Feasibility Study Addendum

Parcel 15 (Portac) Investigation

Ecology Facility Site No. 1215 / Cleanup Site No. 3642

February 2019

Prepared for

Port of Tacoma

Prepared by

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Abbreviations and Acronyms

µg/L	microgram per liter
ARAR	applicable or relevant and appropriate requirement
bgs	below ground surface
CAP	Cleanup Action Plan
CMMP	contaminated media management plan
cm	centimeter
cm/sec	centimeter per second
CSL	cleanup screening level
CUL	MTCA’s Cleanup Levels
CWA	Clean Water Act
DCA	disproportionate cost analysis
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FRTR	Federal Remediation Technologies Roundtable
FS	feasibility study
GCL	geosynthetic clay liner
GSI	GSI Water Solutions, Inc.
HDPE	high-density polyethylene
HMA	hot mix asphalt
IC	institutional control
LEL	lower explosive limit
LLC	limited liability company
Log Yard	former log yard area at the Site
mg/kg	milligram per kilogram
MLLW	mean lower low water
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
NPDES	National Pollutant Discharge Elimination System
NPV	net present value
O&M	operation and maintenance
OF	outfall
Order	Agreed Order
PCP	pentachlorophenol
pH	negative log of the hydrogen ion concentration in solution
POC	point of compliance
Port	Port of Tacoma
Portac	Portac, LLC
PPE	personal protective equipment
PQL	practical quantification limits
PRB	permeable reactive barrier
PSL	Preliminary Screening Levels
RCC	roller-compacted concrete
RCW	Revised Code of Washington
REL	remediation levels
RI	remedial investigation
RI/FS	Remedial Investigation/Feasibility Study
Sawmill	former sawmill area at the Site

SCO	sediment cleanup objective
Site	Parcel 15 – Former Portac sawmill and log yard
SMS	sediment management standards
SR	State Route
SSPA	S.S. Papadopulos & Associates
SVOC	semivolatile organic compound
SWAC	surface weighted average concentration
VCP	Ecology’s Voluntary Cleanup Program
VOC	volatile organic compound
WAC	Washington Administrative Code
ZVI	zero valent iron

1 Introduction

This Feasibility Study Addendum (FS Addendum) was prepared by GSI Water Solutions, Inc. (GSI), on behalf of the Port of Tacoma (Port) to provide additional information in support of the Public Review Draft Feasibility Study (FS) submitted to the State of Washington Department of Ecology (Ecology) in February 2018 (GSI, 2018). The FS was developed in accordance with the requirements of the Agreed Order (Order) No. DE11237 between Ecology, the Port, and Portac, pursuant to the Washington State Model Toxics Control Act ([MTCA]; Revised Code of Washington [RCW] 70.105D), MTCA regulations (Washington Administrative Code [WAC] Chapter 173-340), and Washington's Sediment Management Standards (SMS; WAC 173-204).

The objective of the FS was to address concerns raised during the Remedial Investigation (RI) and identified in the Final RI Report (GSI and SSPA, 2017), screen remedial alternatives compiled in the FS Technical Memorandum (GSI, 2017), and select a preferred remedial alternative. This FS Addendum is being submitted to provide an additional remedial alternative and corresponding evaluation; substantial information concerning the site description, cleanup standards, and description of remedial technologies is contained in the FS and is referenced heavily herein. This FS addendum and the Public Review Draft Feasibility Study constitute the complete Feasibility Study.

2 Site Description

2.1 Site Location

Parcel 15 (the Site[1]) consists of an approximately triangular parcel of about 52 acres of land owned by the Port. The Site is located at 4215 State Route (SR) 509 – North Frontage Road in an industrial area between Interstate 5 and Commencement Bay, in Tacoma, Washington, as shown in Figure 1. The Site is bounded by East 4th Street (northern boundary), Alexander Avenue East (western boundary), and North Frontage Road (SR 509) (southeastern boundary). Wapato Creek is situated between Alexander Avenue East and the western edge of the property, and empties into the Blair Waterway through a culvert under East 4th Street. The Blair Waterway is in the southern portion of Commencement Bay, one of multiple industrial waterways developed in the 1900s to support international commerce.

2.2 Site History

Portac and its predecessors leased the Site from the Port beginning in 1974 and vacated the Site in 2009. The Site consists of two functionally distinct historical use areas: the former sawmill area (Sawmill) in the southwestern part of the property, and the former log yard area (Log Yard) occupying the remainder of the Site.

Historical industrial activities conducted on the Site adversely impacted upland soil, groundwater, and surface water in the adjacent Wapato Creek. Environmental investigations and cleanup under Ecology oversight have been ongoing since the late 1980s; they are described in Section 2 of the RI Report and are summarized in the FS.

1 For the purpose of the FS Report, the Site encompasses the Log Yard and Sawmill, and is based on the Site Boundary shown in Exhibit A of the Order. The final Site definition will be updated in the Draft CAP to include any migration of Site-related contamination outside of that Site Boundary.

2.3 Conceptual Site Model

This section provides a brief summary of the Site's conceptual site model as presented in Section 8 and Appendix G of the RI Report.

The Site encompasses the Log Yard and Sawmill. Currently, the Log Yard is capped with roller-compacted concrete (RCC), installed as part of a remedial action, with two subsurface stormwater conveyance lines serving as Log Yard drainage (Figure 2). Currently, the Sawmill is partially paved; however, the particular area of interest (the former dip tank) remains unpaved.

The Site-associated contaminants identified for cleanup are arsenic and PCP, with arsenic being the primary driver in the Log Yard, and PCP being the primary driver in the Sawmill. In addition, methane gas is identified as a Site-associated contaminant in the Log Yard and portions of the Sawmill. Further summary description is provided in Section 2.3 of the FS.

3 Cleanup Standards

As discussed in Section 8.1 of the RI Report, the Site-associated contaminants driving the RI and the need for added cleanup at the Site are arsenic and PCP, with arsenic being the primary driver in the Log Yard (Section 8.3.1 of the RI Report), and PCP being the primary driver in the Sawmill, although arsenic and pH also are elevated in some locations in the Sawmill (Section 8.3.2 of the RI Report). In addition, methane gas is identified as a Site-associated contaminant and is present as a result of decomposition of the wood waste associated with the fill containing slag or decomposition of naturally occurring organics (e.g., tide flat deposits). Soil and groundwater cleanup standards must be set for these Site-associated contaminants to ensure that the quality of the cleanup and protection of human health and the environment are not compromised.

A cleanup standard is defined by establishing the following two components of the standard (1) cleanup level (CUL) (s); and (2) POC(s). The CUL is the concentration of a hazardous substance that must be met to avoid risks to human health and the environment through a specified exposure pathway. POCs designate the location on the site where the CULs must be met. Ecology will select final CULs and associated POCs in the Cleanup Action Plan (CAP). Proposed CULs and POCs for purposes of evaluating cleanup actions (i.e., alternatives) and the potential need for conditional POCs and/or contingent remediation levels (RELs) are presented in Section 3 of the FS.

4 Remedial Technology Screening

Potentially applicable remedial technologies for addressing arsenic-impacted groundwater in the Log Yard and residual PCP in the Sawmill were initially screened and identified in Section 4 of the FS.

5 Remedial Technologies

General discussion of each remedial technology and Site-specific application details are provided in Section 5 of the FS. Remedial technologies determined to be effective and implementable through the preliminary screening were advanced for Site-specific consideration.

6 Remedial Alternatives

Drawing from the retained technologies evaluated in Section 5 of the FS and considering Site-specific conditions, five remedial alternatives were initially developed for the Log Yard and three for the Sawmill. These alternatives are presented in Section 6 of the FS. The subsequent sections provide details on a proposed sixth alternative for the Log Yard; no further alternatives were developed for the Sawmill.

6.1 Log Yard Remedial Alternative

The following remedial alternative description builds upon the FS Section 6 for the Log Yard. This remedial alternative is constructed from a selection of remedial technologies presented in FS Section 5. Because of its similarity to Alternative 3, it is labeled Alternative 3A. A matrix of the alternatives and associated remedial technologies is provided in Table 1. Table 1A shows a general timeline for the implementation of Alternative 3A.

6.1.1 Alternative 3A (Figure 4)

- **Conveyance System Improvements:** Conveyance system improvements for this alternative include the installation of tide gates, removal of the spill containment vessels, and slip lining or other trenchless pipe installation over two construction seasons. In the first construction season, tide gates would be installed at each outfall to prevent diurnal backflow from Wapato Creek. Additionally, an evaluation of the pipe seepage would be conducted in the first construction season and any significant accumulated debris in the stormwater system removed. The investigation would include, but not be limited to, conducting dry weather flow sampling at incremental stations. Removal of the spill containment vault and slip lining the conveyance pipes, or other trenchless pipe repair, between Wapato Creek and the removed vaults would be completed during the second construction season. Table 1A shows an estimated timeline for conveyance system improvements.

  The plan to remove the spill containment vaults is based upon follow-up evaluations of the vaults after the submittal of the FS, where it was determined that the vaults could not be easily sealed. A section of pipe or stormwater vault would then be installed in place of each of the existing vaults.

- **Perched Groundwater Treatment:** This alternative assumes that the perched groundwater would be treated as an early step as part of the phased remedy. This element of the alternative would change the interaction between the infiltrating stormwater and the fill containing slag by capturing perched water with a French Drain type collection systems (see Figure 5). A French Drain or similar groundwater collection system would be designed to remove accumulated water in perched groundwater zones. The system would likely require the use of several laterals spanning the north/south extent of the Log Yard. Conceptually, the system could be a perforated drain pipe within a layer of drain rock, sloped to drain to one or more collector vaults. Alternatively, the perforated drain pipes could be jacked horizontally into place from each collector vault to limit penetrations through the existing cap. Accumulating perched water would be treated in situ in the collector vaults that infiltrated downward into a more permeable layer. Overflow from the collector vaults would flow to a trench in the Sawmill Area where it would be treated in situ and infiltrated. Treatment would be provided by a reactive media (e.g. ZVI) to meet cleanup levels at a designated compliance point.

- **Additional Conveyance System Improvements based on Performance Monitoring:** Performance monitoring would be conducted for the conveyance system improvements and perched groundwater treatment system installation after completion of construction of each of these elements. If seepage into the conveyance system with elevated arsenic detections continues after conveyance system improvements, additional sections of pipe would be slip lined or sealed via other trenchless pipe technologies upstream of the removed vaults. Based on preliminary analysis in the RI Report and comparison of groundwater to existing conveyance piping, it is assumed that the primary target repair areas would extend from the outfalls to the spill containment vessels. Groundwater levels in the perched groundwater would be monitored for trends. Findings from this monitoring will be used to evaluate the timing and need for the permeable reactive barrier and low-permeability cap.
- **Permeable Reactive Barrier**: This alternative assumes the PRB would be installed after the perched groundwater treatment system and prior to cap enhancement. It would act as part of the primary remedy. The timing of the PRB installation would be based on the findings from monitoring the perched groundwater treatment system. The PRB would be installed parallel to Wapato Creek along the westernmost boundary of the cap and along a portion of the northwestern boundary (see Figures 4 and 5). The PRB would extend to below the streambed of Wapato Creek and would be expected to key into the underlying low permeability silts. It would be backfilled with reactive media (e.g. iron filing or ZVI) to treat dissolved arsenic in the groundwater passing through the PRB. Before installation, a design study (including bench scale testing) would be completed to determine the appropriate dimensions and composition of the PRB to optimize treatment and long-term effectiveness. Based on preliminary analysis, it is expected that the PRB would extend to a depth of approximately 25 feet bgs with reactive media placed between the interval of 10 and 25 feet bgs to intercept impacted groundwater (Figure 5). A low-permeability material to inhibit surface water infiltration and provide structural strength, such as a low-strength concrete, would be placed atop the reactive media and to restore the grade. The PRB performance and the MNA program would be monitored to determine effectiveness and the reactive media replenishment schedule.
- **Contingency Low-Permeability Cap (Rubblize RCC and Install Clay Liner):** In this alternative, the cap proposed in Alternative 3 (see Section 6 of the FS), or land use improvements creating an equivalent hydraulic barrier as the low-permeability geosynthetic clay liner (GCL), would be constructed. Differing from Alternative 3, the proposed cap is contingent upon the performance of the PRB and site development. For cost estimating, it was assumed that the low-permeability cap would be constructed, if needed, 5 years after construction of the PRB. The timing of the construction of the low-permeability cap, if needed, would be adjusted to match up with additional development at the site (e.g. warehouse construction).

