Aspect CONSULTING

MEMORANDUM

Project No.: 090066-002

October 8, 2010

To: Steven Rowe, Darigold, Inc.

cc: (TBD)

From: Doug Hillman, LHG
Principal Hydrogeologist

Dave Heffner, PE
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Re: **Addendum to Draft Focused Feasibility Study**
Rainier Avenue Facility Remediation

The primary purpose of this technical memorandum is to supplement the development and evaluation of remedial alternatives documented in the draft Focused Feasibility Study (FFS; dated February 2010) prepared by Sound Environmental Strategies (SES) for Darigold's Rainier Avenue Facility located at 4058 Rainier Avenue South in Seattle. Releases from former underground storage tank (UST) systems have impacted soil and groundwater in the North Yard of the facility with petroleum hydrocarbons in the gasoline and diesel ranges, as well as the gasoline additive methyl tertiary-butyl ether (MTBE). Multiple site investigations have been conducted by SES and others over the past 20 years. (Site features and exploration locations are shown on Figure 1.) In addition, SES pilot-tested several remedial technologies in June 2008, and designed and oversaw installation of an air sparge/soil vapor extraction (AS/SVE) system in August 2008. That system has yet to be operated.

The Washington State Model Toxics Control Act (MTCA) specifies that a feasibility study be conducted in accordance with WAC sections 173-340-350 through 173-340-390, to develop and evaluate remedial alternatives to enable a cleanup action to be selected. Before addressing remedial alternatives, this technical memorandum expands on the draft FFS discussion of exposure pathways, evidence of natural attenuation of contaminants, and remedial action objectives. Following the discussion of remedial alternatives, recommendations are provided regarding the preferred alternative and additional investigation and pilot testing needs.

Exposure Pathways

An exposure pathway is the mechanism through which an individual or population comes into contact with a hazardous substance. For a given pathway to be considered "complete," the following must exist at a site:

- A release of hazardous substance to the environment;
- A point at which a receptor can be exposed to the hazardous substance; and
- A route by which chemical intake can occur (i.e., ingestion, inhalation, or dermal contact).

Complete exposure pathways are the "risk drivers" behind a cleanup action.

Groundwater/Drinking Water

Section 2.6.5 of the draft FFS states that the groundwater/drinking water pathway is considered incomplete because the municipal water supply for the City of Seattle is far removed from the site. Under MTCA, however, drinking water is considered the highest beneficial use of groundwater at most sites irrespective of water supply. It is unlikely that this site would qualify for an exemption from drinking water beneficial use under MTCA [WAC 173-340-720(2)]. Therefore, drinking water use of groundwater should be considered a potentially complete exposure pathway.

Surface Water

Section 2.1 of the draft FFS notes that the building has a perimeter and basement slab drain system that discharges to a storm sewer main located in the South Andover Street right-of-way. It is also acknowledged that impacted soil and separate-phase hydrocarbon (SPH) have been detected within several feet of the north side of the building. However, the building drain system was apparently not evaluated as a potential route of contaminant migration, and Section 4.5.1 states:

> *With the exception of the storm and sanitary sewer lines that pass within 10 to 15 feet of the former 2004 UST excavation it is assumed that the subsurface utilities at the property are not considered migration pathways for contaminated groundwater.*

Aspect used information from SES's *Interim Corrective Action Plan* along with the 1986 building design drawings to develop Cross Section A-A', presented on Figure 2. (Figure 1 shows the cross section location.) The building's north wall is supported by pairs of auger cast piles. Spaced along the wall span at intervals of approximately 22 feet on-center, the pile pairs each have individual pile caps on which the wall rests. A 6-inch-diameter perforated perimeter drain pipe runs along the upper outside corners of the pile caps, and parallel 6-inch-diameter perforated pipes located just beneath the basement floor slab are manifolded together to provide sub-slab drainage. The two drain systems discharge through a common 6-inch-diameter pipe to manhole CB#8968 in the North Yard (see Figure 1 for manhole location). From there, drainage water is routed to the storm sewer main under South Andover Street.

MW-7 and MW-14 are shown on the cross section, along with the ranges of liquid levels measured in those wells during periodic groundwater monitoring. SPH has been consistently detected floating on the groundwater in MW-7 since November 2004. MW-14, on the other hand, has not only been SPH-free, but also has had no detectable concentrations of contaminants dissolved in groundwater. Note that the top of the range measured in MW-7 is at approximately the same elevation as the nearby perimeter drain pipe. This suggests that, when the water table is high, SPH and impacted groundwater along the north wall have the potential to enter the perimeter drain pipe. (And it may help explain why contamination has not been detected beneath the building.) Storm sewer discharge from CB#8968 should be further evaluated as a potential route of offsite contaminant migration.

Soil Vapor/Indoor Air

Section 2.6.3 of the draft FFS references Risk-Based Concentrations (RBCs) developed by the State of Oregon Department of Environmental Quality (ODEQ) to evaluate the vapor intrusion (VI) pathway, and states that baseline screening levels have not yet been established by the Washington State Department of Ecology (Ecology). While we agree with SES's conclusion that the VI pathway must be considered complete until proven otherwise, we believe it is appropriate to reference Ecology's draft *Guidance for Evaluating Soil Vapor Intrusion in Washington State: Investigation and Remedial Action*, dated October 2009. Section 3.1.1 of this guidance document establishes a "Tier I" process in which shallow groundwater concentration data are compared to groundwater screening levels to evaluate the need for further assessment or action to address the VI pathway. The screening level for benzene is 2.4 micrograms per liter (µg/L). A benzene concentration of 1,700 µg/L was measured in a groundwater sample collected from Well PE-01 (located within several feet of the building's north wall) in May 2010. Therefore, application of Ecology's Tier I process indicates that VI is a potentially complete exposure pathway.

Evidence of Natural Attenuation of Contaminants

Section 4.0 of the draft FFS states that all three of the remedial alternatives evaluated would conclude with monitored natural attenuation (MNA) of residual contamination, since it is unreasonable to assume that application of active remedial technologies will not leave any residuals. We agree with this assessment, and believe it is useful to provide evidence that natural attenuation is ongoing at the site. Figure 3 presents concentration trends over the period May 2007 through May 2010 for the primary constituents of concern [benzene, MTBE, and total petroleum hydrocarbon (TPH) in the gasoline and diesel ranges] in five of the site's most highly impacted groundwater monitoring wells (MW-3, MW-4, MW-11, MW-12, and PE-01). (Well MW-7 is also presumed to be highly impacted, but that well typically contains SPH and is not sampled.) The MTCA Method A groundwater cleanup levels are also indicated for comparison. Concentrations measured in groundwater are highly variable over time, due in part to fluctuations caused by the annual rise and fall of the groundwater table. In addition, MTBE was not included on the analyte list until recently, making it especially difficult to evaluate a concentration trend for that constituent. For the other three constituents, however, an overall downward trend in concentrations is apparent. The trend is clearest in MW-3, the well with the highest constituent concentrations at the start of the 3-year period. This is consistent with the fact that MW-3 is located closest to the presumed UST source area. That is, whereas concentrations may trend higher further from the source as contaminants are transported in groundwater, concentrations in the immediate source area should not increase once the source has been removed. The fact that they appear to have decreased substantially during the 3-year period evaluated suggests that significant natural attenuation is occurring.

Remedial Action Objectives

Remedial action objectives (RAOs) are identified as follows in Section 4.1.3 of the draft FFS:

> *The remedial action objectives for the Site are to mitigate exposure risks to human health and the environment by eliminating SPH conditions and reducing the mass of contamination in soil and groundwater beneath the Site, and to obtain a Property-specific No Further Action determination from Ecology.*

In order to facilitate development of revised remedial alternatives below, we propose that RAOs be articulated as follows:

- Conduct SPH removal to the maximum extent practicable, in accordance with WAC 173-340-450(4).
- Ensure that contamination does not migrate off site via the storm sewer utility between manhole CB#8968 and the sewer main under South Andover Street.
- Ensure that VI does not cause air concentrations in the building basement to exceed MTCA Method B cleanup levels for indoor air.
- Remediate site soils and groundwater to achieve MTCA Method A cleanup levels throughout the site.
- Implement institutional controls (e.g., a deed restriction prohibiting well installation) to prevent exposure to impacted groundwater in the North Yard, until groundwater cleanup levels are achieved.
- Implement institutional controls (e.g., a deed restriction addressing invasive work) to prevent exposure to impacted soils and groundwater in the North Yard, until cleanup levels are achieved.

Remedial Alternatives

Summary of Alternatives Included in the Draft FFS

The following remedial alternatives were developed and evaluated in the draft FFS:

- SES 1 – Excavation to 10-Foot Depth with AS/SVE;
- SES 2 – Targeted Excavation with Dual-Phase Extraction; and
- SES 3 – Extensive Excavation.

