Public Review Draft Feasibility Study

Former Precision Engineering Property
1231 South Director Street
Seattle, Washington

for

Dick Morgan

April 24, 2026

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Bellingham, Washington 98225
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GeoEngineers

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File No. 25806-001-03
April 24, 2026

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Acronyms and Abbreviations

AO	Agreed Order
bgs	below ground surface
CAAs	Cleanup Action Alternatives
CAO	Cleanup Action Objectives
CAP	Cleanup Action Plan
CFR	Code of Federal Regulations
Chromium	All forms of chromium, unless noted otherwise
cPAH	carcinogenic polycyclic aromatic hydrocarbon
CSID	cleanup site ID
CSM	conceptual site model
COC	contaminant of concern
CrIII	trivalent chromium
CrVI	hexavalent chromium
CSID	cleanup site ID
CSM	conceptual site model
CWA	Clean Water Act
DCA	disproportionate cost analysis
DCAP	Draft Cleanup Action Plan
Ecology	Washington State Department of Ecology
EPA	United States Environmental Protection Agency
FS	feasibility study
FSID	facility site ID
IHS	indicator hazardous substances
ISCR	in-situ chemical reduction
ISS	in-situ solidification and stabilization
LDW	Lower Duwamish Waterway
mg/kg	milligrams per kilogram
MTCA	Model Toxics Control Act
MNA	monitored natural attenuation
NFA	No Further Action
NPDES	National Pollutant Discharge Elimination System
OMM	operation, maintenance and monitoring
PCOCs	potential contaminants of concern

PCUL	preliminary cleanup level
PRB	permeable reactive barrier
the Property	1231 South Director Street in Seattle, Washington
RCRA	Resource, Conservation and Recovery Act
RI	Remedial Investigation
the Site	Where contamination is located
TCE	trichloroethylene
TEQ	toxic equivalent concentration
TPH	total petroleum hydrocarbon (diesel- and/or oil-range)
WAC	Washington Administrative Code
ZVI	zero-valent iron
µg/L	microgram per liter

Executive Summary

GeoEngineers, Inc. has prepared this Feasibility Study (FS) report on behalf of Dick Morgan for the former Precision Engineering, Inc. site located south of the South Park community of Seattle, in King County, Washington. Historically, the site was used for industrial operations, including hard chromium plating which resulted in contamination to soil, groundwater, and indoor air. The site is a Model Toxics Control Act (MTCA) Site with Cleanup Site ID 4532. The site is currently occupied by a commercial sales and wire rope manufacturing business.

The primary contaminants of concern at the site include hexavalent chromium, trichloroethylene (TCE), and total petroleum hydrocarbons (TPH) in soil and groundwater. Indoor air impacts were remedied during interim actions in 2020. The site is divided into four Areas of Concern (AOCs):

- **AOC1 (Former Plating Area):** Highest contamination levels, particularly chromium and TCE in soil and groundwater.
- **AOC2 (Warehouse 1 - North):** Low concentrations of TCE in soil and groundwater and minimal chromium contamination in soil.
- **AOC3 (Ditch):** Surficial soil contamination, including chromium and minor TPH contamination.
- **AOC4 (Three TPH Hotspots):** Isolated “hotspots” of TPH in soil without groundwater impact.

Potential cleanup alternatives were evaluated based on MTCA general cleanup requirements, action- and media-specific requirements, and public concerns. Five alternatives were evaluated that included a combination of monitored natural attenuation (MNA), institutional controls, engineering controls, in-situ remediation (enhanced bioremediation, in-situ chemical reduction [ISCR] and sorption with activated carbon [AC], and solidification), and excavation with offsite disposal with AOC-specific implementation as appropriate for each portion of the Site.

A disproportionate cost analysis (DCA) was performed to determine the most effective and cost-efficient alternative for the Site. The DCA uses six criteria, including protectiveness, permanence, long-term effectiveness, management of cleanup risks, implementability, and cost.

The results of this FS indicate the preferred alternative includes the following remedial technologies: ISS for AOC1; ISCR with AC for AOC2; excavation with offsite disposal for AOC3; and MNA with institutional controls for AOC4. The preferred alternative provides the highest benefit-to-cost ratio, ensure long-term protectiveness, and compliance with MTCA. The preferred alternative is expected to reduce or eliminate risks to human health and the environment and use engineering and institutional controls appropriately to prevent future exposure. Groundwater and indoor air will be monitored for a sufficient period of time after cleanup activities are complete to confirm cleanup effectiveness.

The proposed cleanup action will be detailed in a Draft Cleanup Action Plan (DCAP) and final Cleanup Action Plan (CAP).

This Executive Summary should be used only in the context of the full report for which it is intended.

1.0 Introduction

GeoEngineers, Inc. (GeoEngineers) has prepared this Feasibility Study (FS) report on behalf of Dick Morgan (the Client) for the former Precision Engineering, Inc. site (herein referred to as the "Precision Property" or "the Site"). The Site is located at 1231 South Director Street in King County, Washington, and is south-southeast adjoining to the South Park neighborhood of Seattle (Figure 1-1).

Historically, the Property was used for industrial operations, including hard chromium plating. CL Frazier Properties, LLC, currently owns the Precision Property, where Pacific Industrial Supply, Inc. (Pacific Industrial Supply) operates an industrial equipment manufacture and supply store.

1.1 REGULATORY FRAMEWORK

The Site is on the Contaminated Sites List maintained by the Washington State Department of Ecology (Ecology) with cleanup site ID (CSID) 4532 and facility site ID (FSID) 2056. The Site is defined by the area where hazardous substances associated with Precision Engineering's (Precision's) historical operations on or off the Precision Property have come to be located in environmental media as a result of historical releases and subsequent environmental fate and transport mechanisms.

Agreed Order No. DE 18079 (AO) was negotiated between the Washington State Department of Ecology (Ecology) and Dick Morgan with an effective date of December 18, 2020. The AO requires preparation of a Remedial Investigation (RI) , FS, and a preliminary Draft Cleanup Action Plan (DCAP). A public review draft RI Report was prepared (GeoEngineers 2026) that characterizes the Site, including the distribution of hazardous substances and the potential threat these substances pose to human health and the environment. The RI also provided media-specific screening levels for the hazardous substances identified based on an evaluation of potential receptors. This FS uses the information in the RI to develop proposed cleanup standards and objectives and to evaluate Cleanup Action Alternatives (CAAs) to meet those objectives for the Site. A DCAP will be prepared after finalization of this FS that documents the selected cleanup action. This FS Report was developed in general accordance with the Model Toxics Control Act (MTCA) (Washington Administrative Code [WAC] chapter 173-340).

1.2 PURPOSE AND OBJECTIVES

The purpose of this FS Report is to develop and evaluate CAAs to address contamination identified in the RI and select a preferred CAA consistent with MTCA requirements to ensure protection of human health and the environment by eliminating, reducing or otherwise controlling risk posed through each exposure pathway and migration route. It has been prepared in accordance with the requirements defined by the MTCA (WAC 173-340-351) and follows the format of the Ecology FS Checklist (Ecology 2016). The overall objective is to clean up the Site and achieve a No Further Action (NFA) with a potential environmental covenant recorded for the Precision Property.

1.3 SITE HISTORY AND DESCRIPTION

This section summarizes the Site history and Site description. For a complete description, see the RI (GeoEngineers 2026).

The Site is located at 1231 South Director Street on King County tax Parcel No. 0001600055, and is developed with one 62,000-square-foot building with three warehouse bays. The surrounding area is a mix of industrial and residential properties (Figure 1-2). A towing and limousine service business has operated on the adjacent property to the east formerly identified as the Kaspac/Chiyoda cleanup site. A business that repairs and sells refrigerators is located west of the Precision Property. Residential homes are located north of the Precision Property. A northbound onramp for State Route (SR) 99 is located south-adjacent to the Precision Property. The onramp is part of a larger SR 99 "cloverleaf" (see Figure 1-2).

The Precision Property as well as nearby industrial properties are labeled in Figure 1-2. Past and present cleanup sites near the Precision Property are highlighted in Figure 1-2, including the former Kaspac/Chiyoda property, Warner's Auto Repair, DBA & Airbus, KRS Marine, and Delta Marine Industries.

Precision operated an industrial manufacturing business on the property from 1968 to 2005. The operation included manufacturing and repairing hydraulic cylinders, metal rolls used in the manufacturing of paper and sheet metal products, and other equipment. Services included grinding and polishing, honing, hard-chrome plating, milling, welding, and application of flame- and arc-applied metal coating much of which involved the use of chromic acid. Historical areas or activities of interest include chromic acid plating tanks, parts washing using trichloroethylene (TCE), and former trench drains connected to the sanitary sewer; this equipment was removed in 2005. The Property was sold to CL Frazier Properties in 2007. The property has been occupied by Pacific Industrial Supply, a wire rope and marine/industrial supply distributor, from 2007 to present (2026). Additional environmental investigations occurred between 2005 and 2023, culminating with a RI (the third for the Site) (GeoEngineers 2026).

Current 2026 Precision Property features are shown in Figure 1-3. Pacific Industrial Supply has retail space in Warehouses 1 and 2, wire rope manufacturing in Warehouse 2, and storage in Warehouse 3 and the building areas south of Warehouse 1. Figure 1-3 shows the locations of 23 monitoring wells installed between 1988 and 2023 for environmental investigations, including but not limited to, three RIs that have been performed for the Site.

The Site is relatively flat aside from steep (approximately 50 degree) slopes along the northern and western perimeters, and is almost entirely covered with impervious surfaces. Stormwater flows to a single catch basin located south of Warehouse 2 (Figure 1-3). The catch basin conveys stormwater via a short section of underground stormwater pipe through a manhole and additional stormwater pipe and discharges to a ditch south of the property boundary. The ditch also receives stormwater from the former Kaspac/Chiyoda property, the western portion of 14th Avenue South, and the northern portion of the SR 99 onramp. The ditch discharges from the low point to the south through a culvert to the SR 99 cloverleaf stormwater pond system.

2.0 Summary of the Remedial Investigation

This section summarizes the RI conceptual site model (CSM), and presents indoor air data collected following completion of the RI.

2.1 CONCEPTUAL SITE MODEL

The RI CSM identified that the primary sources and release mechanisms at the Site included historical leaks and spills of process chemicals and waste that occurred primarily in and near Warehouse 1 (Figure 1-3). The CSM is shown in Figure 2-1. Historical contaminant sources included chromic acid plating tanks and vaults, TCE storage and use, and potential spills and leaks from other tanks or associated industrial activities. Contamination was released to the soil and groundwater with subsequent releases to soil vapor and indoor air (TCE)[1]. Surface water and sediment are not affected.

Potential exposure pathways include:

- Dermal contact with, and/or incidental ingestion of, chemicals in the soil at the Site. This pathway is currently incomplete due to buildings and pavement. However, it could be a complete exposure pathway in the future if soils at the Site were exposed.
- Inhalation of airborne particles (dust) generated from soil at the Site. This is also only a future pathway if soils at the Site are exposed.
- Inhalation of air vapors emanating from soil and/or groundwater via vapor intrusion into the building or outdoors. TCE is the only air contaminant of concern (COC). This pathway is incomplete following the interim remedial actions performed in 2020. The pathway could be a complete exposure pathway in the future if soil under Warehouse 1 was exposed. Another potential pathway would be if cracks in the concrete floor that were sealed with sealant in 2020 are not periodically re-sealed.
- Dermal contact with or ingestion of chemicals in groundwater. This pathway is currently incomplete. Groundwater is currently not used for drinking water at or downgradient of the Site. Potential future pathways could include dermal contact of groundwater by construction workers.
- Dermal contact with or incidental ingestion of ditch soils or stormwater, or inhalation of soil dust, in the ditch south of the property. The pathway is complete but considered minor/unlikely due to the following:
  - The limited area of contaminated soil in the ditch, estimated to be less than 0.1 acres.
  - The limited use of the ditch. People do not regularly use or enter the ditch and the ditch is low quality habitat for terrestrial biota and surrounded on all sides by developed commercial businesses and highways.

Multiple RIs have established that the Site is not a source of contamination to the Lower Duwamish Waterway (LDW).

2.2 POST-REMEDIAL INVESTIGATION DATA

Post-RI data includes two rounds of indoor air sampling for TCE per the Ecology-approved Vapor Intrusion Priority Work Plan (MFA 2020) performed in November 2023 and November and December 2024. The sampling is a continuation of indoor air sampling events for TCE following interim actions in 2020 to reduce indoor air TCE concentrations. The RI included data through February 2023. The data collected indicate indoor air TCE concentrations have decreased to below the RI screening level since the implementation of the interim actions in April 2020. TCE in indoor air has been detected at concentrations less than the screening level during the past four sampling events. A data summary table (Table A-1), lab data, and data validation report for the monitoring events and a figure showing sample locations are included in Appendix A.

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[1] Interim actions in 2020 have reduced indoor air concentrations of TCE to below screening levels, as discussed in the RI.

3.0 Basis for the Cleanup Action

Cleanup Action Objectives (CAOs) form the basis for evaluating and selecting remedial technologies and cleanup actions that will be successful at a given site. CAOs consist of location-, chemical-, and medium-specific goals for protecting human health and the environment. CAOs are dependent on the chemicals and pathways that pose a risk to people and natural resources associated with a site. Development of CAOs involves several steps, as described below and in the following sections:

- Identify laws and regulatory standards (potentially applicable or relevant and appropriate requirements and anticipated permits [ARARs]) that set the framework and requirements for the development of cleanup standards and implementation of a cleanup action.
- Develop cleanup levels and points of compliance at which an acceptable risk level is attained.
- Identify locations and media requiring cleanup based on selected cleanup standards.

3.1 POTENTIALLY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS AND ANTICIPATED PERMITS

This section discusses the potential ARARs and anticipated permits associated with the cleanup action at the Site.

Cleanup actions conducted under MTCA must comply with the state and federal laws that have jurisdiction over the cleanup or that Ecology determines may apply to the cleanup (WAC 173-340-710). These laws, implementing regulations, standards, limitations or other requirements are referred to as ARARs.

The ARARs identified for cleanup of the Site are listed in Table 3-1. The procedures, standards, and other requirements specified in MTCA are the primary ARARs governing cleanup actions at the Site. Additional ARARs regulate specific components of the cleanup, including disposal of hazardous waste, management of extracted groundwater during construction, and worker safety during implementation.

MTCA cleanup actions conducted under an AO are generally exempt from the procedural requirements of many state and local permits. Typically, cleanup actions are exempt from the procedural requirements of the Washington State Clean Air Act, solid waste management, water pollution control, and local regulations. However, permits associated with two national programs that are administered by the State - the Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES) permits, and those permits required for treatment, storage or disposal of hazardous waste under the Resource, Conservation and Recovery Act (RCRA) - still apply, as do the federally-required permits. Regardless of the permit exemptions, the cleanup actions must meet the substantive requirements of the subject regulations.

3.2 CLEANUP ACTION OBJECTIVES

The general objective of the cleanup action is to eliminate, reduce or otherwise control to the extent practicable, unacceptable risks to human health and the environment posed by Site-related hazardous substances in impacted media in accordance with the MTCA cleanup regulation (Chapter 173-340 WAC) and other applicable regulatory requirements. The individual CAOs for the cleanup action at the Site are specific to certain media and COCs, exposure routes, and receptors. The CAOs are based on an assumed unrestricted land use, even though current and anticipated future Site use is for industrial/commercial purposes.

The media and exposure pathways of concern for the Site are identified in Section 2.1 and include potential human and ecological exposures to Site-related contaminants that are present in soil, groundwater, and indoor air. The CAOs for the Site include the following:

- Prevent people from contacting contaminants in soil and ditch stormwater, and groundwater (dermal contact, ingestion).
- Prevent Site workers being exposed to contaminants resulting from soil vapor migrating to indoor air (inhalation of indoor air).

Ingestion for soil, ditch stormwater, and groundwater would be incidental. Groundwater is not currently used for drinking water at or downgradient of the Site as described in Section 2.2. Therefore, the CAOs do not include preventing use of groundwater as potable water. However, institutional controls will be included in the remedy that prevent withdrawal of groundwater from the Site for potable and non-potable uses.

3.3 CLEANUP STANDARDS

Cleanup standards are used to develop cleanup action alternatives that will ultimately achieve CAOs and lead to post-remedy conditions that are protective of human health and the environment. Cleanup standards consist of: (1) chemical concentrations in environmental media that are protective of human health and the environment (i.e., cleanup levels), (2) the locations where the cleanup levels must be met (i.e., points of compliance), and (3) other regulatory requirements that apply to the site (i.e., applicable state and federal laws).

3.3.1 Proposed Cleanup Levels and Indicator Hazardous Substances

Proposed cleanup levels and indicator hazardous substances were developed in consultation with Ecology.

The proposed cleanup levels address exposure pathways addressed in this FS that include soil direct contact and groundwater discharge to marine surface water. Potential terrestrial ecological exposures were not considered because this pathway was determined in the RI to be incomplete.

The proposed cleanup levels were developed for a subset of contaminants referred to as indicator hazardous substances (IHSs) as defined in WAC 173-340-703. For cleanup planning purposes, the selection of IHSs eliminate from consideration those hazardous substances that contribute a small percentage of the overall threat to human health and the environment.

The IHSs were selected from the list of potential contaminants of concern (PCOCs) identified in the RI Report (GeoEngineers 2026). Cleanup action alternatives for the Site are developed based on the following IHSs in soil and groundwater: chromium[2], TCE, and total petroleum hydrocarbons (TPH; diesel and/or oil-range organics). The only IHS in indoor air is TCE.

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[2] “Chromium” in this FS generally refers to all common forms of chromium including chromium 6 (CrVI), chromium 3 (CrIII), total chromium (sum of CrVI and CrIII). If a specific form of chromium is discussed, the form will be specified (i.e., CrVI).

The proposed cleanup levels (PCULs) used in this FS are shown for soil, groundwater, and air in Tables 3-2, 3-3, and 3-4 respectively for both IHSs and other PCOCs for completeness. The PCULs were developed in consultation with Ecology, as part of the RI (RI Appendix Q; GEI 2026).

The RI included mercury, 1,4-dioxane, and carcinogenic polycyclic aromatic hydrocarbon (cPAH) total toxic equivalent concentration (TEQ) as PCOCs. Additional considerations for these PCOCs include:

- Mercury is not a contaminant associated with chromium plating sites based on a literature review of Environmental Protection Agency (EPA) information (EPA 2021) and a review of eight plating cleanup sites in Washington State[3]. Soil mercury concentrations at the site are generally low ranging from non-detect to a maximum of 2 milligrams per kilogram (mg/kg) in 72 out of 74 samples. The two soil samples that exceeded 2 mg/kg included HA-3-0.5 (2.65 mg/kg) and HA-4-0.5 (2.28 mg/kg). These samples were located within the ditch but were removed as part of a remedial excavation in 2007/2008. There is no clear spatial pattern to the mercury detections in soil and no identified source area in the former process areas. Total and dissolved mercury only exceeded the RI groundwater screening level consistently in one out of 23 monitoring wells (MW7, a deep well). It is likely that mercury detections at the Site are related to burning of fossil fuels in the highly urbanized/industrial setting of south Seattle (i.e., from vehicle and industrial air emissions).
- 1,4-dioxane was only detected in one out of 33 soil samples at the Site in well MW22 located off-property and far from potential source areas at Precision Engineering. 1,4-dioxane was not collocated with Site TCE exceedances as would be expected given that 1,4-dioxane is generally known to potentially be present in TCE as a stabilizer. 1,4-dioxane exceeded the RI groundwater screening level in shallow monitoring wells in Warehouse 1 and in wells adjacent to the building but did not exceed the screening level in the wells located further downgradient from the Site (i.e., MW18 through MW23 located along the SR 99 on-ramp and 14th Avenue South). 1,4-dioxane did not exceed the screening level in the ditch water samples.
- cPAHs are not collocated with petroleum hydrocarbon screening level exceedances as would be expected. Rather, cPAHs are present at low concentrations that tend to increase away from the Site towards the roadways. This suggests cPAHs are potentially present as a background condition and/or from adjacent roadways rather than sourced from the Site[4].

3.3.2 *Points of Compliance*

The standard point of compliance for soil based on the protection of groundwater is throughout the Site. For the protection of human health via direct contact, the standard point of compliance for soil is from ground surface to 15 feet below ground surface (bgs). This FS includes at least one alternative that assumes the standard point of compliance for soil.

The standard point of compliance for groundwater is throughout the site. MTCA allows use of a conditional point of compliance when it can be demonstrated that it is not practicable to meet cleanup levels throughout the site within a reasonable restoration time frame (WAC 173-340-720[8][c]). This FS includes

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[3] Mercury is not a COC at the following eight plating cleanup sites (CSIDs listed): 58, 794, 1277, 1361, 2468, 3548, 4819, 13060.

[4] Site soil cPAH concentrations are less than urban background concentrations in Seattle (Ecology 2011).

alternatives that are expected to meet cleanup levels at the standard point of compliance and a conditional point of compliance which is at the property boundary.

