change systematically through time, there is a generally decreasing trend that is especially strong for all TPH ranges; however, the trend appears to be weak or even stagnant for MTBE and BTEX compounds. TPH concentrations in MW-2 groundwater samples are below or close to MTCA CULs, while MTBE and BTEX concentrations will take a significant amount of time to reach cleanup levels.

Thus, the groundwater restoration time frame if no remediation takes place would be many years. However, through excavation of on-property soil source removal and with addition of ORC, the time frame is expected to shorten significantly. During this time interval, it may be necessary to use institutional controls, including a soil management plan submitted to the City of Blaine, to limit the use or interaction with groundwater and remnant contaminated soil until monitoring is completed and cleanup levels have been attained.

4.2 Alternative 2—Soil Removal and Monitoring

This alternative would reduce and control exposures to contaminants by the following response actions:

- Remove dispenser islands and other structures
- Excavate identified on-property contaminated soil
- Perform offsite thermal desorption of excavated soil
- Regrade and restore site
- Initiate environmental monitoring and institutional controls

This remedial alternative is similar to Alternative 1 except that it does not incorporate application of ORC into the excavation pit following soil removal on the property. This would modestly reduce costs but prolong the full restoration time frame. As stated in Section 4.1.6, it is difficult to determine the length of the restoration time frame, and the difference in time between Alternative 1 and Alternative 2 cannot currently be quantified. Alternative 2 would achieve source removal by excavating all identified on-property contaminated soil, as feasible, and transporting it for offsite treatment and disposal. Off-property contamination in soil and groundwater would be addressed through a soil management plan filed with the City of Blaine. Groundwater would be addressed through upgradient (on-property) source removal, by on-property monitoring, and through natural attenuation. These measures would be required until complete restoration is achieved for soil and groundwater. The areal extent of the remedial actions is displayed in Figure 5, but without the ORC component.

5.0 Analysis and Comparison of Alternatives

MTCA requires the use of permanent solutions in which cleanup levels will be attained at the site without additional remedial actions; however, MTCA also recognizes that costs of the permanent solution may be disproportionate to the benefits it provides. Disproportionate costs are defined in MTCA as cases where the incremental costs of an alternative over that of a lower cost alternative exceed the incremental degree of benefits provided by the higher cost alternative. In the case of disproportionate costs, MTCA allows selection of a lower cost alternative that "uses permanent solutions to the maximum extent practicable" [WAC 173-340-360(3)]. This lower cost alternative is selected by conducting a disproportionate cost analysis, which compares the costs and benefits of all remedial alternatives in the feasibility study. This analysis also provides a framework for evaluating non-cost criteria of alternatives.

5.1 Permanence Ranking of Alternatives

The disproportionate cost analysis requires that the alternatives be ranked from most to least permanent and that the permanent solution alternative serve as the baseline against which all other alternatives are evaluated. When the benefits of two or more alternatives are equal, the lower cost alternative shall be selected as the preferred alternative.

It is expected that both of the alternatives in this FFS will result in permanent solutions at the Blaine site, although off-property contamination may take a significant amount of time to fully attain cleanup levels. These alternatives are intended to eliminate risk by removing on-property contaminated soil above cleanup level concentrations, and this will result in a beneficial effect on groundwater. Both alternatives will remove from the site a significant amount of source material, and both involve reducing levels of groundwater contamination. Alternative 1 is more active in affecting groundwater contamination, but it has a higher cost.

5.2 Evaluation of Alternatives Using Disproportionate Cost Criteria

MTCA specifies several major criteria for evaluation and comparison of alternatives when conducting a disproportionate cost analysis to determine whether a remedial action is permanent to the maximum extent practicable [WAC 173-340-360(3)(e-f)]. The alternative analysis presented in Table 6 involves an evaluation of each alternative relative to the specified criteria listed below.

Protectiveness. Overall protectiveness of human health and the environment, including the following considerations:

- Degree to which existing risks are reduced,
- Time required to reduce risks and attain cleanup standards,
- Onsite and offsite risks resulting from implementation of the alternative, and
- Improvement in the overall environmental quality.

Permanence. The degree to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the following considerations:

- Adequacy of the alternative in destroying hazardous substances,
- Reduction or elimination of hazardous substance releases or sources of releases,
- Degree of irreversibility of the waste treatment process, and
- Characteristics and quantity of treatment residuals generated.

Cost. The cost to implement the alternative, including the followings costs:

- Cost of construction (cost estimates for treatment technologies include pretreatment, analytical, labor, and waste management costs; the cost of replacement and repair of major elements for the estimated design life of the project is included);
- Net present value of any long-term costs (includes operation and maintenance [O&M] costs, monitoring costs, equipment replacement costs, and the cost of maintaining institutional controls); and
- Agency oversight costs that are cost-recoverable.

Long-term effectiveness. Long-term effectiveness includes the following considerations:

- Degree of certainty that the alternative will be successful,
- Reliability of the alternative during the time that hazardous substances are expected to remain onsite at concentrations exceeding cleanup levels,
- Magnitude of the residual risk with the alternative in place, and
- Effectiveness of controls required to manage the treatment residues or remaining wastes.

Management of short-term risks. Short-term risk includes the risk to human health and the environment associated with the alternative during construction and the implementation and effectiveness of mitigation measures.

Technical and administrative implementability. The ability of the alternative to be implemented includes the following considerations:

- Technical possibility of alternative;
- Availability of necessary offsite facilities, services, and materials;
- Administrative and regulatory requirements;
- Scheduling, size, and complexity;
- Monitoring requirements;
- Access for construction operations and monitoring; and
- Integration with existing facility operations and other current or potential remedial actions.

Consideration of public concerns. Consideration of public concerns includes whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This criterion includes concerns from individuals, community groups, local governments, tribes, federal, and state agencies, or any other organization that may have an interest in or knowledge of the site.

Restoration time frame. In addition to the above criteria, MTCA requires the determination as to whether a cleanup action provides for a reasonable restoration time frame [WAC 173-340-360(4)]. Shorter time frames are preferred, using active remedial measures where practicable, unless the longer time period is associated with a cleanup action having a greater degree of long-term effectiveness. To determine if an alternative has a reasonable restoration time frame, the following factors are to be considered:

- Potential risks posed by the site,
- Practicability of achieving a shorter restoration time frame,
- Current and potential future uses of site and surrounding area and associated resources that may be affected by site releases,
- Likely effectiveness and reliability of institutional controls,
- Ability to control and monitor migration of site hazardous substances and consideration of their toxicity, and
- Natural processes that reduce concentrations of hazardous substances at the site.

An evaluation of the alternative versus the cost criterion was accomplished by preparation of estimates of probable capital costs and expenses for O&M, and by estimating the life-cycle cost for both alternatives using present worth analysis. The time period used in the present worth analysis for each alternative was selected to be only one year, matching the length of time that was costed for groundwater monitoring. The present worth was calculated using a net discount rate of 5 percent before taxes and after inflation.

Estimated capital costs and O&M costs for each alternative are presented in Appendix A and summarized in Table 6. Unit costs were obtained from vendor quotations and from historical costs for other sites; dewatering costs were based on engineering estimates. Costs for offsite disposal and treatment were obtained from the treatment facility. This FS-level cost estimate (-30% and +50%) is accurate and valid only to the extent that components of this project follow those of past similar projects upon which costs are based. When process conditions are not well known, uncertainties in the specified parameters (e.g., treatment volume or excavation rate, concentrations of contaminants, or size of equipment) will result in additional cost uncertainty. Potential costs for stabilizing buildings during excavation are not included in Appendix B. To compensate for uncertainty, a 25-percent contingency amount has been incorporated into the total cost.

5.3 Comparative Evaluation of Alternatives

The remedial action alternatives are usually evaluated relative to the most permanent solution to illustrate the relative pros and cons between alternatives and to assist in identification of the most permanent alternative to the extent practicable. Alternatives 1 and 2 are similar in permanence, although neither option aggressively addresses off-property contamination because it is located under a roadway. However, Alternative 1 may be considered slightly more permanent and aggressive because it applies ORC to the aquifer. Because both alternatives provide relatively permanent solutions, the alternatives will simply be compared against each other using the criteria in Section 5.2. MTCA allows identification of a preferred alternative in the feasibility study [WAC 173-340-350(8)(c)(i)]. The preferred alternative will be identified based on the comparative evaluation presented in Table 6 and discussed below. One of the criteria, public concerns, is typically addressed in the Cleanup Action Plan after comments on the FS Report have been received. The currently anticipated public concerns are included in Table 6.