All three include excavation and offsite disposal of some portion of the impacted soils, and MNA of residual contamination. SES 1 assumes that soils are excavated to a maximum depth of approximately 10 feet, and that shoring systems are not required during excavation. Average depth to groundwater in the impacted area of the North Yard ranges from less than 7 feet below ground surface (bgs) at Well MW04 to roughly 10 feet bgs at MW07. In addition, the groundwater table at a given location may fluctuate over roughly a 1.5-foot depth range (based on periodic observations at Well MW01 since 2004). Since gasoline- and diesel-range petroleum hydrocarbons are less dense than water and of limited solubility, soil contamination is generally not expected to extend much below the bottom of the range of groundwater table fluctuation. Therefore, excavating to a maximum depth of 10 feet in SES 1 is expected to remove the vast majority of contaminant mass. Site investigations have detected a relatively minor amount of soil contamination in the 10- to 14-foot depth range. In SES 2 and SES 3, shoring systems are implemented to allow excavation of all impacted soils (maximum excavation depth of 14 feet assumed).

SES 1 also assumes that the existing AS/SVE system is operated to address contamination along the north end of the building, and oxygen-releasing compound is injected in other selected areas to supplement the natural attenuation process. SES 2 applies dual-phase extraction (DPE) technology to selected areas of the site where impacted soils are not excavated.

Description of Revised Remedial Alternatives

Since most of the contaminant mass is relatively shallow and accessible for removal by conventional excavation methods, the draft FFS identifies soil excavation with off-site treatment/disposal as “the preferred remedy for primary source removal,” and all 3 SES alternatives rely heavily on that technology. While we agree with SES that excavation is feasible and likely to be very effective at this site, we believe it is appropriate that an FFS-level evaluation also include alternatives that rely more heavily on *in situ* treatment technologies. This is especially true given the fact that the logistics of excavating in the congested North Yard will be complex, and significant disruption to Darigold truck traffic and product storage/distribution operations can be expected. Therefore, we have developed the following revised remedial alternatives, representing a broad range of possible responses from “no action” to extensive removal via excavation, for evaluation in this technical memorandum:

- Alternative 1 – No Action;
- Alternative 2 – Operate Existing AS/SVE System with MNA;
- Alternative 3 – *In Situ* Technologies Only;
- Alternative 4 – Targeted Excavation; and
- Alternative 5 – Extensive Excavation.

The revised alternatives are described in this section, and comparatively evaluated with respect to MTCA criteria in the next section. Remedial components of these alternatives are summarized in Table 1. Note that, for purposes of remedial alternative development and evaluation, we assume that contaminants are <u>not</u> migrating off site via the storm sewer utility and VI is <u>not</u> impacting indoor air. We recommend that these potential exposure pathways be further investigated (see Recommendations section below) and, if they <u>are</u> found to be pathways of concern, that they be incorporated into the remedial alternative evaluation process.

Alternative 1 – No Action. Under this alternative, the site would remain in its present condition. The existing AS/SVE system would not be operated, and periodic monitoring would not be conducted. This alternative is retained as a baseline for comparison of other alternatives, and to help ensure that remedial actions are not taken unless they are warranted.

Alternative 2 – Operate Existing AS/SVE System with MNA. The primary objective of operating the existing AS/SVE system under this alternative would be to remove SPH in the vicinity of Well MW07, to satisfy the MTCA requirement for free product removal. AS/SVE is not generally considered to be a particularly effective technology for SPH removal, but it may prove successful for the limited extent of SPH observed. Contamination associated with the balance of the site (outside the influence of the existing AS/SVE system) would be allowed to attenuate naturally over time. Natural attenuation depends on intrinsic environmental factors to reduce contaminant concentrations through such processes as biodegradation, abiotic chemical transformation, adsorption, and dispersion. Monitoring is required to evaluate the effectiveness of natural attenuation and to determine when cleanup levels have been achieved. Per WAC 173-340-370(7), Ecology expects that natural attenuation may be appropriate at sites where:

a) Source control has been conducted to the maximum extent practicable;

b) Leaving contaminants on-site during the restoration time frame does not pose an unacceptable threat to human health or the environment;

c) There is evidence that natural biodegradation or chemical degradation is occurring and will continue to occur at a reasonable rate at the site; and

d) Appropriate monitoring requirements are conducted to ensure that the natural attenuation process is taking place and that human health and the environment are protected.

This alternative would include implementing property deed restrictions prohibiting the installation of drinking water wells and addressing conditions under which invasive work may be carried out in the North Yard. Periodic monitoring would be conducted to assess attenuation of contaminants, and the deed restrictions would remain in effect until soil and groundwater cleanup levels are achieved throughout the site.

Components of the existing AS/SVE system are shown in green on Figure 1. The system includes three air sparge wells (AS-01 through AS-03) and five soil vapor extraction wells (MW07, MW10, MW11, MW18, and PE01). The AS wells are designed to inject air beneath the water table, thereby facilitating volatilization of contaminants dissolved in groundwater and adsorbed to soil, as well as SPH. The SVE wells extract soil vapor from the vadose zone (above the water table). They are designed for higher flow rates than the AS wells so that, in addition to capturing air injected by those wells, the SVE wells depressurize the vadose zone, causing atmospheric air to be drawn in. The increased oxygen made available by operation of the AS/SVE system increases aerobic biodegradation activity both above and below the water table. Thus, contaminant removal is achieved through both volatilization and biodegradation. Removal of SPH would depend almost exclusively on volatilization, however, since indigenous microbes are not active in SPH.

If further investigation determines that VI is a potential exposure pathway of concern at the north end of the building under ambient conditions, the SVE wells of the existing system could likely be operated (with air sparging turned off) to address that concern. On the other hand, it is also possible that operation of the AS/SVE system for the purpose of contaminant removal from the subsurface could inadvertently induce VI in the building, even though VI may not be a concern when the system is off. This is because the SVE wells may not effectively capture all the sparge air injected by the AS wells. If a portion of the contaminant-laden sparge air migrates under the building rather than toward an SVE well, VI may result. If this is the case, it may be possible to alleviate the problem by adjusting system operation (e.g., by decreasing sparge rates and increasing extraction rates). Prior to implementation, this alternative (and Alternative 3) would warrant testing of the existing AS/SVE system to determine operating characteristics and influence.

Alternative 3 – *In Situ* Technologies Only. Under this alternative, *in situ* remediation technologies would be applied over the entire North Yard area where petroleum-impacted soils exceeding MTCA Method A cleanup levels have been detected. In addition to operating the existing AS/SVE system, AS/SVE technology would be applied in the former UST area northeast of the building (see Figure 4), where relatively permeable soils should facilitate AS/SVE effectiveness. A grid of AS and SVE wells would be installed in this area and, similar to the existing system along the building's north wall, sub-grade piping would supply sparge air to the AS wells and convey extracted soil vapors away from the SVE wells. Equipment, instrumentation, and piping in the existing AS/SVE enclosure could likely be modified/supplemented to handle the expanded well network, so that the above-grade footprint of the expanded system would not increase appreciably over that of the current system.

In the remaining areas of impact, where less permeable soils would likely impede AS/SVE effectiveness, injection of oxygen-releasing compound is proposed. Figure 4 shows the estimated area to be addressed by this technology. Injection of oxygen-releasing compound to accelerate biodegradation of contaminants is discussed in Section 4.5.1 of the draft FFS. We concur with SES that this is a promising *in situ* technology for application at this site, and that pilot testing is warranted. The goals of pilot-testing injection of oxygen-releasing compound would include the following:

- confirm its effectiveness in the site's less permeable soils;
- confirm its effectiveness in treating not just petroleum hydrocarbons, but also MTBE (testing in the vicinity of Well MW04 is recommended); and
- develop design information for full-scale application of the technology.

Assuming pilot testing is successful, multiple injection events would likely be required during full-scale application (3 aggressive injection events are assumed in the cost estimate), with periodic monitoring of subsurface conditions to assess remediation progress. Once contaminant concentrations are substantially reduced, MNA would likely be relied on to ultimately achieve cleanup levels.

Applying *in situ* remediation technologies as proposed in this alternative is expected to substantially reduce the remediation time frame compared to reliance on MNA alone. As an order-of-magnitude estimate, it is expected that MNA alone would require over 30 years to achieve cleanup levels throughout the site, whereas 10 years is a reasonable expectation if the *in situ* remediation technologies proposed in this alternative are aggressively applied.

Alternative 4 – Targeted Excavation. Under this alternative, soil excavation with off-site treatment/disposal would be used to address the most highly impacted areas of the site, and injection of oxygen-releasing compound would be applied to the remainder of the impacted area. Areas proposed for targeted excavation under this alternative are shown on Figure 5. Excavation boundaries were determined by evaluating soil quality data for benzene and TPH in the gasoline and diesel ranges against the corresponding MTCA Method A cleanup levels. (MTBE was not included in this evaluation, as we are not aware that any soil samples have been analyzed for that compound.) Areas where concentrations detected in soil exceed 20 times the benzene cleanup level, 10 times the gasoline-range TPH cleanup level, and/or 3 times the diesel-range TPH cleanup level are proposed for excavation in this alternative. These exceedance factors were selected to account for the relative susceptibility of the constituents to biodegradation. That is, since benzene is much more susceptible to biodegradation than diesel-range TPH, injection of oxygen-releasing compound can generally be relied on to effect larger reductions in benzene concentrations over a given period of time. Therefore, remediation time frame can be reduced more effectively by focusing excavation efforts on soils with large diesel-range TPH exceedences rather than large benzene exceedences.