The standard point of compliance for air is in the ambient (outdoor) air and air within any building, utility vault, manhole or other structure large enough for a person to fit into throughout the site.

3.3.3 Other Regulatory Requirements

Other regulatory requirements refer to ARARs. These are discussed in Section 3.1 above.

3.4 AREAS REQUIRING CLEANUP

The areas requiring cleanup are those locations where the IHSs chromium, TCE, and/or TPH exceed proposed cleanup levels. Figure 3-1 shows the approximate location of these areas. The Site is characterized in terms of four Areas of Concern (AOCs). AOCs are used for the Site due to the differences in types and concentrations of contamination in each area. It is not appropriate to select a single cleanup alternative that applies to the entire Site because of these differences. The four AOCs and their characteristics include the following.

- **AOC1: Former Plating Tank Area.** AOC1 is situated within the southern portion of Warehouse 1 where the former chromic acid plating tanks were located. Also present in this area were former sanitary sewer trench drains and the TCE tank. AOC1 is located where concentrations of COCs are highest at the Site, including:
    - Hexavalent chromium in soil up to 3,500 mg/kg and in groundwater up to 163,000 micrograms per liter (µg/L).
    - TCE in soil up to 1.16 mg/kg and in groundwater up to 14.1 µg/L.
    - There are no TPH exceedances in AOC1.

  Soil contamination is present to approximately 15 feet bgs. Groundwater is contaminated in shallow monitoring well MW5 which is screened 10 to 20 feet bgs. Deeper groundwater located beneath the aquitard in MW15 is not contaminated.
- **AOC2: Warehouse 1 – North.** AOC2 is located within the northern portion of Warehouse 1 where grinding and cleaning of metal using TCE occurred. Trench drains were also present in this area. AOC2 is considerably different than AOC1 in terms of the types and concentrations of contamination. AOC1 contains very high concentrations of hexavalent chromium in soil and groundwater whereas AOC2 contains low or in some cases non-detectable concentrations of hexavalent chromium. AOC2 contains low concentrations of TCE in soil (maximum of 0.281 mg/kg) between approximately 1 and 10 feet bgs and TCE in groundwater in shallow well MW14 (approximately 20-40 µg/L) with the screen interval from 10 to 20 feet bgs. Deeper groundwater was not encountered to a depth of 50 feet bgs in AOC2. There is no TPH contamination in AOC2.
- **AOC3: Ditch.** AOC3 is a portion of the ditch south of the property. The ditch contains moderate concentrations of chromium in shallow soil up to about 2 feet bgs and one slight TPH exceedance (3,806 mg/kg total TPH). TCE is not a COC in AOC3.
- **AOC4: Three TPH Hotspots.** AOC4 includes three isolated TPH hotspots with no other COC exceedances:

- GP21. Located in the southeast corner of Warehouse 1 where TPH was 25,000 mg/kg at 6.5 feet bgs in 2005.
- SB5. Located along the eastern property boundary and near the Kaspac-Chiyoda former chemical storage area where TPH was 2,320 mg/kg at 11 feet bgs in 2014.
- SB3. Located along the southern property line where TPH was 22,000 mg/kg at 2 feet bgs in 2014.

These three hotspots are overlain by the existing building or surface pavement. Samples collected in borings surrounding each hotspot do not contain TPH exceedances confirming the hotspots are isolated. TPH does not exceed preliminary cleanup levels in on-site (nor off-site) shallow or deep groundwater from monitoring wells downgradient of the hotspots.

4.0 Identification and Screening of Remedial Technologies

This section identifies and screens potentially applicable remedial technologies for developing cleanup action alternatives in accordance with MTCA requirements under WAC 173-340-351. Sources of information used to develop the list of technologies include EPA publications and databases, text references, vendor information, and professional experience at similar sites.

The technology screening evaluation was performed for Site-related contaminants in soil, groundwater, and air on an AOC basis. The evaluation focuses on demonstrated technologies appropriate for the size, cleanup time frame, and conditions at the Site within each AOC. Remedial technologies that were considered fall into the following categories:

1. No Action
2. Institutional Controls
3. Engineering Controls
4. In-Situ Remediation
5. Excavation with Off-Site Disposal

Potentially applicable technologies within the categories listed above were evaluated and screened based on EPA's criteria of effectiveness, implementability, and cost (EPA 1988). The technologies considered effective and technically implementable given current knowledge of the Site and cost-effectiveness relative to competing options were retained for inclusion in cleanup action alternatives described in Section 5. The components of each of the three primary screening criteria – effectiveness, implementability, and relative cost – are explained below.

- **Effectiveness**
  - Effectiveness refers to the ability of each technology process option to address CAOs, site-specific IHSs, and protect human health and the environment relative to other remedial technologies. Effectiveness was evaluated based on the following:
    - The ability of a technology process option to achieve the established CAOs.
    - The degree to which the technology process option protects human health and the environment during construction and implementation.
    - Likely effectiveness considering Site-specific conditions.

- **Implementability**
  - Implementability refers to the technical and administrative feasibility of a technology process option. Implementability was evaluated based on the following:
    - The institutional aspects of implementation, including the ability to obtain necessary permits and public acceptance.
    - The availability of support services and equipment and the degree to which the technology process option has been demonstrated to be implementable at other sites.
- **Relative Cost**
  - This criterion was used to compare relative capital and operation, maintenance, and monitoring (OMM) costs of the technology process options. Each technology was evaluated based on whether relative costs (based on engineering judgment) are expected to be low, moderate or high compared to other remedial technologies. In general, AOC-specific considerations are discussed in the technology screening described below where applicable. Note that a limited number of technologies were considered appropriate for AOC3 and AOC4 given their simplicity.

4.1 NO ACTION

The no-action alternative is not considered effective at achieving Site CAOs or MTCA requirements. No action is retained for comparative purposes only in the evaluation of other remedial technologies and the cleanup action alternatives.

4.2 INSTITUTIONAL CONTROLS

Institutional controls limit or prohibit activities that may interfere with the integrity of a cleanup action or that may result in exposure to hazardous substances at a site (WAC 173-340-440[1]). These controls may include physical measures such as fences and formal land use restrictions, such as deed restrictions, restrictive covenants or maintenance requirements.

Institutional controls by themselves would not be protective of human health or satisfy the CAOs for this Site. However, institutional controls are applicable and are retained as potential components of all alternatives. These controls are effective and easily implemented when combined with an active cleanup.

4.3 ENGINEERING CONTROLS

Engineering controls are used to mitigate the effects of contaminants by preventing receptors from potential exposures. Remedial alternatives for AOC1 and AOC2 include engineering control measures to address TCE in indoor air in Warehouse 1, if necessary. TCE in indoor air is not currently a pathway of concern following successful interim actions performed in 2020. Furthermore, remedial technologies included in the cleanup alternatives for AOC1 and AOC2 are expected to further reduce soil vapor TCE concentrations at the Site.

The Site is currently covered by pavement or buildings except for the ditch south of the property. The pavement and building act as engineering controls to prevent direct contact with contaminated soil. Engineering controls are retained for consideration as a component of active remediation alternatives.

4.4 IN-SITU REMEDIATION

In-situ remediation involves the treatment of contaminated media without removal from its native location. Several common in-situ treatment technologies were evaluated for applicability to the contaminants and conditions at the Site on an AOC basis, including chemical, biological, and physical treatment methods as summarized below.

The potential success of in-situ remediation varies in each AOC, which further supports the approach to divide the site into different AOCs.

4.4.1 Monitored Natural Attenuation

Monitored natural attenuation (MNA) is the process of documenting natural physical and biological processes that reduce the concentration, toxicity, and/or mobility of contamination. Specific natural processes that reduce contaminant concentrations include biodegradation, sorption, dilution, volatilization, and chemical reactions. MNA is implemented by monitoring these natural processes to document they are effectively attenuating site contaminants.

TCE and TPH impacts at the Site are generally well suited for use of MNA, although an extended restoration timeframe would likely be needed with MNA alone for AOC1 and AOC2. Natural attenuation of hexavalent chromium is also possible, although the current high concentrations in soil in AOC1 indicate that MNA alone may not achieve cleanup levels. MNA is retained for use within the cleanup action alternatives for all AOCs.

4.4.2 Enhanced Bioremediation

Enhanced bioremediation is a general term that describes a broad class of technologies that involve stimulating biological mechanisms to degrade contaminants. A common form of enhanced bioremediation at sites with metal and/or solvent contaminants that degrade or change form anaerobically include adding a biological amendment (typically via injection) that promotes reducing conditions in the subsurface. Anaerobic bioremediation could be effective at the Site for TCE and to a lesser extent chromium but would not be appropriate for petroleum hydrocarbons, which typically degrade aerobically. The technology is retained for consideration for AOC1 and AOC2 contaminated with TCE and/or chromium. Enhanced bioremediation is not considered applicable in AOC3 or AOC4 where contaminants are limited to the vadose zone.

4.4.3 In-Situ Chemical Reduction (ISCR)

Chemical reduction is the process of chemically converting hazardous contaminants into non-hazardous (or less toxic) compounds that are less mobile, more stable, and/or inert. In-situ chemical reduction (ISCR) technologies typically involve the placement of reduction compounds or reduction generating materials, including liquid or colloidal iron solutions such as zero-valent iron (ZVI) into the saturated zone through temporary injection points or in trenches. ISCR can be paired with enhanced bioremediation technologies to create both a biological and chemical reactive treatment zone.

This treatment technology typically relies on the passive flow of groundwater through subsurface permeable zones (grids) or barriers of reactive material (such as permeable reactive barriers [PRBs]) to treat dissolved-phase contaminants. Grids are typically used within source zones, while barriers are typically placed downgradient from known or suspected source material and perpendicular to groundwater flow to intersect groundwater plumes.

ISCR could be effective at treating Site COCs (TCE and hexavalent chromium) in AOC1 and AOC2 which most typically degrade anaerobically like the enhanced anaerobic bioremediation described above. ISCR could be a cost-effective treatment option based on the existing Site use (active business) and infrastructure overlying chromium and TCE contamination. ISCR is retained for potential use in the cleanup action alternatives for AOC1 and AOC2. ISCR is not considered applicable in AOC3 or AOC4 where contaminants are limited to the vadose zone.

4.4.4 Activated-Carbon Based Treatment

In-situ activated-carbon based technologies typically involve injecting or emplacing activated carbon (AC)-based amendments into contaminated groundwater to adsorb dissolved phase contaminants to the carbon surface where they can be degraded (EPA 2018). Contaminant degradation then frees up carbon surface area for additional adsorption of contaminants. AC-based amendments typically include other reactive products to promote contaminant degradation through chemical reduction (e.g., ZVI), enhanced biological processes (e.g., nutrients, electron acceptors, and bacteria) or chemical oxidation (e.g., hydrogen peroxide, calcium peroxide, sodium persulfate, etc.). Enhanced biodegradation and ISCR paired with AC-based treatment are applicable to site contaminants. Treatability or pilot-level testing would be completed to determine the most effective AC-based amendments and to refine a remedial design as with any in-situ technology. AC-based treatment could achieve Site CAOs and is therefore retained for potential use in remedial alternatives in AOC1 and AOC2 where dissolved phase contaminants are present

4.4.5 In-Situ Solidification/Stabilization (ISS)

In-situ solidification/stabilization (ISS) refers to treatment technologies that involve mixing contaminated material with reagents that reduce the mobility of contaminants. These methods do not destroy contaminants but keep them from leaching into groundwater. Solidification encapsulates contaminants in a solid material that is relatively impermeable to water. Solidification involves mixing soil with a binding agent such as cement, asphalt or fly ash. Stabilization also involves mixing binding agents with soil. However, the binding agents also cause a chemical reaction with contaminants to reduce leachability.

ISS in AOC1 or AOC2 would require drilling or cutting large holes through the concrete floor of Warehouse 1 or removing the floor within the AOCs. A drill rig with a mixing head or excavator would be used to mix the reagents underground.

The advantages of ISS include its relative speed over other in-situ technologies and the ability to immobilize multiple contaminant types (e.g., chromium, TCE, and TPH). Advantages of ISS compared to excavation include less soil that would need to be transported and disposed off-site[5] and reduced groundwater dewatering requirements. Disadvantages include an expected high level of disruption to Site business operations during implementation similar to excavation. Cobbles and boulders can impede mixing and heterogeneity of soils can cause uneven performance. ISS does require some excavation with off-site disposal due to the swelling or displacement of soils upon mixing with the reagents.

ISS of impacted materials would address CAOs in AOC1 and AOC2 by immobilizing contaminants in soil which are an on-going source of groundwater contamination in these AOCs. ISS of soil is retained for

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[5] Some soil would still need to be excavated and disposed off-site due to soil swelling and reagent volume.

potential use in the remedial alternatives at AOC1 and AOC2. ISS is not considered appropriate for AOC3 and AOC4 given their simplicity and the fact that contaminants within these AOCs are limited to the vadose zone.

4.4.6 Thermal Treatment

In-situ thermal treatment is a general term that describes a class of technologies that use heat to promote volatilization and potentially oxidation of contaminants to enhance their removal. The two primary in-situ thermal treatment approaches include steam enhanced extraction injection via subsurface well points or electrical resistance heating which uses alternating current between subsurface electrode elements to heat the subsurface.

Thermal treatment technologies are most applicable to TCE, although they could be effective at treating TPH and hexavalent chromium under the right conditions. Thermal treatment is typically most cost-effective at sites with highly concentrated source zones of contamination, which make other removal or treatment methods infeasible. The very high cost of this technology is prohibitive for sites with lower concentrations and/or lower quantities of contaminant mass to remove. Thermal treatment technologies are excluded from further consideration for all AOCs due to the extensive aboveground infrastructure requirements and availability of more proven and cost-effective technologies to treat Site contaminants.

4.5 EXCAVATION WITH OFF-SITE DISPOSAL

This technology involves excavation, loading, and transportation of contaminated soil and overlying concrete and/or asphalt off-site followed by backfilling with clean fill and restoring concrete and/or asphalt. Excavated materials would be characterized for off-site disposal at licensed and permitted disposal facilities. Excavation at the Site may require temporary dewatering if soil is removed below the water table. The extracted groundwater would require pretreatment prior to discharge if groundwater dewatering is necessary.

Advantages of excavation include its relative speed over in-situ technologies, high level of permanence, and limited long-term monitoring, operations, and maintenance requirements after completion. Disadvantages include relatively high capital costs to implement and an expected high level of disruption to Site business operations, especially for excavation performed within indoor spaces such as AOC1 and AOC2 within Warehouse 1.

Excavation and off-site disposal of impacted materials would address CAOs by removing the mass of Site-related contaminants. Excavation with off-site disposal is retained for potential use in the remedial alternatives in all AOCs.

5.0 Description of Cleanup Action Alternatives

This section describes the CAAs for each AOC using the remedial technologies retained in Section 4.

The cleanup alternatives share several common elements. These common elements are not necessarily called out in the description detail of the individual alternatives. However, their costs are included in the total estimated cost for each alternative (Appendix B).

The following elements are common to each alternative:

- Monitoring: Conduct a monitoring program to evaluate attenuation and long-term stability of lower concentration dissolved contaminants outside the immediate area of active treatment, where applicable. Following active soil and/or groundwater treatment, groundwater monitoring would continue following treatment completion to evaluate treatment efficacy and long-term conditions associated with COCs in groundwater.
- Institutional Controls: Each alternative will leave some contamination in place; therefore, institutional controls are required. Institutional controls will likely include use restrictions, maintenance requirements, and financial assurances. Specific institutional controls for the cleanup action will be defined during future steps in the cleanup process.
- Engineering Controls: Engineering controls may be required to address TCE and related VOCs in indoor air. An air monitoring program will be conducted to evaluate whether an engineering control (EC) beyond the sealant-system previously applied in Warehouse 1 during the interim action will be required to mitigate future vapor intrusion into the building. Air monitoring is included as a component of each alternative for AOC1 and AOC2.

5.1 ALTERNATIVE 1: MNA IN EACH AOC

Alternative 1 includes addressing contamination using MNA for each AOC and involves monitoring groundwater and indoor air at the Site for the long term (likely decades). A monitoring program would be implemented in accordance with established guidelines for MNA. Actions outlined in the monitoring plan would evaluate the effectiveness of natural attenuation on Site contaminants. The performance monitoring plan would identify monitoring wells to be used, groundwater sampling, and analyses, including quality control procedures, monitoring frequency, and metrics for evaluating MNA performance.

Groundwater monitoring (described above) would evaluate whether natural attenuation processes are performing as anticipated and will ultimately achieve cleanup levels. It is anticipated that select existing wells would be used for monitoring.

MNA alone likely does not meet the MTCA minimum requirements at least for AOCs 1, 2, and 3 due to the anticipated extended restoration timeframe needed, particularly for AOC3 where soil contamination is exposed. MNA for AOC4 may be appropriate because groundwater is not impacted in AOC4 and contamination in the vadose zone can easily be mitigated via existing surface caps. The MNA only alternative is only included as a baseline against which to compare other alternatives.

5.2 ALTERNATIVE 2: ENHANCED BIOREMEDIATION IN AOC1 AND AOC2, EXCAVATION OF AOC3, MNA IN AOC4

Alternative 2 addresses contamination in saturated soil and groundwater in AOCs 1 and 2 using enhanced bioremediation. Enhanced bioremediation in AOC1 would be conducted to address the highest concentrations of hexavalent chromium and TCE in groundwater and saturated soil in the former plating tank area where the original chromium source was located and groundwater impacts are the greatest. Enhanced bioremediation in AOC2 would address lower concentrations of hexavalent chromium and TCE in groundwater and saturated soil in the northern portion of Warehouse 1. MNA would be used in peripheral areas of AOCs 1 and 2 where contaminant concentrations are lower and natural processes would be expected to attenuate contaminants based on existing data. Excavation of AOC3 would remove contaminated soil from the ditch and MNA would be used for AOC4.

Enhanced Bioremediation AOC1 and AOC2

Amendments used for enhanced anaerobic bioremediation, which is expected to be the most effective treatment mechanism for TCE and hexavalent chromium in AOCs 1 and 2, may include microbes such as Dehalococcoides (DHC), nutrients, and organic substrates for use as electron donors which promote reducing conditions. Enhanced anaerobic bioremediation is commonly achieved by injecting amendments into the saturated zone which speeds up the natural biodegradation processes. Typically, this process requires an extended period to establish conditions favorable for degradation. Injections would likely be accomplished using temporary injection points using direct-push drilling technology in a grid across the AOC. Multiple applications (rounds of drilling and injection) of amendments are commonly needed to sustain favorable conditions long enough to meet Site CAOs. Two applications to depths up to 20 feet bgs in AOCs 1 and 2 were assumed for the purposes of this FS.

Excavation AOC3

Alternative 2 addresses contamination in AOC3 via excavation and off-site disposal. Excavation would be performed during the dry season using standard erosion control measures and excavation equipment. The ditch would be excavated to approximately 2 feet bgs within AOC3 and confirmation soil samples would be collected to confirm contaminants were removed to concentrations at or below cleanup levels. The ditch would be backfilled with clean soil, seeded, and monitored and maintained through the first wet season to ensure vegetation was re-established.

MNA AOC4

Alternative 2 addresses contamination in AOC4 by monitoring groundwater for a short period. Assuming groundwater concentrations of petroleum hydrocarbons remain the same (i.e., below cleanup levels) or decrease as is expected through natural attenuation processes, there would be no further action required in AOC4.

Alternative 2 would use existing monitoring wells and a monitoring program to evaluate the performance of natural attenuation processes for each AOC similar to Alternative 1. Installation of up to three new wells was assumed for performance and compliance monitoring purposes as up to three existing wells may need to be decommissioned in AOCs 1 and/or 2. CAOs associated with direct-contact would be addressed in AOCs 1, 2, and 4 by monitoring and maintaining existing impermeable surfaces and in AOC3 by removal of contaminated soil. Enhanced bioremediation in AOCs 1 and 2 would also reduce the potential for indoor air impacts from TCE. However, soil and groundwater TCE concentrations in AOCs 1 and 2 are currently relatively low and indoor air is currently not impacted following implementation of 2020 interim actions for TCE in indoor air.

5.3 ALTERNATIVE 3: ISCR WITH AC-BASED TREATMENT IN AOCS 1 AND 2, EXCAVATION OF AOC3, MNA IN AOC4

Alternative 3 is the same as Alternative 2 except that hexavalent chromium and TCE in AOCs 1 and 2 would be treated using ISCR supplemented with AC-based treatment, which is expected to be more effective and achieve CAOs within a shorter timeframe compared to bioremediation.

As described in Section 4.4.3, chemical reductants could include liquid or colloidal iron-based solutions such as ZVI or other reduction reagents that can be used separately or in combination. Chemical catalysts may be utilized to assist with reactivity and accelerate reaction rates. AC-based amendments (Section 4.4.4) can be injected with ISCR amendments to adsorb contaminants within the treatment zone prior to chemical reduction. A key advantage of this approach over using ISCR alone is that the carbon will adsorb vinyl chloride, a degradation product of TCE, which can accumulate following ISCR treatment because of its different primary degradation mechanism (aerobic vs. anaerobic). For the purposes of this FS, only one application of ISCR with AC-based treatment is assumed.