Through the analysis and evaluation of alternatives using the specified criteria, both of the presented alternatives are capable of permanently removing site contaminants from the subsurface, although off-property contaminant removal will be slow. The difference in risk reduction between the alternatives is minor, because the discriminator is the application of ORC in Alternative 1, which affects the downgradient area under the roadway, where risks are minimal. The differences between alternatives in levels of contaminant reduction are not necessarily predictable, but Alternative 1 would provide slightly more thorough and more certain reduction due to ORC application. Both alternatives carry a measure of uncertainty for off-property contamination. The following text highlights further the significant pros, cons, and differences between alternatives.

Alternative 1 involves removal of on-property identified contaminated soil to the extent practicable, using conventional excavation. This alternative first involves removing the dispenser islands, canopy, and four wells prior to accessing the subsurface contamination. All contaminated soil is transported 85 miles to Everett, Washington, for treatment and reuse. In addition, approximately 8,000 pounds of ORC are added to the southwestern margin of the western excavation pit, to produce a single time-release effect on contaminant biodegradation in the downgradient aquifer. ORC is believed to decrease the overall time frame for groundwater remediation. There are negligible implementation risks or concerns involved with ORC application, and placing it in an open excavation is an efficient delivery system. This alternative has the advantage of fully removing all identified on-property contaminated soil, but there is the likelihood of not completely identifying remnant contamination. This alternative has the risk of exposing workers and neighbors to petroleum vapors and dust during soil removal, loading, and dewatering. In addition, the number of truckloads of soil and backfill that are transported through Blaine may impact local residents and workers, with resultant traffic and noise concerns. The total cost for Alternative 1 is approximately $692,000 present worth (including 25 percent contingency).

Alternative 2 is very similar to Alternative 1 in terms of characteristics and benefits/risks, but without the addition of ORC in the excavation pit. This alternative removes on-property contaminants the same as Alternative 2, but without ORC it does not benefit the downgradient aquifer under Peace Portal Drive as does Alternative 1. Because ORC application adds negligible implementation risks and concerns, Alternative 2 has similar evaluative criteria to Alternative 1 but with less environmental benefit. The main difference between the two alternatives is this added benefit (for Alternative 1) and the different costs, which for Alternative 2 is approximately $606,000 present worth (including 25 percent contingency).

The direct cost of the ORC material is about $56,000, and there are some additional minor costs applied in design, labor, and contingency. But considering the possible benefits to the downgradient aquifer, the shorter restoration time frame, and the ease of application and delivery into the aquifer via the open excavation, this additional cost of Alternative 1 appears to be warranted based on all MTCA criteria discussed above.

Considering that both alternatives present similar implementation risks and other concerns, but that Alternative 1 provides additional restoration benefits, this alternative has been identified as the preferred remedial alternative for the Blaine site. Alternative 1 meets the goals of MTCA in that it is protective of human health and the environment; it meets the preference for a permanent solution, active remediation, and reasonable (although unknown) restoration time frame; it is expected to have relatively low short-term risks; it is readily implementable; it takes into account currently anticipated public concerns; and it is compatible with the future land use of the property.

6.0 References

BEK (Bek Purnell Engineering). 1997. Monitoring Well Installation and Ground Water Analysis Blaine Mini Mart. October 30, 1997.

Ecology. 2009. Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action. Review Draft, October 2009. Publication No. 09-09-047.

Ecology. 2010. Regulated Underground Storage Tanks Site List. https://fortress.wa.gov/ecy/tcpwebreporting/reports.aspx

Environmental Associates, Inc. 2005. Subsurface Sampling and Testing Blaine Mini Mart (Gas Station and Convenience Store). December 08, 2005.

Johnson, P.C. and Ettinger, R.A. 1991. Heuristic Model for Predicting the Intrusion Rate of Contaminant Vapors into Buildings. Environmental Science and Technology, vol. 25, no.8. pp. 1445-1452.

Northwest Tank and Environmental Services, Inc. 2010. Field Report Testing Summary. January 08, 2010.

SAIC. 2010. Site Characterization Report, Blaine Mini Mart, Blaine, Washington. Submitted to Ecology, July 21, 2010.

Whatcom Environmental Services. 2008. Groundwater Monitoring Well Sampling – Blaine Mini Mart (Ecology Facility Site ID # 42128291). May 02, 2008.

LIMITATIONS

As part of this report, SAIC's investigation was restricted to collection and analyses of a limited number of environmental samples, visual observations and field data, in addition to summarizing available information from previous site documents. Because the current investigation consisted of evaluating a limited supply of information, SAIC may not have identified all potential items of concern. This report is intended to be used in its entirety; taking or using excerpts from this report is discouraged.

Tables

Table 1
Cleanup Levels in Soil and Groundwater
Blaine Mini Mart Site

Hazardous Substance	Soil (mg/kg)		Groundwater (µg/L)	
	MTCA Method A Soil CULs	Simplified TEE MTCA Table 749-2 used as CULs	MTCA Method A Groundwater CULs	Vapor Intrusion Protection for Groundwater CULs
Benzene	0.03	--	5	2.6
Toluene	7	--	1,000	3,200
Ethylbenzene	6	--	700	8,000
Xylenes	9	--	1,000	900
MTBE	0.1	--	20	190,000
EDC	--	--	5	4
Naphthalenes	5	--	160	550
TPH: gasoline-range	30	200	800	--
TPH: diesel-range	2,000	460	500	--
TPH: heavy oil-range	2,000	460	500	--

-- = No cleanup level promulgated

Underlined cleanup levels are those utilized going forward in this FFS report.

Table 2
Vapor Intrusion Modeling Results

Blaine Mini Mart Groundwater Sample Concentrations (µg/L)

Monitoring Well	Benzene Groundwater Concentration		Toluene Groundwater Concentration		Ethylbenzene Groundwater Concentration		Total Xylenes[1] Groundwater Concentration		MTBE Groundwater Concentration	EDC[2] Groundwater Concentration	Naphthalene Groundwater Concentration
	Min	Max	Min	Max	Min	Max	Min	Max			
MW-2	**12,000**	**120,000**	**18,000**	**180,000**	**2,000**	**18,000**	**11,000**	**110,000**	22,000	**50**	**400**
MW-4	**2,800**		1,800		440		**3,870**		89	**10**	0.92
Vapor Intrusion Groundwater Screening Levels (µg/L):	*2.4*		*15,000*		*2,800*		*440*		*86,000*	*4.2*	*170*

Modeled Indoor Air Concentrations (µg/m³) Calculated from Groundwater Concentrations

Monitoring Well	Benzene Indoor Air Concentration		Toluene Indoor Air Concentration		Ethylbenzene Indoor Air Concentration		Total Xylenes[1] Indoor Air Concentration		MTBE Indoor Air Concentration	EDC Indoor Air Concentration	Naphthalene Indoor Air Concentration
	Min	Max	Min	Max	Min	Max	Min	Max			
MW-2	**1,450**	**14,900**	**2,350**	**24,300**	259	**2,410**	**1,260**	**13,100**	368	**1.18**	**2.36**
MW-4	**61.7**		14.8		9.6		**74.3**		0.486	0.065	0.00248
Method B Indoor Air CULs (µg/m³):	*0.32*		*2,200*		*460*		*46*		*14,000*	*0.096*	*1.4*

Modeled Site-Specific Groundwater Concentrations (µg/L) Protective of Vapor Intrusion Pathway

Monitoring Well	Benzene Groundwater Concentration	Toluene Groundwater Concentration	Ethylbenzene Groundwater Concentration	Total Xylenes[1] Groundwater Concentration	MTBE Groundwater Concentration	EDC Groundwater Concentration	Naphthalene Groundwater Concentration
MW-2	2.6	3,200	8,000	900	190,000	4	550
MW-4	14.5	18,000	48,000	5,500	600,000	15	1,150
MTCA Method A Groundwater CULs (µg/L):	*5.0*	*1,000*	*700*	*1,000*	*20*	*5*	*160*
Selected Groundwater CULs for Blaine (µg/L):	***2.6***	***1,000***	***700***	***900***	***20***	***4***	***160***

MTBE = Methyl tertiary-butyl ether
EDC = 1,2-Dichloroethane
Yellow highlighted cells are those that exceed groundwater screening levels or indoor air cleanup levels.
Vapor intrusion groundwater screening levels and indoor air cleanup levels are from Ecology (2009).
Modeling exposure factors were based on unrestricted land use (residental).
[1] Of the three xylene isomers, m-xylene provides the highest risk in the JEM modeling; therefore, it was used to model the total xylenes concentrations.
[2] EDC was detected in well MW-1 (10 µg/L) but not in MW-2 or MW-4 due to elevated detection limits in samples from these wells.
As a result, half the detection was utilized for sake of modeling EDC at MW-2 (100 U µg/L) and MW-4 (10 U µg/L).