The vertical extent of excavation is assumed to be limited in this alternative similar to SES 1 in the draft FFS. That is, excavation depth is generally limited to approximately 10 feet, so that shoring systems are not required. However, by targeting only the more highly impacted soils for excavation (as described above), the volume of soils requiring excavation is significantly less – roughly 2,300 cubic yards (cy), versus 3,300 cy for SES 1.

In areas where soil impacts extend below the excavation depth, oxygen-releasing compound would be spread on the excavation bottom prior to backfilling with clean imported soil, to promote biodegradation of residual contamination. One exception is excavation in the vicinity of Well MW07, where thorough SPH removal would be an important objective. In SES 1, SES proposes to operate the existing AS/SVE system to remove SPH and remediate soils along the north wall of the building (similar to Aspect's Alternative 3), and to excavate to 10-foot depth just north of the system. The Figure 2 cross section shows the approximate configuration of relevant features in this area, including the range of depths at which SPH has been observed in MW07. Excavation would likely be conducted in the summer, when the water table tends to be low. It appears that excavation depth would need to extend to approximately the base of the pile cap (i.e., roughly 11-foot depth) to remove SPH floating on the water table. Aspect's geotechnical review of this scenario indicates that soil may be safely excavated down to the base of the pile cap and southward to the north wall of the building without compromising the building foundation. (Modified soil backfilling and compaction requirements would be specified in the immediate vicinity of the building.) Therefore, we believe thorough SPH removal via excavation is achievable in this alternative.

Removing the most highly-impacted soils from the site is expected to result in a significantly faster cleanup compared to Alternative 3. The cost estimate for this alternative assumes that only 2 aggressive injection events are needed, versus 3 in Alternative 3. A remediation time frame of 5 to 7 years is a reasonable expectation under this alternative, again assuming that the *in situ* remediation technology (injection of oxygen-releasing compound) is aggressively applied.

Alternative 5 – Extensive Excavation. Under this alternative, it is assumed that all soils with MTCA Method A cleanup level exceedences are excavated and treated/disposed of offsite. The approximate area requiring excavation, based on Aspect's evaluation of soil cleanup level exceeedences, is shown on Figure 6. Where necessary, shoring systems would be used to allow access to deeper impacted soils (maximum excavation depth of 14 feet assumed) that would be left in place in Alternative 4. All excavated areas would be backfilled with clean imported soil.

This alternative is intended to be comparable to SES 3. Note that the boundaries of the estimated excavation area shown on Figure 6 are somewhat different than those depicted by SES on Figure 10 of the draft FFS. However, the estimated volume of soil requiring excavation is nearly the same in both cases (roughly 6,000 cy). The actual extent of impacted soils requiring excavation would be determined by completing characterization trenches (described in Section 4.5.1 of the draft FFS) and by monitoring during excavation.

Once impacted soils are removed from the site, residual groundwater exceedences are expected to naturally attenuate to below MTCA Method A cleanup levels within a couple years. Therefore, a remediation time frame of 1 to 3 years is a reasonable expectation under this alternative.

Present Worth Cost Estimates

Present worth cost estimates for the 5 revised remedial alternatives are summarized in Table 2. These FS-level estimates, which have an intended accuracy of -30/+50 percent, include “sunk costs” that have already been incurred (primarily for pilot testing, design, and construction of the existing AS/SVE system), as well as estimated future costs. Future costs include those related to future remedial action pilot testing, design, and implementation, and costs associated with long-term monitoring and reporting. Itemization of estimated costs is provided in Attachment A. Present worth estimates are based on 2011 dollars and assume a real discount rate of 1.6 percent (consistent with the SES estimates) for both past and future expenditures. Major construction expenditures, including the AS/SVE system expansion in Alternative 3 and soil excavation in Alternatives 4 and 5, are assumed to occur in 2011.

Rather than developing independent cost estimates from scratch, we reviewed SES’s itemized estimates for SES 1 and SES 3 (Tables 4 and 6 in the draft FFS) and, where appropriate, used them as a basis for estimating costs for common items. For example, our estimated cost for extensive soil excavation in Alternative 5 is taken without adjustment from Table 6 in the draft FFS (SES 3), since the excavation scenarios in those two alternatives are nearly identical. Similarly, estimated costs for soil excavation in SES 1 (Table 4 in the draft FFS) were scaled for use in our targeted excavation alternative (Alternative 4). By using consistent unit costs, the cleanup alternative cost estimates presented in the draft FFS can be compared with greater confidence to the estimated costs of the revised alternatives developed in this technical memorandum.

The estimated present worth costs range from $288,000 for Alternative 1, which represents the present worth of costs incurred to date, up to $4,380,000 for Alternative 5. Attachment A contains additional notes and assumptions regarding the remedial alternative cost estimates.

Comparative Evaluation of Revised Remedial Alternatives

In this section, we perform a comparative evaluation of the revised remedial alternatives, in accordance with WAC 173-340-350, “Remedial Investigation and Feasibility Study.” The alternatives are evaluated against criteria stated in WAC 173-340-360, “Selection of Cleanup Actions.” The following criteria are considered in this comparative evaluation:

Threshold Criteria

- Protection of human health and the environment;
- Compliance with cleanup standards and applicable state and federal laws;
- Provision for compliance monitoring;

Other Criteria

- Use of permanent solutions to the maximum extent practicable;

- Provision for a reasonable restoration time frame; and
- Consideration of public concerns.

All cleanup actions must meet the requirements of the threshold criteria. The other criteria are considered in selecting from among the alternatives that fulfill the threshold requirements.

In the following subsections, the revised remedial alternatives are comparatively evaluated with respect to each of the criteria listed above. Evaluation results are summarized in Table 2.

Protection of Human Health and the Environment. This threshold criterion considers the overall protectiveness of the alternatives, including the degree to which existing risks are reduced, the time required to reduce risk and attain cleanup levels, on- and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.

Assuming that contaminants are not migrating off site via the storm sewer utility and that VI is not impacting indoor air, all 5 alternatives are equally protective of human health and the environment under current exposure conditions. Under future conditions, however, Alternative 1 is not adequately protective because deed restrictions would not be implemented to prevent potential future exposures to impacted media.

Compliance with Cleanup Standards and Applicable Laws. Alternatives 2 through 5 are expected to comply with applicable laws and, given sufficient time, to achieve cleanup standards. Alternative 1 would not comply with WAC 173-340-440(4)(a), which states that institutional controls (such as deed restrictions) are required when cleanup levels are established using Method A or B and hazardous substances remain at the site at concentrations that exceed the applicable cleanup level.

Provision for Compliance Monitoring. This threshold criterion requires that the alternatives provide for compliance monitoring. Under MTCA, compliance monitoring encompasses the following types of monitoring:

- **Protection monitoring** confirms that human health and the environment are adequately protected during construction and the operation and maintenance (O&M) period of a cleanup action;
- **Performance monitoring** confirms that the cleanup action has attained cleanup levels and/or other performance standards such as construction quality control measurements or monitoring necessary to demonstrate compliance with a permit; and
- **Confirmation monitoring** confirms the long-term effectiveness of the cleanup action once cleanup levels and/or other performance standards have been attained.

Alternatives 2 through 5 are judged to provide adequate provision for compliance monitoring. These alternatives include long-term monitoring to assure that cleanup levels are ultimately achieved throughout the impacted aquifer. Protection monitoring will be conducted in accordance with site-specific safety and health plans during the construction and O&M periods associated with application of the AS/SVE, injection, and soil excavation technologies, and in the event that invasive work is performed in impacted areas of the North Yard. Performance monitoring of contaminant concentrations will be conducted to evaluate remediation progress and to ultimately confirm that cleanup levels have been achieved.

Alternative 1 does not include any future compliance monitoring. Therefore, it is judged to be deficient relative to this criterion.

Since Alternative 1 does not fully meet the requirements of the threshold criteria discussed above, it is eliminated from further consideration in this comparative evaluation.

Use of Permanent Solutions to Maximum Extent Practicable. The permanence of a solution considers the extent to which the alternative permanently reduces the toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying the hazardous substances, the reduction or elimination of hazardous substance releases and sources of releases, the degree of irreversibility of waste treatment processes, and the characteristics and quantity of treatment residuals generated.