In the event the low-permeability cap is needed, the existing RCC cap would be rubblized and the underlying gravel course removed to install a low-permeability GCL atop the fill containing slag and sloped to drain. The GCL could have an effective permeability of approximately $3x10^{-9}$ cm/sec and generally good long-term performance against settlement because of the cohesive nature of associated clay material (Appendix B of the FS). A working surface would be constructed atop the GCL and the Site would be restored to a similar existing grade. It is assumed rubblized RCC and existing gravel are adequate materials for constructing the subgrade for the working surface and would be stockpiled for reuse. The working surface generally would be composed sequentially of a geogrid, gravel, and standard HMA surface (typical cross section and evaluation provided in Appendix B of the FS). While the HMA surface would reduce stormwater infiltration, it would not be maintained as an environmental cap and would undergo regular Port operational maintenance. GCL maintenance would incorporate repairs to the GCL as needed and could be accomplished through spot excavation and GCL patch installation.

- **Monitored Natural Attenuation**: Conduct a monitoring program to evaluate arsenic attenuation and cap performance within the groundwater flow path between capped areas and POCs. MNA is described in more detail in FS Section 5.1.1.

- **Institutional Controls:** Attach the CMMP, contamination notifications, and land development restrictions to the property deed. Deed restrictions would describe how to maintain Site conditions, cap maintenance, protection of the PRB, and maintenance of the stormwater conveyance system. ICs are described in more detail in FS Section 5.7.

7 Remedial Alternative Evaluation Criteria

This section provides descriptions of the MTCA requirements and evaluation criteria used to determine the efficacy of the assembled alternatives.

7.1 Threshold Requirements

Remedial actions performed under MTCA must meet a set of minimum requirements or threshold requirements. Per WAC 173-340-360(2)(a), alternatives that do not meet the threshold requirements are not considered viable remedial alternatives under MTCA. Threshold requirements are as follows:

- **Protect human health and environment –** Consider the degree to which an alternative meets MTCA cleanup standards, the degree to which the remedy is permanent, and the short-term risk associated with implementing the remedy.
- **Comply with cleanup standards –** For an alternative to be considered viable, the alternative must comply with cleanup standards, including the CULs, POCs, and ARARs discussed in Section 3.
- **Comply with applicable state and federal laws –** Remedial actions under MTCA must comply with applicable state and federal laws deemed relevant as discussed in Section 3.

- **Provide for compliance monitoring –** Per WAC 173-340-410, compliance monitoring can include protection, performance, or confirmational monitoring. For remedies that propose onsite disposal, isolation, or containment as the selected cleanup action for all or a portion of a site, a long-term monitoring plan is required.

7.2 Other MTCA Requirements

- **Use permanent solutions to the maximum extent practicable –** Per WAC 173-340-200, a permanent solution means a cleanup action that meets cleanup standards without further action being required at the site or any other site involved with the cleanup action, other than the approved disposal of any residue from the treatment of hazardous substances.
- **Provide for a reasonable restoration time frame –** Per WAC 173-340-360(4), cleanup actions should provide for a reasonable restoration timeline considering factors such as:
    - Potential risks posed by the site to human health and the environment
    - Practicability of achieving a shorter restoration time frame
    - Current use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
    - Potential future use of the site, surrounding areas, and associated resources that are, or may be, affected by releases from the site
    - Availability of alternative water supplies
    - Likely effectiveness and reliability of ICs
    - Ability to control and monitor migration of hazardous substances from the site
    - Toxicity of the hazardous substances at the site
    - Natural processes that reduce concentrations of hazardous substances and have been documented to occur at the site or under similar site conditions
- **Consider public concerns –** As outlined in WAC 173-340-600, MTCA provides for public participation through various avenues including public notices, a site register, public meetings, etc. Specific notice requirements must be followed for, among others, off-property conditional POCs and CULs for groundwater flowing into nearby surface water.

7.3 Disproportionate Cost Analysis (DCA)

The MTCA DCA calls for comparing the costs and benefits of alternatives and selecting the alternative with incremental costs that are not disproportionate to the incremental benefits. The evaluation criteria for the DCA are specified in WAC 173-340-360(2) and (3), and include protectiveness, permanence, cost, long-term effectiveness, management of short-term risks, implementability, and consideration of public concerns. As outlined in WAC 173-340-360(3), MTCA provides a methodology that uses the criteria listed below.

- **Protectiveness –** The overall protectiveness of a cleanup action alternative is evaluated on the basis of several factors: overall protectiveness of human health and the environment, including the degree to which existing risks are reduced; time required to reduce the risk at the Site and attain cleanup standards; onsite and offsite risks resulting from implementing the alternative; and improvement of the overall environmental quality.

- **Permanence –** MTCA specifies that when selecting a remedial alternative, preference will be given to actions that are "permanent solutions to the maximum extent practicable." Evaluation criteria include 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.
- **Cost –** Costs associated with implementing an alternative include design, construction, long-term monitoring, agency oversight, ICs, the net present value (NPV) of any long-term costs, and agency oversight. Long-term costs include operation and maintenance costs, monitoring costs, equipment replacement costs, and the cost of maintaining ICs. Unit costs were developed using construction cost estimates provided by relevant vendors and contractors, review of actual costs incurred from past remediation projects, EPA and Interstate Technology and Regulatory Council guidance documents, and professional judgment (Appendix A).
- **Long-Term Effectiveness –** Long-term effectiveness is the degree of certainty that the alternative will be successful in maintaining compliance with cleanup standards during the long-term performance of the cleanup action, the magnitude of residual risk with the alternative in place, and the effectiveness of controls required to manage treatment residues or remaining wastes. MTCA provides a guide for ranking the long-term effectiveness of different types of technologies. MTCA ranks technologies in descending order as follows:
    - Reuse or recycling
    - Detoxification
    - Immobilization or solidification
    - Disposal in an engineered, lined, and monitored facility
    - Onsite isolation/containment with attendant engineered controls
    - ICs and monitoring
- **Management of Short-Term Risks –** The risk to human health and the environment associated with the alternative during construction and implementation, and the effectiveness of measures that will be taken to manage such risks.
- **Implementability –** The ability of the alternative to be implemented, including consideration of whether the alternative is technically possible; availability of necessary offsite facilities, services and materials; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirement; access for construction operations and monitoring; and integration with existing facility operations and other current or potential remedial actions. It also includes administrative factors associated with permitting and completing the cleanup.
- **Consideration of Public Concerns –** Consideration about whether the community has concerns regarding the alternative and, if so, the extent to which the alternative addresses those concerns. This process includes concerns from individuals, community groups, local governments, tribes, federal and state agencies, or any other organization that may have an interest in or knowledge of the site.

8 Alternative Evaluation

This section provides an evaluation and comparative analysis of Alternative 3A for Log Yard using the MTCA criteria outlined in the Section 7.1. Detailed evaluation of other Log Yard and Sawmill remedial alternatives is included in Section 8 of the FS. For the purposes of this FS Addendum the evaluation summaries and resulting DCA scores of the Log Yard remedial alternatives are carried through from the FS and included in Table 2 for comparison to Log Yard Alternative 3A. Figure 6 depicts the relative cost/benefit rankings from the DCA for all Log Yard alternatives.

8.1 Threshold Requirements

All of the alternatives considered in the FS, in addition to Alternative 3A, meet the four threshold MTCA criteria:

- **Protection of human health and the environment:** All alternatives considered control of identified risks to human health and the environment.
- **Compliance with cleanup standards:** All alternatives are expected to meet site cleanup standards. Remediation levels for arsenic are applied in each alternative during the restoration time frame.
- **Compliance with applicable state and federal regulations:** All alternatives are expected to comply with ARARs.
- **Provision for compliance monitoring:** All alternatives include compliance monitoring to verify compliance with cleanup standards.

8.2 Restoration Time-Frame

Log Yard: All of the alternatives considered in the FS, in addition to Alternative 3A, are expected to achieve cleanup objectives within a similar time frame. That time varies as described below:

- Groundwater restoration time-frame: Residual groundwater contamination is expected to remain within the Site under all alternatives. Following remedial actions (groundwater treatment, capping or soil removal), residual groundwater contamination is expected to attenuate as a result of ongoing geochemical processes that sequester arsenic. However, this is expected to require many decades under all alternatives. No practicable alternatives were defined that could result in a more rapid groundwater restoration time frame. Given the extended restoration time frames for Site groundwater, all FS cleanup alternatives include contingent remedial actions for arsenic in groundwater. As described in Section 3.4 of the FS, RELs will be used to determine whether or not contingent remedial actions should be undertaken at the Site.
- Restoration time-frame for benthic receptors, sediments and surface water: Despite the extended groundwater restoration time frame, RI monitoring documented that concentrations of arsenic in Wapato Creek surface water were below levels protective of aquatic organisms and groundwater background levels, the levels in sediments were below natural background, and arsenic concentrations in porewater were below those protective of benthic organisms. Therefore, aquatic and benthic receptors are expected to remain protected throughout the groundwater restoration time frame.
- Termination of stormwater migration pathway: Groundwater infiltration to the stormwater system currently serves as a preferential pathway for arsenic migration to Wapato Creek.

Stormwater conveyance system repair or replacement is proposed in all Log Yard remedial alternatives and is considered to be a priority action. Implementation of initial stormwater system improvements in years one and two, construction of perch groundwater treatment in year five, construction of additional conveyance system improvements (if needed) in year six, and construction of the PRB in year 10 would be expected following regulatory approval.

8.3 Climate Change Evaluation

Climate change vulnerabilities were not identified at the Site during the RI; however, a review of current climate change predictions for the Puget Sound and a cursory evaluation of remedial alternatives resiliency to climate change was conducted. A summary of this evaluation is in Section 8.3 of the FS. In addition, future predicted precipitation modeling was completed as part of the evaluation of the long-term performance of a low-permeability cap. A summary of this evaluation is presented in Appendix B of the FS.

8.4 Disproportionate Cost Analysis

The DCA is used to define the remedial alternatives that are considered permanent to the maximum extent practicable.

8.4.1 Benefit Scoring and Weighting Criteria

For each remedial alternative, the overall relative benefit was determined on the basis of the sum of weighted scores for each DCA criterion as outlined in Section 7.3. For each criterion, the alternative was scored on a scale of 1 to 10 based on the degree to which the alternative meets that criterion. A score of 1 indicates that the alternative poorly meets the criterion and a score of 10 indicates that the alternative provides the highest benefit for that criterion. For each alternative, the individual criterion scores were weighted to lend preference to protectiveness, permanence, and long-term effectiveness. The same weighting factors were used in the evaluation of Sawmill and Log Yard alternatives. The respective weighting factors are:

- Protectiveness: 25 percent
- Permanence: 20 percent
- Long-term effectiveness: 20 percent
- Management of short-term risks: 15 percent
- Technical and administrative implementability: 10 percent
- Consideration of public concerns: 10 percent

8.4.2 Log Yard (Table 2)

Comparative analysis used to determine the benefit scoring and overall ranking of proposed remedial alternatives in the Log Yard are described below. The individual benefit scores and rankings from the FS and this FS Addendum are provided in Table 2.