Table 3
Screening of Cleanup Alternative Components

Cleanup Action Category	Cleanup Alternative Component	Description of Action	Effectiveness	Implementability	Relative Cost: Capital	Relative Cost: O&M	Alternative Selection Screening Comment
No Action	None	None	Does not reduce contaminant exposures except by natural attenuation processes (not monitored)	No implementation	Zero	Zero	Rejected – protectiveness
Institutional Controls/ Access Restrictions	Physical access controls	Use of signs or security measures to limit or prevent public access	Limits direct contact with surface soils for short-term uses only	Readily implemented	Low	Low	Rejected – effectiveness and protectiveness
	Deed restriction or soil manage-ment plan	Covenants or plans to limit conveyance of property and the types of land uses and construction allowed	Minimizes disturbance and direct contact with remaining subsurface contamination, or plans for interacting with contamination	Readily implemented	Low	Low	Retained
	Groundwater monitoring	Use of wells to monitor contaminant concentrations and groundwater quality over time	Effective in determining residual contaminant levels after remedial measures implemented	Readily implemented	Low	Low	Retained
Containment	Surface cap	Capping and maintaining cap to prevent receptor exposure	Effective to prevent surface exposure if maintained; not protective of intrusive work, groundwater protection, or for unrestricted land use	Readily implemented on-property	Moderate	Low	Rejected – effectiveness and protectiveness
	Subsurface vapor barrier	Vapor barrier placed at shallow depth extending over entire contaminated area	Effective when properly placed; effectiveness diminished by future subsurface construction or repair/upgrade for utilities or other station structures	Implementable on-property with shallow excavation, difficult off-property or where subsurface utilities exist	Moderate	Low	Rejected – effectiveness
Removal/ Excavation	Deep soil excavation	Remove soil down to 20+ feet bgs using large-diameter augers (auger shafts)	Effective for permanent removal of soil contamination from the deep area (to about 20 feet bgs); minimizes amount of dewatering	Readily implemented, especially for deep soil	High	Zero	Rejected – cost
	Shallow to medium soil excavation	Excavate soil to approximately 20 feet bgs using standard excavation techniques	Effective for permanent shallow to moderate depth soil contamination from the property	Readily implemented for shallow to moderate depth soil	Moderate	Zero	Retained
	Excavation dewatering	Collect water from excavation and pre-treat by filtration or sedimentation	Effective for controlling water in excavation into saturated soils of moderate to low permeability	Readily implemented	Moderate	Moderate	Retained

Table 3
Screening of Cleanup Alternative Components

Cleanup Action Category	Cleanup Alternative Component	Description of Action	Effectiveness	Implementability	Relative Cost		Alternative Selection Screening Comment
					Capital	O&M	
On-Site Treatment	Soil vapor extraction	Removal of volatile contaminants from the vadose zone by vacuum-induced air flow	Poor effectiveness in thin vadose zone contaminated areas containing heteroge-neous and fine-grained soil	Readily implemented in shallow vadose zone	Moderate	Low	Rejected – effectiveness
	Air sparging with soil vapor extraction	Removal of volatile contaminants from the saturated zone by air injection into the aquifer and collection of vapors by soil vapor extraction	Moderate to poor effectiveness in fine-grained soils due to low permeability; same problems with soil vapor extraction as above	Readily implemented	Moderate	Low	Rejected – effectiveness
	Multi-phase extraction	Removal of groundwater and vapors, to expose more of the smear zone for vapor removal	Moderate to poor effectiveness in fine-grained soils due to low permeability and low extraction of vapor and groundwater (narrow radius of influence)	Readily implemented	Moderate to high	Moderate	Rejected – effectiveness
	Chemical oxidation	Injection of oxidant chemicals into aquifer to promote in-situ chemical oxidation; may also be placed in excavation before backfilling	Effective in reducing organic contaminant concentrations but may require multiple chemical injections to be effective in higher concentration areas	Readily implemented; injection or placement volumes and distribution or radius of influence are critical to good distribution; silt-rich units at Blaine may limit distribution	Moderate	Low	Retained
	Monitored natural attenuation	Attenuation of groundwater contaminants by natural processes of biodegradation, adsorption, dispersion, and dilution	Moderately effective for degradable contaminants; however, degradation typically occurs over a long time frame	Readily implemented	Low	Low	Retained
	Activated carbon filtration	Treatment of contaminated vapors from soil vapor extraction, air sparging, or contaminated groundwater from dewatering by adsorption onto activated carbon	Highly effective treatment for volatiles present in air or water media collected from the subsurface	Readily implemented; requires monitoring for contaminant breakthrough and change out when carbon is spent	Moderate	Moderate	Retained

Table 3
Screening of Cleanup Alternative Components

Cleanup Action Category	Cleanup Alternative Component	Description of Action	Effectiveness	Implementability	Relative Cost		Alternative Selection Screening Comment
					Capital	O&M	
Off-Site Treatment	Thermal Desorption	Use of high heat process to desorb petroleum constituents from soil	Highly effective in removing nonhazardous petroleum constituents from soil	Readily implemented, but requires significant travel	High	Zero	Retained

Table 4
Development of Cleanup Alternatives

ACTION	ALTERNATIVE 1 Soil Removal, ORC Application, and Monitoring	ALTERNATIVE 2 Soil Removal and Monitoring
Remove dispenser islands and other structures	●	●
Excavate soil by standard methods, with trench box	●	●
Excavation dewatering and treatment	●	●
Off-site treatment/disposal of excavated soil	●	●
Application of ORC in excavation pit	●	
Regrade and restore site	●	●
Implement groundwater monitoring	●	●
Implement institutional controls	●	●

Table 5
Concentrations Through Time for MW-2 Groundwater

Sampling Date	Benzene (μg/L)	Toluene (μg/L)	Ethyl-benzene (μg/L)	Total Xylenes (μg/L)	MTBE (μg/L)	TPH-gas (μg/L)	TPH-diesel (μg/L)	TPH-oil (μg/L)
10/22/1997	12,000	18,000	2,000	11,000	--	94,000	--	--
11/11/2005	120,000	180,000	18,000	110,000	22,000	1,100,000	300,000	300,000
4/22/2008	26,000	27,000	3,600	20,000	--	150,000	2,500 U	250 U
3/17/2010	22,000	18,000	2,400	13,500	3,900	160	750	500 U
MTCA CULs for site:	*2.6*	*1,000*	*700*	*1,000*	*20*	*800*	*500*	*500*