Alternatives 3 through 5 are all judged to provide a high degree of permanence because the active remedial technologies they employ have been demonstrated to permanently reduce contaminant concentrations at sites impacted by petroleum hydrocarbons in the gasoline and diesel ranges. AS/SVE removes contaminants via volatilization, and also increases aerobic biodegradation activity in the subsurface. Volatilized contaminants would be adsorbed onto activated carbon (SVE exhaust treatment) and ultimately destroyed during thermal regeneration of the carbon. Aerobic biodegradation, which is also the principal removal mechanism for injection of oxygen-releasing compound, provides contaminant destruction via microbial metabolism. Although soil excavation with offsite treatment/disposal does not necessarily result in contaminant destruction (i.e., if disposal without treatment is implemented), it is considered to provide a high degree of permanence because contaminants are physically removed from the site.

MNA reduces contaminant concentrations through such processes as biodegradation, abiotic chemical transformation, adsorption, and dispersion. Given sufficient time, MNA will likely achieve the MTCA Method A soil and groundwater cleanup levels. However, employing MNA as the principal remedial technology is generally not considered to provide as high a degree of permanence as the active technologies discussed above, due to uncertainties associated with MNA. For example, it is unclear in the end what portion of the contaminant mass may be destroyed (e.g., via biodegradation and abiotic chemical transformation), and what portion may remain at the site (e.g., adsorbed onto soil or dispersed). For this reason, Alternative 2 is judged to only partially meet this criterion.

Provision for a Reasonable Restoration Time Frame. Restoration time frame refers to the time it will take to achieve cleanup standards. To assess the degree to which an alternative provides for a reasonable restoration time frame, the following factors are considered:

- Potential risks posed by the Site to human health and the environment;
- Practicability of achieving a shorter restoration time frame;

- Current use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site;
- Potential future use of the Site, surrounding areas, and associated resources that are, or may be, affected by releases from the Site;
- Availability of alternative water supplies;
- Likely effectiveness and reliability of institutional controls;
- Ability to control and monitor migration of hazardous substances from the Site;
- Toxicity of the hazardous substances at the Site; and
- Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the Site or under similar Site conditions.

As summarized in Table 2, restoration time frame estimates range from just 1 to 3 years for Alternative 5, to 30 years or more for Alternative 2. Since Alternatives 4 and 5 both achieve large contaminant reductions (via soil excavation) within a short time period, and are expected to achieve soil and groundwater cleanup levels in 7 years or less, they are judged to generally meet this criterion. Since the restoration time frame for Alternative 2 is highly uncertain and likely to be at least several decades, it is not considered to meet this criterion. Alternative 3, which employs *in situ* technologies expected to significantly accelerate the restoration rate over Alternative 2, is judged to partially meet this criterion.

Consideration of Public Concerns. Public concerns are most likely to arise from construction aspects of the soil excavation alternatives (Alternatives 4 and 5). Both private residences and retail businesses are situated in close proximity to the site. Excavating and hauling off site several thousand tons of soil and importing clean backfill soil will create traffic congestion, noise, and possibly odors during construction. While these nuisance conditions can be somewhat mitigated through careful planning, engineering, and implementation of construction methods and traffic control, they cannot be completely eliminated. For this reason, Alternatives 4 and 5 are judged to only partially meet this criterion.

Implementation of the *in situ* technologies in Alternatives 2 and 3 is not expected to cause the above-noted nuisance conditions for Darigold's neighbors to any significant extent. As discussed above, these two alternatives result in much longer restoration time frames, which could potentially raise exposure concerns for some neighbors. However, since contamination is currently contained within the fenced Darigold property and monitoring will ensure that offsite migration does not occur, this is not considered to be a significant concern. Therefore, Alternatives 2 and 3 are judged to generally meet this criterion.

Recommendations

[For discussion at our meeting scheduled for October 14th. We are prepared to recommend Alternative 4 (targeted excavation) as the preferred remedial alternative. We also recommend that storm sewer discharge from CB#8968 be further evaluated as a potential route of offsite contaminant migration, that VI be investigated at the north end of building in the vicinity of Well MW07, and that ORC® injection be pilot-tested.]

Limitations

Work for this project was performed and this memorandum prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities, at the time the work was performed. It is intended for the exclusive use of Darigold, Inc., for specific application to the referenced property. This memorandum does not represent a legal opinion. No other warranty, expressed or implied, is made.

Attachments

Table 1 – Components of Revised Remedial Alternatives
Table 2 – Comparison of Revised Remedial Alternatives
Figure 1 – Site Plan Showing Cleanup Level Exceedences and Alignment of Cross Section A-A'
Figure 2 – Cross Section A-A'
Figure 3 – Concentration Trends in Highly Impacted Groundwater Monitoring Wells
Figure 4 – Alternative 3 - Remediation Using *In Situ* Technologies Only
Figure 5 – Alternative 4 - Targeted Excavation
Figure 6 – Alternative 5 - Extensive Excavation
Attachment A – Cost Estimates for Revised Remedial Alternatives

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Table 1 - Components of Revised Remedial Alternatives

FFS Tech. Memo, Darigold Rainier Avenue Facility

Components of Revised Remedial Alternatives	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Permitting, design, & infrastructure already invested[(1)]	X	X	X	X	X
Deed restrictions (e.g., prohibiting installation of drinking water wells and addressing invasive work) until cleanup levels are achieved.		X	X	X	
Operation of existing AS/SVE system.		X	X		
Construction and operation of AS/SVE system expansion.			X		
ORC® injection.			X	X	
Excavation of soils to 10-foot depth with contaminant concentrations that exceed MTCA Method A cleanup levels by more than 20X for benzene, 10X for gasoline-range TPH, and 3X for diesel-range TPH.				X	
Excavation of all soils with contaminant concentrations exceeding MTCA Method A cleanup levels.					X
Monitored natural attenuation of residual contaminants via periodic groundwater sampling, until cleanup levels are achieved.		X	X	X	X

Notes:
(1) This line item accounts primarily for pilot testing, design, and construction of the existing AS/SVE system.

Table 2 - Comparison of Revised Remedial Alternatives

FFS Tech. Memo, Darigold Rainier Avenue Facility

	Threshold Criteria			Other Criteria[1]			
	Protection of Human Health and the Environment	Compliance with Cleanup Standards and Applicable Laws	Provision for Compliance Monitoring	Use of Permanent Solutions to the Maximum Extent Practicable	Provision for a Reasonable Restoration Time Frame	Consideration of Public Concerns	Estimated Present Worth Cost[1]
Alternative 1– No Action	░	░	□	(Note 2)	[30+ yrs] (Note 2)	(Note 2)	$288,000
Alternative 2– Operation of Existing AS/SVE System, Monitored Natural Attenuation, and Deed Restrictions	■	■	■	░	[30+ yrs] □	■	$1,200,000
Alternative 3– Construction/Operation of Expanded AS/SVE System, ORC® Injection, Monitored Natural Attenuation, and Deed Restrictions	■	■	■	■	[10 yrs] ░	■	$2,150,000
Alternative 4– Targeted Soil Excavation, ORC® Injection, Monitored Natural Attenuation, and Deed Restrictions	■	■	■	■	[5 - 7 yrs] ■	░	$2,200,000
Alternative 5– Excavation of All Soils Exceeding MTCA Method A Cleanup Levels and Monitored Natural Attenuation	■	■	■	■	[1 - 3 yrs] ■	░	$4,380,000

Notes:

[1] Estimated present worth costs are in 2011 dollars, and were calculated using a real discount rate of 1.6 percent. The itemized estimates are provided in Attachment A.

[2] Since Alternative 1 does not satisfy the threshold criteria, it is not evaluated with respect to the other criteria.

□ Does Not Generally Meet Criterion
░ Criterion Partially Met
■ Criterion Generally Met

LEGEND

B-1	SOIL BORING
E-1	SOIL EXCAVATION BASE OR SIDEWALL SAMPLE
SG-1	SOIL GAS SAMPLE
MW01	GROUNDWATER MONITORING WELL
PE01	PILOT TEST WELL
	NOTE: Green wells have been incorporated into the soil vapor extraction (SVE) system.
AS-01	AIR SPARGING WELL
	CATCH BASIN OR CURB INLET
	MANHOLE
	PROPERTY BOUNDARY
	APPROXIMATE PARCEL BOUNDARY
SS	SANITARY SEWER
SD	STORM SEWER
	ZIPPER DRAIN
	FORMER UST
	APPROXIMATE FORMER UST EXCAVATION (SES, 2004)
	APPROXIMATE FORMER UST EXCAVATION (SD&C, 1998)
A A'	ALIGNMENT OF GENERALIZED CROSS SECTION (REFER TO FIGURE 2)
UST	UNDERGROUND STORAGE TANK

Detection of MTCA Method A Cleanup Level Exceedences

- SOIL ONLY
- GROUNDWATER ONLY
- SOIL AND GROUNDWATER

Note:
- Among the explorations, only the monitoring wells (MWs) and Well PE01 have groundwater sampling results.
- Groundwater cleanup level exceedences are based on the four monitoring rounds between August 2009 and May 2010.