- **Protectiveness:** All proposed remedial alternatives meet the protectiveness threshold criteria and would be protective of human health and environment. However, significant differences in protectiveness were identified among the alternatives. Alternative 3 and 3A were the highest-ranked capping alternatives because both use a low-permeability cap expected to protectively address the source of perched water and reduce groundwater flux to Wapato Creek. The cap also separates the infiltration control layer from the working surface, providing better protection of cap performance over the long term in comparison to other alternatives. Alternative 3 addresses the stormwater pathway through raising and replacement of the stormwater system and Alternative 3A address the stormwater pathway through a combination of draining the perched water zone and stormwater system repairs. Because the replacement of the stormwater system in Alternative 3 occurs earlier than for 3A, it provides a more robust barrier to the stormwater pathway earlier than the stormwater system repairs of Alternative 3A. However, the placement of the drainage system in Alternative 3A within the perched water zone provides more direct source reduction, consequently each alternative was awarded the same ranking score for protectiveness.

- **Permanence:** Scores for remedy permanence generally follow those for protectiveness. Among the capping alternatives, Alternative 3 and 3A both received the highest score for permanence because of their use of the low-permeability cap, separation of the cap working surface from the infiltration control layer, and stormwater system replacement.
- **Long-Term Effectiveness:** Scores for long-term effectiveness were highest for those alternatives expected to require the least active maintenance to protect remedy performance for the long term. Among the capping alternatives, long-term effectiveness scores were highest for Alternative 3 and 3A. Initial investments in a low -permeability cap under Alternative 3 or the perched groundwater treatment and PRB in Alternative 3A are expected to control the high-arsenic concentrations in perched groundwater and reduce arsenic flux toward Wapato Creek most effectively, enhancing the performance of natural attenuation processes. The separation of the cap working surface from the infiltration control layer enhances the long-term performance of the cap and makes the remedy less dependent on active cap inspections and maintenance in comparison to Alternatives 1, 2, and 4. The remedies for Alternative 3 and 3A do not require long-term active groundwater extraction, treatment, and monitoring, as required under Alternative 4. Alternative 5 received a high score for long-term effectiveness because of its use of offsite disposal in a commercial landfill for management of contaminated soils, rather than onsite containment beneath a cap.
- **Management of Short-Term Risks:** Scores for short-term risk-management varied significantly among the alternatives. Those alternatives that require the greatest exposure of contaminated materials during remedy implementation (i.e., Alternatives 4 and 5) received the lowest scores. Alternatives 1, 2, and 3 received higher scores because those alternatives require little or no exposure of contaminated soils or groundwater during remedy implementation. Alternative 3A received a higher score than Alternatives 4 and 5 but less than other alternatives as it requires more direct exposure to contaminated soils via the early implementation of the perched groundwater treatment and PRB but less exposure than Alternatives 4 and 5.
- **Implementability:** All Log Yard alternatives are considered to be sufficiently implementable to be evaluated in the FS. However, the complexity of implementation requirements varies significantly among the alternatives. Alternative 3A is considered to be the highly implementable because the primary remedial technologies, the perched groundwater treatment and PRB, can be implemented most easily with current facility use.

  Alternatives 1, 2 are considered the most implementable because these alternatives use relatively simple construction methods not requiring exposure of contaminated soils or groundwater, and do not require additional permitting as do Alternatives 3, 4, or 5. Alternative 3 and 3A requires more regrading of the Site during cap construction, and will require issuance of a construction stormwater permit not required under Alternatives 1 and 2 because of the rubblization of the RCC cap. Implementation requirements for Alternatives 4 and 5 are much greater, resulting in lower scores for implementability. To be protective, Alternative 4 requires the use of short-term and long-term management methods for extracted groundwater. This would include development and maintenance of an individual NPDES permit, and performance of active groundwater treatment, monitoring, and reporting throughout the life-cycle of the remedy. Alternative 5 requires implementation of the largest construction effort, use of management practices to prevent contaminant releases via stormwater, and implementation of measures to ensure safety during offsite transportation and disposal of contaminated soils removed from the Site.

- **Consideration of Public Concerns:** Public concerns will be evaluated after the public comment period and alternative scoring altered as appropriate.

- **Cost:** Cost estimates for each alternative are provided in Appendix A and were evaluated on a 100-year timescale to fully capture the expected long-term care costs of the proposed remedies. Because of the areal extent of the Site and quantity of contaminated media present, remedies are material sensitive. Alternative 5, which proposes Site-wide excavation and offsite disposal, was estimated to have the highest cost (approximately $31 million). Alternatives 1 through 4 vary in initial construction cost, driven primarily by cap material quantities and significance of existing cap alteration. In terms of NPV, Alternatives 1 through 4 fall into a similar overall cost, ranging from $9.5 to $12.2 million.

8.4.3 Disproportionate Cost Analysis

Consistent with MTCA evaluation requirements, DCA is used to identify a preferred alternative that is considered permanent to the maximum extent practicable. An alternative is not considered permanent to the maximum extent practicable if the costs of the alternative are disproportionate to the incremental benefits of the alternative over those of other lower-cost alternatives (WAC 173-340-360(3)(i)). DCA results are presented in Figure 6 for the Log Yard. The DCA results for the Sawmill are unchanged and are shown in Table 8 and in Figure 14 of the FS.

Log Yard: Benefits of remediation alternatives for the Log Yard are presented along with costs in Figure 6. Environmental benefits increase in the following order: Alternative 1 (lowest), 4, 2, 3, 3A, and 5 (highest). The incremental benefit increases in rough proportion with cost from Alternatives 1 through 3A. However, a large (more than two-fold) cost increase occurs between Alternatives 3A and 5 without a corresponding increase in environmental benefits. Environmental benefits increase only 6 percent in contrast to a 190 percent increase in costs. Based on the disproportionate increase in costs for Alternative 5, Alternative 3A is identified as the preferred remedial alternative. Alternative 3A is permanent to the maximum extent practicable.

9 Preferred Remedial Alternatives

Based on the investigation results presented in the RI Report and remedial evaluation in the FS Report and this FS Addendum, **Alternative 3A was selected as the preferred remedial alternative for the Log Yard** and **Alternative 2 was selected as the preferred remedial alternative for the Sawmill.** These alternatives meet all of the threshold requirements under MTCA and provide for optimal benefit as determined in the DCA. Summary considerations for selecting these alternatives are as follows:

- **Log Yard Alternative 3A (compared to Alternative 3):**
    - **Permanence**
        - Reduces perched water quantity rapidly and most directly.
        - Prevents arsenic discharges to the stormwater system.
    - **Protectiveness**
        - Minimizes risks of arsenic transport to Wapato Creek.
    - **Long-Term Effectiveness**
        - Same proposed low-permeability cap (contingent) which separates the infiltration control layer from the working surface, protecting it from damage.
    - **Implementability**
        - Integrates best with facility operations, installation of the perched groundwater treatment and PRB as the primary remedies can be completed more quickly than enhanced cap installation.
- **Log Yard Alternative 3A (compared to Alternative 5):**
        - The cost of Alternative 5 is disproportionate to the benefit compared to Alternative 3A.

10 References

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Tables

Remedial Technology	Alternative 1	Alternative 2	Alternative 3	Alternative 3A	Alternative 4	Alternative 5	Remedy Detail
Log Yard Cap/Soil							
Existing Cap Maintenance and Monitoring	X			X	X		Maintenance activities includes regular inspections and periodic crack repair and resurfacing using a suitable overlay.
Cap Enhancement (geogrid and gravel)		X					Cap enhancement would include cap upgrades to reduce the effects of cracking and reduce effective cap permeability to precipitation. In this alternative the infiltration control layer is considered to be the asphalt concrete working surface. On-going monitoring and maintenance of the cap will also be required and include regular inspections and periodic repair and maintenance of infiltration control layer.
Cap Enhancement (low permeability)			X	X			This alternative includes the rubbilization of the existing roller compacted concrete (RCC) cap and installation of a low permeability infiltration conctrol layer separate from the working surface. For costing purposes, the preliminary design used in this FS includes a geosynthetic clay liner (GCL) that would be installed atop the rubbilized RCC, with subsequent layers of recycled gravel base coarse, geogrid, new gravel base coarse, and a asphalt concrete working surface. For the purposes of this FS, the asphalt concrete working surface is considered separate from maintenance and monitoring following installation as the infiltration control layer would subsequently be separate. On-going monitoring and maintenance of the GCL would be required and include regular inspections and periodic repair and maintenance.
Source Removal (Excavation and Disposal)						X	Fill containing slag would be removed and disposed offsite. RCC and cap subgrade materials overlaying the source material are assumed to be clean and would be stockpiled on site during removal for subsequent use as fill material. Existing stormwater conveyance system reconstruction and usable surface restoration would be required.
Institutional Controls	X	X	X	X	X		Periodic inspection and/or repair of engineered system or barrier while contamination remains. A notification of potential exposure for workers handling impacted soils would be attached to the property deed.
Stormwater							
Conveyance System Interim Repair			X			X	This remedy is the same approach as conveyance system repair detailed below, however, this remedy does not include slip lining. This remedy is considered to be an interim action to reduce groundwater seepage prior to a full conveyance system replacement.
Conveyance System Repair	X	X		X	X		Conveyance system repair incorporates lining the existing system (pipes, manholes, and spill containment vessels) to significantly reduce leakage where joints and cracks are observed, as well as slip-lining sections at the lowest elevations. It is assumed in this remedy that an investigation and incremental repair approach will be adopted. The repair approach may include cleaning the existing lines,video surveying the system, collecting dry weather flow samples at intermediate stations, followed by sealing identified cracks and joints. Installation of tide gates at OF 2 and OF 3 is part of this work. Slip lining is assumed for this report to extend from OF 2 and OF 3 to the respective spill containment vessels, approximately 300 feet up line. Replacement of vaults is assumed for Alternative 3A for this report. Periodic maintenance, monitoring, and repair of the improved conveyance system would be conducted to prevent groundwater seepage.
Conveyance System Replacement			X	X		X	A replacement system would incorporate the abandonment of the existing system and construction of a shallower, watertight system. This alternative would require periodic monitoring, maintenance, and repair of the improved conveyance system would be needed to prevent groundwater infiltration.
Institutional Controls	X	X	X	X	X		Periodic inspection and/or repair of engineered system or barrier while contamination remains. A notification of potential exposure for workers handling stormwater containing site related contaminants would be attached to the property deed.

Remedial Technology	Alternative 1	Alternative 2	Alternative 3	Alternative 3A	Alternative 4	Alternative 5	Remedy Detail
Groundwater							
Monitored Natural Attenuation	X	X	X	X	X	X	Periodic monitoring would be conducted to ensure cleanup goals are met.
Permeable Reactive Barrier	X	X	X	X	X	X	A permeable reactive barrier would be installed parallel to Wapato Creek inside the fenceline and running along the full extent of the westernmost boundary of the cap and along the northwestern boundary near identifed perched water areas. The barrier would extend to below the stream bed of Wapato Creek and be backfilled with reactive media (such as iron filings or zero valent iron) to treat dissolved arsenic in the groundwater flux.
Perched Groundwater Treatment				X			A French Drain or similar groundwater collection system would be designed to remove accumulated water in perched groundwater zones. The system would likely require the use of several laterals spanning the north/south extent of the Log Yard. Conceptually, the system could be a perforated drain pipe within a layer of drain rock, sloped to drain to one or more collector vaults. Accumulating perched water would be treated in situ in the collector vaults that infiltrated downward into a more permeable layer. Overflow from the collector vaults would flow to a trench in the Sawmill Area where it would be treated in situ and infiltrated. Treatment would be provided by a reactive media (e.g. ZVI).
Extraction and Ex Situ Treatment					X		Areas of perched groundwater will be extracted via sumps, shallow wells, or french drains to minimized areas of perched groundwater in contact with the fill containing slag. Ex-situ treatment may include precipitation and separation media (e.g., filters, iron reactive media, etc.). Separated arsenic would be disposed offsite and the treated groundwater would be discharged to surface water.
Institutional Controls	X	X	X	X	X	X	Periodic inspection and/or repair of engineered system or barrier while contamination remains. A notification of potential exposure for workers handling impacted groundwater would be attached to the property deed.
Soil Gas							
Institutional Controls	X	X	X	X	X	X	Methane gas does not present an imminent hazard under existing site conditions. A notification of potential hazardous conditions for trenchworkers or vapor intrusion to enclosed structures would be attached to the property deed.