MNA procedures would be implemented outside the treatment footprints of AOCs 1 and 2 using a subset of new and existing monitoring wells and a monitoring program to evaluate the performance of natural attenuation processes.

Proposed cleanup action elements for AOC3 (excavation) and AOC4 (MNA) are the same as in Alternative 3.

5.4 ALTERNATIVE 4: ISS IN AOC1, ISCR WITH AC IN AOC2, EXCAVATION OF AOC3, MNA FOR AOC4

Alternative 4 is the same as Alternative 3 except that AOC1 COCs would be treated using ISS which is anticipated to be more effective, achieve CAOs within a shorter timeframe, and is more permanent relative to ISCR with AC-based treatment. Depending on the implementation means and methods, ISS may not achieve the same treatment depth in AOC1 as Alternatives 2 and 3. For this FS, we assumed that a maximum treatment depth of 15 feet bgs can be achieved in AOC1.

ISS (as described in Section 4.4.5) in AOC1 would not degrade contaminants as with Alternatives 2 and 3 but solidifies and/or stabilizes them in place to greatly reduce or eliminate contaminant leaching to groundwater. ISS would include drilling holes or removing the concrete floor in AOC1. A drill rig with mixing auger or an excavator would be used to add and mix contaminated soil with a binding agent. Excess soil due to swelling during mixing would require removal and off-site disposal. For cost estimating purposes, we conservatively assumed that all soil removed will be disposed as hazardous waste (Subtitle C) due to the high concentrations of hexavalent chromium.

Alternative 3 is the same as Alternative 2 for AOCs 2, 3, and 4.

5.5 ALTERNATIVE 5: TARGETED EXCAVATION OF AOCS 1, 2, 4; EXCAVATION OF AOC3

Alternative 5 addresses soil contamination in AOCs 1, 2, and 4 via targeted shallow soil excavation and complete excavation of AOC3; the treatment footprints were assumed to be the same as the active in-situ alternatives (Alternatives 2 through 4). However, more contamination is anticipated to be left in place under this alternative versus the in-situ alternatives due to implementability considerations in AOCs 1 and 2 which will limit the excavation depth. In each AOC, excavated soil would be disposed off-site.

In this alternative, soil with contamination exceeding preliminary cleanup levels would be excavated to about 5 feet bgs in AOCs 1 and 2 using common earthwork methods, which is the assumed maximum practical depth of excavation within the building. All contaminated soil in AOC3 would be excavated since the target depth is 2 feet bgs and the soil is readily accessible. The ability to excavate contaminated soil in AOC4 is variable: the soil contamination at boring SB3 is less than 6 feet bgs in an easily excavatable area (pavement with no surrounding buildings or property lines). However, the soil contamination at SB5 and GP21 would be more challenging to remove due to a combination of factors, including contamination depth (11 feet or more bgs at SB5, below the groundwater table), and the presence of buildings (GP21 is located near the eastern edge of Warehouse 1), and/or property lines (SB5 is directly adjacent to the eastern property line). For the purposes of this FS, only excavation of soil surrounding SB3 is assumed. An area of approximately 15 feet by 15 feet by 6 feet bgs was assumed for cost estimating purposes.

MNA would be used for the remaining contamination at depth in AOCs 1, 2, and 4.

The proposed bottom of the excavation in AOCs 1 and 2, 5 feet bgs, is approximately the depth where groundwater has been observed in monitoring wells in Warehouse 1. It is therefore conservatively assumed that dewatering would be required for AOCs 1 and 2. Minor dewatering would also be required for AOC4 where the excavation depth of 6 feet bgs is also approximately the depth where groundwater has been observed in monitoring well MW18. Extracted groundwater would likely be disposed in the sanitary sewer and require on-site treatment prior to disposal. Disposal pre-treatment requirements would be established under a sewer disposal authorization issued by King County for permitted disposal. Excavated soil would be transported off-site for disposal. For cost estimating purposes, it is assumed approximately half the excavated soil can be disposed at a permitted Subtitle D facility with the other half requiring Subtitle C disposal as hazardous waste. The excavation would be backfilled with clean imported fill and the concrete floor restored.

6.0 Cleanup Action Evaluation Criteria

This section describes the MTCA threshold requirements, evaluation criteria, and analysis procedures for evaluating cleanup action alternatives.

6.1 MTCA EVALUATION CRITERIA

MTCA evaluation criteria used to evaluate the cleanup action alternatives are described in the following sections.

6.1.1 MTCA General Requirements

MTCA cleanup actions must comply with general requirements. Cleanup action alternatives that do not comply with the general requirements are not considered suitable alternatives under MTCA. As provided in WAC 173-340-360(3)(a); the 10 general requirements for remedial actions include:

1. Protect human health and the environment, including likely vulnerable populations and overburdened communities;

2. Comply with the cleanup standards;
3. Comply with applicable state and federal laws;
4. Prevent or minimize present and future releases and migration of hazardous substances in the environment;
5. Provide resilience to climate change impacts that have a high likelihood of occurring and severely compromising the cleanup's long-term effectiveness;
6. Provide for compliance monitoring;
7. Not rely primarily on institutional controls and monitoring at a site, or portion thereof, if it is technically possible to implement a more permanent cleanup action;
8. Not rely primarily on dilution and dispersion unless the incremental costs of any active remedial measures over the costs of dilution and dispersion grossly exceed the incremental degree of benefits of active remedial measures;
9. Ensure a reasonable restoration time frame; and
10. Utilize permanent solutions to the maximum extent practicable.

6.1.2 Action Specific Requirements

When applicable, cleanup actions must use remediation levels, institutional controls, provide financial assurances, and provide for periodic reviews in accordance with the WAC.

6.1.3 Media Specific Requirements

6.1.3.1 SOIL

A soil cleanup must treat, remove or contain contaminated soil located where a school or childcare center is located and properties that qualify as a residential area based on current use or potential future use. The intent of this requirement is to clarify the more stringent soil cleanup standards required for sites with school, childcare or residential use, and thus, the requirement does not apply at all sites.

6.1.3.2 GROUNDWATER

A permanent groundwater cleanup must be implemented when such an action is practicable or if Ecology determines that a permanent action is in the public interest. A nonpermanent groundwater cleanup is permitted when the permanent conditions do not apply. If the groundwater cleanup is nonpermanent, then the cleanup action must treat or remove the source of groundwater contamination at sites where there are liquid wastes, areas contaminated with high concentrations of hazardous substances, highly mobile hazardous substances or hazardous substances that cannot be reliably contained. The cleanup action must also contain contaminated groundwater to the maximum extent practicable to prevent lateral and vertical expansion of the groundwater volume affected by the hazardous substances and to prevent the migration of the hazardous substances.

6.1.4 Public Concerns and Tribal Rights and Interests

Ecology supervised cleanups must consider public concerns, including the concerns of likely vulnerable populations and overburdened communities, and tribal rights and interests when evaluating the cleanup alternatives. The Precision Engineering site cleanup is an Ecology supervised cleanup.

6.2 MTCA DISPROPORTIONATE COST ANALYSIS

A DCA is performed to evaluate cleanup action alternatives that meet the MTCA minimum requirements. The DCA process compares the benefits and costs of the alternatives to identify which alternative has incremental costs that are not disproportionate to its incremental benefits, thereby defining the alternative that is permanent to the maximum extent practicable.

6.2.1 DCA Benefit Criteria

The environmental benefits for the alternatives are evaluated based on six criteria in WAC 173-340-360(5)(d):

1. **Protectiveness** – The degree to which the alternative protects human health and the environment, including likely vulnerable populations and overburdened communities. Includes consideration of the degree to which the alternative reduces existing risks, the cleanup timeframe, the on-site and off-site risks remaining after implementing the alternative, and the improvement of the overall environmental quality for enacting the alternative.
2. **Permanence** – The degree 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 process, and the characteristics and quantity of treatment residuals generated.
3. **Long-term effectiveness** – The degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. The following types of cleanup action components, in descending order, are used as a guide in assessing the relative degree of long-term effectiveness (WAC 173-340-360[5][d][iii][B]):
    a. Reuse or recycling;
    b. Destruction or detoxification;
    c. Immobilization or solidification;
    d. On-site or off-site disposal in an engineered, lined, and monitored facility;
    e. On-site isolation or containment with attendant engineering controls (ECs); and
    f. Institutional controls and monitoring.
4. **Management of implementation risks** – The risks to human health and the environment, including likely vulnerable populations and overburdened communities, associated with the alternative during construction and implementation and the effectiveness of the alternative to manage such risks. Risks can occur from worker or public exposure to contaminants, other releases of contaminants to the environment, and physical hazards created by construction and related materials management.
5. **Technical and administrative implementability** – The ability to implement the alternative, including consideration of technical difficulty regardless of cost, the availability of necessary offsite facilities, services and materials, administrative and regulatory requirements, scheduling; project size and

complexity, monitoring requirements, access for construction operations and monitoring, and integration with existing facility operations.

6. **Costs** – The costs of remedial actions necessary to implement the alternative, including both construction and post-construction costs. Construction costs include design, permitting, construction, waste management, compliance monitoring, construction management, establishment of institutional controls, and regulatory oversight. Post-construction costs include operation and maintenance activities necessary to maintain the effectiveness of the cleanup, waste management and disposal, replacement or repair of equipment, permit renewal, compliance monitoring, maintaining institutional controls, financial assurances, periodic reviews, post-construction management, and regulatory oversight.

6.2.2 DCA Scoring

The DCA scoring process compares the relative overall benefit and cost of the cleanup alternatives to identify which alternative is permanent to the maximum extent practicable; this alternative is selected as the preferred remedy. The benefits of each alternative were evaluated based on five of the MTCA DCA criteria discussed above. Each criteria is given a score between 1 and 10 with 1 being the lowest score and 10 being the highest. For each alternative, the individual criterion scores were then weighted as follows:

- Protectiveness 35 Percent
- Permanence 20 Percent
- Long-term effectiveness 25 Percent
- Management of implementation risks 10 Percent
- Technical and administrative implementability 10 Percent

These DCA weighting factors emphasize criteria most directly associated with the primary goals and objectives of the cleanup, starting with protectiveness, then long-term effectiveness and permanence. Management of short-term risks and technical and administrative implementability were given the lowest equal weights due to the expected current and future land use (industrial) which make these factors more controllable. Protectiveness and long-term effectiveness criteria were deemed the most critical to achieving CAOs, and therefore, were weighted more heavily than permanence.

The total weighted benefit scores are compared to the estimated cost to implement the alternative, including the cost of construction, the net present value of any long-term expenses, and agency oversight costs that are recoverable from the responsible parties. Long-term costs cover operation and maintenance, monitoring, equipment replacement, and institutional controls.

A benefit-to-cost ratio is calculated for each alternative by dividing its total weighted benefit score by its total cost.

6.2.3 Determination of Permanence to the Maximum Extent Practicable

Under MTCA, preference is given to cleanup actions that use permanent solutions to the maximum extent practicable. By definition, permanent remedies require no additional action to meet cleanup standards. A practicable cleanup action is designed, constructed, and implemented in a reliable cost-effective manner.

A cleanup action is not considered practicable if the incremental costs are disproportionate to the incremental benefits when compared to lower-cost alternatives.

The MTCA DCA analysis for this FS uses a relative benefit-to-cost ratio to compare the alternatives and determine whether incremental cost increases are disproportionate to respective incremental increase in benefits. To calculate the relative benefit-to-cost ratio for each alternative, the total weighted benefit score was divided by the total cost. Alternatives with incremental benefits that are disproportionately small in comparison to the incremental cost produce lower relative benefit/cost ratios.

7.0 Evaluation of Cleanup Action Alternatives

This section summarizes the evaluation results for cleanup action alternatives developed using a quantitative approach as prescribed in MTCA 173-340-350 and -360. The degree to which each cleanup action alternative uses permanent solutions to the maximum extent practicable was determined using a disproportionate cost analysis of the alternatives as described in Section 6.2. Alternatives were evaluated against weighted benefit criteria, scored on a scale from 1 (lowest score) to 10 (highest score) and summed to develop a total weighted relative benefit score for the alternative. A discussion of the scoring considerations for each criterion and the cost of each alternative is presented in the sections that follow.

Five alternatives were evaluated for the Site as summarized in Tables 7-1 through 7-3. Each of the cleanup action alternatives meet the MTCA requirements except Alternative 1 (MNA only).

7.1 PROTECTIVENESS

Alternative 1 (MNA) is not protective of human health and the environment under current site use in AOC3 because contaminated soils are currently exposed. Additionally, even though MNA is currently protective in AOCs 1, 2, and 4 (due to impermeable caps), it may not be protective under future conditions. For example, human health and the environment could potentially not be protected in the future i.e., if the building and/or pavement were demolished. For these reasons, Alternative 1 scored the lowest in protectiveness.

Alternatives 2 and 3 were assigned similar scores for protectiveness with Alternative 3 slightly above Alternative 2 because of the added confidence in the ISCR and AC treatment technology for AOCs 1 and 2 over enhanced bioremediation. This is particularly applicable for AOC1 where chromium concentrations are high and direct chemical reduction is expected to be more effective.

Alternative 4 is expected to be the most protective because more contamination will be treated in AOCs 1 and 2 compared to Alternative 5 where treatment depth is limited by excavation limits inside the warehouse. A faster restoration timeframe is assumed for Alternative 4 due to the additional treatment in AOCs 1 and 2.

7.2 PERMANENCE

Alternative 1 (MNA) scores the lowest on permanence for similar reasons to those discussed above for protectiveness under current versus future site conditions. Alternative 2 (enhanced bioremediation in AOCs 1 and 2) has a moderate permanence score due to uncertainties related to bioremediation's effectiveness at maintaining reducing conditions. The remaining alternatives have a tight range of scores for protectiveness (7 to 9) due to the more aggressive approaches which are anticipated to permanently degrade, stabilize, and/or remove contaminants. Alternative 5 was given the highest permanence score because the highest concentrations of contaminants will be removed from the Site, although relocated to a landfill.

7.3 LONG-TERM EFFECTIVENESS

Alternative 1 (MNA) is not expected to be effective over the long term based on the high concentrations of COCs in soil, particularly in AOC1. The remaining alternatives are effective over the long term with scores ranging from 6 for Alternative 2 to a score of 9 for Alternative 4. Excavation (Alternative 5) was given a lower score than Alternative 4 (ISS and ISCR with AC) because of the limited treatment depth in AOCs 1 and 2 (5 feet bgs) which will leave contaminant mass in place within those AOCs.

7.4 MANAGEMENT OF IMPLEMENTATION RISKS

Alternative 1 (MNA) scores very high (10) for implementation risks because there would be no required activity beyond monitoring groundwater and indoor air. Alternatives 2 and 3 rank the next highest with scores of 9. Alternatives 4 and 5 rank the lowest due to substantial worker and public exposure to contamination during the implementation phase.

7.5 TECHNICAL AND ADMINISTRATIVE IMPLEMENTABILITY

Each alternative ranks relatively high on administrative and technical implementability. Alternative 5 received the lowest score (7) due to the technically challenging nature of implementing excavation inside the building (AOCs 1 and 2) and near the eastern property boundary (one of the hotspots of AOC4). The excavation activities under Alternative 5 may require several weeks, including mobilization, excavation, and demobilization. Alternative 5 includes indoor excavation, outdoor excavation, groundwater dewatering treatment and disposal, transport and handling of significant quantities of soil both inside and outside the building, and associated significant disruption to business operations. Other alternatives would be shorter in duration (approximately 1 to 2 weeks) and less disruptive to the business operations.

7.6 COST

Estimated implementation costs for the alternatives, including contingency ranged from $1,117,000 (Alternative 1) to $2,085,000 (Alternative 5). Contingency costs were assigned as a percentage of the total estimated base cost for each alternative. Contingency was determined based on the relative complexity and associated uncertainties regarding implementation or effectiveness for each alternative.

Costs for each of the alternatives are summarized in Table 7-3. Detailed cost estimates are presented in Appendix B.

8.0 Disproportionate Cost Analysis

A relative benefit-to-cost ratio is used to compare the cleanup action alternatives to determine whether costs are disproportionate to benefits.

Table 7-3 presents the total weighted relative benefit score for each alternative calculated using the raw scores and respective weighting factor for each criterion. The costs for each alternative are also provided in Table 7-3. The benefits, costs, and relative benefit-to-cost ratio are presented graphically in Figure 8-1.

The total weighted relative benefit scores for the alternatives range from 5.00 (Alternative 1) to 8.60 (Alternative 4) as shown in Table 7-3 and Figure 8-1. Under MTCA, costs must be considered when selecting the alternative that is permanent to the maximum extent practicable and costs are disproportionate to benefits, if the incremental costs of the alternative over that of a lower cost alternative exceed the incremental degree of benefits achieved by the alternative over that of lower cost alternative. Graphically, this concept is illustrated in Figure 8-1. Based on Figure 8-1 and the relative benefit ranking of remedial cost ranking presented in Table 7-3, Alternative 4 has the highest benefit-to-cost ratio.

The DCA process described above was completed in general accordance with Ecology's guidance for selecting a preferred cleanup alternative which is permanent to the maximum extent practicable (PMEP) (PMEP Ecology 2025A). Additionally, Ecology's PMEP tool (Ecology 2025B) was used to confirm that Alternative 4 is PMEP. PMEP tool results are included as Appendix C.

9.0 Preferred Cleanup Action Alternative for Each AOC

The preferred alternative has the highest benefit per unit cost and is determined to be permanent to the maximum extent practicable in accordance with MTCA. The preferred alternative is Alternative 4, which includes the following remediation technologies for each AOC:

- AOC1 – Former Plating Area: ISS
- AOC2 – Warehouse 1 – North: ISCR with AC
- AOC3 – Ditch: Excavation
- AOC4 – Three TPH Hotspots MNA with institutional and engineering controls

Contamination in each AOC is addressed either by removal (AOC3), treatment (AOC 1, AOC 2) or controls (AOC4).

The final cleanup action for the Site will be presented in the Draft Cleanup Action Plan (DCAP) and developed in more detail in an Engineering Design Report.

The preferred alternative was selected based on results of the DCA that comparatively evaluates the relative benefit and cost of each alternative. The preferred alternative has the highest benefit-to-cost ratio and therefore is considered permanent to the maximum extent practicable. The alternative provides the optimum balance between cost, benefit, and certainty of long-term performance while meeting the threshold and other requirements for cleanup actions set forth in MTCA.

The preferred alternative for each AOC will:

- Protect human health and the environment by destroying/converting contaminants in AOC1 and AOC2, removing contaminants in AOC3, and managing contaminants in AOC4 through the use of institutional and engineering controls.

- Protect exposure to contaminants in shallow soil by future workers at the property by maintaining the existing building and paved surfaces and implementing institutional controls that restrict access to contaminants left in place following cleanup.
- Provide for groundwater and indoor air monitoring to ensure that groundwater continues to meet cleanup levels at the point of compliance and that indoor air continues to be unimpacted.

10.0 References

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EPA 2021. AP 42, Fifth Edition, Volume I Chapter 12: Metallurgical Industry, 12.20 Electroplating Process Description. October 2021.

GeoEngineers 2026. “Public Review Draft Remedial Investigation, Former Precision Engineering Property, 1231 South Director Street, Seattle, Washington,” dated November 11, 2024. Revised April 8, 2026.

11.0 Limitations

We have prepared this report for the exclusive use of Dick Morgan for the Former Precision Engineering Property, located at 1231 South Director Street, Seattle, Washington. Dick Morgan may distribute copies of this report to authorized agents and regulatory agencies as may be required for the Project.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted environmental science practices in this area at the time this report was prepared. The conclusions and opinions presented in this report are based on our professional knowledge, judgment and experience. No warranty, express or implied, applies to this report.