NOTES:

1.) COMPONENTS OF THE AIR SPARGE/SOIL VAPOR EXTRACTION (AS/SVE) SYSTEM INSTALLED IN AUGUST 2008 ARE COLORED GREEN ON THIS FIGURE

REFERENCES: SES, FIELD MEASUREMENTS, 2004-2009
DARIGOLD, INC, FACILITY DRAWINGS, 2005.
CITY OF SEATTLE, SEWER CARD NOS. 1442, 1443, AND 5412, 2001.
SD&C, UNDERGROUND STORAGE TANK SITE ASSESSMENT REPORT, 1998.

N
0 40 80
Feet

Aspect CONSULTING

Site Plan Showing Cleanup Level Exceedences and Alignment of Cross Section A-A'

Darigold - Rainier Avenue Facility
Seattle, Washington

DATE:	Sept 2010
DESIGNED BY:	DAH
DRAWN BY:	PMB
REVISED BY:	-
PROJECT NO.	090066
FIGURE NO.	1

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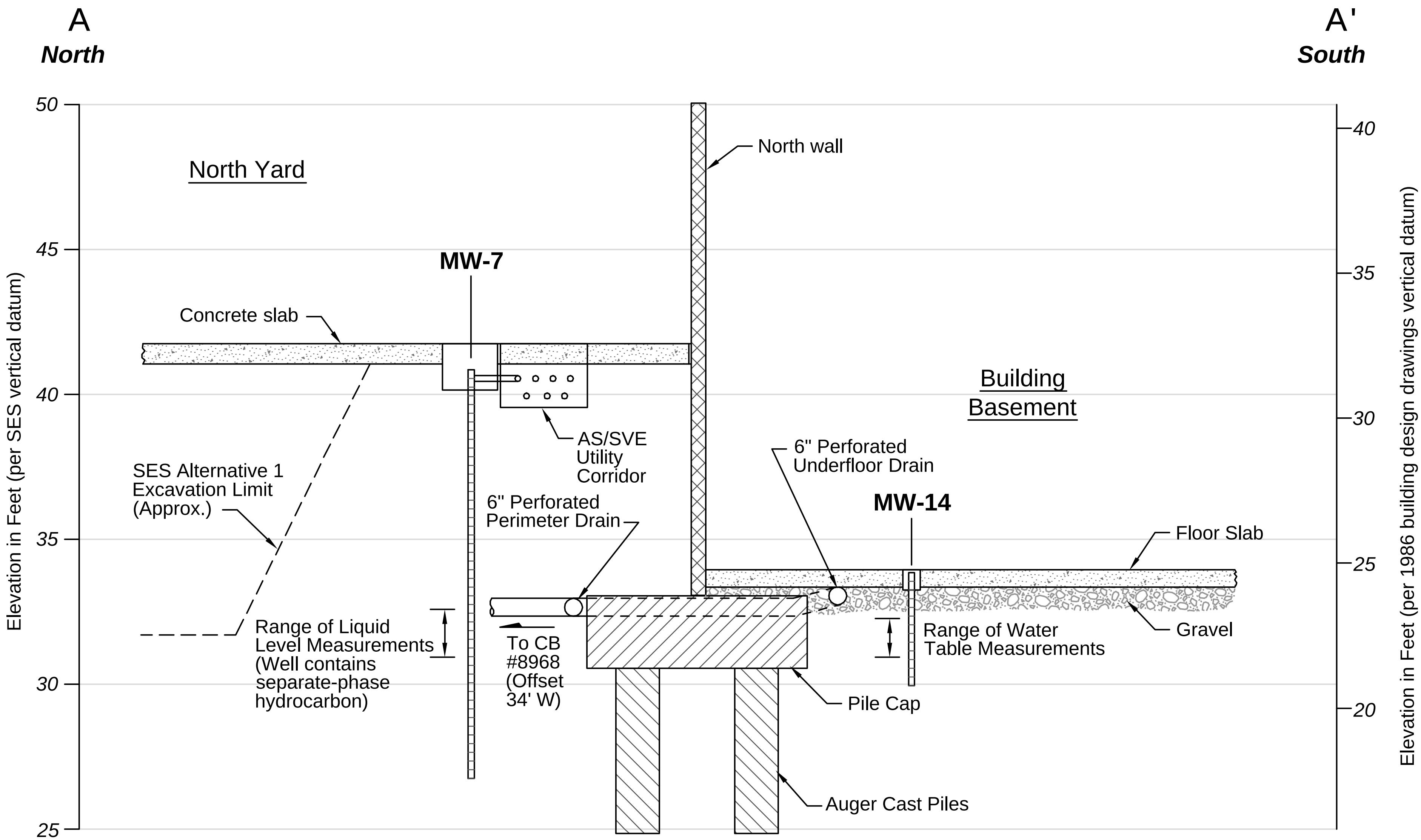

Note: All dimensions, elevations and orientations are approximate.

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Feet

Aspect CONSULTING

Cross Section A-A'

Darigold - Rainier Avenue Facility
Seattle, Washington

DATE:	Sept 2010	PROJECT NO.	090066
DESIGNED BY:	DAH		
DRAWN BY:	PMB	FIGURE NO.	2
REVISED BY:	-		

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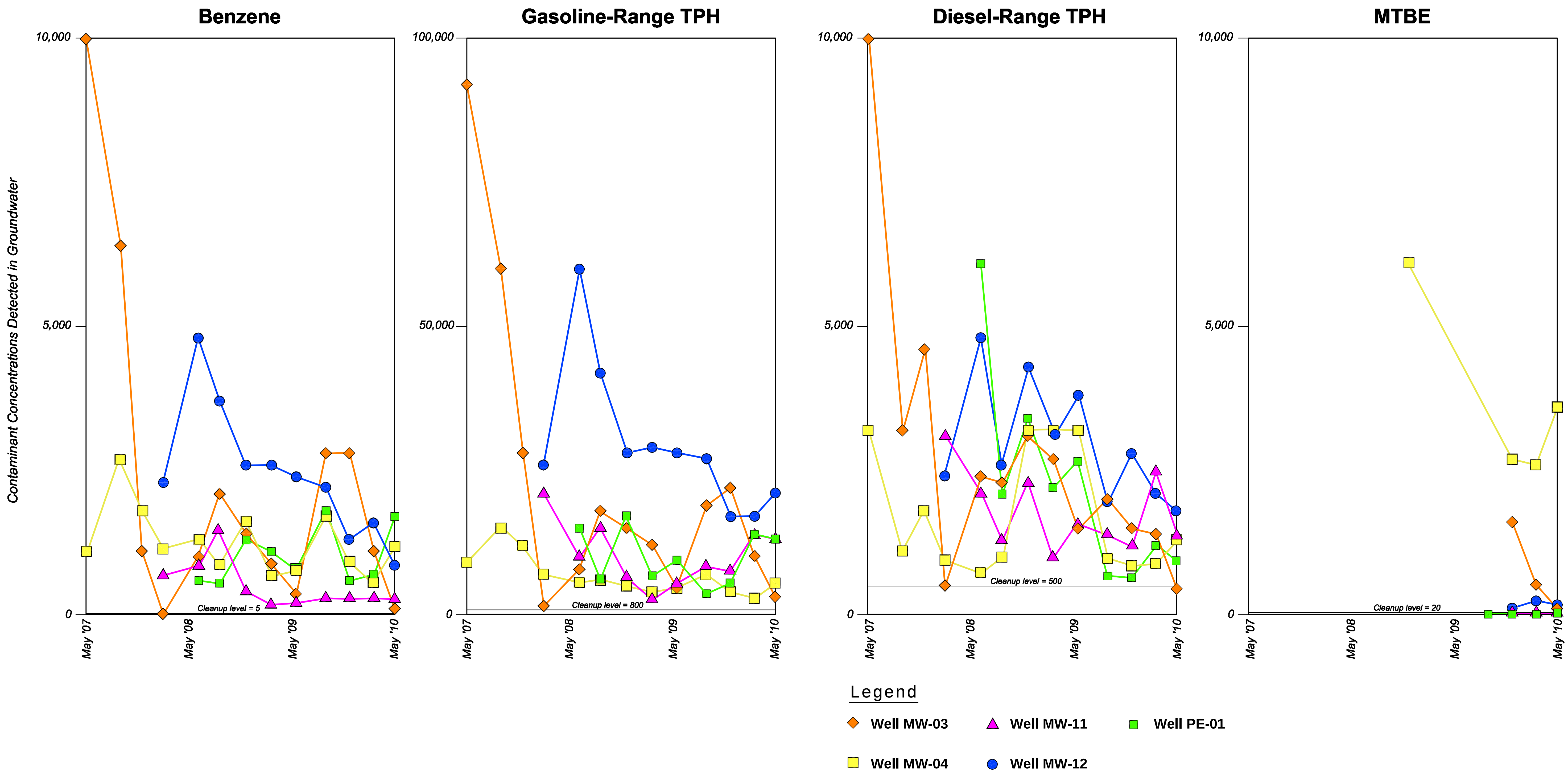

Note: Groundwater in well MW-07 is also presumed to be highly impacted, but that well typically contains separate-phase hydrocarbon (SPH) and is not sampled.