Table 6
Comparison of Cleanup Alternatives

Evaluation Factor	ALTERNATIVE 1 Soil Removal, ORC Application, and Monitoring	ALTERNATIVE 2 Soil Removal and Monitoring
Protectiveness	• High degree of on-property risk reduction due to elimination of risk through source removal and active one-time groundwater treatment • Short time frame for on-property risk reduction: immediate source removal and groundwater treatment implementation with rapid impacts; remedial objectives for soil contaminant reduction met immediately upon completion • Moderate probability of additional short-term risks (exposure to contaminated soils, vapor emanations, and offsite transport) due to implementation • High degree of environmental quality improvement due to elimination of risk from on-property soil	• High degree of on-property risk reduction due to elimination of risk through source removal, but without active groundwater treatment • Short time frame for on-property risk reduction: immediate source removal but no groundwater treatment thus taking longer for downgradient cleanup; remedial objectives for soil met immediately upon completion • Moderate probability of additional short-term risks (exposure to contaminated soils, vapor emanations, and offsite transport) due to implementation • High degree of environmental quality improvement due to elimination of risk from on-property soil
Permanence	• Hazardous substances in on-property soil fully removed by excavation and destroyed by thermal desorption • Hazardous substances in groundwater treated via source removal, natural attenuation, and once by ORC • Elimination of future potential for contaminant release due to excavation • Does not include onsite waste treatment process for soils; therefore, no irreversibility and no treatment residuals related to soils • Onsite waste treatment process (ORC) for groundwater will result in limited irreversibility; presence of treatment residuals in aquifer after reaction of ORC	• Hazardous substances in on-property soil fully removed by excavation and destroyed by thermal desorption • Hazardous substances in groundwater treated slowly via source removal and natural attenuation • Elimination of future potential for contaminant release due to excavation • Does not include onsite waste treatment process for soils; therefore, no irreversibility and no treatment residuals related to soils • No groundwater treatment
Cost	• $647,000 capital cost • $692,000 total cost, present worth @ 5%	• $561,000 capital cost • $606,000 total cost, present worth @ 5%
Long-Term Effectiveness	• High degree of certainty for success due to on-property soil removal by excavation; some uncertainty arises from contaminated soil areas potentially missed in excavation; one-time ORC application expected to have modest impact • Moderate degree of certainty for success of groundwater treatment by ORC, although only a one-term application • High degree of reliability due to on-property contaminant removal • Low magnitude of residual risk due to on-property source removal and ORC treatment of groundwater • Excellent degree of effectiveness for offsite disposal facility to treat soil wastes for future reuse	• High degree of certainty for success due to on-property soil removal by excavation; some uncertainty arises from contaminated soil areas potentially missed in excavation; no groundwater treatment results in decreased effectiveness • High degree of reliability due to on-property contaminant removal • Low magnitude of residual risk due to on-property source removal • Excellent degree of effectiveness for offsite disposal facility to treat soil wastes for future reuse

Table 6
Comparison of Cleanup Alternatives

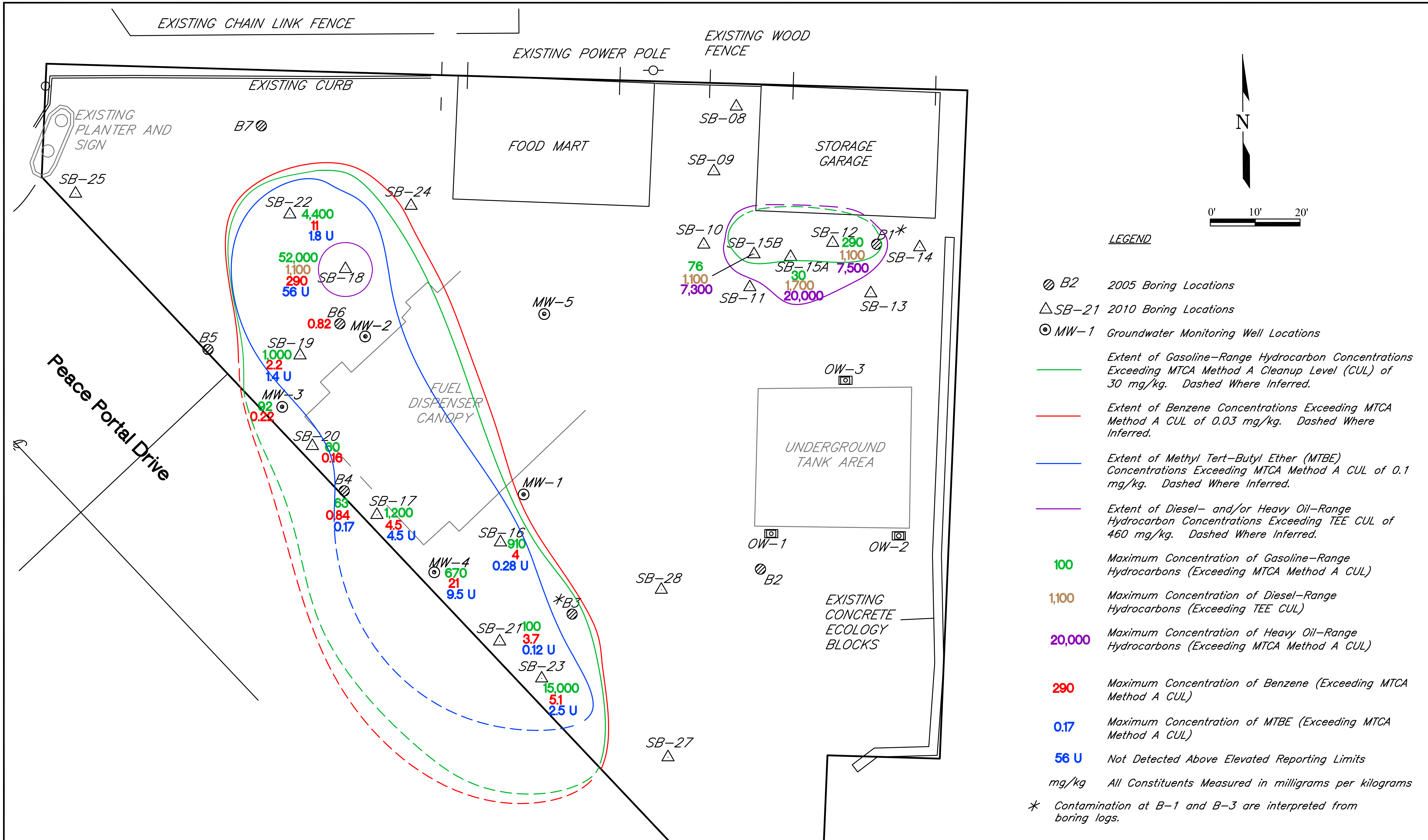
Evaluation Factor	ALTERNATIVE 1 Soil Removal, ORC Application, and Monitoring	ALTERNATIVE 2 Soil Removal and Monitoring
Management of Short-Term Risks	• Moderate potential for short-term risks of worker exposures to contaminants in soil and air during excavation and loading • Moderate potential of short-term risks for nearby individuals to be exposed to air/dust contaminants generated by excavation • Moderate risk to public for offsite releases and traffic accidents during transport of excavated contaminated soils for disposal	• Moderate potential for short-term risks of worker exposures to contaminants in soil and air during excavation and loading • Moderate potential of short-term risks for nearby individuals to be exposed to air/dust contaminants generated by excavation • Moderate risk to public for offsite releases and traffic accidents during transport of excavated contaminated soils for disposal
Technical and Administrative Implementability	• High technical possibility, uses standard construction techniques; moderate probability of on-property soil contamination left in place due to utility or building interferences • All offsite services are readily available • Expected to comply with all regulations • Long-term monitoring of groundwater required, with final cleanup estimated at many years (less than Alternative 1) • Access difficulties reduced by removing dispensers and canopy; some difficulties may arise from proximity to buildings • Remedial action will require coordination with the City of Blaine for traffic issues and possible utility concerns	• High technical possibility, uses standard construction techniques; moderate probability of on-property soil contamination left in place due to utility or building interferences • All offsite services are readily available • Expected to comply with all regulations • Long-term monitoring of groundwater required, with final cleanup estimated at many years (more than Alternative 1) • Access difficulties reduced by removing dispensers and canopy; some difficulties may arise from proximity to buildings • Remedial action will require coordination with the City of Blaine for traffic issues and possible utility concerns
Consideration of Public Concerns	To be addressed after public comment period; anticipated public concerns would be moderate due to impact of vapors, noise, truck traffic, movement of contaminated soil, and gas station availability interruption	To be addressed after public comment period; anticipated public concerns would be moderate due to impact of vapors, noise, truck traffic, movement of contaminated soil, and gas station availability interruption
Estimated Restoration Time Frame	A number of years from application of ORC until off-property groundwater and soil attain CULs; ORC will speed up the overall process faster than Alternative 2	A number of years from implementation until off-property groundwater and soil attain CULs; without ORC, this process will take longer than Alternative 1