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Tables

Table 3-1

Potential Applicable Laws and Relevant and Appropriate Requirements (ARARs) Governing Cleanup

Former Precision Engineering Property
Seattle, Washington

SUBJECT REGULATED	STATE/LOCAL STATUTES AND IMPLEMENTING REGULATIONS	FEDERAL STATUTES AND IMPLEMENTING REGULATIONS	NOTES
General Cleanup			
Hazardous waste cleanup	Model Toxics Control Act (MTCA) Cleanup Regulation (RCW 70.105D; Chapter 173-340 WAC)	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 USC Chapter 103; 40 CFR Chapter I, Subchapter J)	State law has precedence; primary regulations governing cleanup actions at the Site. Most state and local permits are waived because the work is being conducted under an Agreed Order, but MTCA requires that permit substantive requirements must be met. All federal permits governing the remedial action are still required.
Environmental impact review	State Environmental Policy Act (SEPA) (RCW 43.21C, Chapters 197-11 and 173-802 WAC)	National Environmental Policy Act (NEPA) (42 USC Chapter 55 § 4321 et seq.; 40 CFR Chapter V, Parts 1500-1508)	Ecology would likely be the lead agency and make the determination of compliance with SEPA.
Water Quality			
General	Water Pollution Control Act (RCW 90.48); Water Quality Standards for Surface Waters of Washington (Chapter 173-201A WAC); Underground Injection Control (UIC; Chapter 173-218 WAC)	Federal Water Pollution Control Act (aka Clean Water Act [CWA]) (33 USC Chapter 26 §1251 et seq.; 40 CFR Chapter 1, Subchapter D)	State implements most components of the CWA. Water quality is considered in the development of cleanup objectives, short-term performance during construction, and long-term performance of the remedy. UIC requirements apply if cleanup action requires in-situ injection of remedial products.
Discharge of Construction-generated water	Water Pollution Control Act (RCW 90.48); National Pollution Discharge Elimination System Program (Chapter 173-220 WAC)	CWA Section 402	If discharge of extracted water is required in connection with implementation of the cleanup remedy, an NPDES permit administered by the State will be required. Local NPDES requirements for stormwater may also apply.
Disposal of Contaminated Material			
Management, transport and disposal of hazardous wastes	Solid and Hazardous Waste Management Act (RCW 70.105); Dangerous Waste Regulations (Chapter 173-303 WAC)	Resource Conservation and Recovery Act (RCRA) (40 CFR 260 and 261); 49 USC Chapter 51 Transportation of Hazardous Material; 40 CFR 171-180	Federal regulations are implemented by the State. Pertains to soil, water, and debris waste handling and landfill disposal. Management and disposal process is administered by the State and all substantive requirements must be met. Transportation is regulated by the US Department of Transportation.
Management, transport and disposal of solid wastes	Solid and Hazardous Waste Management Act (RCW 70.95; Chapters 173-305, 173-350 WAC and others)	RCRA (40 CFR 257 Subpart A)	Affects land disposal and transportation of excavated material and debris from the Site; process is administered by the State and all substantive requirements must be met.
Other Laws or Requirements			
Air quality	Clean Air Act (RCW 70.94); Ambient Air Quality Standards (Chapter 173-746 WAC); Puget Sound Clean Air Agency Regulation 1	Clean Air Act (42 USC, Chapter 85 Air Pollution, Prevention and Control)	Administered by the State and local authorities; substantive requirements apply to construction activities during implementation of the remedy.
Health and safety	Washington Industrial Safety and Health Act (RCW 49.17; Chapters 296-62, 296-843 WAC and others)	Occupational Safety and Health Act (OSHA) (29 USC Chapter 15; 29 CFR 1910, 1926)	Applicable to investigation and construction phases of a cleanup.
Objects, landscapes or structures of historical or archaeological significance	Regulations addressing these resources include SEPA, the Governor's Executive Order 05-05, and SMA (i.e., no one single regulation or authority). RCW's 27.44, 27.53, 68; WAC's 25-48, 365-196-450 and others also apply.	National Historic Preservation Act (NHPA) (16 USC 470 et seq. Section 106), Archeologic Resources Protection Act (ARPA) (16 USC 470aa-470mm)	State laws govern local projects; federal law governs those requiring federal permits or funds. Protection of significant historic, archaeological and traditional cultural sites from damage or loss during development is coordinated by the State's Department of Archaeological and Historic Preservation (State Historic Preservation Office), and includes evaluating compliance with Section 106 of the federal law.

Table 3-2

PCOCs and PCULs in Soil[1]

Former Precision Engineering Property

Seattle, Washington

Preliminary Contaminant of Concern (PCOC)	Preliminary Cleanup Level (PCUL) (mg/kg)
Chromium, total (IHS)	1.00E+02
Chromium, trivalent (IHS)	1.00E+02
Chromium, hexavalent (IHS)	2.70E-02
Copper	3.20E+03
Lead	2.50E+02
Mercury	7.00E-02
Zinc	2.40E+04
TPH (IHS)	2.00E+03
Trichloroethylene (IHS)	2.00E-03
1,4-Dioxane	5.00E-02
cPAHs	N/A – Based on pathway to surface water
Total cPAH TEQ	1.90E-01

Notes:

[1]This table was adapted from that presented in RI Appendix Q (Table 4). Shaded PCOCs were not identified as IHSs as part of the FS.

PCOC = Potential contaminant of concern

PCUL = Preliminary cleanup level

IHS = Indicator Hazardous Substance

TPH = Total petroleum hydrocarbons (diesel and heavy oil range hydrocarbons)

cPAHs = Carcinogenic polycyclic aromatic hydrocarbons including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-c,d)pyrene.

cPAH TEQ = Carcinogenic polycyclic aromatic hydrocarbon total toxic equivalent concentration.

mg/kg = milligrams per kilogram

Table 3-3

PCOCs and PCULs in Groundwater[1]

Former Precision Engineering Property

Seattle, Washington

Preliminary Contaminant of Concern (PCOC)	Preliminary Cleanup Level (PCUL) (µg/L)
Chromium, total (IHS)	1.00E+02
Chromium, trivalent (IHS)	2.40E+04
Chromium, hexavalent (IHS)	1.40E+00
TPH (IHS)	5.00E+02
Trichloroethylene (IHS)	4.00E+00
Vinyl Chloride	2.90E-01
1,4-Dioxane	4.40E-01

Notes:

[1]This table was adapted from that presented in RI Appendix Q (Table 1). Shaded PCOCs were not identified as IHSs as part of the FS. PCULs are based on protection of drinking water.

PCOC = Potential contaminant of concern

PCUL = Preliminary cleanup level

IHS = Indicator Hazardous Substance

TPH = Total petroleum hydrocarbons (diesel and heavy oil range hydrocarbons)

µg/L = microgram per liter

Table 3-4

PCOCs and PCULs in Air[1]

Former Precision Engineering Property

Seattle, Washington

Preliminary Contaminant of Concern (PCOC)	Preliminary Cleanup Level (PCUL) (μg/m^3)	Groundwater Screening Level for Vapor Intrusion (μg/L)
Trichloroethylene (IHS)	3.30E-01	1.40E+00
Vinyl Chloride[2]	2.80E-01	3.30E-01
1-Methylnaphthalene[3]	1.37E-03	1.70E-01

Notes:

[1]This table was adapted from that presented in RI Appendix Q (Table 3). Shaded PCOCs were not identified as IHSs as part of the FS.

[2] Vinyl chloride was sampled in indoor air in 2006, 2015, and 2020, and did not exceed indoor air cleanup levels in any samples. Vinyl chloride was therefore not identified as a COC for indoor air as part of the RI.

[3] 1-Methylnaphthalene exceeded the PCUL of 0.17 ug/L in only two out of 68 groundwater samples, both of which occurred in MW-18, outside the building as documented in the RI.
1-Methylnaphthalene was therefore not identified as a COC for indoor air as part of the RI.

PCOC = Potential contaminant of concern

PCUL = Preliminary cleanup level

IHS = Indicator Hazardous Substance

μg/L = microgram per liter

μg/m^3 = microgram per cubic meter

Table 7-1

MTCA Requirements: Evaluation of Alternatives

Former Precision Engineering Property

Seattle, Washington

MTCA Cleanup Action Requirements		Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
		MNA in AOCs 1, 2, 3, and 4	Enhanced bio in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISCR w/AC in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISS in AOC1 ISCR w/AC in AOC2 Excavation of AOC3 MNA in AOC4	Targeted Excavation of AOCs 1, 2, and 4 Excavation of AOC 3
General Criteria						
Protection of Human Health and the Environment		No	Yes	Yes	Yes	Yes
Compliance With Cleanup Standards		No	Yes	Yes	Yes	Yes
Compliance With Applicable State and Federal Regulations		Yes	Yes	Yes	Yes	Yes
Prevent or Minimize Present and Future Releases and Migration of Hazardous Substances in the Environment		No	Yes	Yes	Yes	Yes
Provide Resilience to Climate Change Impacts		Yes	Yes	Yes	Yes	Yes
Provision for Compliance Monitoring		Yes	Yes	Yes	Yes	Yes
Not Rely Primarily on Institutional Controls and Monitoring at a Site if More Action is Feasible		**See DCA Analysis**				
Not Rely Primarily on Dilution and Dispersion unless costs are disproportionate to benefits						
Reasonable Restoration Time Frame						
Permanent Solutions to the Maximum Extent Practicable						
Action-Specific Criteria						
Use Remediation Levels in Accordance with Washington Administrative Code		Yes	Yes	Yes	Yes	Yes
Use Institutional Controls in Accordance with Washington Administrative Code		Yes	Yes	Yes	Yes	Yes
Provide for Financial Assurances in Accordance with Washington Administrative Code		Yes	Yes	Yes	Yes	Yes
Provide for Periodic Reviews in Accordance with Washington Administrative Code		Yes	Yes	Yes	Yes	Yes
Compliance with MTCA Media-Specific Criteria						
Soil	Treat, remove, or contain contaminated soil on schools, childcare facilities and residential properties (based on current/future site use)	**Not Applicable: The site is not a school, childcare facility or residential property under current use, and is unlikely to be in the future due to surrounding site use and zoning. Therefore, this criteria is not applicable.**				
Groundwater	Achieve cleanup levels at the standard point of compliance without further remedial action required if practicable. Otherwise: 1) treat or remove source(s) where there are liquid wastes, high concentrations of highly mobile hazardous substances, or hazardous substances that cannot be reliably contained and, 2) contain contaminated groundwater to the maximum extent practicable.	**See DCA Analysis**				
Public Concerns and Tribal Rights and Interests						
Consideration for Public Concerns and Tribal Rights and Interests		Yes	Yes	Yes	Yes	Yes

Notes:

AOC = Area of Concern
MNA = monitored natural attenuation
Enhanced Bio = enhanced bioremediation
ISCR w/AC = in-situ chemical reduction with activated carbon (sorption)
DCA = disproportionate cost analysis
ISS = in-situ solidification/stabilization
MTCA = Model Toxics Control Act

Table 7-2

Evaluation of Cleanup Action Alternatives

Former Precision Engineering Property

Seattle, Washington

Evaluation Criteria	Criteria Description	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
		MNA in AOCs 1, 2, 3, and 4	Enhanced bio in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISCR w/AC in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISS in AOC1 ISCR w/AC in AOC2 Excavation of AOC3 MNA in AOC4	Targeted Excavation of AOCs 1, 2, and 4 Excavation of AOC 3
Restoration Time Frame		**Soil: >30 years Groundwater: >30 years**	**Soil: >30 years Groundwater: >15 years**	**Soil: >30 years Groundwater: 10 years**	**Soil: <1 year Groundwater: 5 years**	**Soil: >15 years Groundwater: 10 years**
The restoration time frame is the period of time needed for a cleanup action to achieve cleanup levels at the point of compliance. Reasonable restoration timeframe evaluation considers the following factors: potential risks to receptors, practicability of shorter restoration timeframe, long-term effectiveness of alternative, current and future site use, ability to control and monitor plume, availability of alternative water supplies, toxicity of hazardous substances, documented natural attenuation processes and public concerns and tribal rights and interests.		Alternative will use natural attenuation processes to degrade contaminants; a long restoration timeframe is assumed based on current site conditions. Exposure to untreated contaminants in AOCs 1, 2, and 4 are addressed by the concrete floor of the building and/or paved surfaces, and institutional controls. Exposure in AOC3 would be unmitigated.	Alternative will speed up natural biodegradation processes to degrade TCE, and convert CrVI to less toxic/mobile CrIII, in saturated soil and groundwater in a moderate to long timeframe in AOCs 1 and 2. Excavation in AOC3 would remove contamination in a short timeframe. MNA in AOC4 would use natural processes to reduce contamination in soil over a long timeframe.	Alternative will degrade TCE via sorption and reductive and abiotic processes, and reduce CrVI to less toxic/mobile CrIII, in saturated soil and groundwater in a moderate timeframe in AOCs 1 and 2. Excavation in AOC3 would remove contamination in a short timeframe. MNA in AOC4 would use natural processes to reduce contamination in soil over a long timeframe.	Alternative will stabilize but not remove soil that contains relatively high concentrations of contaminants in AOC1. Complete stabilization process may take up to 1 year. Soil that contains lower concentrations of contaminants would remain onsite in AOC1 at depths greater than is technically feasible to safely mix . ISS in AOC1 will reduce concentrations of COCs in groundwater at and downgradient of AOC1, though with a slightly longer timeframe compared to Alternative 5. However, the overall restoration time for groundwater is expected to be faster due to treatment of the entire contaminated zone in AOC2 versus Alternative 5 which will leave contamination in place below the excavation prism. Relative restoration timeframes for AOC3 and AOC4 are the same as in Alternative 3.	Alternative will remove shallow soil that contains relatively high concentrations of contaminants in AOC1, and will remove soil that contains lower concentrations of contaminants in AOCs 2, 3, and 4. Soil that contains lower concentrations of contaminants in AOCs 1 and 2 would remain onsite at depths greater than is technically feasible to safely excavate in those AOCs. Source removal through excavation would greatly reduce concentrations of COCs in groundwater at and downgradient of AOC1, and should also reduce groundwater COCs in AOC2. Restoration timeframe is assumed to be similar to Alternative 3 because of the deeper contamination which will be left in place to attenuation in AOC1 and AOC2.
Relative Benefits Ranking (Scored from 1-lowest to 10-highest)						
Protectiveness		**Score = 4**	**Score = 6**	**Score = 7**	**Score = 9**	**Score = 8**
	Overall protectiveness of human health and the environment including the degree to which existing risks are reduced, time required to reduce risk at the facility and attain cleanup standards, on-site and off-site risks resulting from implementing the alternative, and improvement of the overall environmental quality.	Low degree of protectiveness because soil that contains relatively high concentrations of contaminants will remain onsite in AOCs 1, 2 and 4, albeit under building/paved surfaces. Contaminated soil would remain exposed in AOC3.	Lower degree of protectiveness compared to other active alternatives based on slower biodegradation processes and more uncertainty regarding implementation/effectivness in AOCs 1 and 2.	In AOCs 1 and 2, the degree of protectiveness is lower compared to Alternatives 4 and 5 due to uncertainties regarding implementation (product contact with contamination) due to geologic site conditions. Uses reduction methods that are more aggressive than Alternative 2, with corresponding faster restoration timeframe estimate. In AOCs 3 and 4, protectiveness is the same as described under Alternative 2.	Similar degree of protectiveness as excavation (Alternative 5), but slightly higher because ISS in AOC1 will treat deeper soils. Contaminants in soil in AOC1 will be solidified/stabilized thereby reducing contaminant concentrations in groundwater. Protectiveness in AOCs 2, 3, and 4 would be the same as described under Alternative 3.	High degree of protectiveness because all soil contamination would be removed from AOC3, and the majority of soil contamination (highest concentrations) would be removed from AOCs 1, 2, and 4. Low concentrations of COCs in soil would remain at depths greater than 5 feet bgs in AOCs 1 and 2, albeit underneath the building.
Permanence		**Score = 3**	**Score = 5**	**Score = 7**	**Score = 8**	**Score = 9**
	The degree 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 process, and the characteristics and quantity of treatment residuals generated.	Permanent for AOCs 1, 2, and 4 only if the Site use remains unchanged. If the site were redeveloped, the contaminated soil and/or groundwater in AOCs 1, 2, and 4 could be exposed and/or mobilized. Not permanent for AOC3 where contaminated soils are currently exposed	Less permanent than Alternatives 3 through 5 due to the uncertainty regarding bioremediation's effectiveness in destroying COCs over the long term in AOCs 1 and 2, particularly TCE's reductive degradation product vinyl chloride. Excavation of AOC3 would be permanent. MNA in AOC4 would be permanent, however the restoration timeframe would be long.	Alternative 3 uses aggressive reduction processes that are expected to quickly degrade TCE in groundwater and saturated soil, and convert CrVI to less toxic/mobile CrIII in AOCs 1 and 2. Less permanent for AOCs 1 and 2 than Alternatives 4 and 5 due to the higher uncertainty with this in-situ treatment technologies effectiveness versus solidification/stabilization or excavation. Alternative 3 permanance in AOCs 3 and 4 is the same as described in Alternative 2	In AOC1, there would be a similar degree of permanence when compared to Alternative 5, but slightly lower due to long-term uncertainties with solidified mass versus complete removal. The mobility of contaminants in AOC1 will be reduced or eliminated, but not the toxicity or volume of contaminants. This is the same with excavation of AOC1, however the contaminants will be off-site. If the site were redeveloped in the future (i.e. removal of building and concrete floor), the presence of the solidified/stabilized soil in AOC1 may need to be reevaluated. Same permenance for AOCs 2, 3, and 4 as described in Alternative 3.	Higher permanence than other alternatives because much (but not all) contaminated soil will be removed from the Site. Soil would be relocated in a landfill, however.

Evaluation Criteria	Criteria Description	Alternative 1 MNA in AOCs 1, 2, 3, and 4	Alternative 2 Enhanced bio in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	Alternative 3 ISCR w/AC in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	Alternative 4 ISS in AOC1 ISCR w/AC in AOC2 Excavation of AOC3 MNA in AOC4	Alternative 5 Targeted Excavation of AOCs 1, 2, and 4 Excavation of AOC 3
Effectiveness over the Long Term	Includes the degree of certainty that the alternative will be successful, the reliability of the alternative during the period of time hazardous substances are expected to remain on-site at concentrations that exceed cleanup levels, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes.	**Score = 4** Similar to permanence, this alternative is theoretically effective over the long term for AOCs 1, 2, and 4 as long as all contamination remains under building/paved surfaces, groundwater remains clean at the point of compliance, and indoor air remains unimpacted. Less effective over the long term for AOC3. MNA alone generally cannot be considered permanent because Site conditions could change, which could cause exposure to soil contamination; mobilization of groundwater contaminants; and/or exposure via the indoor air pathway (AOCs 1, 2, and 4).	**Score = 6** Bioremediation in AOCs and 2 would result in the complete and irreversible degradation of TCE in groundwater and saturated soil, and the conversion of CrVI to CrIII. Conditions following completion of initial treatment should be favorable for sustaining these conditions, however aerobic conditions could reverse the chromium conversion. Monitoring in AOCs 1 and 2 will determine if treatment meets CAOs and evaluate the need to rely on MNA for continued long-term reduction. Contact with contaminants in shallow unsaturated soil in AOCs 1 and 2 would be addressed by the concrete floor of the building, and institutional controls. Excavation of AOC3, and MNA in AOC4, would be effective over the long term.	**Score = 8** Chemical reduction used in Alternative 3 in AOCs 1 and 2 would result in the complete and irreversible destruction of TCE in groundwater and saturated soil, and conversion of CrVI to CrIII. Reversibility of CrIII to CrVI is unlikely, particularly with the added protection of sorption, but cannot be ruled out completely. Monitoring of AOCs 1 and 2 would determine if treatment meets CAOs in those AOCs, and evaluate the need to rely on MNA for continued long-term reduction. Effectiveness in AOCs 3 and 4 is the same as that described under Alternative 2.	**Score = 9** ISS in AOC1 is expected to be very effective over the long term due to treatment of the majority of the contaminated zone. There is potential for future site use to change the stabilized mass in AOC1. Effectiveness is higher than Alternative 3 in AOC1 because of increased certainty of treating the contaminated zone and longevity of ISS versus ISCR/AC products. Effectiveness over the long term in AOCs 2, 3, and 4 is the same as described under Alternative 3.	**Score = 8** Excavation of contaminated soil would be effective over the long term. Only soil with low concentrations of COCs in AOCs 1 and 2 will remain onsite at depth and would be covered by buildings and managed using institutional controls.Effectiveness is slightly less than Alternative 4 because of the smaller volume of treatment provided in AOCs 1 and 2 (targeted excavations).
Management of Implementation Risks	The risks to human health and the environment, including likely vulnerable populations and overburdened communities, associated with the alternative during construction and implementation, and the effectiveness of the alternative to manage such risks.	**Score = 10** Generally low risks in AOCs 1, 2, and 4 due to only groundwater and indoor air monitoring required for those AOCs.	**Score = 9** In-situ treatment by bioremediation in AOCs 1 and 2 involves limited short-term risks during construction. Injection of non-toxic bioremediation materials will involve installing temporary injection wells and operating temporary mixing and injection infrastructure. Excavation of AOC3 also involves limited short-term risk due to handling and transport of contaminated soil. MNA of AOC4 presents relatively low risk due to monitoring only.	**Score = 9** Same as Alternative 2.	**Score = 8** For AOC1, there would be higher short term risks associated with solidification/stabilization (and excavation) compared to other in-situ alternatives. The short term risks of ISS are slightly lower than excavation because far less contaminated soil would need to be transported out of the building to a staging area for loading and offsite disposal. Risks in AOCs 2, 3, and 4 are the same as described under Alternative 2.	**Score = 7** Higher short term risks are associated with excavation versus the other alternatives due to the risks associated with completing the excavation inside the existing building for AOCs 1, 2, and one of the AOC4 hotspots. Risks are higher than Alternative 4 due to significantly more soil removal required under Alternative 5 in AOCs 1, 2, and 4.
Technical and Administrative Implementability	The ability to implement the alternative, including consideration of technical difficulty regardless of cost; the availability of necessary offsite facilities, services, and materials; administrative and regulatory requirements; scheduling; project size and complexity; monitoring requirements; access for construction operations and monitoring; and integration with existing facility operations.	**Score = 10** Highly technically implementable compared to other alternatives, requiring only monitoring.	**Score = 9** Technically implementable, however, injection activities inside Warehouse 1 for AOCs 1 and 2 will be challenging compared to typical outdoor projects. Enhanced bioremediation in AOCs 1 and 2 would likely need to be performed twice to achieve the CAOs. Excavation of AOC3 and MNA in AOC4 are easily implementable. This alternative receives a slightly higher score than Alternatives 4 and 5 because Alternative 2 implementation is fully in-situ in AOCs 1, 2, and 4.	**Score = 9** Same as Alternative 2.	**Score = 8** Technically implementable, however solidification/stabilization inside Warehouse 1 (for AOC1) will be challenging compared to typical outdoor ISS projects. Typical 10-yard dump trucks likely cannot be loaded inside the building. Therefore concrete and some excavated soil would likely need to be transported in smaller vehicles to a staging area, with second handling required for loading into 10-yard dump trucks. The soil volume to be handled in AOC1 would be less than the volume under Alternative 5. Implementability in AOCs 2, 3, and 4 woudl be the same as described in Alternative 2.	**Score = 7** Technically implementable, however, excavation inside Warehouse 1 for AOCs 1 and 2 will be more challenging compared to typical outdoor excavation projects. Typical 10-yard dump trucks likely cannot be loaded inside the building. Any material excavated from within Warehouse 1 would need to be transported to a staging area, with second handling required for loading into 10-yard dump trucks. The overall volume of excavated soil would be much higher in Alternative 5 compared to all other alternatives.