Table 1A
Log Yard Alternative 3A Timeline
Feasibility Study Addendum
Parcel 15

Remedial Element	Work Item	Dependent On	Estimated Begin Date	Estimated End Date	Estimated Timeline
Log Yard Cap/Soil	Existing Cap Maintenance and Monitoring - complete seal coat on cap		Summer/Fall 2018	long term maintenance	YR 0
Groundwater	Monitored Natural Attenuation	Final CAP	Feb-19	long term monitoring	YR 1
Log Yard Cap/Soil	Institutional Controls	Final CAP	6 month after Final CAP	12 months after Final CAP	YR 1
Stormwater	Institutional Controls				
Soil Gas	Institutional Controls				
Stormwater	Conveyance System Inspection and Cleaning - conveyance piping video inspection for seepage	Final CAP and high groundwater level in perched zone	Spring 2019	Summer 2019	YR 1
	- conveyance piping cleaning	pipe inspection shows cleaning needed			
	Tide gate installation summer	Final CAP	Summer/Fall 2019	Fall 2019	
Stormwater	Conveyance System Improvements - remove spill containment vaults - slip line conveyance pipe from creek to vaults	Final CAP	Summer/Fall 2020	Fall 2020	YR 2
	- monitoring seepage after repairs	completion of vault removal and slip lining pipe	Fall 2020	Fall 2024	YR 2 to 5
Groundwater	Perched Groundwater Treatment	groundwater monitoring shows no decrease in perched zone water levels in response to conveyance sytem repairs and cap maintenance	3 years after conveyance system repairs	3 months after beginning construction	YR 5
	- perched GW Treatment Monitoring - perched GW Treatment O&M	perched groundwater treatment system installation	after construction	long term operation	
Stormwater	Additional Conveyance System Improvements - slip line conveyance pipe upstream of the former vaults	monitoring shows ongoing significant seepage into pipe upstream of former vaults	Summer/Fall 2025	Fall 2025	YR 6
Groundwater	Permeable Reactive Barrier	groundwater monitoring shows no downward trend in concentrations due to perched zone treatment and conveyance sytem repairs	5 years after conveyance system and perched water actions	long term operation	YR 10
Log Yard Cap/Soil	Cap Enhancement (low perm)	groundwater monitoring shows that the PRB performance isn't showing trends toward long term protectiveness	5 years after PRB installation	long term maintenance	YR 15
Stormwater	Conveyance System Replacement	completed with cap enhancement	5 years after PRB installation	long term maintenance	YR 15

Remedial Alternative[1]	Protectiveness (25%)[2]	Permanence (20%)	Long-Term Effectiveness (20%)	Short-Term Risk Management (15%)	Technical and Administrative Implementability (10%)	Public Concerns (10%)	Environmental Benefit Score	Probable Cost[3]	Benefit Score / Probable Cost[4]
	Relative Ranking - Scored from 1 (lowest) to 10 (highest)								
Alternative 1 - Cap Overlay - Conveyance System Repair - PRB - MNA - Institutional Controls	Achieves a lower score for protectiveness than other alternatives. However, the capping approach is less protective than those under Alternatives 2 and 3. Frequent inspections and sealing of cracks will be required to maintain cap performance. The stormwater repairs are less robust than the system replacement conducted under Alternatives 3 and 5. Protectiveness is enhanced with the use of a contingent PRB.	Achieves a low-medium score for permanence. Permanence under this alternative is lower than under Alternatives 2 and 3, because the capping approach does less to reduce the production of arsenic-contaminated perched groundwater as much as other alternatives, and no treatment of this water is provided as under Alternative 4. The alternative also uses stormwater line repairs rather than replacing the system. Together these factors result in a greater risk of arsenic migration toward Wapato Creek, and a greater likelihood that contingent groundwater treatment will be required.	Alternative 1 achieves a low-medium score for long-term effectiveness. Unlike Alternative 3, the permeability of the cap is not reduced, and arsenic-contaminated perched water will continue to be generated at significant rates. The cap performance will also require frequent inspections and sealing of cracks that are expected to occur at higher rates than under Alternative 2. The repair-in place of the stormwater system has a higher likelihood of failure over the long-term in comparison to the system raising and replacement as performed under Alternative 3. Groundwater flux rates will be higher than under Alternatives 2 or 3, placing higher demands on natural attenuation processes, and increasing the likelihood that a contingent PRB will be required.	This Alternative has a medium-high score for short-term risk management. It involves less extensive construction activities than under any other alternatives, and requires no exposure of arsenic-contaminated soils. The alternative uses routine construction methods (asphalt overlay placement) for capping. Stormwater management risks are minimized by keeping the existing RCC cap in place.	Alternative 1 has a medium-high score for implementability. Initial design and construction requirements are less than under any other alternatives. It uses standard construction methods for capping. It will not require a construction stormwater permit and will not expose contaminated soils. However, this alternative will require more frequent inspections and cap maintenance activities over the long-term.	Evaluation pending public comment.	4.2	$9.5M	0.44
	3	**3**	**4**	**8**	**8**	**--**			
Alternative 2 - Enhanced Cap - Conveyance System Repair - PRB - MNA - Institutional Controls	Achieves a medium score for protectiveness. Protectiveness of Alternative 2 is higher than for Alternative 1, because measures are taken to reduce ongoing crack formation within the cap surface layer. However, the capping approach is less protective than Alternative 3. Frequent inspections and sealing of cracks will be required to maintain cap performance. The stormwater repairs are less robust than the system replacement conducted under Alternatives 3 and 5. Protectiveness is enhanced with the use of a contingent PRB.	Achieves a medium score for permanence. Permanence under this alternative is better than under Alternative 1 but less than Alternative 3. The capping approach reduces anticipated infiltration in comparison to Alternative 1. However, the capping approach does less to address the generation of perched groundwater in comparison to Alternative 3. The alternative also uses stormwater line repairs rather than replacing the system. Together these factors result in a an intermediate risk of arsenic migration toward Wapato Creek, and an intermediate risk that contingent groundwater treatment will be required.	Alternative 2 achieves a medium score for long-term effectiveness. The long-term cap performance is expected to be better than under Alternative 1, with reduced surface cracking. However, the permeability of the cap is not reduced as much as under Alternative 3. The cap performance will also require frequent inspections and maintenance in comparison to Alternative 3. The repair-in place of the stormwater system has a higher likelihood of failure over the long-term in comparison to the system raising and replacement as performed under Alternative 3. Groundwater flux rates will be higher than under Alternative 3, placing higher demands on natural attenuation processes, and increasing the likelihood that a contingent PRB will be required.	This Alternative has a medium-high score for short-term risk management. It involves less extensive construction activities than under alternatives 3, 4 or 5. It does not requires exposure of arsenic-contaminated soils. The alternative uses routine construction methods (gravel placement and asphalt paving) for capping. Stormwater management risks are minimized by keeping the existing RCC cap in place.	Alternative 2 has a medium-high score for implementability. Initial design and construction requirements are less than under alternatives 3, 4 or 5. It uses standard construction methods for capping. It will not require a construction stormwater permit and will not expose contaminated soils. However, this alternative will require more frequent inspections and cap maintenance activities over the long-term in comparison to alternative 3.	Evaluation pending public comment.	5.5	$10.5M	0.52
	5	**5**	**6**	**8**	**8**	**--**			

Remedial Alternative[1]	Protectiveness (25%)[2]	Permanence (20%)	Long-Term Effectiveness (20%)	Short-Term Risk Management (15%)	Technical and Administrative Implementability (10%)	Public Concerns (10%)	Environmental Benefit Score	Probable Cost[3]	Benefit Score / Probable Cost[4]
	Relative Ranking - Scored from 1 (lowest) to 10 (highest)								
Alternative 3 - Low Permeability Cap - Conveyance System Replacement - PRB - MNA - Institutional Controls	Achieves a high level of overall protectiveness through the use of a low-permeability composite cap to reduce infiltration through source material and prevent accumulation of perched water. The infiltration control layer is separated from the cap working surface to minimize the risks of cap damage during long-term maintenance. The stormwater conveyance system will be replaced and raised to prevent groundwater infiltration. Protectiveness is enhanced with the use of a contingent PRB. Given anticipated reduction in infiltration and groundwater flux, the need for the PRB is less likely than under Alternatives 1, 2 or 4.	Achieves a medium-high score for permanence. Permanence under this alternative is enhanced over Alternatives 1, 2 and 4 by including both a more robust cap and a new stormwater system. The cap design is expected to reduce the generation of high-arsenic perched water in comparison to Alternatives 1, 2 and 4. The stormwater system replacement will also prevent future seepage of arsenic-containing groundwater into the storm drainage system.	Achieves a high level of long-term effectiveness through the use of a low-permeability composite cap to reduce infiltration through source material and prevent accumulation of arsenic-contaminated perched water. The infiltration control layer is separated from the cap working surface to maximize long-term cap performance and minimize dependence on ongoing cap inspections and maintenance. The stormwater conveyance system will be replaced and raised rather than being repaired in place, eliminating risks that leaks would recur over the long-term. The reduction in infiltration and groundwater flux under this alternative optimizes conditions for ongoing natural attenuation of arsenic, reducing the likelihood that the contingent PRB will be required. If the PRB is required, the lifespan of the treatment media will be improved relative to other alternatives with higher groundwater flux rates.	This Alternative has a medium-high score for short-term risk management. It involves more extensive construction activities during initial cap installation than under Alternatives 1, 2 or 4. However, this initial work is offset over the long-term by fewer requirements for on-site inspections and cap maintenance actions. Construction-related risks are lower than under Alternative 5, because the arsenic-contaminated soils will not be exposed to workers or to stormwater during cap installation. The alternative includes significant on-site construction activities, but does not involve extensive off-site transportation of contaminated soils as under Alternative 5.	Alternative 3 has a lower score for implementability than Alternatives 1 or 2, because initial design and construction requirements are greater. Though the alternative doesn't require exposure of contaminated soils, it will involve removal of the RCC cap and re-grading of cap materials. A construction stormwater permit will be required. However, this alternative will require less frequent inspections and cap maintenance activities over the long-term in comparison to alternatives 1, 2 and 4.	Evaluation pending public comment.	6.8	$12.3M	0.55
	8	**7**	**8**	**7**	**7**	**--**			
Alternative 3A - Conveyance System Repair - Perched Groundwater Treatment - Permeable Reactive Barrier -MNA - Low Permeability Cap Contingency - Institutional Controls	Achieves a high level of overall protectiveness through the use of a perched groundwater treatment system and a contingent PRB. The stormwater conveyance system will be sliplined in areas affected by groundwater infiltration and replaced when the property is developed or contigency low permeability cap implemented. Protectiveness is enhanced by directly removing perched water and reducing arsenic flux to groundwater and Wapato creek. A contigent PRB near Wapato Creek and a low permeability cap would be implemented if criteria conditions are exceeded. With this tiered approach the overall protectiveness of the remedy is enhanced.	Achieves a high score for permanence. Permanence under this alternative is enhanced over Alternatives 1, 2 and 3 by directly removing perched groundwater. This alternative is more permanent than Alternative 4 as it integrates better with Port land use planning and employs a more robust contigent cap design. The cap design is expected to reduce the generation of high-arsenic perched water in comparison to Alternatives 1, 2 3, and 4. The stormwater system repair (slipline) and eventual replacement will also prevent future seepage of arsenic-containing groundwater into the storm drainage system.	Achieves a high level of long-term effectiveness through the use of perched groundwater treatment, stormwater system improvements, a PRB, and a contingent low-permeability cap to reduce perched water in source material and subsequent migration pathways. At the time of property development or implementation of the contingent low permeability cap, the stormwater conveyance system will be replaced eliminating risks that leaks would recur over the long-term. The reduction in infiltration and groundwater flux under this alternative optimizes conditions for ongoing natural attenuation of arsenic, reducing the likelihood that the contingent PRB will be required. If the PRB is required, the lifespan of the treatment media will be improved relative to other alternatives with higher groundwater flux rates.	This alternative has a medium score for short-term risk management. It involves more extensive construction activities during the perched water drain installation and initally during cap installation than under Alternatives 1, 2, 3, or 4. Construction-related risks are lower than under Alternative 5, because the quantity of arsenic-contaminated soils workers will be exposed to will be much less. The alternative includes significant on-site construction activities, but does not involve extensive off-site transportation of contaminated soils as under Alternative 5.	Alternative 3A has the highest score for implementability because it integrates best with property development planning and current uses. Implmentation of the perched water treatment in this alternative is expected to be less complex and requiring less long term maintenance as it is not expected to discharge in situ.	Evaluation pending public comment.	7.0	$11.4M	0.61
	8	**9**	**8**	**6**	**7**	**--**			