Notes:

1. All concentrations are in micrograms per liter (ug/L).
2. The groundwater cleanup levels shown are base on Washington State Model Toxics Control Act (MTCA) Method A.

Aspect CONSULTING

Concentration Trends in Highly Impacted Groundwater Monitoring Wells

Darigold Rainier Avenue Facility

Seattle, Washington

DATE:	Aug 2010	PROJECT NO.	090066
DESIGNED BY:	DAH		
DRAWN BY:	PMB	FIGURE NO.	3
REVISED BY:			

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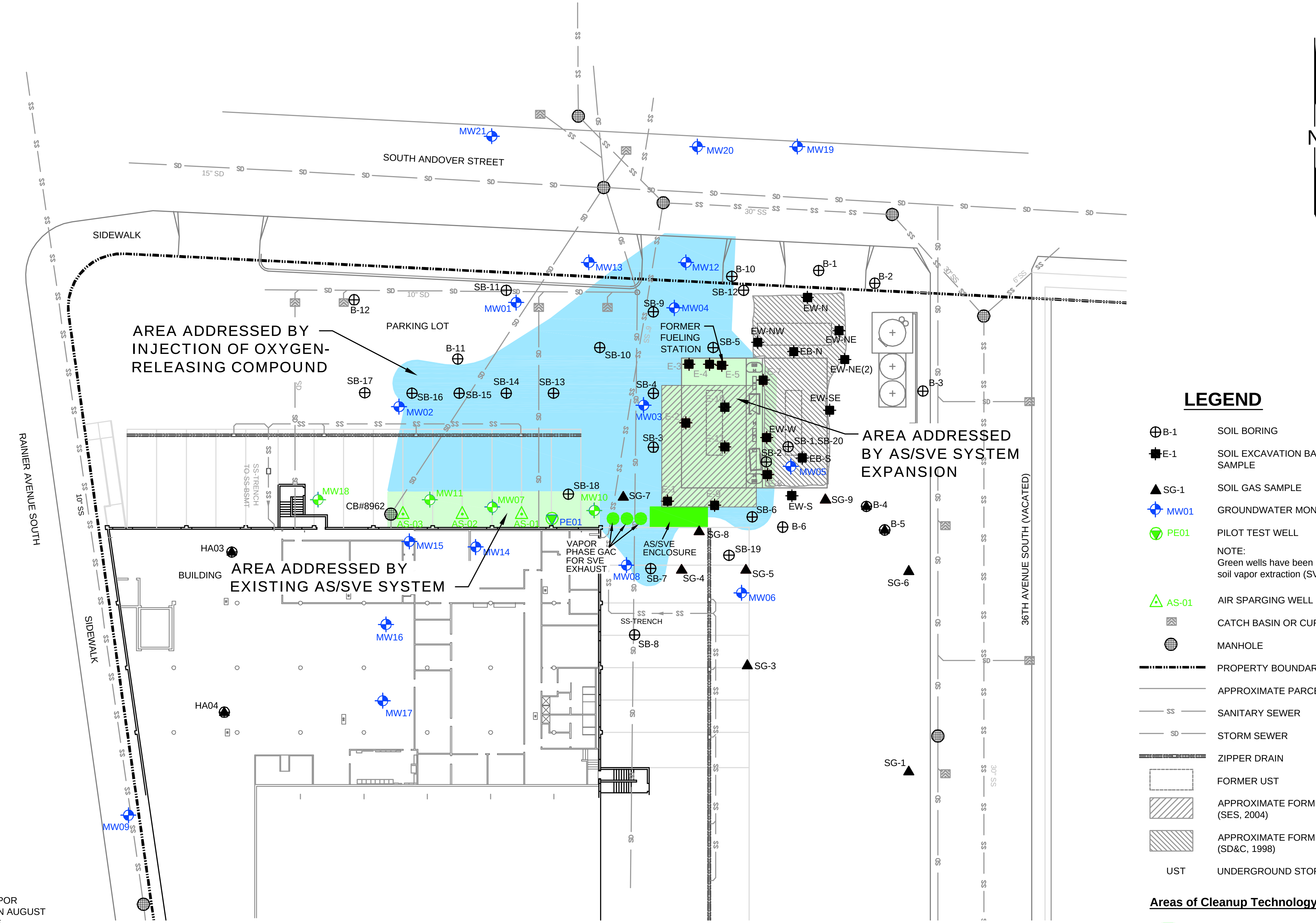

LEGEND

B-1	SOIL BORING
E-1	SOIL EXCAVATION BASE OR SIDEWALL SAMPLE
SG-1	SOIL GAS SAMPLE
MW01	GROUNDWATER MONITORING WELL
PE01	PILOT TEST WELL
	NOTE: Green wells have been incorporated into the soil vapor extraction (SVE) system.
AS-01	AIR SPARGING WELL
	CATCH BASIN OR CURB INLET
	MANHOLE
	PROPERTY BOUNDARY
	APPROXIMATE PARCEL BOUNDARY
SS	SANITARY SEWER
SD	STORM SEWER
	ZIPPER DRAIN
	FORMER UST
	APPROXIMATE FORMER UST EXCAVATION (SES, 2004)
	APPROXIMATE FORMER UST EXCAVATION (SD&C, 1998)
UST	UNDERGROUND STORAGE TANK

Areas of Cleanup Technology Application

	AIR SPARGING / SOIL VAPOR EXTRACTION (AS/SVE)
	INJECTION OF OXYGEN-RELEASING COMPOUND

NOTES:

1.) COMPONENTS OF THE AIR SPARGE/SOIL VAPOR EXTRACTION (AS/SVE) SYSTEM INSTALLED IN AUGUST 2008 ARE COLORED GREEN ON THIS FIGURE

REFERENCES : SES, FIELD MEASUREMENTS, 2004-2009
DARIGOLD, INC, FACILITY DRAWINGS, 2005.
CITY OF SEATTLE, SEWER CARD NOS. 1442, 1443, AND 5412, 2001.
SD&C, UNDERGROUND STORAGE TANK SITE ASSESSMENT REPORT, 1998.

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Feet

Aspect CONSULTING

Alternative 3 - Remediation Using *In Situ* Technologies Only

Darigold - Rainier Avenue Facility
Seattle, Washington

DATE: Sept 2010	PROJECT NO. 090066
DESIGNED BY: DAH	
DRAWN BY: PMB	FIGURE NO. 4
REVISED BY: -	

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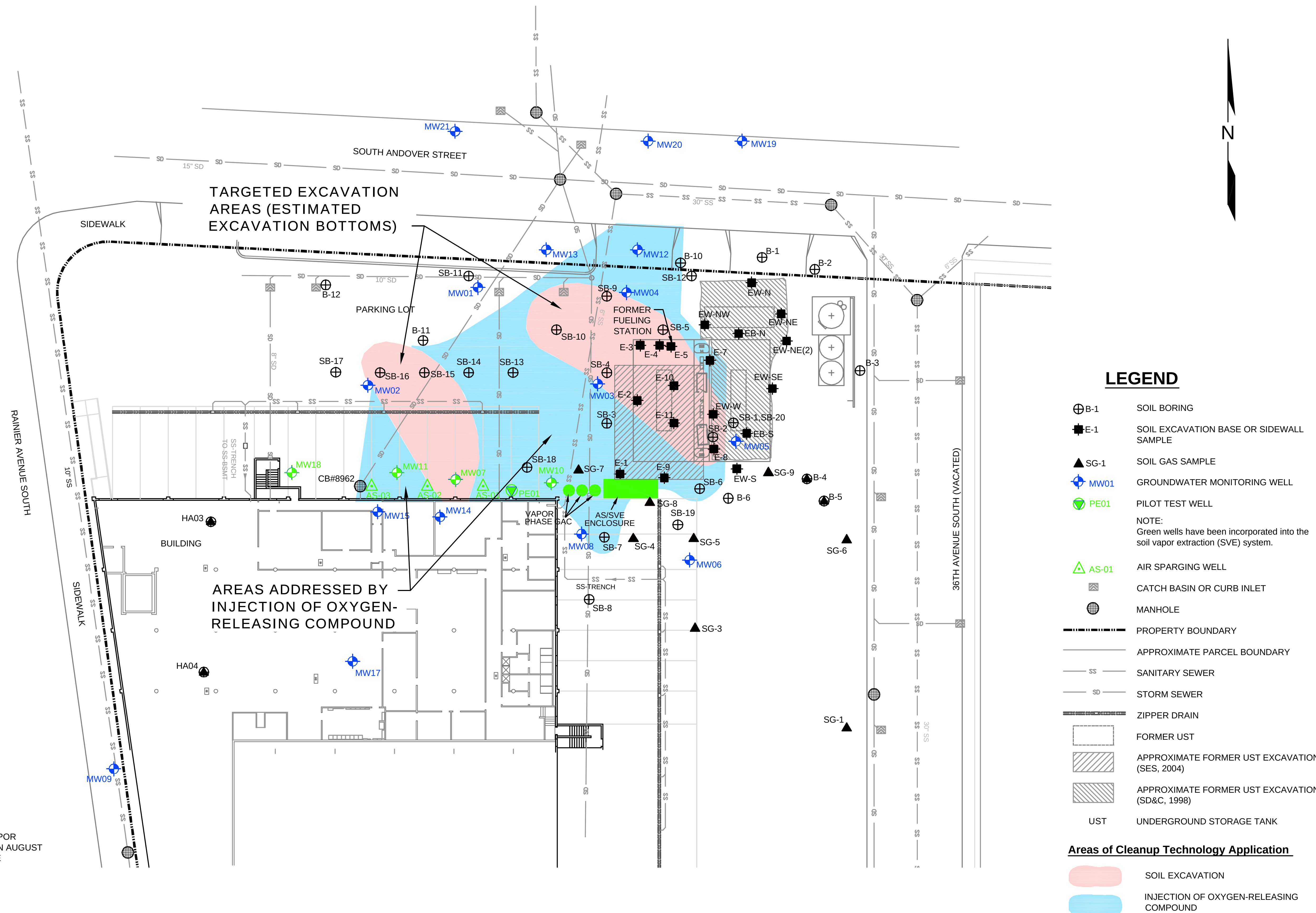