Notes:

ISCR w/AC = in-situ chemical reduction with activated carbon
AOC1 = Area of Concern
bgs = below ground surface
CAO = cleanup action objective
COC = contaminant of concern
CrVI = hexavalent chromium
CrIII = trivalent chromium
CUL = cleanup level
DCA = disproportionate cost analysis
ISS = in-situ solidification/stabilization
POC = point of compliance
MTCA = Model Toxics Control Act
MNA = monitored natural attenuation
TCE = trichloroethene

Table 7-3

Summary of MTCA Evaluation and Ranking of Cleanup Action Alternatives

Former Precision Engineering Property

Seattle, Washington

Remedial Alternative	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
	MNA in AOCs 1, 2, 3 and 4	Enhanced bio in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISCR w/AC in AOC1, AOC2 Excavation of AOC3 MNA in AOC4	ISS in AOC1 ISCR w/AC in AOC2 Excavation of AOC3 MNA in AOC4	Targeted Excavation of AOCs 1, 2, and 4 Excavation of AOC 3
Evaluation					
Restoration Time Frame for Active Cleanup	**Soil: >30 years Groundwater: >30 years**	**Soil: >30 years Groundwater: >15 years**	**Soil: >30 years Groundwater: 10 years**	**Soil: <1 year Groundwater: 5 years**	**Soil: >15 years Groundwater: 10 years**
Relative Benefits Ranking					
Protectiveness (weighted as 35%)	4	6	7	9	8
Permanence (weighted as 20%)	3	5	7	8	9
Long-Term Effectiveness (weighted as 25%)	4	6	8	9	8
Management of Implementation Risks (weighted as 10%)	10	9	9	8	7
Technical and Administrative Implementability (weighted as 10%)	10	9	9	8	7
Overall Weighted Benefit Score	**5.00**	**6.40**	**7.65**	**8.60**	**8.00**
Disproportionate Cost Analysis					
Remedy Permanent to Maximum Extent Practicable	Yes	Yes	Yes	Yes	Yes
Potential Base Remedy Costs for Feasibility Purposes	$1,064,134	$1,468,606	$1,243,418	$1,320,407	$1,813,483
Contingency	5%	25%	25%	20%	15%
Potential Base Remedy Costs with Contingency for Feasibility Purposes	$1,117,340	$1,835,757	$1,554,272	$1,584,488	$2,085,505
Low Range Costs (-30%) With Contingency	$782,138	$1,285,030	$1,087,990	$1,109,142	$1,459,853
High Range Costs (+50%) With Contingency	$1,676,010	$2,753,636	$2,331,408	$2,376,733	$3,128,257
Relative Benefit Ranking to Remedial Cost (Benefit/$1,000,000)	4.47	3.49	4.92	5.43	3.84
Costs Disproportionate to Incremental Benefits	No	Yes	No	No	Yes
Overall Alternative Ranking	**3**	**5**	**2**	**1**	**4**

Notes:

AC = activated carbon

AOC1 = Area of Concern 1 (Former Plating Tank Area)

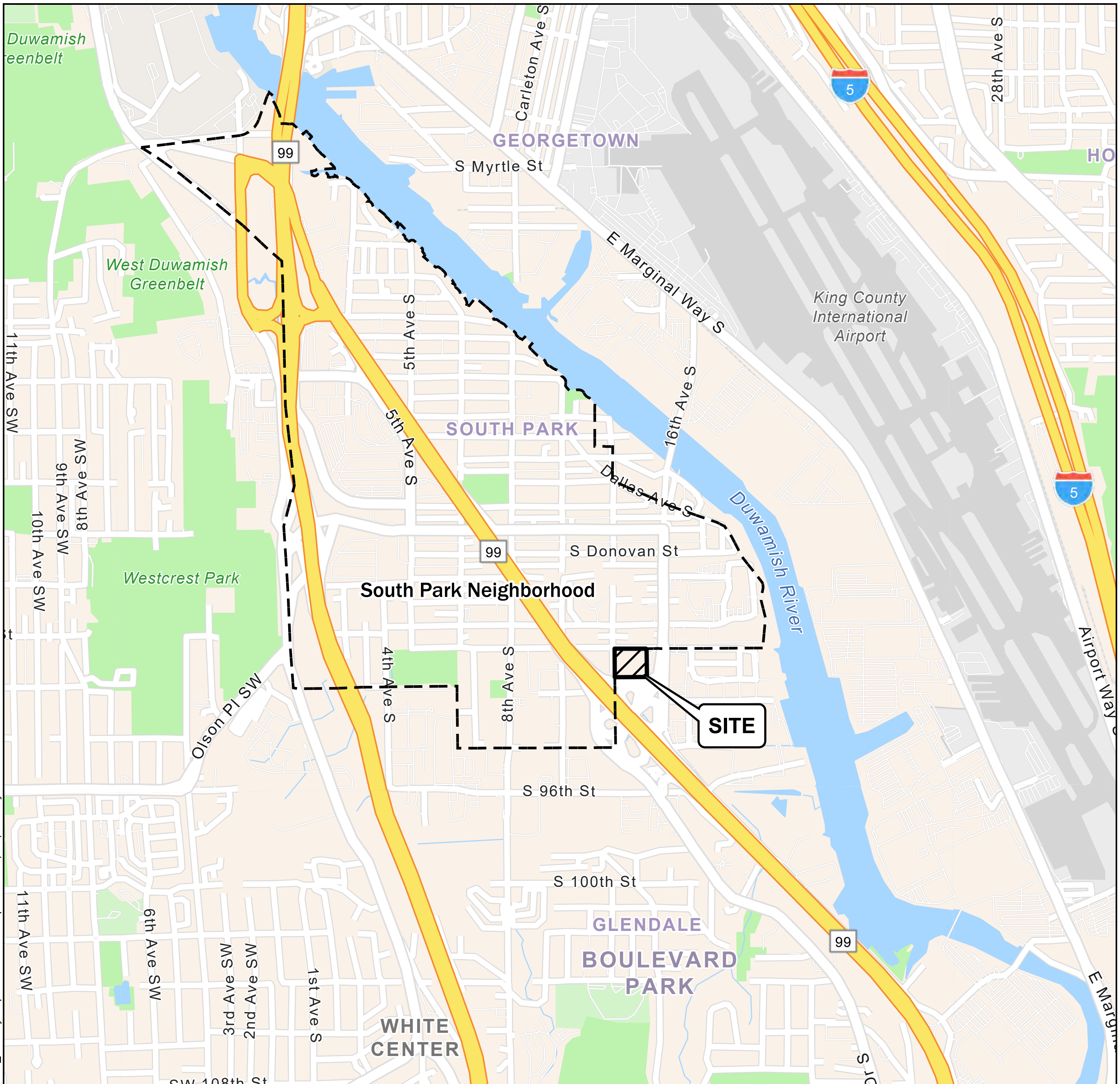
ISCR = In-situ Chemical Reduction

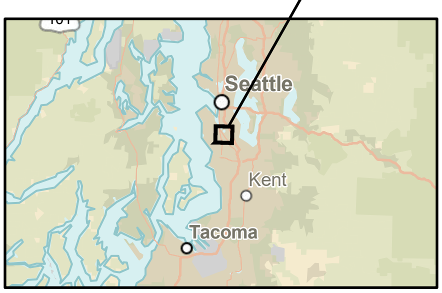
ISS = in-situ solidification/stabilization

MNA = monitored natural attenuation

MTCA = Model Toxics Control Act

Figures





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Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: ESRI

Projection: NAD 1983 UTM Zone 10N

Vicinity Map

Precision Engineering, Inc.
Seattle, Washington

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Figure 1-1

P:\25\25806001\GIS\25806001_Project\25806001_Project.aprx\2580600100_F11_VicinityMap2023 Date Exported: 03/28/24 by ccabrera

Legend

- Former Precision Engineering Property
- Nearby Current and/or Former Contaminated Sites
- King County Parcels

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: 2021 image and GIS data from King County GIS.

Projection: NAD 1983 StatePlane Washington North FIPS 4601 Feet

N W E S

200 0 200

Feet

Site and Surroundings

Precision Engineering, Inc.
Seattle, Washington

GEOENGINEERS

Figure 1-2

P:\25\25806001\GIS\25806001_Project\25806001_Project.aprx\2580600102_F21_SiteSurroundings Date Exported: 05/17/24 by ccabrera

Legend

- Shallow Monitoring Well
- Deep Monitoring Well
- Former Tank/Ditch Excavation Area
- Drainage Ditch
- Stormwater Runoff
- Catch Basin
- Stormwater Piping with Outfall
- Sanitary Sewer
- Natural Gas
- Property Parcel

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: 2021 image from King County GIS.

Projection: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet

N W E S

60 0 60

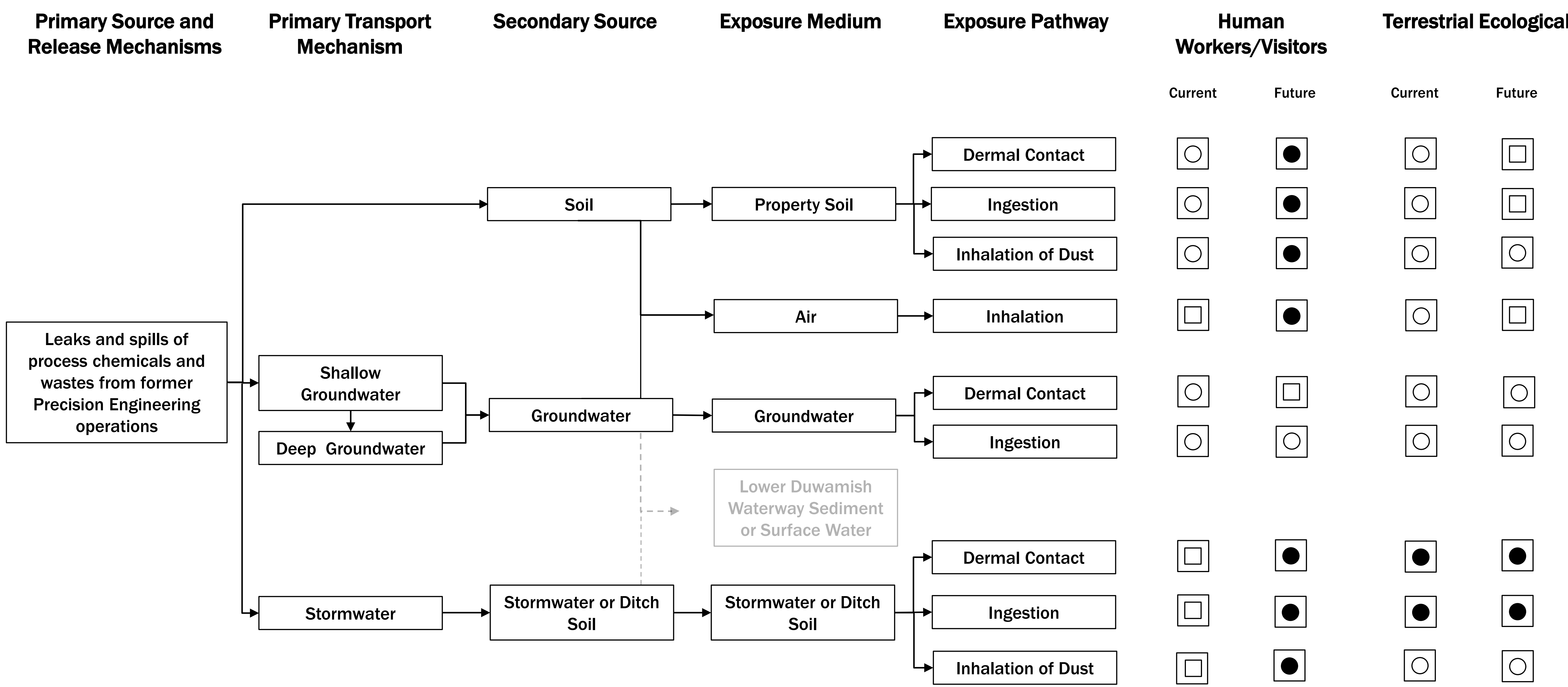
Feet

Site Features - 2024

Precision Engineering, Inc.
Seattle, Washington

GeoEngineers

Figure 1-3



Legend

- ● Complete Exposure Pathway
- ○ Incomplete Exposure Pathway
- □ Complete but Minor/Unlikely Exposure Pathway

N
Not to Scale

Conceptual Site Model

Precision Engineering, Inc.
Seattle, Washington

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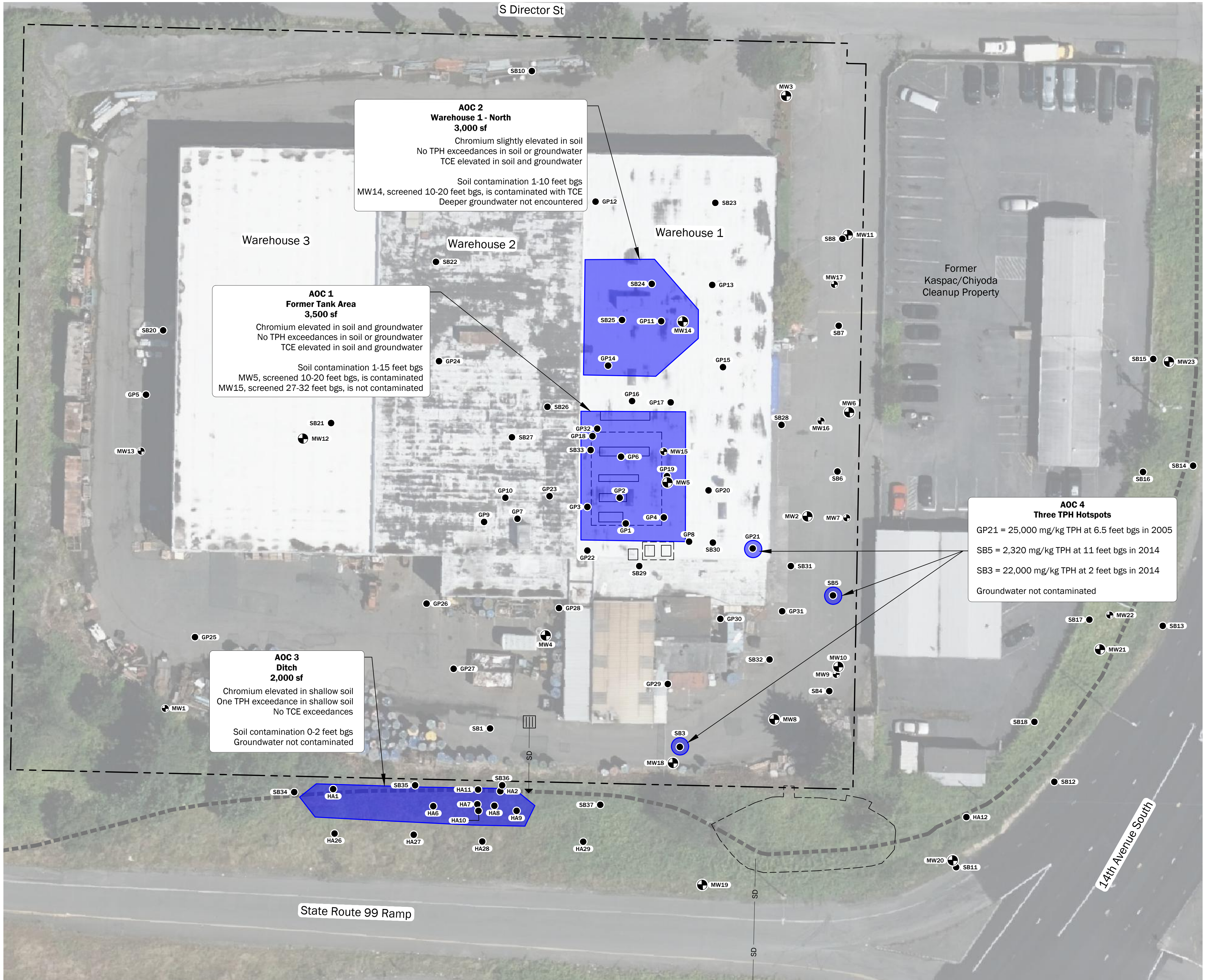
Figure 2-1

25806-001-02 Date Exported: 5/24/24



Legend

- ● Soil Boring/Hand Auger
- Shallow Monitoring Well
- Deep Monitoring Well
- Former chromic acid tank
- Drainage Ditch
- Catch Basin
- SD — Stormwater Piping with Outfall
- Former Tank/Ditch Excavation Area
- Property Parcel

Notes:

AOC = Area of Concern
SF = square feet
TPH = Total Petroleum Hydrocarbons (oil-range)
TCE = Trichloroethylene

Source:

- Aerial from Microsoft Bing, 2022

Projection: WA State Plane, North Zone, NAD83, US Foot

Disclaimer: This figure was created for a specific purpose and project. Any use of this figure for any other project or purpose shall be at the user's sole risk and without liability to GeoEngineers. The locations of features shown may be approximate. GeoEngineers makes no warranty or representation as to the accuracy, completeness, or suitability of the figure, or data contained therein. The file containing this figure is a copy of a master document, the original of which is retained by GeoEngineers and is the official document of record.