Table 2. Log Yard DCA Evaluation

Remedial Alternative[1]	Protectiveness (25%)[2]	Permanence (20%)	Long-Term Effectiveness (20%)	Short-Term Risk Management (15%)	Technical and Administrative Implementability (10%)	Public Concerns (10%)	Environmental Benefit Score	Probable Cost[3]	Benefit Score / Probable Cost[4]
	Relative Ranking - Scored from 1 (lowest) to 10 (highest)								
Alternative 4 - Cap Overlay - Conveyance System Repair - Perched Water Ex Situ Treatment - PRB - MNA - Institutional Controls	Achieves a medium score for overall protectiveness through the continued use and maintenance of a surface cap to reduce infiltration through source material, stormwater conveyance system repairs, natural attenuation and institutional controls. Perched water is actively addressed through extraction, ex situ treatment and discharge to Wapato Creek. Protectiveness is enhanced with the use of a contingent PRB. However, the capping approach is less protective than those under Alternatives 2 and 3 because more cracking and infiltration will likely occur under Alternative 1.	Achieves a medium score for permanence. Like Alternative 1 the capping approach used does less to address the production of arsenic-contaminated perched groundwater in comparison to alternatives 2 or 3. The active extraction and treatment of this water will require extensive ongoing operation and maintenance in order to remain effective. The repair-in place of the stormwater system has a higher likelihood of failure over the long-term in comparison to the system raising and replacement as performed under Alternative 3.	Alternative 4 achieves a medium level of long-term effectiveness. Unlike Alternative 3, the permeability of the cap is not reduced, and arsenic-contaminated perched water will continue to be generated at significant rates. Though the perched water is managed through extraction and treatment, these measures will require extensive ongoing operation, monitoring and maintenance to prevent inadvertent discharge of contaminated groundwater. The cap performance will also require frequent inspections and sealing of cracks that are expected to occur at higher rates than under Alternative 2. The repair-in place of the stormwater system has a higher likelihood of failure over the long-term in comparison to the system raising and replacement as performed under Alternative 3.	This Alternative has a medium score for short-term risk management. It involves more extensive construction activities during initial cap installation than under Alternatives 1 or 2, including installation of drains and sumps for extraction of groundwater. Appropriate methods will be required to prevent discharge of contaminated groundwater during treatment system start-up and initial operation. Construction-related risks are lower than under Alternative 5, because the arsenic-contaminated soils will not be exposed to workers or to stormwater during cap installation. The alternative includes significant on-site construction activities, but does not involve extensive off-site transportation of contaminated soils as under Alternative 5.	Alternative 4 has a lower score for implementability than alternatives 1, 2 or 3. This reduction in score reflects the increased complexity of construction associated with installation of the perched water extraction and treatment system. Alternative 4 uses standard construction methods for capping, will not require a construction stormwater permit and will not expose contaminated soils. However, this alternative will require more frequent inspections and cap maintenance activities over the long-term in comparison to alternative 3. This alternative also require long-term operation, maintenance of the water treatment system, including procurement and periodic renewal of a NPDES permit.	Evaluation pending public comment.	5.1	$10.9M	0.47
	6	**5**	**6**	**6**	**5**	**--**			
Alternative 5 - Conveyance System Repair - Excavation and Disposal -Conveyance System Replacement - PRB - MNA - Institutional Controls	Achieves a high level of overall protectiveness through excavation and off-site disposal of arsenic contaminated soils. Residual groundwater contamination will remain and will be managed by stormwater system replacement, natural attenuation and institutional controls. Given the presence of residual groundwater contamination and potential increases in groundwater infiltration and flux after cap removal, this alternative includes a content PRB to ensure protectiveness.	Achieves a higher score for permanence than other alternatives by removing slag and contaminated soils that are a potential ongoing source of groundwater contamination. Residual groundwater contamination will remain. That contamination is managed through institutional controls, stormwater system replacement and a contingent groundwater PRB.	Achieves a high score for long-term effectiveness through excavation and offsite disposal of arsenic contaminated soils. These soils will be transferred to an off-site commercial landfill, rather than be contained on-site beneath an environmental cap. Residual groundwater contamination will remain and will be managed by stormwater system replacement, natural attenuation and institutional controls. Given the presence of residual groundwater contamination and potential increases in groundwater infiltration and flux after cap removal, this alternative includes a content PRB to ensure long-term effectiveness of groundwater controls.	Alternative 5 has a low-medium score for short-term risk management. Short-term risks associated with this alternative would be moderately high. . The work includes extensive construction activities to remove, transport and safely manage contaminated soils without exposing workers to contaminate-related risks. Stormwater and dust will need to be appropriately managed during construction activities. This alternative also involves significant modifications to existing site conditions with the removal of the existing cap and changes to groundwater control measures. These changes could affect existing groundwater attenuation processes (this risk is managed with the contingent PRB).	This alternative has a medium score for implementability. The project will require a construction general stormwater permit and additional control measures to manage construction-related stormwater containing arsenic. The project will require extensive off-site transportation of contaminated soils. The duration of the construction project is longer than under the other Alternatives, impacting ongoing site uses to a greater degree.	Evaluation pending public comment.	7.2	$31.0M	0.23
	9	**10**	**9**	**4**	**5**	**--**			

Remedial Alternative[1]	Protectiveness (25%)[2]	Permanence (20%)	Long-Term Effectiveness (20%)	Short-Term Risk Management (15%)	Technical and Administrative Implementability (10%)	Public Concerns (10%)	Environmental Benefit Score	Probable Cost[3]	Benefit Score / Probable Cost[4]
	Relative Ranking - Scored from 1 (lowest) to 10 (highest)								

Notes:

1. Consideration of public concerns is not addressed in this table because the public has not yet had an opportunity to provide comments.
2. Each of the DCA criteria listed were weighted, so the overall DCA score would be influenced by criteria directly relating to protectiveness and effectiveness. A score of 10 represents an alternative that satisfies the criteria to the highest degree.
3. Probable cost reflects the total estimated cost including applicable contingencies (see cost detail in Appendix A).
4. Probable costs were evaluated in increments of $1 million for comparison to benefit scoring.
5. A formula error in the orginal FS cost estimating tables for Alternative 4 was corrected as part of this FS Addendum effort, correspondingly Alternative 4's cost has been updated.

PRB = permeable reactive barrier

MNA = monitored natural attenuation

Figures

FIGURE 1

Vicinity Map

Feasibility Study Addendum
Parcel 15
Tacoma, WA

Date: September 7, 2018
Data Sources: PORTAC, Aerial photo taken September 2016 by Metro

GSI Water Solutions, Inc.

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FIGURE 2

Current Site Conditions Map

Feasibility Study Addendum
Parcel 15
Tacoma, WA

LEGEND

Site Features[1]

- Monitoring Well
- Perched Monitoring Well
- Stormwater Outfall

Site Storm Features

- Outfall
- Vault
- Storm Line

All Other Features

- Site Boundary[2]
- Cap[3]
- Former Dip Tank Excavation/Fill Extent (Approximate)
- Groundwater Contour, Dashed Where Inferred (Event 1-May 2016)
- Perched Water (Event 1-May 2016)

NOTES:

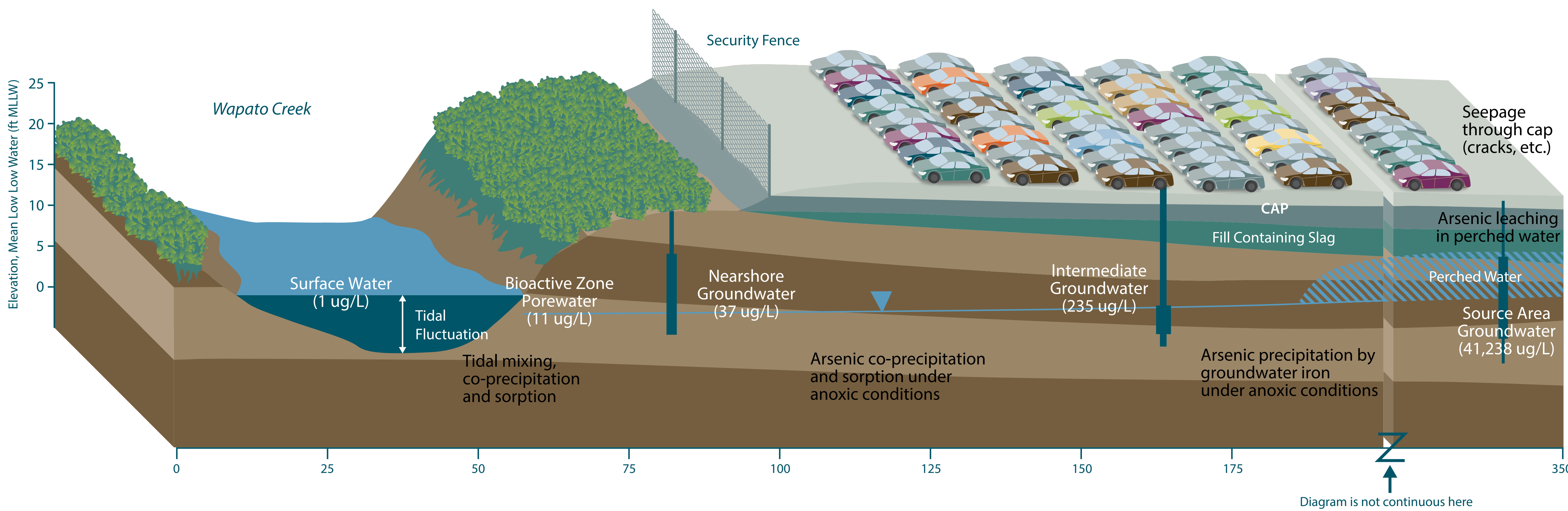
1. Locations surveyed May 2016.
2. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
3. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).

N

0 115 230 345
Feet

Date: September 20, 2018
Data Sources: PORTAC, Aerial photo taken September 2016 by Metro

GSI Water Solutions, Inc.