Figures

Figure 1. Location Map for the Blaine Mini Mart Site

SAIC® From Science to Solutions

DEPARTMENT OF ECOLOGY State of Washington



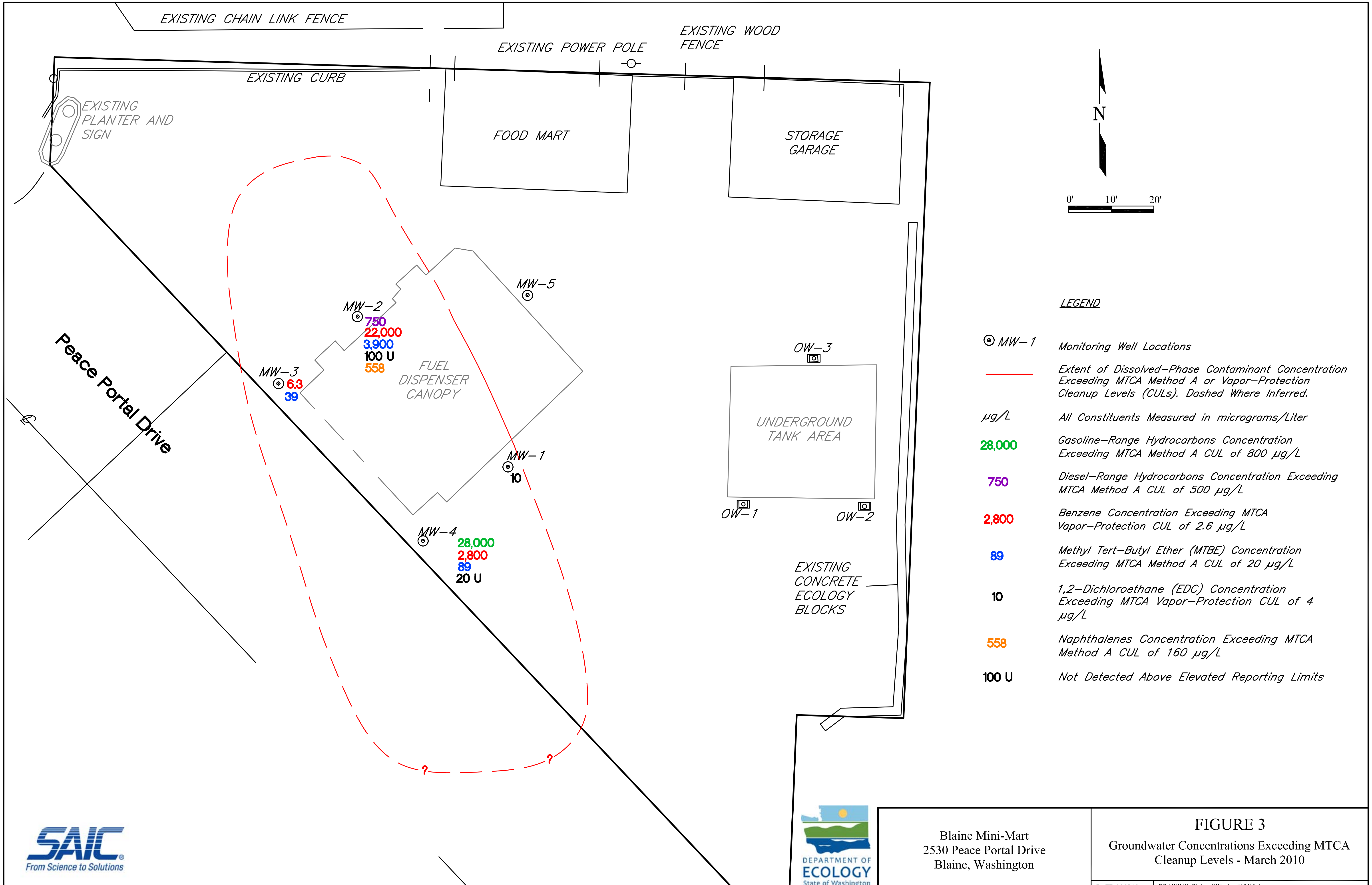
SAIC
From Science to Solutions

DEPARTMENT OF ECOLOGY
State of Washington

Blaine Mini-Mart
2530 Peace Portal Drive
Blaine, Washington

FIGURE 2
Soil Concentrations of Selected Contaminants Exceeding MTCA Cleanup Levels

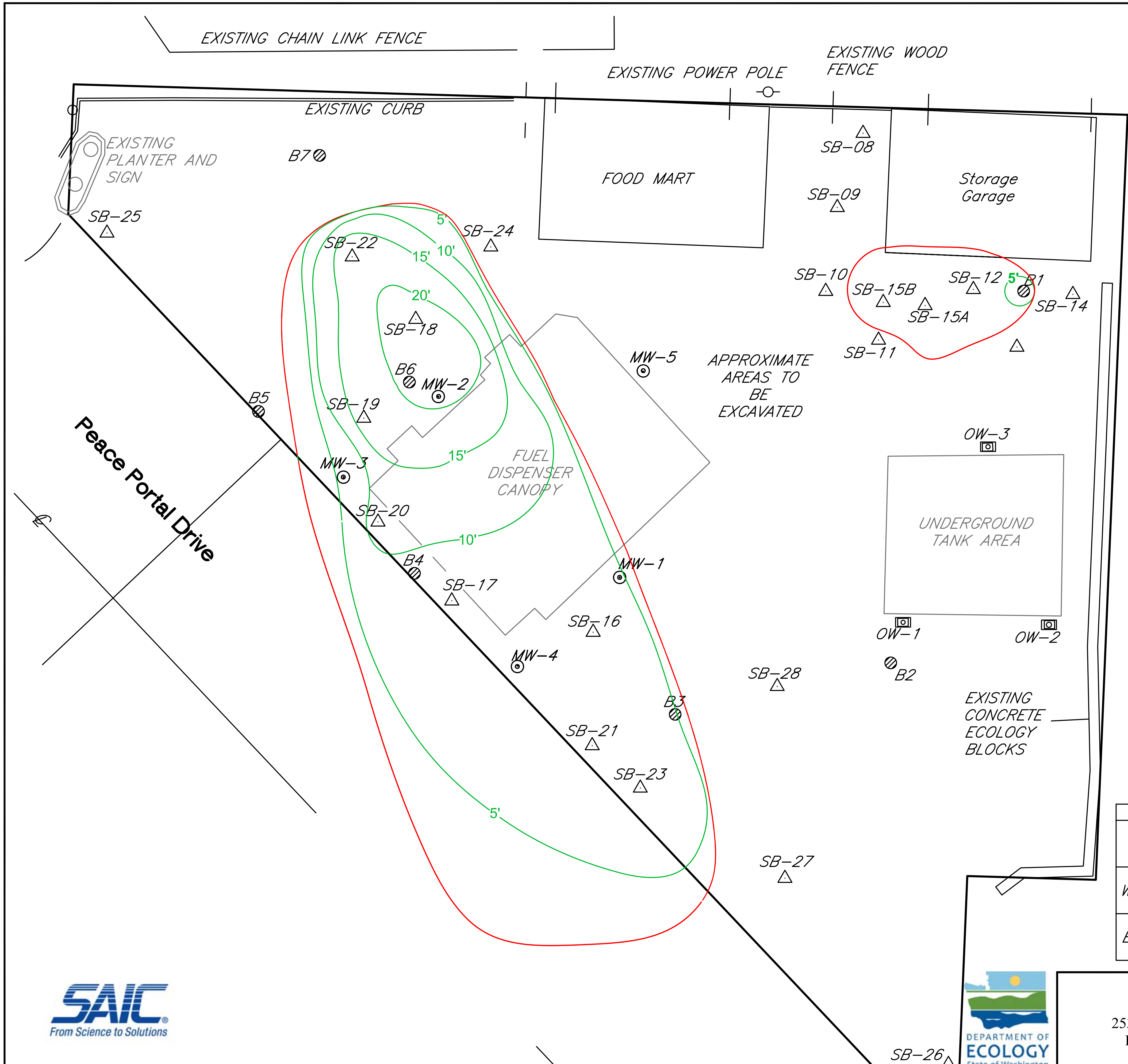
DATE: 07/27/10 DRAWING: Blaine_Soil Conc.dwg



Blaine Mini-Mart
2530 Peace Portal Drive
Blaine, Washington

FIGURE 3
Groundwater Concentrations Exceeding MTCA Cleanup Levels - March 2010

DATE: 06/07/10 | DRAWING: Blaine_GW_ajw_060410.dwg



LEGEND

B2	2005 Boring Locations
SB-21	2010 Boring Locations
MW-1	Groundwater Monitoring Well Locations
(red line)	Area of Contamination, Lateral Extent of combined MTCA Cleanup Level Exceedances (Approximate Location)
10' (green line)	Extent of Contamination at Stated Depth (Feet Below Ground Surface, Approximate Location)
2	Approximate Depth of Top of Contamination
10	Approximate Depth of Bottom of Contamination
(20)	Contamination extends deeper than the base of boring; parentheses represent estimated bottom depth of contamination.

Analytical data obtained from MW-2 and B-6 may not represent impacted soil in these borings. Depth range of impacted soil was estimated based on field screening measurements.