NOTES:

1.) COMPONENTS OF THE AIR SPARGE/SOIL VAPOR EXTRACTION (AS/SVE) SYSTEM INSTALLED IN AUGUST 2008 ARE COLORED GREEN ON THIS FIGURE

REFERENCES : SES, FIELD MEASUREMENTS, 2004-2009
DARIGOLD, INC, FACILITY DRAWINGS, 2005.
CITY OF SEATTLE, SEWER CARD NOS. 1442, 1443, AND 5412, 2001.
SD&C, UNDERGROUND STORAGE TANK SITE ASSESSMENT REPORT, 1998.

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Aspect CONSULTING

Alternative 4 - Targeted Excavation

Darigold - Rainier Avenue Facility
Seattle, Washington

DATE: Sept 2010	PROJECT NO. 090066
DESIGNED BY: DAH	
DRAWN BY: PMB	FIGURE NO. 5
REVISED BY: -	

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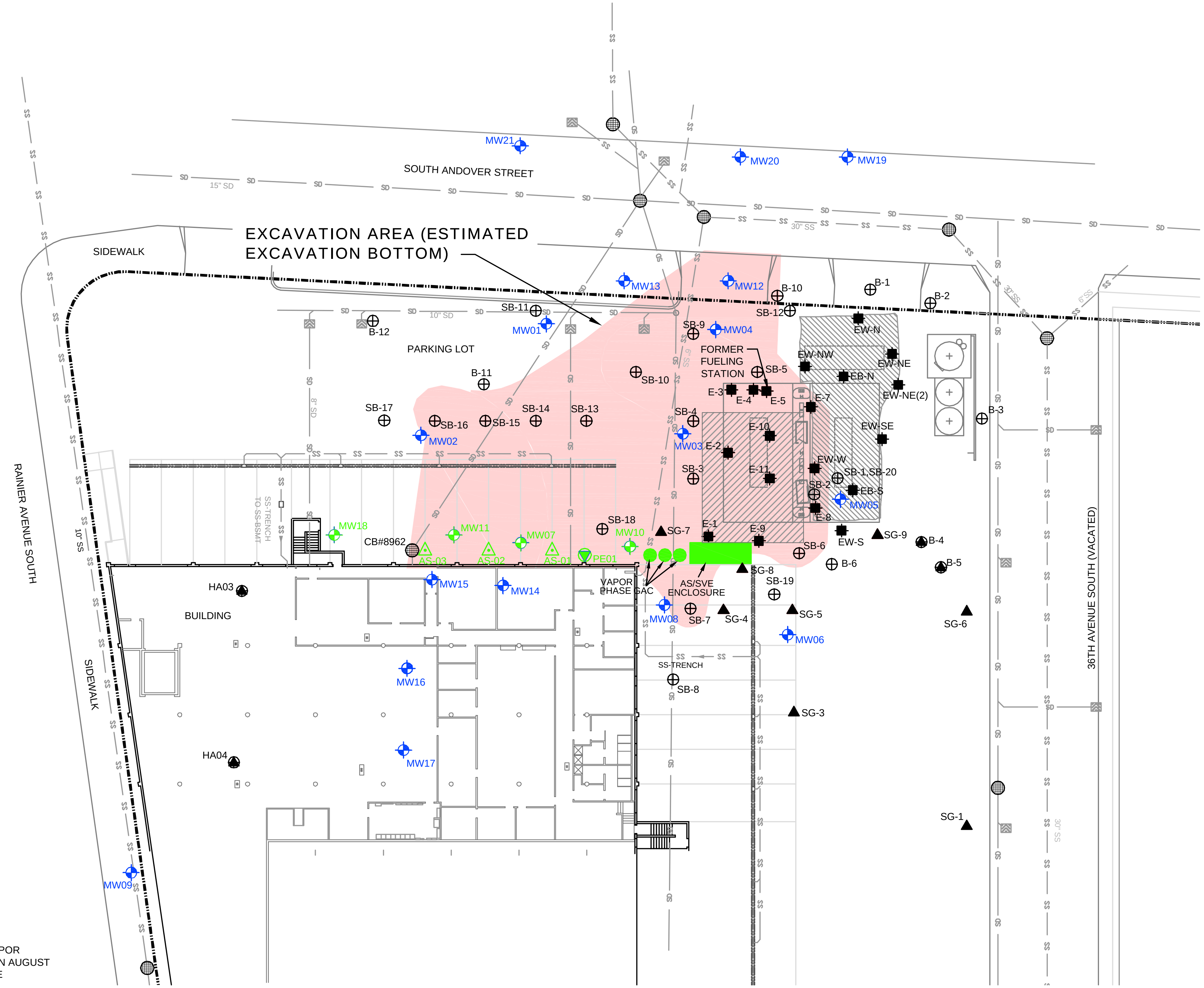

NOTES:

1.) COMPONENTS OF THE AIR SPARGE/SOIL VAPOR EXTRACTION (AS/SVE) SYSTEM INSTALLED IN AUGUST 2008 ARE COLORED GREEN ON THIS FIGURE

LEGEND

B-1	SOIL BORING
E-1	SOIL EXCAVATION BASE OR SIDEWALL SAMPLE
SG-1	SOIL GAS SAMPLE
MW01	GROUNDWATER MONITORING WELL
PE01	PILOT TEST WELL
	NOTE: Green wells have been incorporated into the soil vapor extraction (SVE) system.
AS-01	AIR SPARGING WELL
	CATCH BASIN OR CURB INLET
	MANHOLE
	PROPERTY BOUNDARY
	APPROXIMATE PARCEL BOUNDARY
SS	SANITARY SEWER
SD	STORM SEWER
	ZIPPER DRAIN
	FORMER UST
	APPROXIMATE FORMER UST EXCAVATION (SES, 2004)
	APPROXIMATE FORMER UST EXCAVATION (SD&C, 1998)
UST	UNDERGROUND STORAGE TANK

Areas of Cleanup Technology Application

SOIL EXCAVATION

REFERENCES : SES, FIELD MEASUREMENTS, 2004-2009
DARIGOLD, INC, FACILITY DRAWINGS, 2005.
CITY OF SEATTLE, SEWER CARD NOS. 1442, 1443, AND 5412, 2001.
SD&C, UNDERGROUND STORAGE TANK SITE ASSESSMENT REPORT, 1998.

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Aspect CONSULTING

Alternative 5 - Extensive Excavation

Darigold - Rainier Avenue Facility
Seattle, Washington

DATE: Sept 2010
DESIGNED BY: DAH
DRAWN BY: PMB
REVISED BY: -

PROJECT NO. 090066

FIGURE NO. 6

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ATTACHMENT A

Cost Estimates for Revised Remedial Alternatives

Table A.1 - Cost Estimate for Alternative 1

No Action

FFS Tech. Memo, Darigold Rainier Avenue Facility

	No. of Units	Units	Unit Cost	Cost	Year of Expenditure	Present Worth Cost	Notes
SUNK COSTS							
Permitting, design, & infrastructure already invested	1	ls	$275,000	$275,000	2008	$288,412	(3)
TOTAL PRESENT WORTH COST (2011 Dollars)						**$288,412**	

Notes:

1) These FS-level cost estimates are based on 2011 dollars and have an accuracy of -30/+50 percent.

2) Present worth costs are calculated using a real discount rate of 1.6 percent, consistent with the SES cost estimate basis.

3) Sunk costs are primarily 2008 expenditures for pilot testing, design, and construction of the existing AS/SVE system.