N

0 50

Feet

Areas Requiring Cleanup

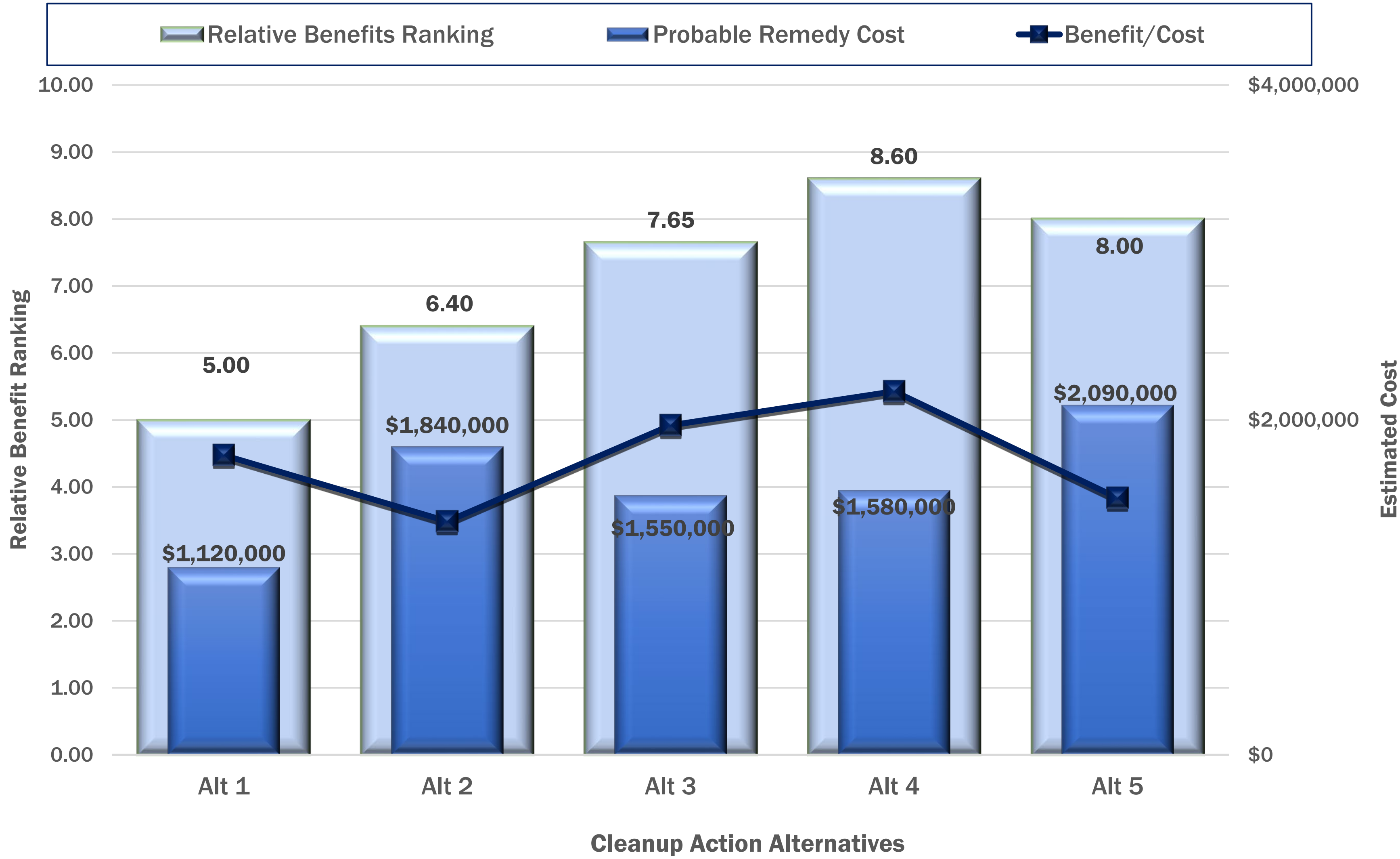
Precision Engineering, Inc.
Seattle, Washington

GeoEngineers

Figure 3-1

P:\25\25806001\CAD\03\FS Report\2580600103_F3-1_Areas Requiring Cleanup.dwg 3-1 Date Exported:1/2/2025 10:44 AM - by Michael R. Woods

25806-001-03 Date Exported: April 17, 2025



Disproportionate Cost Analysis

Former Precision Engineering Property
Seattle, Washington

GeoEngineers

Figure 8-1

Appendices

Appendix A
Indoor Air TCE Results 2020 through 2024

Table A-1

Indoor Air TCE Results - 2020 to 2024

Former Precision Engineering Property

Seattle, Washington

Sample Location	Sample Identification	Sample Collection Start Date	Sample Collection End Date	Trichloroethene ($\mu g/m^3$)
RAD1	RAD1-121720	12/17/2020	1/7/2021	**0.54**
	RAD1-032221	3/22/2021	4/12/2021	**0.44**
	RAD1-062121	6/21/2021	7/12/2021	**0.42**
	RAD1-092021	9/20/2021	10/11/2021	**0.27**
	RAD1-091622	9/16/2022	10/7/2022	**0.19**
	RAD1-022323	2/23/2023	3/2/2023	**0.052**
	RAD1-110723	11/7/2023	11/28/2023	**0.080**
	RAD1-112624	11/26/2024	12/17/2024	0.056 U
RAD2	RAD2-022323	2/23/2023	3/2/2023	0.048 U
	RAD2-110723	11/7/2023	11/28/2023	0.048 U
	RAD2-112624	11/26/2024	12/17/2024	0.056 U
RAD3	RAD3-022323	2/23/2023	3/2/2023	**0.089**
	RAD3-110723	11/7/2023	11/28/2023	**0.082**
	RAD3-112624	11/26/2024	12/17/2024	**0.12**
RAD4	RAD4-121720	12/17/2020	1/7/2021	**0.87**
	RAD4-032221	3/22/2021	4/12/2021	**0.95**
	RAD4-062121	6/21/2021	7/12/2021	**0.76**
	RAD4-092021	9/20/2021	10/11/2021	**0.28**
	RAD4-091622	9/16/2022	10/7/2022	**0.27**
	RAD4-022323	2/23/2023	3/2/2023	**0.089**
	RAD4-110723	11/7/2023	11/28/2023	**0.080**
	RAD4-112624	11/26/2024	12/17/2024	**0.13**
RAD5	RAD5-121720	12/17/2020	1/7/2021	**0.77**
	RAD5-032221	3/22/2021	4/12/2021	**0.71**
	RAD5-062121	6/21/2021	7/12/2021	**0.38**
	RAD5-092021	9/20/2021	10/11/2021	**0.16**
	RAD5-091622	9/16/2022	10/7/2022	**0.14**
	RAD5-022323	2/23/2023	3/2/2023	**0.085**
	RAD5-110723	11/7/2023	11/28/2023	**0.063**
	RAD5-110723	11/26/2024	12/17/2024	**0.12**
MTCA Method B VI CUL[1]				0.33
Indoor Air Action Level, Workplace Scenario[2]				7.5

Notes:

Each sample was collected over a three-week period using a Radiello R130 passive indoor air sampler.

A **bolded** value indicates that the analyte was detected at the reported concentration.

A shaded cell indicated that the analyte was detected at a concentration greater than the MTCA Method B VI CUL.

CUL = cleanup level

MTCA = Model Toxics Control Act

$\mu g/m^3$ = microgram per cubic meter

VI = vapor intrusion

U = analyte not detected above laboratory reporting limits

Reference:

[1] Ecology Cleanup level and risk calculation data tables. Washington State Department of Ecology, Lacey, Washington

[2] Ecology Implementation Memorandum No.22 vapor intrusion investigations and short-term trichloroethene toxicity. Washington State Department of Ecology, Lacey, Washington.

Legend

- Sub-slab soil gas sample
- Indoor/outdoor air sample
- Former chromic acid tank
- Stormwater Runoff
- Drainage Ditch
- Catch Basin
- Stormwater Piping with Outfall
- Former Tank/Ditch Excavation Area
- Property Parcel

Source(s):
- Aerial from Microsoft Bing, 2022

Projection: WA State Plane, North Zone, NAD83, US Foot

Disclaimer: This figure was created for a specific purpose and project. Any use of this figure for any other project or purpose shall be at the user's sole risk and without liability to GeoEngineers. The locations of features shown may be approximate. GeoEngineers makes no warranty or representation as to the accuracy, completeness, or suitability of the figure, or data contained therein. The file containing this figure is a copy of a master document, the original of which is retained by GeoEngineers and is the official document of record.

N

0 60

Feet

Air/Soil Gas Investigation Locations 2005 - 2024

Precision Engineering, Inc.
Seattle, Washington

GEOENGINEERS

Figure A-1

GEOENGINEERS

Data Validation Report

1101 Fawcett Avenue, Suite 200, Tacoma, Washington 98402, Telephone: 253.383.4940, Fax: 253.383.4923 www.geoengineers.com

Project: Dick Morgan – Precision Engineering November 2023 and November/December 2024 Radiello Air Samples

GEI File No: 25806-001-03

Date: January 10, 2025

This report documents the results of a United States Environmental Protection Agency (USEPA)-defined Stage 2A data validation (USEPA Document 540-R-08-005; USEPA 2009) of analytical data from the analyses of air samples collected as part of the November 2023 and November/December 2024 sampling events, and the associated laboratory quality control (QC) samples. The samples were obtained from the Precision Engineering site located at 1231 S Director Street in Seattle, Washington.

Objective and Quality Control Elements

GeoEngineers, Inc. (GeoEngineers) completed the data validation consistent with the USEPA Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review (USEPA, 2020) (National Functional Guidelines) to determine if the laboratory analytical results meet the project objectives and are usable for their intended purpose. Data usability was assessed by determining if:

- The samples were analyzed using well-defined and acceptable methods that provide detection and reporting limits below applicable regulatory criteria;
- The precision and accuracy of the data are well-defined and sufficient to provide defensible data; and
- The quality assurance/quality control (QA/QC) procedures utilized by the laboratory meet acceptable industry practices and standards.

The data validation included review of the following QC elements:

- Data Package Completeness
- Chain-of-Custody Documentation
- Holding Times
- Surrogate Recoveries
- Method Blanks
- Laboratory Control Samples/Laboratory Control Sample Duplicates
- Continuing Calibrations (CCALs)

Validated Sample Delivery Groups

This data validation summary included review of the sample delivery group (SDG) listed below in Table 1.

TABLE 1: SUMMARY OF VALIDATED SAMPLE DELIVERY GROUPS

LABORATORY SDG	SAMPLES VALIDATED
2311611	RAD1-110723, RAD2-110723, RAD3-110723, RAD4-110723, RAD5-110723
2412535	RAD1-112624, RAD2-112624, RAD3-112624, RAD4-112624, RAD5-112624

Chemical Analysis Performed

Eurofins Air Toxics, Inc. (Eurofins) located in Folsom, California, performed laboratory analysis on the air samples using the following method:

- Volatile Organic Compounds (VOCs) by GC/MS collected on Charcoal-based Passive Samplers

Data Validation Summary

The results for each of the QC elements are summarized below.

Data Package Completeness

Eurofins analyzed the air samples evaluated as part of this data validation. The laboratory provided the required deliverables for the data validation. The laboratory followed adequate corrective action processes and the identified anomalies were discussed in the case narrative.

CHAIN-OF-CUSTODY DOCUMENTATION

Chain-of-custody (COC) forms were provided with the laboratory analytical reports. The COC documentation parameters were met.

HOLDING TIMES

The holding time is defined as the time that elapses between sample collection and sample analysis. Maximum holding time criteria exist for each analysis to help ensure that the analyte concentrations found at the time of analysis reflect the concentration present at the time of sample collection.

Established holding times were met for the requested analyses.

SURROGATE RECOVERIES

A surrogate compound is a compound that is chemically similar to the organic analytes of interest, but unlikely to be found in an environmental sample. Surrogates are used for organic analyses and are added to the samples, standards, and blanks to serve as an accuracy and specificity check of each analysis. The surrogates are added at a known concentration and percent recoveries are calculated following analysis.

The surrogate recoveries for field samples were within the laboratory control limits.

METHOD BLANKS

Method blanks are analyzed to ensure that laboratory procedures and reagents do not introduce measurable concentrations of the analytes of interest. Method blanks were analyzed with each batch of samples, at a frequency of 1 per 20 samples. None of the analytes of interest were detected above the reporting limits in the method blanks.

LABORATORY CONTROL SAMPLES/LABORATORY CONTROL SAMPLE DUPLICATES

A laboratory control sample (LCS) is a blank sample that is spiked with a known amount of analyte and then analyzed. An LCS is similar to an MS, but without the possibility of matrix interference. As there is no actual sample matrix (such as soil or groundwater) in the analysis, the analytical expectations for accuracy and precision are usually more rigorous and qualification would apply to the samples in the batch, instead of the parent sample only.

Laboratory control sample analyses should be performed once per analytical batch or every 20 field samples, whichever is more frequent. The recovery criteria for laboratory control samples are specified in the laboratory documents, as are the relative percent difference (RPD) control limits for LCS/LCSD sample sets.

The frequency requirements were met for each analysis, and the percent recovery and RPD values were within the proper control limits.

CONTINUING CALIBRATIONS (CCALS)

The continuing calibrations were conducted according to the laboratory methods and consisted of the appropriate number of standards. The percent difference (%D) and relative response factors (RRF) were within the internal laboratory control limits, or the control limits stated in the National Functional Guidelines (USEPA 2020).

Overall Assessment

As was determined by this data validation, the laboratory followed the specified analytical methods. Accuracy was acceptable, as demonstrated by the surrogate and LCS/LCSD percent recovery values. Precision was acceptable, as demonstrated by the LCS/LCSD RPD values.

No analytical results were qualified. The data are acceptable for the intended use.

References

U.S. Environmental Protection Agency (USEPA). 2009. “Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use,” EPA-540-R-08-005. January 2009.

U.S. Environmental Protection Agency (USEPA). 2020. “Contract Laboratory Program National Functional Guidelines for Organic Superfund Methods Data Review,” EPA-540-R-201-005. November 2020.

12/12/2023
Ms. Katy Atakturk
GeoEngineers, Inc.
2101 4th Ave Suite 950

Seattle WA 98121

Project Name: Precision Engineering
Project #: 25806-001-01
Workorder #: 2311611

Dear Ms. Katy Atakturk

The following report includes the data for the above referenced project for sample(s) received on 11/29/2023 at Eurofins Air Toxics LLC.

The data and associated QC analyzed by Passive S.E. RAD130/SKC are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Eurofins Air Toxics LLC. for your air analysis needs. Eurofins Air Toxics Inc. is committed to providing accurate data of the highest quality. Please feel free to contact the Project Manager: Monica Tran at 916-985-1000 if you have any questions regarding the data in this report.

Regards,

Monica Tran

Monica Tran
Project Manager

eurofins | Air Toxics

WORK ORDER #: 2311611

Work Order Summary

CLIENT:	Ms. Katy Atakturk GeoEngineers, Inc. 2101 4th Ave Suite 950 Seattle, WA 98121	**BILL TO:**	CORP Accounts Payable GeoEngineers, Inc. 8410 154th Avenue NE Redmond, WA 98052
PHONE:	206-728-2674	**P.O. #**	
FAX:	206-728-2732	**PROJECT #**	25806-001-01 Precision Engineering
DATE RECEIVED:	11/29/2023	**CONTACT:**	Monica Tran
DATE COMPLETED:	12/12/2023		

FRACTION #	NAME	TEST
01A	RAD1-110723	Passive S.E. RAD130/SKC
02A	RAD2-110723	Passive S.E. RAD130/SKC
03A	RAD3-110723	Passive S.E. RAD130/SKC
04A	RAD4-110723	Passive S.E. RAD130/SKC
05A	RAD5-110723	Passive S.E. RAD130/SKC
06A	Lab Blank	Passive S.E. RAD130/SKC
07A	CCV	Passive S.E. RAD130/SKC
08A	LCS	Passive S.E. RAD130/SKC
08AA	LCSD	Passive S.E. RAD130/SKC

CERTIFIED BY: Heidi Hayes DATE: 12/12/23

Technical Director

Certification numbers: AZ Licensure AZ0775, FL NELAP – E87680, LA NELAP – 02089, NH NELAP – 209222, NJ NELAP - CA016, NY NELAP - 11291, TX NELAP – T104704434-22-18, UT NELAP – CA009332022-14, VA NELAP - 12240, WA ELAP - C935
Name of Accreditation Body: NELAP/ORELAP (Oregon Environmental Laboratory Accreditation Program) CA300005-017
Eurofins Environment Testing Northern California, LLC certifies that the test results contained in this report meet all requirements of the 2016 TNI Standard.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000

LABORATORY NARRATIVE
RAD130 Passive SE by Mod EPA TO-17
GeoEngineers, Inc.
Workorder# 2311611

Five Radiello 130 (Solvent) samples were received on November 29, 2023. The laboratory analyzed the charcoal sorbent bed of the passive sampler following modified method EPA TO-17. The VOCs were chemically extracted using carbon disulfide and an aliquot of the extract was injected into a GC/MS for identification and quantification of volatile organic compounds (VOCs).

The mass of each target compound adsorbed by the sampler was converted to units of concentration using the sample deployment time and the sampling rate for each VOC. If sampling rates were calculated by the lab or the manufacturer, the concentration result has been flagged as an estimated value. Results are not corrected for desorption efficiency.

The reference method used for this procedure is EPA TO-17, which describes the collection of VOCs in ambient air using sorbents and analysis by GC/MS. Because TO-17 describes active sample collection using a pump and thermal desorption as the preparation step, several modifications are required. Modifications to TO-17 are listed in the table below:

Requirement	***TO-17***	***ATL Modifications***
Sample Collection	Pump pulls measured air volume through sorbent tube	VOCs in air adsorbed onto sorbent bed passively through diffusion
Sample Preparation	Thermal extraction	Solvent extraction
Sorbent tube conditioning	Condition newly packed tubes prior to use	Charcoal-based sorbent is a single use media and conditioning is conducted by vendor.
Instrumentation	Thermal desorption introduction system	Liquid injection introduction system
Internal Standard	Gas-phase internal standard introduced on the tube or focusing trap during analysis	Liquid-phase internal standard introduced on the tube at the time of extraction
Media and sample storage	<4 deg C, 30 days	Media shelf life is determined by vendor; sample hold-time is 6 months for the RAD130 and WMS. Sample preservation requirements are storage in a cool, solvent-free refrigerator and optional use of ice during shipping.
Internal Standard Recovery	+/-40% of daily CCV area	-50% to +100% of daily CCV area

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

The uptake rates were corrected based on average field temperatures if provided. In the absence of field temperatures, the uptake rates determined at 25 deg C were used.

To calculate ug/m3 concentrations in the Lab Blank, a sampling duration of 30183 minutes was applied. The assumed temperature used for the uptake rate is listed on the data page. If the field temperatures were provided, the rate was adjusted in the same manner as the field samples.

Definition of Data Qualifying Flags

Ten qualifiers may have been used on the data analysis sheets and indicate as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

UJ- Non-detected compound associated with low bias in the CCV

N - The identification is based on presumptive evidence.

C - Estimated concentration due to calculated sampling rate

CN - See case narrative explanation.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

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Summary of Detected Compounds
VOCS BY PASSIVE SAMPLER - GC/MS

Client Sample ID: RAD1-110723

Lab ID#: 2311611-01A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.080

Client Sample ID: RAD2-110723

Lab ID#: 2311611-02A

No Detections Were Found.

Client Sample ID: RAD3-110723

Lab ID#: 2311611-03A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.082

Client Sample ID: RAD4-110723

Lab ID#: 2311611-04A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.080

Client Sample ID: RAD5-110723

Lab ID#: 2311611-05A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.13	0.063

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Client Sample ID: RAD1-110723

Lab ID#: 2311611-01A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120708sim**	**Date of Collection:**	**11/28/23 9:33:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis:**	**12/7/23 11:06 AM**
		Date of Extraction:	**12/7/23**

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.080

Temperature = 77.0F , duration time = 30177 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	105	70-130

Air Toxics

Client Sample ID: RAD2-110723

Lab ID#: 2311611-02A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120709sim**	**Date of Collection:**	**11/28/23 9:30:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis:**	**12/7/23 11:34 AM**
		Date of Extraction:	**12/7/23**

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	Not Detected	Not Detected

Temperature = 77.0F , duration time = 30178 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

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Client Sample ID: RAD3-110723

Lab ID#: 2311611-03A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120710sim**	**Date of Collection: 11/28/23 9:39:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 12:01 PM**
		Date of Extraction: 12/7/23

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.082

Temperature = 77.0F , duration time = 30179 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	103	70-130

Client Sample ID: RAD4-110723

Lab ID#: 2311611-04A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120711sim**	**Date of Collection: 11/28/23 9:23:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 12:28 PM**
		Date of Extraction: 12/7/23

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.17	0.080

Temperature = 77.0F , duration time = 30183 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

eurofins

Air Toxics

Client Sample ID: RAD5-110723

Lab ID#: 2311611-05A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120712sim**	**Date of Collection:**	**11/28/23 9:42:00 AM**
Dil. Factor:	**1.00**	**Date of Analysis:**	**12/7/23 12:55 PM**
		Date of Extraction:	**12/7/23**

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	0.13	0.063

Temperature = 77.0F , duration time = 30177 minutes.
Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	103	70-130

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Client Sample ID: Lab Blank

Lab ID#: 2311611-06A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120705sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 09:43 AM**
		Date of Extraction: 12/7/23

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.048	Not Detected	Not Detected

Temperature = 77.0F , duration time = 30183 minutes.
Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	101	70-130

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Client Sample ID: CCV

Lab ID#: 2311611-07A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120702sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 08:20 AM**
		Date of Extraction: NA

Compound	%Recovery
Trichloroethene	101

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	101	70-130

Air Toxics

Client Sample ID: LCS

Lab ID#: 2311611-08A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120703sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 08:48 AM**
		Date of Extraction: 12/7/23

Compound	%Recovery	Method Limits
Trichloroethene	104	70-130

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	104	70-130

Air Toxics

Client Sample ID: LCSD

Lab ID#: 2311611-08AA

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18120704sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/7/23 09:16 AM**
		Date of Extraction: 12/7/23

Compound	%Recovery	Method Limits
Trichloroethene	105	70-130

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	104	70-130

Air Toxics

1/3/2025
Ms. Katy Atakturk
GeoEngineers, Inc.
2101 4th Ave Suite 950

Seattle WA 98121

Project Name: Dick Morgan Precision Engines R1
Project #: 25806-001-01
Workorder #: 2412535

Dear Ms. Katy Atakturk

The following report includes the data for the above referenced project for sample(s) received on 12/18/2024 at Eurofins Air Toxics LLC.

The data and associated QC analyzed by Passive S.E. RAD130/SKC are compliant with the project requirements or laboratory criteria with the exception of the deviations noted in the attached case narrative.

Thank you for choosing Eurofins Air Toxics LLC. for your air analysis needs. Eurofins Air Toxics Inc. is committed to providing accurate data of the highest quality. Please feel free to contact the Project Manager: Monica Tran at 916-985-1000 if you have any questions regarding the data in this report.