Contamination at B-1 and B-3 are interpreted from boring logs.

Note: Contamination depth is given in feet and represents the combined vertical range of soil contamination at each boring for all hazardous substances.

Estimated Excavation Areas and Volumes

	Area (sq ft)	Volume (cu yd)	Volume (tons)
Western Plume	4836	2003	3125
Eastern Plume	620	69	108

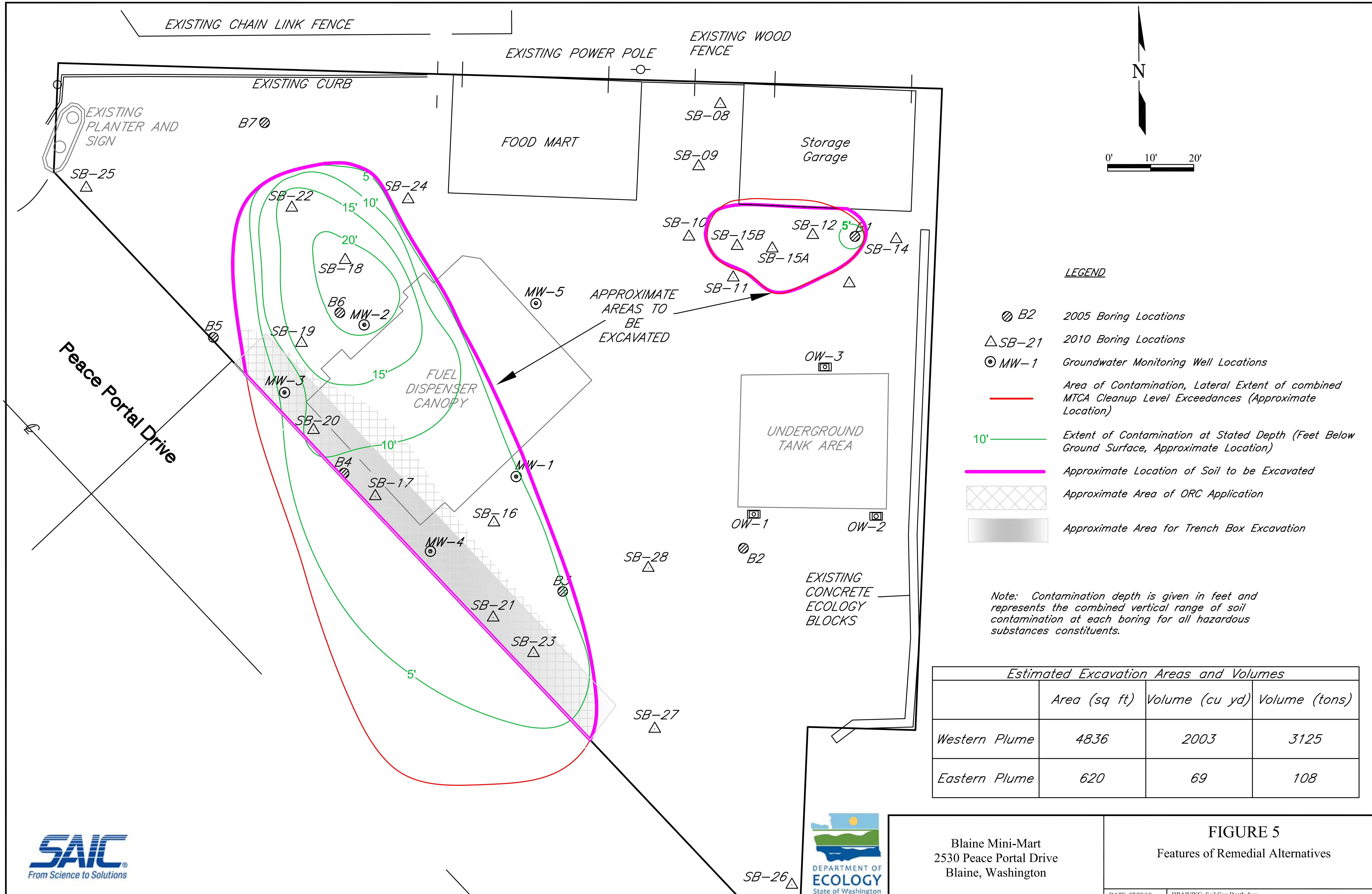
SAIC
From Science to Solutions

DEPARTMENT OF ECOLOGY
State of Washington

Blaine Mini-Mart
2530 Peace Portal Drive
Blaine, Washington

FIGURE 4
Extent of Impacted Soil Exceeding MTCA Cleanup Levels

DATE: 07/08/10 DRAWING: Soil Con Depth.dwg



Estimated Excavation Areas and Volumes			
	Area (sq ft)	Volume (cu yd)	Volume (tons)
Western Plume	4836	2003	3125
Eastern Plume	620	69	108

Blaine Mini-Mart
2530 Peace Portal Drive
Blaine, Washington

FIGURE 5

Features of Remedial Alternatives

DATE: 07/08/10 DRAWING: Soil Con Depth.dwg

Appendix A
Vapor Intrusion Modeling Runs
(Provided only electronically)

Appendix A Vapor Intrusion Modeling Runs

(Provided only electronically)

For an electronic copy on this appendix please send a request to the Site manager below and you will receive a copy on CD in the mail.

Isaac Standen
Washington State Department of Ecology
Toxics Cleanup Program
Headquarters
(360)-407-6776
FAX: (360)-407-7154
ista461@ecy.wa.gov

Appendix B
Remedial Alternative Cost Estimates

Remedial Alternatives for Blaine Mini Mart
Summary of Remedial Alternatives

Remedial Alternatives	Non-Discounted Cost			
	Capital Cost	O&M Cost	Total Cost	Duration
Alternative 1 - Soil Removal, ORC Application, and Monitoring	$647,184	$47,344	$694,528	1 year monitoring
Alternative 2 - Soil Removal and Monitoring	$560,780	$47,344	$608,124	1 year monitoring

Remedial Alternatives	Discounted Cost (Nominal Rate = 5%)			
	Capital Cost	O&M Cost	Total Cost	Duration
Alternative 1 - Soil Removal, ORC Application, and Monitoring	$647,184	$45,089	$692,274	1 year monitoring
Alternative 2 - Soil Removal and Monitoring	$560,780	$45,089	$605,869	1 year monitoring

General Notes:

1. The following markups have been applied to all costs: 8% Design, 5% Office Task Labor/Supplies, 3% Field Task Labor/Supplies, and 25% Contingency. Design markup cost has not been applied to O&M cost totals.

Remedial Alternatives for Blaine Mini Mart
Alternative 1 - Soil Removal, ORC Application, and Monitoring
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
CAPITAL			
Excavation Subcontractor Mobilization	ls	$10,000	Mobilization, project management and demobilization.
Subcontractor pre-construction plans and geotech	ls	$10,000	Preparation and submittal of pre-construction plans and reports.
Utility Locate			
Subcontractor Private Utilty Locate	ls	$1,600	Quote from GeoMarkout.
Well Abandonment			
Decommission Monitoring wells MW-1, MW-2, MW-3, and MW-4	ea	4	Assume 4 monitoring wells will be decommissioned by filling the casing with bentonite pellets from the bottom of the well to the land surface.
Cost for Decommissioning 4 monitoring wells	$/ea	$241	Assume 2" casing, 5' to 10' screen, 8" well mount, cost developed from Cascade Drilling.
SAIC oversight	hr	10	
SAIC oversight	$/hr	$73	
Cost for SAIC oversight			
Traffic Control / Site Control			
Estimated duration for traffic control / site control needs	days	15	
Traffic control / Site control daily rate	$/day	$200	Historic costs, include signage, and flaggers (if necessary).
Station Decommissioning			
Removal-Disposal of dispenser and canopy	ls	$6,800	Quote from Clearcreek Contractors.
Concrete slab volume	cy	10	Estimated volume of concrete.
Cost for concrete slab removal and recycling	$/cy	$20	Historic costs.
Truck and Trailer driver	hr	13.5	Round trip hours.
Cost for Truck and Trailer driver	$/hr	$121	Truck and Trailer hourly rate.
Asphalt volume	cy	10	Estamated volume of asphalt.
Cost for asphalt slab removal and recycling	$/cy	$20	Historic costs.
Vac Truck to remove residual gasoline in product piping/USTs	ls	$2,000	Historic costs.
SAIC oversight	hr/day	50	Assume the station decommission will take a week.
Cost of SAIC oversight	$/hr	$73	
On-site Analytical Lab			
On-site lab used during all excavation work	days	10	10 days for excavation activities and lab time.
On-site lab daily rate	$/day	$1,600	ESN mobile laboratory quote.
SOIL EXCAVATION BY STANDARD EXCAVATOR			
Contaminated Soil Volume	ton	2546	Contaminated soil minus trench box (tons).
Excavation and loading costs	$/ton	$10	Quote from Clearcreek Contractors of open excavation, bank yards; trench box is separate (below).
ORC Installation	lbs	8,000	Cost estimate from Adventus.
Cost of ORC (lbs)	$/lbs	$7	
Cost of ORC installation			
SAIC oversight	hr/day	105	Assume the excavation + ORC application will take 10.5 days.
Cost of SAIC oversight	$/hr	$73	
TRENCH BOX WITH SOIL EXCAVATION			
Trench box installation and removal, soil removal, and backfilling (ton)			
Trench box excavation volume (ton)	tons	686	Assume 10' wide x 115' long x 10' deep (at 1.56 ton/bank yd).
Cost of trench box excavation ($/ton)	($/ton)	$60	Cost for excavating, trench boxing, backfilling this zone.
Total cost of trench box excavation		$41,184	