LEGEND

- Soil Boring/Well
- Screened Interval May 2016
- May 2016 Water Level
- Perched Groundwater

Geology

- Roller Compacted Concrete
- Gravel Base Course
- Fill Containing Slag
- Silty Sand
- Fine Grained Deposits (Silt and Clay)

FIGURE 3

Conceptual Site Model - Log Yard

Feasibility Study Addendum
Parcel 15
Tacoma, WA

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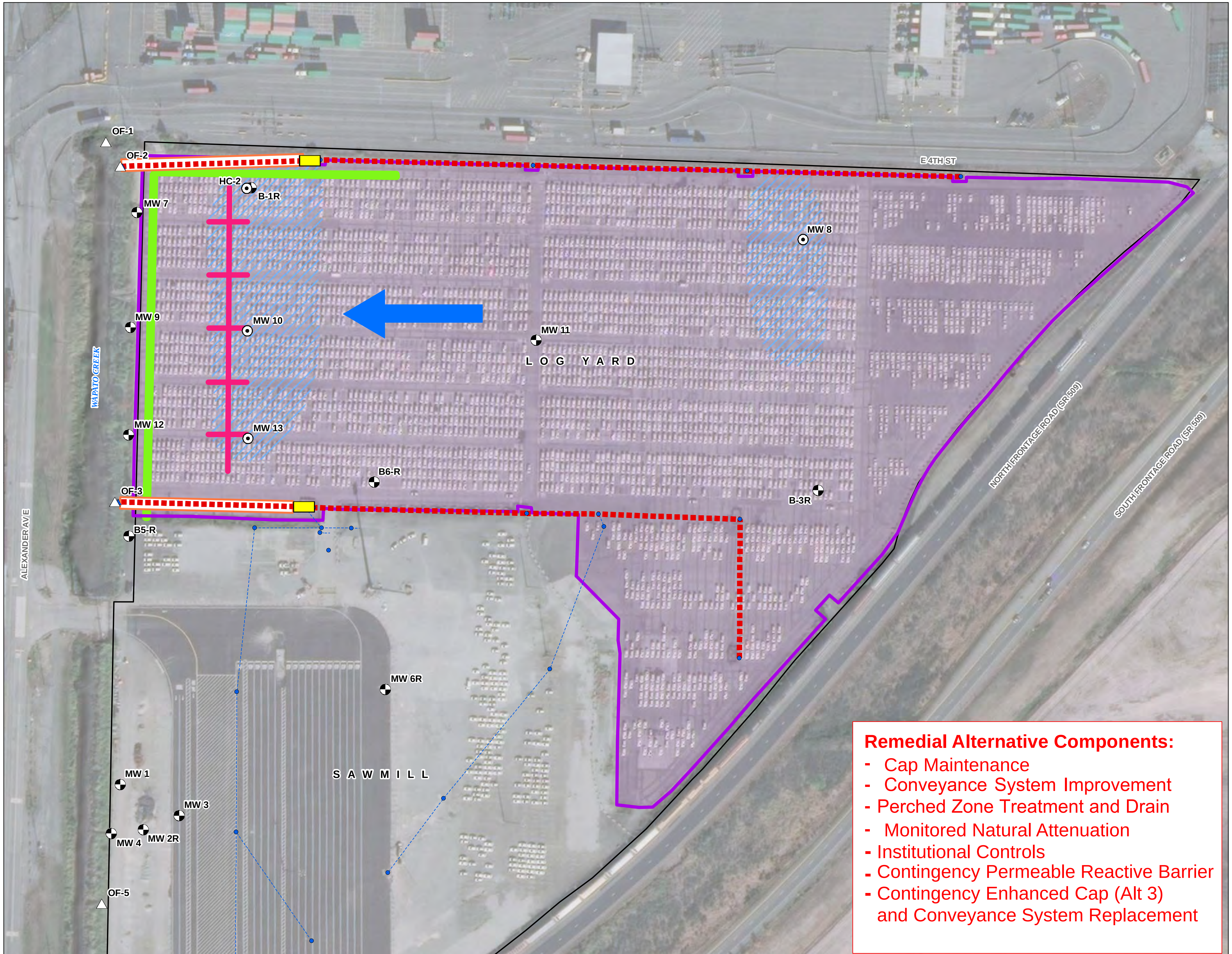
FIGURE 4

Log Yard Remedial Alternative 3A

Feasibility Study Addendum
Parcel 15
Tacoma, WA



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LEGEND

Site Features[1]

- Monitoring Well
- Perched Monitoring Well
- Stormwater Outfall

Site Storm Features

- Outfall
- Vault
- Storm Line

Remedial Alternative Features

- Replace Stormwater Vault (YR 3)[5]
- Slip Line Stormwater Line (YR 3)[5]
- Permeable Reactive Barrier[4] (YR 5)[5]
- Perched Zone Treatment and Drain (YR 5)[5]
- Enhanced Cap - Same as Alt 3 (YR 15)[5]
- Replace Stormwater System (YR 15)[5]

All Other Features

- Site Boundary[2]
- Perched Water (Event 1-May 2016)
- Groundwater Flow Direction

NOTES:

1. Locations surveyed May 2016.
2. Site Boundary defined in Exhibit A of the Draft Agreed Order No. DE 11237 (Ecology, 2015).
3. Cap extent defined on Figure 2 of the Former Portac Inc. Site (AQEA, 2014).
4. Permeable reactive barrier dimensions and extent are subject to change during remedial design.
5. Year that work assumed to be implemented for costing purposes

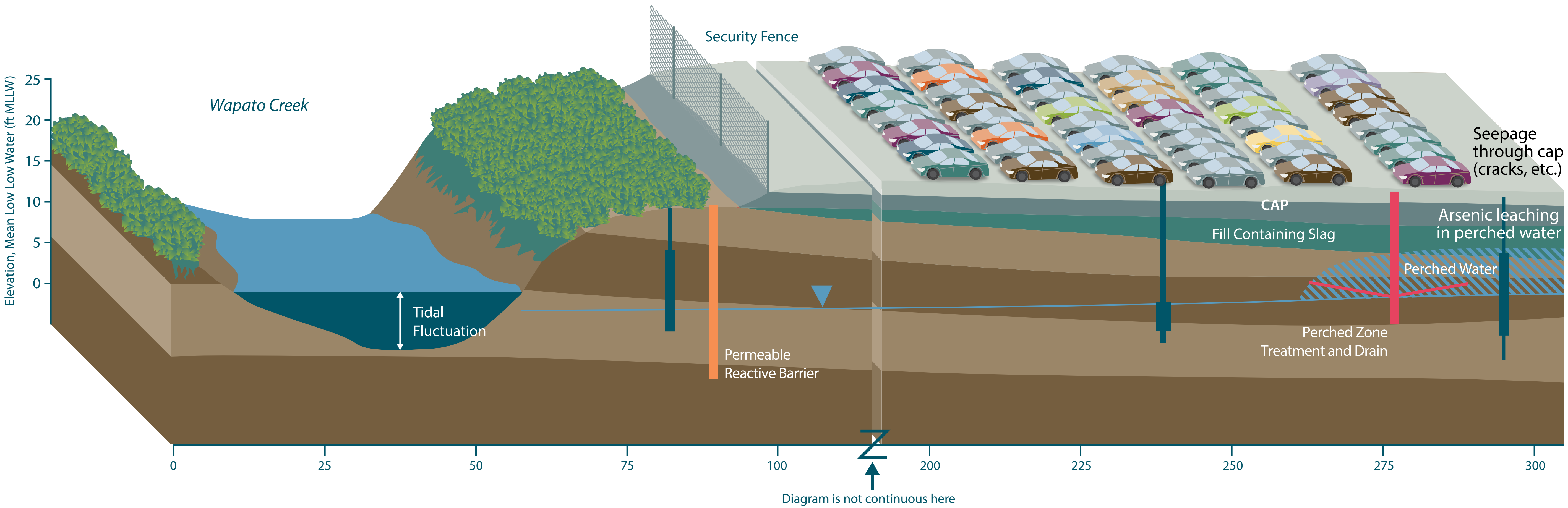
HMA: Hot Mix Asphalt
RCC: Roller Compacted Concrete
GCL: Geosynthetic Clay Liner

N

0 90 180 270
Feet

Date: October 9, 2018
Data Sources: PORTAC, Aerial photo taken September 2016 by Metro

GSI Water Solutions, Inc.



LEGEND

- Soil Boring/Well
- Screened Interval May 2016
- Permeable Reactive Barrier
- Perched Zone Treatment and Drain
- May 2016 Water Level
- Perched Groundwater

Geology

- Roller Compacted Concrete
- Gravel Base Course
- Fill Containing Slag
- Silty Sand
- Fine Grained Deposits (Silt and Clay)

FIGURE 5

Log Yard Remedial Alternative 3A

Feasibility Study Addendum
Parcel 15
Tacoma, WA

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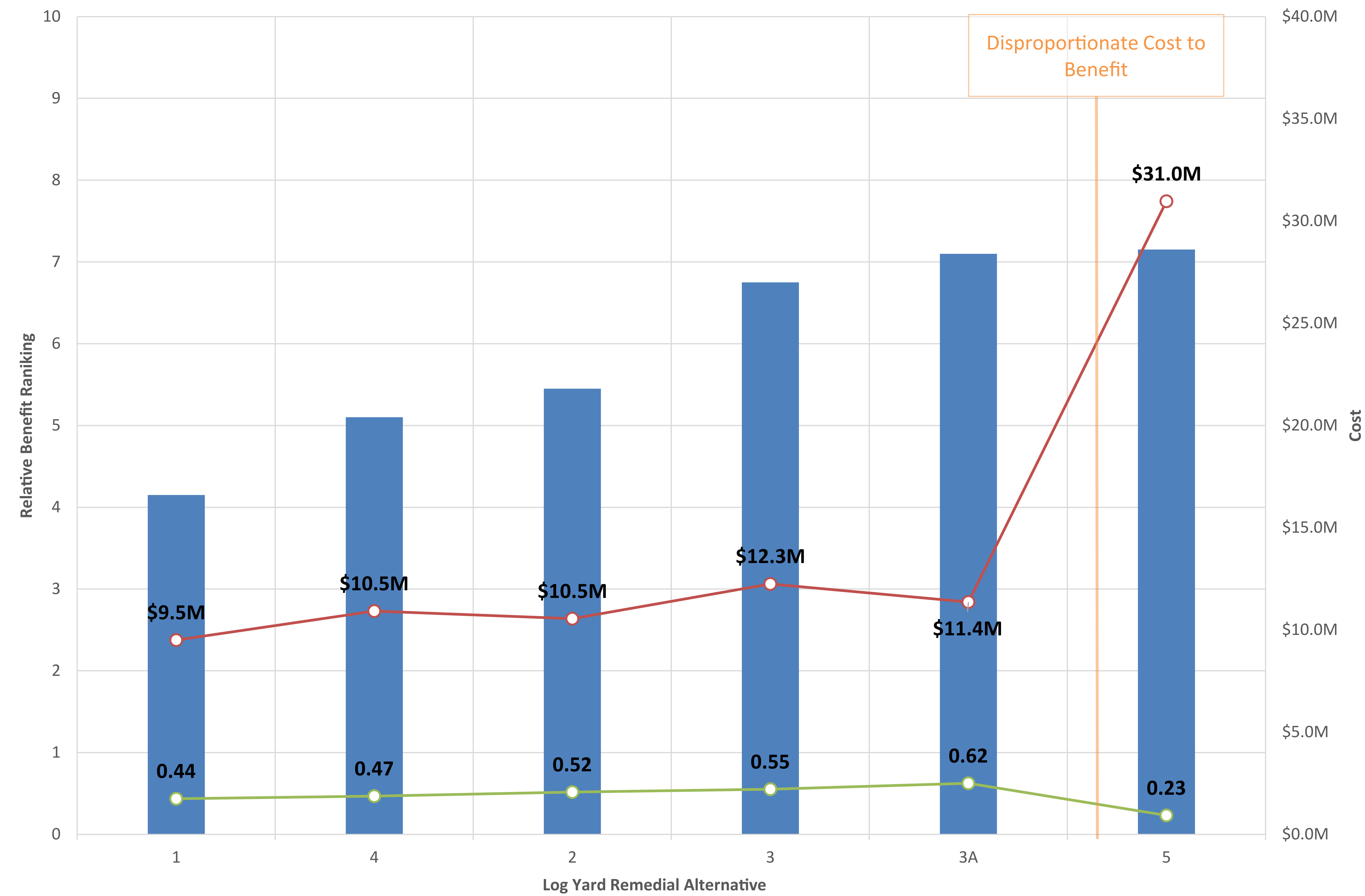

LEGEND

- Relative Benefit Ranking
- Relative Benefit / Cost ($M)
- Estimated Cost

FIGURE 6

Disproportionate Cost Analysis

Feasibility Study Addendum
Parcel 15
Tacoma, WA

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APPENDIX A

Cost Estimating Tables

Remedial Alternatives		Net Present Value[2]
Log Yard		
Alternative 1	Asphalt Overlay, Stormwater System Repair, MNA, PRB Contingency	$9,505,000
Alternative 2	Enhanced Cap, Stormwater System Repair, MNA, PRB Contingency	$10,549,000
Alternative 3	Low Permeability Cap, Stormwater System Replacement, MNA, PRB Contingency	$12,254,000
Alternative 3A	Perched Zone Treatment, PRB, Stormwater System Repair, MNA, Low Permeability Cap Contingency	$11,383,000
Alternative 4	Asphalt Overlay, Stormwater System Repair, Ex Situ Treatment, MNA, PRB Contingency	$10,921,000
Alternative 5	Excavation & Off-site Disposal, Stormwater System Replacement, MNA, PRB Contingency	$30,964,000

Notes:

1. Estimated costs are in 2017 dollars
2. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016 (2.4%) for a discount rate of (3.1%).