Regards,

Monica Tran

Monica Tran
Project Manager

Air Toxics

WORK ORDER #: 2412535

Work Order Summary

CLIENT:	Ms. Katy Atakturk GeoEngineers, Inc. 2101 4th Ave Suite 950 Seattle, WA 98121	**BILL TO:**	CORP Accounts Payable GeoEngineers, Inc. 8410 154th Avenue NE Redmond, WA 98052
PHONE:	206-728-2674	**P.O. #**	
FAX:	206-728-2732	**PROJECT #**	25806-001-01 Dick Morgan Precision Engines R1
DATE RECEIVED:	12/18/2024	**CONTACT:**	Monica Tran
DATE COMPLETED:	01/03/2025		

FRACTION #	NAME	TEST
01A	RAD1-112624	Passive S.E. RAD130/SKC
02A	RAD2-112624	Passive S.E. RAD130/SKC
03A	RAD3-112624	Passive S.E. RAD130/SKC
04A	RAD4-112624	Passive S.E. RAD130/SKC
05A	RAD5-112624	Passive S.E. RAD130/SKC
06A	Lab Blank	Passive S.E. RAD130/SKC
07A	CCV	Passive S.E. RAD130/SKC
08A	LCS	Passive S.E. RAD130/SKC
08AA	LCSD	Passive S.E. RAD130/SKC

CERTIFIED BY: Heidi Hayes DATE: 01/03/25

Technical Director

Cert. No.: AZ Licensure-AZ0775, FL NELAP-E87680, LA NELAP–02089, MN NELAP-2836569, NH NELAP–209224-A, NJ NELAP-CA016, NY NELAP-11291, TX NELAP-T104704434, UT NELAP-CA009332023-16, VA NELAP-13180, WA NELAP-C935
Name of Accreditation Body: NELAP/ORELAP (Oregon Environmental Laboratory Accreditation Program) CA300005-21
Eurofins Environment Testing Northern California, LLC certifies that the test results contained in this report meet all requirements of the 2016 TNI Standard.

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA - 95630
(916) 985-1000

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LABORATORY NARRATIVE
RAD130 Passive SE by Mod EPA TO-17
GeoEngineers, Inc.
Workorder# 2412535

Five Radiello 130 (Solvent) samples were received on December 18, 2024. The laboratory analyzed the charcoal sorbent bed of the passive sampler following modified method EPA TO-17. The VOCs were chemically extracted using carbon disulfide and an aliquot of the extract was injected into a GC/MS for identification and quantification of volatile organic compounds (VOCs).

The mass of each target compound adsorbed by the sampler was converted to units of concentration using the sample deployment time and the sampling rate for each VOC. If sampling rates were calculated by the lab or the manufacturer, the concentration result has been flagged as an estimated value. Results are not corrected for desorption efficiency.

The reference method used for this procedure is EPA TO-17, which describes the collection of VOCs in ambient air using sorbents and analysis by GC/MS. Because TO-17 describes active sample collection using a pump and thermal desorption as the preparation step, several modifications are required. Modifications to TO-17 are listed in the table below:

Requirement	***TO-17***	***ATL Modifications***
Sample Collection	Pump pulls measured air volume through sorbent tube	VOCs in air adsorbed onto sorbent bed passively through diffusion
Sample Preparation	Thermal extraction	Solvent extraction
Sorbent tube conditioning	Condition newly packed tubes prior to use	Charcoal-based sorbent is a single use media and conditioning is conducted by vendor.
Instrumentation	Thermal desorption introduction system	Liquid injection introduction system
Internal Standard	Gas-phase internal standard introduced on the tube or focusing trap during analysis	Liquid-phase internal standard introduced on the tube at the time of extraction
Media and sample storage	<4 deg C, 30 days	Media shelf life is determined by vendor; sample hold-time is 6 months for the RAD130 and WMS. Sample preservation requirements are storage in a cool, solvent-free refrigerator and optional use of ice during shipping.
Internal Standard Recovery	+/-40% of daily CCV area	-50% to +100% of daily CCV area

Receiving Notes

There were no receiving discrepancies.

Analytical Notes

The uptake rates were corrected based on average field temperatures if provided. In the absence of field temperatures, the uptake rates determined at 25 deg C were used.

To calculate ug/m3 concentrations in the Lab Blank, a sampling duration of 25925 minutes was applied. The assumed temperature used for the uptake rate is listed on the data page. If the field temperatures were provided, the rate was adjusted in the same manner as the field samples.

Definition of Data Qualifying Flags

Ten qualifiers may have been used on the data analysis sheets and indicate as follows:

B - Compound present in laboratory blank greater than reporting limit (background subtraction not performed).

J - Estimated value.

E - Exceeds instrument calibration range.

S - Saturated peak.

Q - Exceeds quality control limits.

U - Compound analyzed for but not detected above the reporting limit.

UJ- Non-detected compound associated with low bias in the CCV

N - The identification is based on presumptive evidence.

C - Estimated concentration due to calculated sampling rate

CN - See case narrative explanation.

File extensions may have been used on the data analysis sheets and indicates as follows:

a-File was requantified

b-File was quantified by a second column and detector

r1-File was requantified for the purpose of reissue

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Summary of Detected Compounds
VOCS BY PASSIVE SAMPLER - GC/MS

Client Sample ID: RAD1-112624

Lab ID#: 2412535-01A

No Detections Were Found.

Client Sample ID: RAD2-112624

Lab ID#: 2412535-02A

No Detections Were Found.

Client Sample ID: RAD3-112624

Lab ID#: 2412535-03A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	0.12	0.070

Client Sample ID: RAD4-112624

Lab ID#: 2412535-04A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	0.13	0.070

Client Sample ID: RAD5-112624

Lab ID#: 2412535-05A

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	0.12	0.068

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Client Sample ID: RAD1-112624

Lab ID#: 2412535-01A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122612sim**	**Date of Collection:**	**12/14/24 10:20:00 A**
Dil. Factor:	**1.00**	**Date of Analysis:**	**12/26/24 01:28 PM**
		Date of Extraction:	**12/26/24**

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	Not Detected	Not Detected

Temperature = 77.0F , duration time = 25920 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

Client Sample ID: RAD2-112624

Lab ID#: 2412535-02A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122613sim**	**Date of Collection: 12/14/24 10:30:00 A**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 01:55 PM**
		Date of Extraction: 12/26/24

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	Not Detected	Not Detected

Temperature = 77.0F , duration time = 25920 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	103	70-130

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Client Sample ID: RAD3-112624

Lab ID#: 2412535-03A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122614sim**	**Date of Collection:**	**12/14/24 10:10:00 A**
Dil. Factor:	**1.00**	**Date of Analysis:**	**12/26/24 02:21 PM**
		Date of Extraction:	**12/26/24**

Compound	**Rpt. Limit (ug)**	**Rpt. Limit (ug/m3)**	**Amount (ug)**	**Amount (ug/m3)**
Trichloroethene	0.10	0.056	0.12	0.070

Temperature = 77.0F , duration time = 25915 minutes.
Container Type: Radiello 130 (Solvent)

Surrogates	**%Recovery**	**Method Limits**
Toluene-d8	102	70-130

Air Toxics

Client Sample ID: RAD4-112624

Lab ID#: 2412535-04A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122615sim**	**Date of Collection: 12/14/24 10:25:00 A**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 02:48 PM**
		Date of Extraction: 12/26/24

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	0.13	0.070

Temperature = 77.0F , duration time = 25920 minutes.
Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

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Client Sample ID: RAD5-112624

Lab ID#: 2412535-05A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122616sim**	**Date of Collection: 12/14/24 10:15:00 A**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 03:14 PM**
		Date of Extraction: 12/26/24

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	0.12	0.068

Temperature = 77.0F , duration time = 25925 minutes.
Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

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Client Sample ID: Lab Blank

Lab ID#: 2412535-06A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122605sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 10:14 AM**
		Date of Extraction: 12/26/24

Compound	Rpt. Limit (ug)	Rpt. Limit (ug/m3)	Amount (ug)	Amount (ug/m3)
Trichloroethene	0.10	0.056	Not Detected	Not Detected

Temperature = 77.0F , duration time = 25925 minutes.

Container Type: Radiello 130 (Solvent)

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

Air Toxics

Client Sample ID: CCV

Lab ID#: 2412535-07A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name: 18122602sim		**Date of Collection:** NA
Dil. Factor: 1.00		**Date of Analysis:** 12/26/24 08:47 AM
		Date of Extraction: NA

Compound	%Recovery
Trichloroethene	100

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	99	70-130

Client Sample ID: LCS

Lab ID#: 2412535-08A

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122603sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 09:21 AM**
		Date of Extraction: 12/26/24

Compound	%Recovery	Method Limits
Trichloroethene	90	70-130

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	103	70-130

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Client Sample ID: LCSD

Lab ID#: 2412535-08AA

VOCS BY PASSIVE SAMPLER - GC/MS

File Name:	**18122604sim**	**Date of Collection: NA**
Dil. Factor:	**1.00**	**Date of Analysis: 12/26/24 09:48 AM**
		Date of Extraction: 12/26/24

Compound	%Recovery	Method Limits
Trichloroethene	90	70-130

Container Type: NA - Not Applicable

Surrogates	%Recovery	Method Limits
Toluene-d8	102	70-130

Air Toxics

Method : Passive SE GC/MS (Sh)-TCE only

CAS Number	Compound	Rpt. Limit (ug)
79-01-6	**Trichloroethene**	**0.10**

	Surrogate	Method Limits
2037-26-5	Toluene-d8	70-130

Appendix B
Cleanup Action Alternatives Cost Estimates

Table B-1

Alternatives Cost Estimate Summary

Former Precision Engineering, Inc.
Seattle, Washington

Alternative	Description	Capital Costs	O&M Costs	Contingency[1] (%)	Contingency Costs	Total Costs (Capital, O&M and Contingency)
1	MNA in AOCs 1-4	$52,710	$1,011,424	5%	$53,207	$1,117,340
2	Enhanced Bioremediation (AOC1 & AOC2), Excavation (AOC3), MNA (AOC4)	$890,389	$578,217	25%	$367,151	$1,835,757
3	ISCR with AC (AOC1 & AOC2), Excavation (AOC3), MNA (AOC4)	$839,201	$404,216	25%	$310,854	$1,554,272
4	ISS (AOC1), ISCR with AC (AOC2), Excavation (AOC3), MNA (AOC4)	$1,108,301	$212,106	20%	$264,081	$1,584,488
5	Targeted Excavation (AOC1, AOC2, AOC4), Excavation (AOC3)	$1,409,266	$404,216	15%	$272,022	$2,085,505

Notes:

[1] Contingency includes (1) scope contingency, which refers to unknowns, unforeseen circumstances, or unanticipated conditions that cannot be quantified based on available data at the time the estimate is prepared, and (2) bid contingency, which refers to differences between costs identified at the time the estimate is prepared and actual costs at the time the work is performed. EPA identifies the typical range for scope contingency as 10 to 25 percent, and the typical range for bid contingency as 10 to 20 percent ("A Guide to Developing and Documenting Cost Estimates During the Feasibility Study" EPA July 2000, Section 5.4).

AC = activated carbon

EPA = United States Environmental Protection Agency

ISCR = In-situ Chemical Reduction

ISS = In-situ solidification/stabilization

MNA = Monitored natural attenuation

Table B-2

Alternative 1: MNA in AOCs 1-4

Former Precision Engineering, Inc.
Seattle, Washington

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Indirect Capital Construction Costs						
1	Work Plan	LS	1	$20,000	$20,000	Assumes lump sum cost to prepare work plan.
2	Project Management	% of O&M	6%	--	$2,710	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
3	Environmental Covenant	LS	1	$30,000	$30,000	Costs include coordination with Ecology, adjacent property owners, legal fees, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$52,710**	
Annual Operation and Maintenance Costs (30 years)						
4	Ecology Oversight	% of O&M Yearly	1%	--	$160	Professional judgment.
5	Groundwater and Indoor Air Monitoring and Reporting	LS/YR	1	$30,000	$30,000	Annually for 30 years. Based on prior project experience.
6	Cap and Monitoring Well Monitoring, Maintenance and Reporting	LS/YR	1	$10,000	$10,000	Assumed periodic maintenance and/or well replacement. Based on prior project experience.
7	Institutional Controls	LS/YR	1	$5,000	$5,000	Assume annual administrative cost for institutional controls for 30 years. Based on prior project experience.
				Annual Operation and Maintenance Sub-Total	**$45,160**	
				Present Value Operation and Maintenance Costs over estimated duration of 30 years	**$1,011,424**	Present value calculated using equal series present value formula assuming discount rate of 2%. Based on Real 30-year discount rate published in February 2023 Office of Management and Budget Circular No. A-94.
				Total Estimated Costs for Alternative (without Contingency)	**$1,064,134**	
				Low Range of Estimated Costs for Alternative 4 (-30%) Without Contingency	**$744,893**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study."
				High Range of Estimated Costs for Alternative 4 (+50%) Without Contingency	**$1,596,200**	

Notes:

[1] Quantity is an estimate at the level of "concept design."

[2] Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgement. Unit costs are presented in 2025 dollars.

MNA = Monitored Natural Attenuation; LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; EA = each; YR = year

Table B-3

Alternative 2: Enhanced Bioremediation (AOC1 & AOC2), Excavation (AOC3), MNA (AOC4)

Former Precision Engineering, Inc.
Seattle, Washington

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Direct Capital Construction Costs						
Enhanced Bioremediation (AOC1 & AOC2)						
1	Treatability/Pilot Study For In-Situ Technologies	LS	1	$75,000	$75,000	Assumes small pilot study and quarterly data collection to determine reagent estimates. Cost based on previous project experience.
2	Decommission Monitoring Wells	EA	3	$1,000	$3,000	Based on bid pricing for previous projects for shallow wells (chip in place).
3	Injection Event	Event	2	$226,875	$453,750	Based on vendor cost estimate and includes concrete floor repair.
4	New Well Installation	EA	3	$10,000	$30,000	Assumes new wells to be installed for pilot testing and compliance monitoring. Based on previous project experience.
5	Baseline and Performance Monitoring and Reporting	LS	5	$15,000	$75,000	Labor and analytical costs to collect baseline site data and evaluate effectiveness of treatment (4 monitoring events per year at 8 monitoring wells). Based on previous project experience.
Excavation (AOC4)						
6	Excavation	BCY	148	$55	$8,140	Based on vendor estimate to approximately 5 feet bgs and includes surface demolition and disposal, and site restoration (concrete repair).
7	Load, Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	222	$125	$27,750	Assume excavated material will be disposed at Subtitle D facility and 1.5 tons per cubic yard. Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Based on previous project experience.
8	Restoration: Backfill and Hydroseeding	SF	20,000	$1.0	$20,000	Restoration including backfilling with clean soil, hydroseeding and vegetation establishment monitoring.
				Direct Capital Costs Sub-Total	$692,640	
Indirect Capital Construction Costs						
9	Work Plan and Procurement	LS	1	$50,000	$50,000	Assumes lump sump costs to prepare work planning and procurement documents.
10	Remedial Design	% of TDC	3%	--	$20,779	Includes pre-remedial design, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
11	Permitting	% of TDC	1%	--	$6,926	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
12	Construction Management/Oversight	% of TDC	6%	--	$41,558	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
13	Project Management	% of TDC	6%	--	$41,558	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
14	Ecology Oversight	% of TDC	1%	--	$6,926	Professional judgment.
15	Environmental Covenant	LS	1	$30,000	$30,000	Costs include coordination with Ecology, adjacent property owners, legal fees, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	$197,749	

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Annual Operation and Maintenance Costs (15 years)						
16	Groundwater and Indoor Air Monitoring and Reporting	LS/YR	1	$30,000	$30,000	Annually for 15 years. Based on prior project experience.
17	Cap and Monitoring Well Monitoring, Maintenance and Reporting	LS/YR	1	$10,000	$10,000	Assumed periodic maintenance and/or well replacement. Based on prior project experience.
18	Institutional Controls	LS/YR	1	$5,000	$5,000	Assumes annual costs for 15 years for maintaining institutional controls. Based on prior project experience.
Annual Operation and Maintenance Sub-Total					**$45,000**	
Present Value Operation and Maintenance Costs over estimated duration of 15 years					**$578,217**	Present value calculated using equal series present value formula assuming discount rate of 2%. Based on Real 30-year discount rate published in February 2023 Office of Management and Budget Circular No. A-94.
Total Estimated Costs for Alternative 1 (without Contingency)					**$1,468,606**	
Low Range of Estimated Costs for Alternative 1 (-30%) Without Contingency					**$1,028,024**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study."
High Range of Estimated Costs for Alternative 1 (+50%) Without Contingency					**$2,202,908**	

Notes:

[1] Quantity is an estimate at the level of "concept design."

[2] Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgement. Unit costs are presented in 2025 dollars.

LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; EA = each; YR = year

Table B-4

Alternative 3: ISCR with AC (AOC1 & AOC2), Excavation (AOC3), MNA (AOC4)

Former Precision Engineering, Inc.
Seattle, Washington

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Direct Capital Construction Costs						
ISCR with AC (AOC1 & AOC2)						
1	Treatability/Pilot Study For In-Situ Technologies	LS	1	$50,000	$50,000	Assumes small pilot study and quarterly data collection to determine reagent estimates. Cost based on previous project experience.
2	Decommission Monitoring Wells	EA	3	$1,000	$3,000	Based on bid pricing for previous projects for shallow wells (chip in place).
3	Injection Event	Event	1	$435,000	$435,000	Based on vendor cost estimate for product and application. Includes concrete floor repair.
4	New Monitoring Well Installation	EA	3	$10,000	$30,000	Assumes new wells to be installed for pilot testing and compliance monitoring. Based on previous project experience.
5	Baseline and Performance Monitoring and Reporting	LS/Event	5	$15,000	$75,000	Labor and analytical costs to collect baseline site data and evaluate effectiveness of treatment (4 monitoring events per year at 8 monitoring wells). Based on previous project experience.
Excavation (AOC4)						
6	Excavation	BCY	148	$55	$8,140	Based on vendor estimate to approximately 5 feet bgs and includes surface demolition and disposal, and site restoration (concrete repair).
7	Load, Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	222	$125	$27,750	Assume excavated material will be disposed at Subtitle D facility and 1.5 tons per cubic yard. Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Based on previous project experience.
8	Restoration: Backfill and Hydroseeding	SF	20,000	$1.0	$20,000	Restoration including backfilling with clean soil, hydroseeding and vegetation establishment monitoring.
				Direct Capital Costs Sub-Total	**$648,890**	
Indirect Capital Construction Costs						
9	Work Plan and Procurement	LS	1	$50,000	$50,000	Assumes lump sump costs to prepare work planning and procurement documents.
10	Remedial Design	% of TDC	3%	--	$19,467	Includes pre-remedial design, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
11	Permitting	% of TDC	1%	--	$6,489	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
12	Construction Management/Oversight	% of TDC	6%	--	$38,933	Construction management includes field oversight, contractor submittal review, design modifications, construction schedule tracking and completion report. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
13	Project Management	% of TDC	6%	--	$38,933	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
14	Ecology Oversight	% of TDC	1%	--	$6,489	Professional judgment.
15	Environmental Covenant	LS	1	$30,000	$30,000	Costs include coordination with Ecology, adjacent property owners, legal fees, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$190,311**	

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Annual Operation and Maintenance Costs (10 years)						
16	Groundwater and Indoor Air Monitoring and Reporting	LS/YR	1	$30,000	$30,000	Annually for 10 years. Based on prior project experience.
17	Cap and Monitoring Well Monitoring, Maintenance and Reporting	LS/YR	1	$10,000	$10,000	Assumed periodic maintenance and/or well replacement. Based on prior project experience.
18	Institutional Controls	LS/YR	1	$5,000	$5,000	Assumes annual costs for 10 years for maintaining institutional controls. Based on prior project experience.
					Annual Operation and Maintenance Sub-Total	**$45,000**	
					Present Value Operation and Maintenance Costs over estimated duration of 10 years	**$404,216**	Present value calculated using equal series present value formula assuming discount rate of 2%. Based on Real 10-year discount rate published in February 2023 Office of Management and Budget Circular No. A-94.
					Total Estimated Costs for Alternative 1 (without Contingency)	**$1,243,418**	
					Low Range of Estimated Costs for Alternative 1 (-30%) Without Contingency	**$870,392**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study."
					High Range of Estimated Costs for Alternative 1 (+50%) Without Contingency	**$1,865,126**	

Notes:

[1] Quantity is an estimate at the level of "concept design."

[2] Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgement. Unit costs are presented in 2025 dollars.

LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; EA = each; YR = year

Table B-5

Alternative 4: ISS (AOC1), ISCR with AC (AOC2), Excavation (AOC3), MNA (AOC4)

Former Precision Engineering, Inc.
Seattle, Washington

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Direct Capital Construction Costs						
ISS (AOC1)						
1	Treatability/Pilot Study For In-Situ Technologies	LS	1	$50,000	$50,000	Assumes small pilot study and quarterly data collection to determine reagent estimates. Cost based on previous project experience.
2	Decommission Monitoring Wells	EA	2	$1,000	$2,000	Based on bid pricing for previous projects for shallow wells (chip in place).
3	ISS using Excavation Methods	Lump Sum	1	$300,000	$300,000	Based on vendor estimate and includes surface demolition and disposal, and site restoration (concrete repair).
4	Load, Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	200	$575	$115,000	Assume ISS swell equal to 25% of stabilization volume. Assume ISS swell will be disposed at Subtitle C facility. Includes cost for handling, loading, transport and off-site disposal of hazardous material at an approved Subtitle C disposal facility. Based on vendor estimate and previous project experience.
5	New Monitoring Well Installation	EA	2	$10,000	$20,000	Assumes new wells to be installed for pilot testing and compliance monitoring. Based on previous project experience.
ISCR with AC (AOC2)						
2	Decommission Monitoring Wells	EA	1	$1,000	$1,000	Based on bid pricing for previous projects for shallow wells (chip in place).
3	Injection Event	Event	1	$250,000	$250,000	Based on vendor cost estimate for product and application. Includes concrete floor repair.
4	New Monitoring Well Installation	EA	1	$10,000	$10,000	Assumes new wells to be installed for pilot testing and compliance monitoring. Based on previous project experience.
5	Baseline and Performance Monitoring and Reporting	LS/Event	5	$15,000	$75,000	Labor and analytical costs to collect baseline site data and evaluate effectiveness of treatment (4 monitoring events per year at 8 monitoring wells). Based on previous project experience.
Excavation (AOC4)						
6	Excavation	BCY	148	$55	$8,140	Based on vendor estimate to approximately 5 feet bgs and includes surface demolition and disposal, and site restoration (concrete repair).
7	Load, Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	222	$125	$27,750	Assume excavated material will be disposed at Subtitle D facility and 1.5 tons per cubic yard. Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Based on previous project experience.
8	Restoration: Backfill and Hydroseeding	SF	20,000	$1.0	$20,000	Restoration including backfilling with clean soil, hydroseeding and vegetation establishment monitoring.
				Direct Capital Costs Sub-Total	**$878,890**	
Indirect Capital Construction Costs						
7	Work Plan and Procurement	LS	1	$50,000	$50,000	Assumes lump sump costs to prepare work planning and procurement documents.
8	Remedial Design	% of TDC	3%	--	$26,367	Includes pre-remedial design, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
9	Permitting	% of TDC	1%	--	$8,789	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
10	Construction Management/Oversight	% of TDC	6%	--	$52,733	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
11	Project Management	% of TDC	6%	--	$52,733	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
12	Ecology Oversight	% of TDC	1%	--	$8,789	Professional judgment.
13	Environmental Covenant	LS	1	$30,000	$30,000	Costs include coordination with Ecology, adjacent property owners, legal fees, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$229,411**	

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Annual Operation and Maintenance Costs (5 years)						
14	Groundwater and Indoor Air Monitoring and Reporting	LS/YR	1	$30,000	$30,000	Annually for 5 years. Based on prior project experience.
15	Cap and Monitoring Well Monitoring, Maintenance and Reporting	LS/YR	1	$10,000	$10,000	Assumes well replacement for wells within ISS area, and then periodic maintenance/repairs. Based on prior project experience.
16	Institutional Controls	LS/YR	1	$5,000	$5,000	Assumes annual costs for 5 years for maintaining institutional controls. Based on prior project experience.
Annual Operation and Maintenance Sub-Total					**$45,000**	
Present Value Operation and Maintenance Costs over estimated duration of 5 years					**$212,106**	Present value calculated using equal series present value formula assuming discount rate of 2%. Based on Real 30-year discount rate published in February 2023 Office of Management and Budget Circular No. A-94.
Total Estimated Costs for Alternative 1 (without Contingency)					**$1,320,407**	
Low Range of Estimated Costs for Alternative 1 (-30%) Without Contingency					**$924,285**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study."
High Range of Estimated Costs for Alternative 1 (+50%) Without Contingency					**$1,980,610**	

Notes:

[1] Quantity is an estimate at the level of "concept design."

[2] Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgement. Unit costs are presented in 2025 dollars.

LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; EA = each; YR = year

Table B-6

Alternative 5: Targeted Excavation (AOC1, AOC2, AOC4), Excavation (AOC3)

Former Precision Engineering, Inc.
Seattle, Washington

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Direct Capital Construction Costs						
Excavation and Off-Site Disposal (AOC1 through AOC4)						
1	Excavation	Lump Sum	1	$620,000	$620,000	Based on vendor estimate to approximately 5 feet bgs and includes surface demolition and disposal, and site restoration (concrete repair).
2	Decommission Monitoring Wells	EA	4	$1,000	$4,000	Based on bid pricing for previous projects for shallow wells (chip in place).
3	Load, Transport and Dispose Contaminated Material at Subtitle D Landfill	TON	1,797	$125	$224,625	Assume 65% of excavated material will be disposed at Subtitle D facility. Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle D disposal facility. Based on previous project experience.
4	Load, Transport and Dispose Contaminated Material at Subtitle C Landfill	TON	300	$575	$172,500	Assume 35% of excavated material from AOC1 will be disposed at Subtitle C facility. Includes cost for handling, loading, transport and off-site disposal of non-dangerous contaminated material at an approved Subtitle C disposal facility. Based on previous project experience.
5	New Monitoring Well Installation	EA	4	$10,000	$40,000	Assumes new wells to be installed for compliance monitoring. Based on previous project experience.
6	Baseline and Performance Monitoring and Reporting	LS/Event	5	$15,000	$75,000	Labor and analytical costs to collect baseline site data and evaluate effectiveness of treatment (4 monitoring events per year at 8 monitoring wells). Based on previous project experience.
				Direct Capital Costs Sub-Total	**$1,136,125**	
Indirect Capital Construction Costs						
7	Work Plan and Procurement	LS	1	$50,000	$50,000	Assumes lump sump costs to prepare work planning and procurement documents.
8	Remedial Design	% of TDC	3%	--	$34,084	Includes pre-remedial design, remedial design sampling plans, design support studies, engineering survey, plans and specifications, engineers estimate, bid documents and contracting support. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
	Permitting	% of TDC	1%	--	$11,361	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
9	Construction Management/Oversight	% of TDC	6%	--	$68,168	Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
10	Project Management	% of TDC	6%	--	$68,168	Project management includes meetings, planning, coordination, cost and performance reporting. Indirect percentages based on EPA 2000 guidance (EPA, 2000. A Guide to Developing and Documenting Cost Estimates During the Feasibility Study. EPA 540-R-00-002. OSWER 9355.0-75) and professional judgment.
11	Ecology Oversight	% of TDC	1%	--	$11,361	Professional judgment.
12	Environmental Covenant	LS	1	$30,000	$30,000	Costs include coordination with Ecology, adjacent property owners, legal fees, etc. Costs based on professional judgment.
				Indirect Capital Costs Sub-Total	**$273,141**	

Item No.	Description	Unit	Estimated Quantity[1]	Unit Cost[2] (2025 $)	Estimated Cost	Notes
Annual Operation and Maintenance Costs (10 years)						
13	Groundwater and Indoor Air Monitoring and Reporting	LS/YR	1	$30,000	$30,000	Assume annual monitoring of groundwater and indoor air for 10 years.
14	Cap and Monitoring Well Monitoring, Maintenance and Reporting	LS/YR	1	$10,000	$10,000	Assumes well replacement for wells within excavation area, and then periodic maintenance/repairs. Based on prior project experience.
15	Institutional Controls	LS/YR	1	$5,000	$5,000	Assumes annual costs for 10 years for maintaining institutional controls. Based on prior project experience.
Annual Operation and Maintenance Sub-Total					**$45,000**	
Present Value Operation and Maintenance Costs over estimated duration of 10 years					**$404,216**	Present value calculated using equal series present value formula assuming discount rate of 2%. Based on Real 30-year discount rate published in February 2023 Office of Management and Budget Circular No. A-94.
Total Estimated Costs for Alternative 1 (without Contingency)					**$1,813,483**	
Low Range of Estimated Costs for Alternative 1 (-30%) Without Contingency					**$1,269,438**	Accuracy of the total remedial alternative cost is considered -30 to +50 %, a range based on EPA's "A Guide to Developing and Documenting Cost Estimates During the Feasibility Study."
High Range of Estimated Costs for Alternative 1 (+50%) Without Contingency					**$2,720,224**	

Notes:

[1] Quantity is an estimate at the level of "concept design."

[2] Unit costs based on review of: construction cost estimates solicited from applicable vendors and contractors; actual costs incurred during similar, applicable projects; RS Means Construction Cost Data, and professional judgement. Unit costs are presented in 2025 dollars.

LS = lump sum; TDC = total direct capital costs; EPA = Environmental Protection Agency; EA = each; YR = year

Appendix C

PMEP Tool Results

Table 1: Input Data and Cost-Effectiveness Calculations									
Site Information	**Alternative name and present value of total cost of each alternative**								
Site Name	**Alternative Name**	**Alt 1**	**Alt 2**	**Alt 3**	**Alt 4**	**Alt 5**	**not used**	**not used**	**not used**
Former Precision Engineering, Inc.	**Cost ($ in millions)**	$1.06	$1.47	$1.24	$1.32	$1.81			
CSID	**Cost-confidence Upper (+)%**	50%	50%	50%	50%	50%			
4532	**Cost-confidence Lower (-)%**	30%	30%	30%	30%	30%			
Benefit Inputs									
DCA Benefit Criteria	**Weight (%)**	**Scores (relative degrees of benefit)**							
Protectiveness	35%	4.0	6.0	7.0	9.0	8.0			
Permanence (no ties–see cell note)	20%	3.0	5.0	7.0	8.0	9.0			
Long-term effectiveness	25%	4.0	6.0	8.0	9.0	8.0			
Implementation Risk Management	10%	10.0	9.0	9.0	8.0	7.0			
Implementability	10%	10.0	9.0	9.0	8.0	7.0			
Total weighted degrees of benefit	**100%**	**5.00**	**6.40**	**7.65**	**8.60**	**8.00**	**0.00**	**0.00**	**0.00**
Cost Effectiveness (million dollars per total weighted degrees of benefit)									
Cost Effectiveness ($/B)		**$0.21**	**$0.23**	**$0.16**	**$0.15**	**$0.23**			

Table 2: DCA Calculations

	Alternative	Cost ($ millions)	Degrees of Benefit	Permanence Score	Permanence Rank		DCA Order	Alternative	Permanence Score	Cost ($ millions)	Degrees of Benefit	**Cost Effectiveness ($/B)**	**Apparent PMEP Alternative**
Estimated costs	**Alt 1**	**$1.06**	**5.0**	**3.0**	5	alternatives in order of decreasing permanence →	1	**Alt 5**	9.0	$1.81	8.0	**$0.23**	**NO**
and	**Alt 2**	**$1.47**	**6.4**	**5.0**	4		2	**Alt 4**	8.0	$1.32	8.6	**$0.15**	**PMEP**
degrees of benefit	**Alt 3**	**$1.24**	**7.7**	**7.0**	3		3	**Alt 3**	7.0	$1.24	7.7	**$0.16**	**NO**
from the	**Alt 4**	**$1.32**	**8.6**	**8.0**	2		4	**Alt 2**	5.0	$1.47	6.4	**$0.23**	**NO**
RI/FS	**Alt 5**	**$1.81**	**8.0**	**9.0**	1		5	**Alt 1**	3.0	$1.06	5.0	**$0.21**	**NO**
	not used						6		#N/A				
	not used						7		#N/A				
	not used						8		#N/A				

Table 3: Chart Data & Error Bar Calculations										
Alternative	Permanence Score	Cost Effectiveness ($/B)	Cost ($ millions)	Cost confidence (+) %	Cost confidence (-) %	Degrees of Benefit	High Cost ($/B)	Low Cost ($/B)	Upper error range	Lower error range
Alt 5	9.0	$0.23	$1.81	50%	30%	8.0	$0.34	$0.16	$0.11	$0.07
Alt 4	8.0	$0.15	$1.32	50%	30%	8.6	$0.23	$0.11	$0.08	$0.05
Alt 3	7.0	$0.16	$1.24	50%	30%	7.7	$0.24	$0.11	$0.08	$0.05
Alt 2	5.0	$0.23	$1.47	50%	30%	6.4	$0.34	$0.16	$0.11	$0.07
Alt 1	3.0	$0.21	$1.06	50%	30%	5.0	$0.32	$0.15	$0.11	$0.06
	#N/A			Not Found	Not Found		#VALUE!	#VALUE!	#VALUE!	#VALUE!
	#N/A			Not Found	Not Found		#VALUE!	#VALUE!	#VALUE!	#VALUE!
	#N/A			Not Found	Not Found		#VALUE!	#VALUE!	#VALUE!	#VALUE!

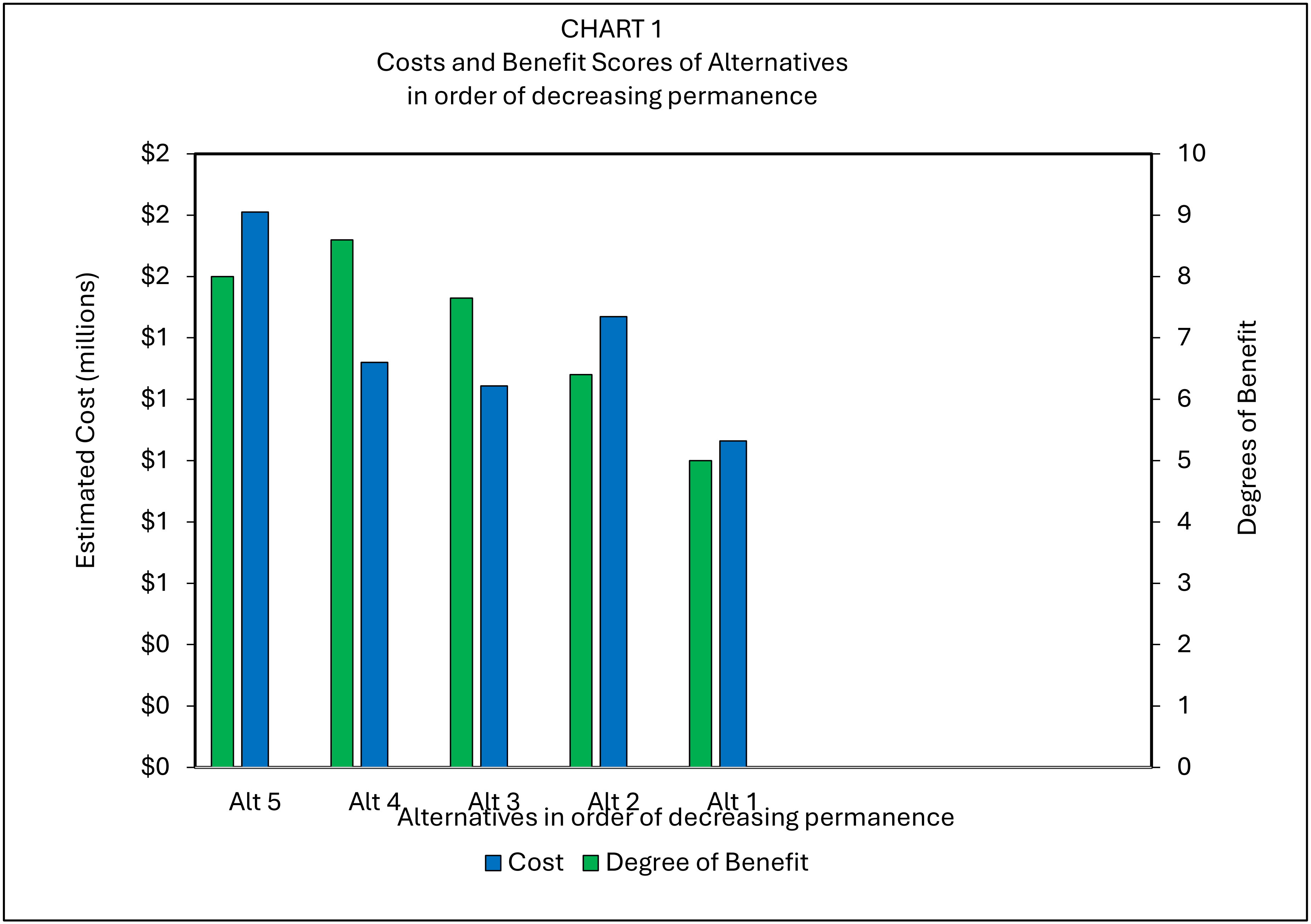
CHART 1
Costs and Benefit Scores of Alternatives
in order of decreasing permanence
Estimated Cost (millions)
$2
$2
$2
$1
$1
$1
$1
$1
$0
$0
$0
Degrees of Benefit
10
9
8
7
6
5
4
3
2
1
0
Alt 5
Alt 4
Alt 3
Alt 2
Alt 1
Alternatives in order of decreasing permanence
Cost
Degree of Benefit

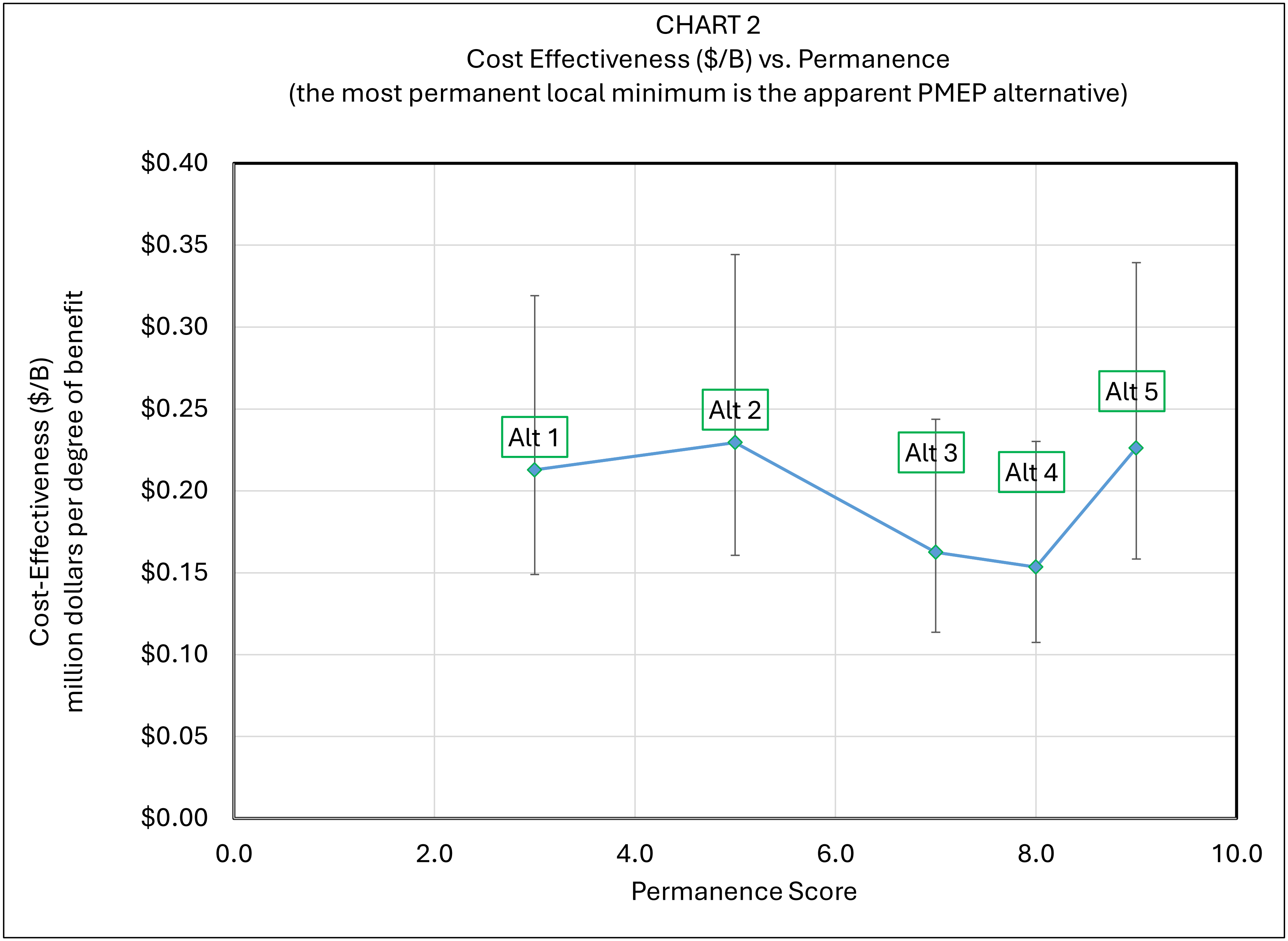
CHART 2
Cost Effectiveness ($/B) vs. Permanence
(the most permanent local minimum is the apparent PMEP alternative)
Cost-Effectiveness ($/B)
million dollars per degree of benefit
$0.40
$0.35
$0.30
$0.25
$0.20
$0.15
$0.10
$0.05
$0.00
0.0
2.0
4.0
6.0
8.0
10.0
Permanence Score
Alt 1
Alt 2
Alt 3
Alt 4
Alt 5