Remedial Alternatives for Blaine Mini Mart
Alternative 1 - Soil Removal, ORC Application, and Monitoring
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
Soil Disposal (Contaminated Material)			
Disposal at CEMEX for Thermal Treatment	ton	3,232	Assumes 1.56 ton/cy (bank yard).
Cost for disposal/treatment at CEMEX	$/ton	$36.26	Quote from CEMEX.
Disposal Transportation	hrs	486	Quote from CEMEX, assumes 4.5 hr RT time for 108 trips (Includes Transport Truck and Trailer round-trip drive time).
Cost of Transportation	$/hr	$115	
EXCAVATION DEWATERING AND TREATMENT SYSTEM			
Frac Tank monthly rental rate	$/mo	$4,000	Historic costs.
GAC dual bed unit monthly rental rate	$/mo	$5,000	Historic costs.
1 HP centrifugal pump	ls	$900	
Distribution piping	ls	$400	
Connectors, valves, gauges	ls	$500	
EXCAVATION BACKFILL AND SITE RESTORATION			
Fill Material (backfill for excavation areas)	$/cy	$15	Historic costs.
Fill Material Volume	cy	2,546	Contaminated excavated volume; trench box backfill is separate.
Install Monitoring Wells			
Install Monitoring Wells Replacement	ea	2	Assume 2 monitoring wells @ 13' bgs with 10' screen.
Cost for installation of well	$/well	1,000	
SAIC oversight	hr/day	20	Assume the well installation will take two days.
Cost of SAIC oversight	$/hr	$55	
Construction Completion Report			
Report	hrs	250	Assume 250 hours to generate construction completion report.
Report	$/hr	$80	
O&M			
Quarterly Groundwater Sampling and Analysis (1 year of monitoring)	year	1	
Sampling Labor	days/year	8	Includes 2 days for sampling 3 site wells per event. Sample all wells using low-flow protocol. Sample for TPH-Gx, TPH-Dx, limited VOCs, PAHs, and obtain field parameter measurements.
Sampling Labor	hrs/year	160	Assume 2 sampling scientists at 10 hours/day, including travel.
Sampling Labor	$/hr	$68	
Analytical Cost	$/year	$9,280	Analyze groundwater samples from 3 wells for NWTPH-Gx (12 @ $60), NWTPH-Dx (12 @ $82), BTEX, MTBE, EDB/EDC (12 @ $101), PAHs (12 @ $221). Includes QA/QC.
Sampling and Analysis Report			
Annual Report	years	1	
Annual Report	hrs	160	Assume 160 hours to generate annual report.
Annual Report	$/hr	$80	

Remedial Alternatives for Blaine Mini Mart
Alternative 1 - Soil Removal, ORC Application, and Monitoring
Cost Estimate

CAPITAL COST **$647,184**

Activity (unit)	Quantity	Unit Cost	Total
Excavation Subcontractor Mobilization	1	$10,000	$10,000
Subcontractor pre-construction plans and geotech	1	$10,000	$10,000
UTILITY LOCATE			
Subcontractor Private Utilty Locate	1	$1,600	$1,600
WELL ABANDONMENT			
Decommissioning of 4 monitoring wells	4	$241	$962
Cost for SAIC oversight	10	$73	$730
TRAFFIC CONTROL			
Traffic control costs (days)	15	$200	$3,000
STATION DECOMMISSIONING			
Removal-Disposal of dispenser and canopy	1	$6,800	$6,800
Concrete removal and recycling (cy)	10	$20	$200
Cost for asphalt slab removal and recycling (cy)	10	$15	$150
Cost for truck and trailer for concrete and asphalt removal (cy)	13.5	$121	$1,634
Cost for vac truck and gasoline removal/disposal (total)	1	$2,000	$2,000
Cost for SAIC oversight	50	$73	$3,650
ON-SITE ANALYTICAL LABORATORY			
On-site analytical lab cost	10	$1,600	$16,000
SOIL REMOVAL BY STANDARD EXCAVATOR			
Soil Excavation (ton)	2,546	$10	$25,459
Cost of ORC installation	8,000	$7	$56,000
Cost for SAIC oversight	105	$73	$7,665
TRENCH BOX WITH SOIL EXCAVATION			
Trench box installation and removal, soil removal, and backfilling (ton)	686	$60	$41,184
SOIL DISPOSAL			
Transport and Disposal by thermal desorption			
Disposal treatment at CEMEX (cy)	3,232	$36.26	$117,204
Disposal Transportation (hr)	486	$115	$55,890
EXCAVATION DEWATERING			
Frac tank rental	1	$4,000	$4,000
Activated carbon rental	1	$5,000	$5,000
Pump	1	$900	$900
Distribution piping	1	$400	$400
Connections, valves, gauges	1	$500	$500
EXCAVATION BACKFILL & SITE RESTORATION			
Fill Material for excavation area (cy)	2,546	$10	$25,459
INSTALL MONITORING WELLS			
Install Monitoring Wells	2	$1,000	$2,000
Cost for SAIC oversight	20	$55	$1,100
CONSTRUCTION COMPLETION REPORT			
Report	1	$20,000	$20,000

Remedial Alternatives for Blaine Mini Mart
Alternative 1 - Soil Removal, ORC Application, and Monitoring
Cost Estimate

Subtotal			$419,487
Design		8%	$33,559
Office Task Labor and Supplies		5%	$20,974
Field Task Labor and Supplies		3%	$12,585
Subtotal			$486,605
Profit		8%	$38,928
Contingency		25%	$121,651
Total			$647,184

Operation and Maintenance Cost **$47,344**

Activity (unit)	Quantity (yrs)	Annual Cost	Total Cost	Present Value
Quarterly Groundwater Sampling & Analysis (year 1)				
Sampling Labor All Events (hr)	1	$10,880	$10,880	$10,362
Analytical Cost All Events	1	$9,280	$9,280	$8,838
Sampling and Analysis Report	1	$12,800	$12,800	$12,190
Subtotal O&M			$32,960	$31,390
Design		0%	$0	$0
Office Task Labor and Supplies		5%	$1,648	$1,570
Field Task Labor and Supplies		3%	$989	$942
Subtotal			$35,597	$33,902
Profit		8%	$2,848	$2,712
Contingency		25%	$8,899	$8,475
Total			**$47,344**	$45,089