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			6%	$19,000
Stormwater System Repair	1	LS	$314,000	$314,000
Design and Permitting			15%	$47,000
Construction Management			10%	$31,000
Project Management			8%	$25,000
Ecology Review/Oversight for Implementation			2%	$6,000
Sales Tax (City of Tacoma)			10.1%	$34,000
Year 1 Costs Subtotal				**$476,000**
Cap Improvement (Year 5) Costs				
Mobilization			4%	$93,000
Cap Resurfacing (4" HMA Overlay)	1	LS	$2,292,412	$2,292,412
Monitoring well repairs/replacement	18	EA	$2,500	$45,000
Design and Permitting			4%	$97,000
Construction Management			3%	$69,000
Project Management			2%	$51,000
Ecology Review/Oversight for Implementation			1%	$25,000
Sales Tax (City of Tacoma)			10.1%	$245,000
Year 5 Costs Subtotal				**$2,917,000**
PRB Contingency (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
Year 10 Costs Subtotal				**$1,327,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
Initial Construction and Other Costs Subtotal				**$4,730,000**
Initial Construction Costs Contingency[2] (20%)				**$946,000**
Total Initial Construction and Other Costs				**$5,676,000**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yr 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$5,500	$5,500	5	$27,500
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Cap Inspections	1	LS	$8,500	$8,500	10	$85,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$3,300	$3,300	10	$33,000
Annual Costs - Yrs 16-100						
Maintain Inst. Controls	1.0	LS	$1,000	$1,000	85	$85,000
Cap Inspections	1.0	LS	$8,500	$8,500	85	$722,500
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1.0	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	85	$578,000
Ecology Review/Oversight for annual events		5%	$1,700	$1,700	85	$144,500
Other Periodic Costs						
Cap Resurfacing (Grinding and 3"HMA)	1	LS	$2,058,000	$2,058,000	yr 25, 45, 65, 85	$8,232,000
Cap Repairs	1	LS	$54,000	$54,000	yr 15, 35, 55, 75, 95	$270,000
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 25, 45, 65, 85	$1,327,000
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000
					Subtotal Long Term Costs	**$11,081,500**
					Long Term Cost Contingency[2] (20%)	**$2,216,300**
					Total Long Term Costs	**$13,297,800**
					Total Construction, Other, and Long Term Costs	**$18,973,800**
					Total Net Present Value[3]	**$9,505,000**

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$476,000	$115,000	$118,200	$709,200	$726,221	$688,361	51	$0	$18,000	$3,600	$21,600	$72,402	$4,719
2	$0	$98,000	$19,600	$117,600	$123,313	$110,790	52	$0	$18,000	$3,600	$21,600	$74,140	$4,581
3	$0	$98,000	$19,600	$117,600	$126,272	$107,535	53	$0	$18,000	$3,600	$21,600	$75,919	$4,446
4	$0	$127,000	$25,400	$152,400	$167,566	$135,262	54	$0	$18,000	$3,600	$21,600	$77,741	$4,315
5	$2,927,000	$98,000	$605,000	$3,630,000	$4,087,017	$3,127,117	55	$54,000	$18,000	$14,400	$86,400	$318,428	$16,754
6	$0	$39,800	$7,960	$47,760	$55,064	$39,935	56	$0	$18,000	$3,600	$21,600	$81,518	$4,065
7	$0	$39,800	$7,960	$47,760	$56,385	$38,761	57	$0	$18,000	$3,600	$21,600	$83,474	$3,946
8	$0	$39,800	$7,960	$47,760	$57,738	$37,622	58	$0	$18,000	$3,600	$21,600	$85,477	$3,830
9	$0	$68,800	$13,760	$82,560	$102,204	$63,124	59	$0	$18,000	$3,600	$21,600	$87,529	$3,718
10	$1,327,000	$39,800	$273,360	$1,640,160	$2,079,150	$1,217,198	60	$0	$18,000	$3,600	$21,600	$89,630	$3,608
11	$0	$39,800	$7,960	$47,760	$61,996	$34,402	61	$0	$18,000	$3,600	$21,600	$91,781	$3,502
12	$0	$39,800	$7,960	$47,760	$63,484	$33,391	62	$0	$18,000	$3,600	$21,600	$93,983	$3,399
13	$0	$39,800	$7,960	$47,760	$65,008	$32,410	63	$0	$18,000	$3,600	$21,600	$96,239	$3,299
14	$0	$39,800	$7,960	$47,760	$66,568	$31,458	64	$0	$18,000	$3,600	$21,600	$98,549	$3,203
15	$54,000	$39,800	$18,760	$112,560	$160,651	$71,961	65	$2,389,750	$18,000	$481,550	$2,889,300	$13,498,634	$415,796
16	$0	$28,200	$5,640	$33,840	$49,457	$20,999	66	$0	$18,000	$3,600	$21,600	$103,336	$3,017
17	$0	$28,200	$5,640	$33,840	$50,644	$20,382	67	$0	$18,000	$3,600	$21,600	$105,816	$2,928
18	$0	$28,200	$5,640	$33,840	$51,860	$19,783	68	$0	$18,000	$3,600	$21,600	$108,355	$2,842
19	$0	$28,200	$5,640	$33,840	$53,104	$19,201	69	$0	$18,000	$3,600	$21,600	$110,956	$2,759
20	$0	$28,200	$5,640	$33,840	$54,379	$18,637	70	$0	$18,000	$3,600	$21,600	$113,619	$2,678
21	$0	$18,000	$3,600	$21,600	$35,543	$11,547	71	$0	$18,000	$3,600	$21,600	$116,346	$2,599
22	$0	$18,000	$3,600	$21,600	$36,396	$11,207	72	$0	$18,000	$3,600	$21,600	$119,138	$2,523
23	$0	$18,000	$3,600	$21,600	$37,269	$10,878	73	$0	$18,000	$3,600	$21,600	$121,997	$2,449
24	$0	$18,000	$3,600	$21,600	$38,164	$10,558	74	$0	$18,000	$3,600	$21,600	$124,925	$2,377
25	$2,389,750	$18,000	$481,550	$2,889,300	$5,227,470	$1,370,819	75	$54,000	$18,000	$14,400	$86,400	$511,694	$9,227
26	$0	$18,000	$3,600	$21,600	$40,018	$9,947	76	$0	$18,000	$3,600	$21,600	$130,994	$2,239
27	$0	$18,000	$3,600	$21,600	$40,978	$9,655	77	$0	$18,000	$3,600	$21,600	$134,138	$2,173
28	$0	$18,000	$3,600	$21,600	$41,962	$9,371	78	$0	$18,000	$3,600	$21,600	$137,357	$2,109
29	$0	$18,000	$3,600	$21,600	$42,969	$9,096	79	$0	$18,000	$3,600	$21,600	$140,653	$2,047
30	$0	$18,000	$3,600	$21,600	$44,000	$8,828	80	$0	$18,000	$3,600	$21,600	$144,029	$1,987
31	$0	$18,000	$3,600	$21,600	$45,056	$8,569	81	$0	$18,000	$3,600	$21,600	$147,486	$1,929
32	$0	$18,000	$3,600	$21,600	$46,137	$8,317	82	$0	$18,000	$3,600	$21,600	$151,025	$1,872
33	$0	$18,000	$3,600	$21,600	$47,245	$8,073	83	$0	$18,000	$3,600	$21,600	$154,650	$1,817
34	$0	$18,000	$3,600	$21,600	$48,378	$7,836	84	$0	$18,000	$3,600	$21,600	$158,362	$1,764
35	$54,000	$18,000	$14,400	$86,400	$198,158	$30,421	85	$2,389,750	$18,000	$481,550	$2,889,300	$21,691,468	$228,997
36	$0	$18,000	$3,600	$21,600	$50,729	$7,382	86	$0	$18,000	$3,600	$21,600	$166,054	$1,662
37	$0	$18,000	$3,600	$21,600	$51,946	$7,165	87	$0	$18,000	$3,600	$21,600	$170,040	$1,613
38	$0	$18,000	$3,600	$21,600	$53,193	$6,954	88	$0	$18,000	$3,600	$21,600	$174,121	$1,565
39	$0	$18,000	$3,600	$21,600	$54,469	$6,750	89	$0	$18,000	$3,600	$21,600	$178,299	$1,519
40	$1,327,000	$18,000	$269,000	$1,614,000	$4,167,751	$489,557	90	$0	$18,000	$3,600	$21,600	$182,579	$1,475
41	$0	$18,000	$3,600	$21,600	$57,115	$6,359	91	$0	$18,000	$3,600	$21,600	$186,960	$1,431
42	$0	$18,000	$3,600	$21,600	$58,486	$6,172	92	$0	$18,000	$3,600	$21,600	$191,448	$1,389
43	$0	$18,000	$3,600	$21,600	$59,890	$5,991	93	$0	$18,000	$3,600	$21,600	$196,042	$1,349
44	$0	$18,000	$3,600	$21,600	$61,327	$5,815	94	$0	$18,000	$3,600	$21,600	$200,747	$1,309
45	$2,389,750	$18,000	$481,550	$2,889,300	$8,400,221	$754,971	95	$54,000	$18,000	$14,400	$86,400	$822,261	$5,082
46	$0	$18,000	$3,600	$21,600	$64,306	$5,478	96	$0	$18,000	$3,600	$21,600	$210,499	$1,233
47	$0	$18,000	$3,600	$21,600	$65,849	$5,317	97	$0	$18,000	$3,600	$21,600	$215,551	$1,197
48	$0	$18,000	$3,600	$21,600	$67,430	$5,161	98	$0	$18,000	$3,600	$21,600	$220,724	$1,162
49	$0	$18,000	$3,600	$21,600	$69,048	$5,009	99	$0	$18,000	$3,600	$21,600	$226,021	$1,128
50	$0	$18,000	$3,600	$21,600	$70,705	$4,862	100	$18,000	$18,000	$7,200	$43,200	$462,892	$2,189
												Net Present Value[3]	$9,505,000

Notes:
1. Estimated costs are in 2017 dollars
2. Contingency rates and design/permitting, etc. percentage cost estimates based upon EPA cost estimating guidance (EPA 540-R-00-002). Relative percentages were altered based upon professional judgement.
3. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016 (2.4%) for a discount rate of (3.1%).