Table A.2 - Cost Estimate for Alternative 2
Operate Existing AS/SVE System with MNA
FFS Tech. Memo, Darigold Rainier Avenue Facility

	No. of Units	Units	Unit Cost	Year of Expenditure	Present Worth Cost	Notes
PRESENT WORTH OF SUNK COSTS (from Table A.1)					**$288,412**	
COSTS RELATED TO CLEANUP INITIATION						(3)
Pre-CAP testing of existing AS/SVE system (incl. PSCAA permit)	1	ls	$70,000	2011	$70,000	
CAP/eng. design/O&M manual/MNA mon. & contingency plan	1	ls	$60,000	2011	$60,000	
Property deed restrictions	1	ls	$10,000	2011	$10,000	
Present Worth of Costs Related to Cleanup Initiation					**$140,000**	

LONGER-TERM COSTS	No. of Units	Units	Unit Cost	Annual Cost	Years of Expenditure	Present Worth Cost	Notes
Annual AS/SVE system O&M costs, incl. electricity	1	ea	$73,000	$73,000	2012 - 2014	$208,833	(4)
Quarterly groundwater monitoring/reporting	4	events	$10,000	$40,000	2011 - 2014	$153,799	(5)
Semi-annual groundwater monitoring/reporting	2	events	$10,000	$20,000	2015 - 2040	$396,677	(6)
Closure reporting	1	ls	$25,000	$25,000	2040	$15,777	(6)
Present Worth of Longer-Term Costs						**$775,086**	
TOTAL PRESENT WORTH COST (2011 Dollars)						**$1,203,498**	

Notes:

1) These FS-level cost estimates are based on 2011 dollars and have an accuracy of -30/+50 percent.
2) Present worth costs are calculated using a real discount rate of 1.6 percent, consistent with the SES cost estimate basis.
3) It is assumed that indoor air and the CB#8962 storm sewer are further investigated, and are determined not to be potential exposure pathways. Investigation costs are not included in this cost estimate.
4) It is assumed that SPH in the vicinity of Well MW07 is demonstrated to be remediated after 3 years of AS/SVE operation, at which point the AS/SVE system is shut down.
5) Quarterly groundwater monitoring is assumed for the first 4 years, followed by semi-annual.
6) The remediation time frame for this alternative is estimated at 30 years or more. This cost estimate assumes that cleanup levels are achieved in 2040.

Table A.3 - Cost Estimate for Alternative 3
In Situ Technologies Only
FFS Tech. Memo, Darigold Rainier Avenue Facility

	No. of Units	Units	Unit Cost	Year of Expenditure	Present Worth Cost	Notes
PRESENT WORTH OF SUNK COSTS (from Table A.1)					**$288,412**	
COSTS RELATED TO CLEANUP INITIATION/CONSTRUCTION						(3)
Pre-CAP testing of existing AS/SVE system (incl. PSCAA permit)	1	ls	$70,000	2011	$70,000	
Pilot study of ORC® injection	1	ls	$50,000	2011	$50,000	
CAP/eng. design/O&M manual/mon. & contingency plan	1	ls	$90,000	2011	$90,000	
Property deed restrictions	1	ls	$10,000	2011	$10,000	
Construct AS/SVE system expansion	1	ls	$180,000	2011	$180,000	
Present Worth of Costs Related to Cleanup Initiation/Construction					**$400,000**	

LONGER-TERM COSTS	No. of Units	Units	Unit Cost	Annual Cost	Years of Expenditure	Present Worth Cost	Notes
Annual AS/SVE system O&M costs, incl. electricity	1	ea	$130,000	$130,000	2012 - 2016	$610,166	(4)
ORC® injection	1	ea	$180,000	-	2012/2014/2016	$515,061	(5)
Quarterly groundwater monitoring/reporting	4	events	$10,000	$40,000	2011 - 2016	$227,113	(6)
Semi-annual groundwater monitoring/reporting	2	events	$10,000	$20,000	2017 - 2021	$86,709	(7)
Closure reporting	1	ls	$25,000	$25,000	2021	$21,331	(7)
Present Worth of Longer-Term Costs						**$1,460,380**	
TOTAL PRESENT WORTH COST (2011 Dollars)						**$2,148,792**	

Notes:

1) These FS-level cost estimates are based on 2011 dollars and have an accuracy of -30/+50 percent.
2) Present worth costs are calculated using a real discount rate of 1.6 percent, consistent with the SES cost estimate basis.
3) It is assumed that indoor air and the CB#8962 storm sewer are further investigated, and are determined not to be potential exposure pathways. Investigation costs are not included in this cost estimate.
4) It is assumed that the expanded AS/SVE system is operated for 5 years.
5) Three ORC® injection events are assumed, occurring at 2-year intervals.
6) Quarterly groundwater monitoring is assumed for the first 6 years, followed by semi-annual.
7) The remediation time frame for this alternative is estimated at 10 years.

Table A.4 - Cost Estimate for Alternative 4
Targeted Excavation
FFS Tech. Memo, Darigold Rainier Avenue Facility

	No. of Units	Units	Unit Cost	Year of Expenditure	Present Worth Cost	Notes
PRESENT WORTH OF SUNK COSTS (from Table A.1)					**$288,412**	
COSTS RELATED TO CLEANUP INITIATION/CONSTRUCTION						(3)
Pilot study of ORC® injection	1	ls	$50,000	2011	$50,000	
CAP/eng. design/permitting/mon. & contingency plan	1	ls	$120,000	2011	$120,000	
Property deed restrictions	1	ls	$10,000	2011	$10,000	
Targeted soil excavation						(4)
- Site Work	1	ls	$928,550	2011	$928,550	
- Subcontractor markup @ 15%	1	ls	$139,283	2011	$139,283	
- Other indirect costs	1	ls	$105,000	2011	$105,000	(5)
Present Worth of Costs Related to Cleanup Initiation/Construction					**$1,352,833**	

LONGER-TERM COSTS	No. of Units	Units	Unit Cost	Annual Cost	Years of Expenditure	Present Worth Cost	Notes
ORC® injection	1	ea	$170,000	-	2012/2014	$329,417	(6)
Quarterly groundwater monitoring/reporting	4	events	$10,000	$40,000	2011 - 2014	$153,799	(7)
Semi-annual groundwater monitoring/reporting	2	events	$10,000	$20,000	2015 - 2017	$54,554	(8)
Closure reporting	1	ls	$25,000	$25,000	2017	$22,729	(8)
Present Worth of Longer-Term Costs						**$560,499**	
TOTAL PRESENT WORTH COST (2011 Dollars)						**$2,201,744**	

Notes:

1) These FS-level cost estimates are based on 2011 dollars and have an accuracy of -30/+50 percent.
2) Present worth costs are calculated using a real discount rate of 1.6 percent, consistent with the SES cost estimate basis.
3) It is assumed that indoor air and the CB#8962 storm sewer are further investigated, and are determined not to be potential exposure pathways. Investigation costs are not included in this cost estimate. In addition, it is assumed that the existing AS/SVE system is rejected as a remedial component without pilot testing.
4) The volume of soil requiring excavation in this alternative is roughly 70 percent that of the volume assumed in SES Alternative 1. The soil excavation costs shown here have been scaled from the SES estimates using this factor.
5) "Other indirect costs" include Aspect labor, Aspect field expenses, and subcontracted laboratory costs.
6) Two ORC® injection events are assumed, occurring at 2-year intervals.
7) Quarterly groundwater monitoring is assumed for the first 4 years, followed by semi-annual.
8) The remediation time frame for this alternative is estimated at 6 years.

Table A.5 - Cost Estimate for Alternative 5
Extensive Excavation
FFS Tech. Memo, Darigold Rainier Avenue Facility

	No. of Units	Units	Unit Cost	Year of Expenditure	Present Worth Cost	Notes
PRESENT WORTH OF SUNK COSTS (from Table A.1)					**$288,412**	
COSTS RELATED TO CLEANUP INITIATION/CONSTRUCTION						(3)
Extensive soil excavation	1	ls	$3,984,000	2011	$3,984,000	(4)
Present Worth of Costs Related to Cleanup Initiation/Construction					**$3,984,000**	

LONGER-TERM COSTS	No. of Units	Units	Unit Cost	Annual Cost	Years of Expenditure	Present Worth Cost	Notes
Quarterly groundwater monitoring/reporting	4	events	$10,000	$40,000	2011 - 2012	$78,120	(5)
Closure reporting	1	ls	$25,000	$25,000	2012	$24,606	(6)
Present Worth of Longer-Term Costs						**$102,726**	
TOTAL PRESENT WORTH COST (2011 Dollars)						**$4,375,139**	

Notes:

1) These FS-level cost estimates are based on 2011 dollars and have an accuracy of -30/+50 percent.
2) Present worth costs are calculated using a real discount rate of 1.6 percent, consistent with the SES cost estimate basis.
3) It is assumed that indoor air and the CB#8962 storm sewer are further investigated, and are determined not to be potential exposure pathways. Investigation costs are not included in this cost estimate.
4) The volume of soil requiring excavation in this alternative is essentially the same as the volume assumed in SES Alternative 3. Therefore, SES's total cost estimate for soil excavation is used for this alternative without adjustment.
5) Quarterly groundwater monitoring is assumed for 2 years.
6) The remediation time frame for this alternative is estimated at 2 years.