Total Alternative Capital and O&M Cost (Non Discounted Cost) **$694,528**

Remedial Alternatives for Blaine Mini Mart
Alternative 2 - Soil Removal and Monitoring
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
CAPITAL			
Excavation Subcontractor Mobilization	ls	$10,000	Mobilization, project management and demobilization.
Subcontractor pre-construction plans, geotech	ls	$10,000	Preparation and submittal of pre-construction plans and reports.
Utility Locate			
Subcontractor Private Utilty Locate	ls	$1,570	Quote from GeoMarkout.
Well Abandonment			
Decommission Monitoring wells MW-1, MW-2, MW-3, and MW-4	ea	4	Assume 4 monitoring wells will be decommissioned by filling the casing with bentonite pellets from the bottom of the well to the land surface.
Cost for Decommissioning 4 monitoring wells	$/ea	240.5	Assume 2" casing, 5'-10' prepack screen, 8" well mount, cost developed from Cascade Drilling.
SAIC oversight	hr	10	
SAIC oversight	$/hr	$73	
Traffic Control / Site Control			
Estimated duration for traffic control / site control needs	days	15	
Traffic control / Site control daily rate	$/day	$200	Historic costs, include signage, and flaggers (if necessary).
Station Decommissioning			
Removal-Disposal of dispenser and canopy	ls	$6,800	Quote from Clearcreek Contractors.
Concrete slab volume	cy	10	Estimated volume of concrete.
Cost for concrete slab removal and recycling	$/cy	$20	Historic costs.
Truck and Trailer driver	hr	13.5	Round trip hours.
Cost for Truck and Trailer driver	$/hr	$121	Truck and Trailer hourly rate.
Asphalt volume	cy	10	Estamated volume of asphalt.
Cost for asphalt slab removal and recycling	$/cy	$20	Historic costs.
Vac Truck to remove residual gasoline in product piping/USTs	ls	$2,000	Historic costs.
SAIC oversight	hr/day	50	Assume the station decommission will take a week.
Cost of SAIC oversight	$/hr	$73	
On-site Analytical Lab			
On-site lab used during all excavation work	days	10	10 days for excavation activities and lab time.
On-site lab daily rate	$/day	$1,600	ESN mobile laboratory quote.
SOIL EXCAVATION BY STANDARD EXCAVATOR			
Contaminated Soil Volume	ton	2546	Contaminated soil minus trench box, tons.
Excavation and loading costs	$/ton	$10	Quote from Clearcreek Contractors of open excavation, bank yards; trench box is separate (below).
SAIC oversight	hr/day	100	Assume the excavation will take 10 days.
Field Geologist rate	$/hr	$73	
Cost of SAIC oversight	day	$7,300	
SOIL EXCAVATION BY TRENCH BOX EXCAVATION			
Trench box installation and removal, soil removal, and backfilling (ton)			
Trench box excavation volume (ton)	tons	686	Assume 10' wide x 115' long x 10' deep (at 1.56 ton/bank yd).
Cost of trench box excavation ($/ton)	($/ton)	$60	Cost for excavating, trench boxing, backfilling this zone.
Total cost of trench box excavation		$41,184	
Soil Disposal (Contaminated Material)			
Disposal at CEMEX for Thermal Treatment	ton	3,232	Assumes 1.56 ton/cy (bank yard).
Cost for disposal/treatment at CEMEX	$/ton	$36.26	Quote from CEMEX.
Disposal Transportation	hrs	486	Quote from CEMEX, assumes 4.5 hr RT time for 108 trips (Includes Transport Truck and Trailer round-trip drive time).
Cost of transportation	$/hr	$115	

Remedial Alternatives for Blaine Mini Mart
Alternative 2 - Soil Removal and Monitoring
Key Parameters and Assumptions

Key Parameters and Assumptions:

Item	Unit	Value	Notes
EXCAVATION DEWATERING AND TREATMENT SYSTEM			
Frac Tank monthly rental rate	$/mo	$4,000	Historic costs.
GAC dual bed unit monthly rental rate	$/mo	$5,000	Historic costs.
1 HP centrifugal pump	ls	$900	
Distribution piping	ls	$400	
Connectors, valves, gauges	ls	$500	
EXCAVATION BACKFILL AND SITE RESTORATION			
Fill Material (backfill for excavation areas)	$/cy	$15	Historic costs.
Fill Material Volume	cy	2,546	
Install Monitoring Wells			
Install Monitoring Wells Replacement	ea	2	Assume 2 monitoring wells @ 13' bgs with 10' screen.
Cost for installation of well	$/well	1,000	
SAIC oversight	hr/day	20	Assume the well installation will take two days.
Cost of SAIC oversight	$/hr	$73	
Construction Completion Report			
Report	hrs	250	Assume 250 hours to generate construction completion report.
Report	$/hr	$80	
O&M			
Quarterly Groundwater Sampling and Analysis (1 year of monitoring)	year	1	
Sampling Labor	days/year	8	Includes 2 days for sampling 3 site wells per event. Sample all wells using low-flow protocol. Sample for TPH-Gx, TPH-Dx, limited VOCs, PAHs, and obtain field parameter measurements.
Sampling Labor	hrs/year	160	Assume 2 sampling scientists at 10 hours/day, including travel.
Sampling Labor	$/hr	$68	
Analytical Cost	$/year	$9,280	Analyze groundwater samples from 3 wells for NWTPH-Gx (12 @ $60), NWTPH-Dx (12 @ $82), BTEX, MTBE, EDB/EDC (12 @ $101), PAHs (12 @ $221). Includes QA/QC.
Sampling and Analysis Report			
Annual Report	years	1	
Annual Report	hrs	160	Assume 160 hours to generate annual report.
Annual Report	$/hr	$80	

Remedial Alternatives for Blaine Mini Mart
Alternative 2 - Soil Removal and Monitoring
Cost Estimate

CAPITAL COST	**$560,780**

Activity (unit)	Quantity	Unit Cost	Total
Excavation Subcontractor Mobilization	1	$10,000	$10,000
Subcontractor pre-construction plans and geotech	1	$10,000	$10,000
Utility Locate			
Subcontractor Private Utilty Locate	1	$1,600	$1,600
Well Abandonment			
Decommissioning of 4 monitoring wells (cost per well)	4	$241	$962
Cost for SAIC oversight	10	$73	$730
Traffic Control			
Traffic control costs (days)	15	$200	$3,000
Station Decommissioning			
Removal-Disposal of dispenser and canopy	1	$6,800	$6,800
Concrete removal and recycling (cy)	10	$20	$200
Cost for asphalt slab removal and recycling (cy)	10	$15	$150
Cost for truck and trailer for concrete and asphalt removal (cy)	13.5	$121	$1,634
Cost for vac truck and gasoline removal/disposal (total)	1	$2,000	$2,000
Cost for SAIC oversight	50	$73	$3,650
On-Site Analytical Lab			
On-site analytical lab cost	10	$1,600	$16,000
SOIL REMOVAL BY STANDARD EXCAVATOR			
Soil Excavation (ton)	2,546	$10	$25,459
Cost for SAIC oversight	100	$73	7,300
SOIL EXCAVATION BY TRENCH BOX EXCAVATION			
Trench box installation and removal, soil removal, and backfilling (ton)	686	$60	41,184
Soil Disposal			
Transport and Disposal by thermal desportion			
Disposal treatment at CEMEX (cy)	3,232	$36.26	$117,204
Disposal Transportation (hr)	486	$115	$55,890
EXCAVATION DEWATERING			
Frac tank rental	1	$4,000	$4,000
Activated carbon rental	1	$5,000	$5,000
Pump	1	$900	$900
Distribution piping	1	$400	$400
Connections, valves, gauges	1	$500	$500
EXCAVATION BACKFILL & SITE RESTORATION			
Fill Material for excavation area (cy)	2,546	$10	$25,459
Install Monitoring Wells			
Install Monitoring Wells	2	$1,000	$2,000
Cost for SAIC oversight	20	$73	$1,460
Construction Completion Report			
Report	1	$20,000	$20,000

Remedial Alternatives for Blaine Mini Mart
Alternative 2 - Soil Removal and Monitoring
Cost Estimate

Subtotal			$363,482
Design		8%	$29,079
Office Task Labor and Supplies		5%	$18,174
Field Task Labor and Supplies		3%	$10,904
Subtotal			$421,639
Profit		8%	$33,731
Contingency		25%	$105,410
Total			$560,780

Operation and Maintenance Cost **$47,344**

Activity (unit)	Quantity (yrs)	Annual Cost	Total Cost	Present Value
Quarterly Groundwater Sampling & Analysis (year 1)				
Sampling Labor All Events (hr)	1	$10,880	$10,880	$10,362
Analytical Cost All Events	1	$9,280	$9,280	$8,838
Sampling and Analysis Report	1	$12,800	$12,800	$12,190
Subtotal O&M			$32,960	$31,390
Design		0%	$0	$0
Office Task Labor and Supplies		5%	$1,648	$1,570
Field Task Labor and Supplies		3%	$989	$942
Subtotal			$35,597	$33,902
Profit		8%	$2,848	$2,712
Contingency		25%	$8,899	$8,475
Total			**$47,344**	$45,089

Total Alternative Capital and O&M Cost (Non Discounted Cost) **$608,124**