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			6%	$19,000
Stormwater System Repair	1	LS	$314,000	$314,000
Design and Permitting			15%	$47,000
Construction Management			10%	$31,000
Project Management			8%	$25,000
Ecology Review/Oversight for Implementation			2%	$6,000
Sales Tax (City of Tacoma)			10.1%	$34,000
			Year 1 Costs Subtotal	**$333,000**
Cap Improvement (Year 5) Costs				
Mobilization			4%	$186,000
Enhanced Cap (geogrid, gravel, 5" HMA cover)	1	LS	$4,610,000	$4,610,000
Monitoring well repairs/replacement	18	EA	$2,500	$45,000
Design and Permitting			4%	$184,000
Construction Management			3%	$138,000
Project Management			2%	$92,000
Ecology Review/Oversight for Implementation			1%	$46,000
Sales Tax (City of Tacoma)			10.1%	$489,000
			Year 5 Costs Subtotal	**$5,790,000**
PRB Contingency (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
			Year 10 Costs Subtotal	**$1,327,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
	Initial Construction and Other Costs Subtotal			**$7,460,000**
	Initial Construction Costs Contingency[2] (20%)			**$1,490,000**
	Total Initial Construction and Other Costs			**$8,950,000**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yr 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$5,500	$5,500	5	$27,500
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Cap Inspections	1	LS	$8,500	$8,500	10	$85,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$3,300	$3,300	10	$33,000
Annual Costs - Yrs 16-100						
Maintain Inst. Controls	1.0	LS	$1,000	$1,000	85	$85,000
Cap Inspections	1.0	LS	$8,500	$8,500	85	$722,500
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1.0	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	85	$578,000
Ecology Review/Oversight for annual events		5%	$1,700	$1,700	85	$144,500
Other Periodic Costs						
Cap Resurfacing (Grinding and 3"HMA)	1	LS	$2,058,000	$2,058,000	yr 35, 65,95	$6,174,000
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 40, 70, 100	$995,250
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000
				Subtotal Long Term Costs		**$9,765,250**
				Long Term Cost Contingency[2] (20%)		**$1,953,050**
				Total Long Term Costs		**$11,718,300**
				Total Construction, Other, and Long Term Costs		**$20,668,300**
				Total Net Present Value[3]		**$10,549,000**

Notes:
1. Estimated costs are in 2017 dollars
2. Contingency rates and design/permitting, etc. percentage cost estimates based upon EPA cost estimating guidance (EPA 540-R-00-002). Relative percentages were altered based upon professional judgement.
3. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016 (2.4%) for a discount rate of (3.1%).

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$333,000	$115,000	$89,600	$537,600	$550,502	$521,803	51	$0	$18,000	$3,600	$21,600	$72,402	$4,719
2	$0	$98,000	$19,600	$117,600	$123,313	$110,790	52	$0	$18,000	$3,600	$21,600	$74,140	$4,581
3	$0	$98,000	$19,600	$117,600	$126,272	$107,535	53	$0	$18,000	$3,600	$21,600	$75,919	$4,446
4	$0	$127,000	$25,400	$152,400	$167,566	$135,262	54	$0	$18,000	$3,600	$21,600	$77,741	$4,315
5	$5,800,000	$98,000	$1,179,600	$7,077,600	$7,968,669	$6,097,103	55	$0	$18,000	$3,600	$21,600	$79,607	$4,189
6	$0	$39,800	$7,960	$47,760	$55,064	$39,935	56	$0	$18,000	$3,600	$21,600	$81,518	$4,065
7	$0	$39,800	$7,960	$47,760	$56,385	$38,761	57	$0	$18,000	$3,600	$21,600	$83,474	$3,946
8	$0	$39,800	$7,960	$47,760	$57,738	$37,622	58	$0	$18,000	$3,600	$21,600	$85,477	$3,830
9	$0	$68,800	$13,760	$82,560	$102,204	$63,124	59	$0	$18,000	$3,600	$21,600	$87,529	$3,718
10	$1,327,000	$39,800	$273,360	$1,640,160	$2,079,150	$1,217,198	60	$0	$18,000	$3,600	$21,600	$89,630	$3,608
11	$0	$39,800	$7,960	$47,760	$61,996	$34,402	61	$0	$18,000	$3,600	$21,600	$91,781	$3,502
12	$0	$39,800	$7,960	$47,760	$63,484	$33,391	62	$0	$18,000	$3,600	$21,600	$93,983	$3,399
13	$0	$39,800	$7,960	$47,760	$65,008	$32,410	63	$0	$18,000	$3,600	$21,600	$96,239	$3,299
14	$0	$39,800	$7,960	$47,760	$66,568	$31,458	64	$0	$18,000	$3,600	$21,600	$98,549	$3,203
15	$0	$39,800	$7,960	$47,760	$68,165	$30,534	65	$2,058,000	$18,000	$415,200	$2,491,200	$11,638,735	$358,506
16	$0	$28,200	$5,640	$33,840	$49,457	$20,999	66	$0	$18,000	$3,600	$21,600	$103,336	$3,017
17	$0	$28,200	$5,640	$33,840	$50,644	$20,382	67	$0	$18,000	$3,600	$21,600	$105,816	$2,928
18	$0	$28,200	$5,640	$33,840	$51,860	$19,783	68	$0	$18,000	$3,600	$21,600	$108,355	$2,842
19	$0	$28,200	$5,640	$33,840	$53,104	$19,201	69	$0	$18,000	$3,600	$21,600	$110,956	$2,759
20	$0	$28,200	$5,640	$33,840	$54,379	$18,637	70	$331,750	$18,000	$69,950	$419,700	$2,207,679	$52,031
21	$0	$18,000	$3,600	$21,600	$35,543	$11,547	71	$0	$18,000	$3,600	$21,600	$116,346	$2,599
22	$0	$18,000	$3,600	$21,600	$36,396	$11,207	72	$0	$18,000	$3,600	$21,600	$119,138	$2,523
23	$0	$18,000	$3,600	$21,600	$37,269	$10,878	73	$0	$18,000	$3,600	$21,600	$121,997	$2,449
24	$0	$18,000	$3,600	$21,600	$38,164	$10,558	74	$0	$18,000	$3,600	$21,600	$124,925	$2,377
25	$0	$18,000	$3,600	$21,600	$39,080	$10,248	75	$0	$18,000	$3,600	$21,600	$127,924	$2,307
26	$0	$18,000	$3,600	$21,600	$40,018	$9,947	76	$0	$18,000	$3,600	$21,600	$130,994	$2,239
27	$0	$18,000	$3,600	$21,600	$40,978	$9,655	77	$0	$18,000	$3,600	$21,600	$134,138	$2,173
28	$0	$18,000	$3,600	$21,600	$41,962	$9,371	78	$0	$18,000	$3,600	$21,600	$137,357	$2,109
29	$0	$18,000	$3,600	$21,600	$42,969	$9,096	79	$0	$18,000	$3,600	$21,600	$140,653	$2,047
30	$0	$18,000	$3,600	$21,600	$44,000	$8,828	80	$0	$18,000	$3,600	$21,600	$144,029	$1,987
31	$0	$18,000	$3,600	$21,600	$45,056	$8,569	81	$0	$18,000	$3,600	$21,600	$147,486	$1,929
32	$0	$18,000	$3,600	$21,600	$46,137	$8,317	82	$0	$18,000	$3,600	$21,600	$151,025	$1,872
33	$0	$18,000	$3,600	$21,600	$47,245	$8,073	83	$0	$18,000	$3,600	$21,600	$154,650	$1,817
34	$0	$18,000	$3,600	$21,600	$48,378	$7,836	84	$0	$18,000	$3,600	$21,600	$158,362	$1,764
35	$2,058,000	$18,000	$415,200	$2,491,200	$5,713,564	$877,144	85	$0	$18,000	$3,600	$21,600	$162,162	$1,712
36	$0	$18,000	$3,600	$21,600	$50,729	$7,382	86	$0	$18,000	$3,600	$21,600	$166,054	$1,662
37	$0	$18,000	$3,600	$21,600	$51,946	$7,165	87	$0	$18,000	$3,600	$21,600	$170,040	$1,613
38	$0	$18,000	$3,600	$21,600	$53,193	$6,954	88	$0	$18,000	$3,600	$21,600	$174,121	$1,565
39	$0	$18,000	$3,600	$21,600	$54,469	$6,750	89	$0	$18,000	$3,600	$21,600	$178,299	$1,519
40	$331,750	$18,000	$69,950	$419,700	$1,083,770	$127,303	90	$0	$18,000	$3,600	$21,600	$182,579	$1,475
41	$0	$18,000	$3,600	$21,600	$57,115	$6,359	91	$0	$18,000	$3,600	$21,600	$186,960	$1,431
42	$0	$18,000	$3,600	$21,600	$58,486	$6,172	92	$0	$18,000	$3,600	$21,600	$191,448	$1,389
43	$0	$18,000	$3,600	$21,600	$59,890	$5,991	93	$0	$18,000	$3,600	$21,600	$196,042	$1,349
44	$0	$18,000	$3,600	$21,600	$61,327	$5,815	94	$0	$18,000	$3,600	$21,600	$200,747	$1,309
45	$0	$18,000	$3,600	$21,600	$62,799	$5,644	95	$2,058,000	$18,000	$415,200	$2,491,200	$23,708,522	$146,528
46	$0	$18,000	$3,600	$21,600	$64,306	$5,478	96	$0	$18,000	$3,600	$21,600	$210,499	$1,233
47	$0	$18,000	$3,600	$21,600	$65,849	$5,317	97	$0	$18,000	$3,600	$21,600	$215,551	$1,197
48	$0	$18,000	$3,600	$21,600	$67,430	$5,161	98	$0	$18,000	$3,600	$21,600	$220,724	$1,162
49	$0	$18,000	$3,600	$21,600	$69,048	$5,009	99	$0	$18,000	$3,600	$21,600	$226,021	$1,128
50	$0	$18,000	$3,600	$21,600	$70,705	$4,862	100	$349,750	$18,000	$73,550	$441,300	$4,728,567	$22,361
												Net Present Value[3]	$10,549,000

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			10%	$10,000
Stormwater System Repair (no slip line)	1	LS	$104,000	$104,000
Design and Permitting			15%	$16,000
Construction Management			10%	$10,000
Project Management			8%	$8,000
Ecology Review/Oversight for Implementation			2%	$2,000
Sales Tax (City of Tacoma)			10.1%	$12,000
			Year 1 Costs Subtotal	**$162,000**
Cap Improvement (Year 5) Costs				
Mobilization			4%	$283,000
Low Permeability Cap (GCL, 5" HMA cover)	1	LS	$6,360,000	$6,360,000
Stormwater System Replacement	1	LS	$672,000	$672,000
Monitoring well repairs/replacement	18	EA	$2,500	$45,000
Design and Permitting			4%	$281,000
Construction Management			3%	$211,000
Project Management			2%	$141,000
Ecology Review/Oversight for Implementation			1%	$70,000
Sales Tax (City of Tacoma)			10.1%	$743,000
			Year 5 Costs Subtotal	**$8,806,000**
PRB Contingency (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
			Year 10 Costs Subtotal	**$1,327,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
			Initial Construction and Other Costs Subtotal	**$10,305,000**
			Initial Construction Costs Contingency[2] (20%)	**$2,061,000**
			Total Initial Construction and Other Costs	**$12,366,000**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yr 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$5,500	$5,500	5	$27,500
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Cap Inspections	1	LS	$8,500	$8,500	10	$85,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$3,300	$3,300	10	$33,000
Annual Costs - Yrs 16-100						
Maintain Inst. Controls	1.0	LS	$1,000	$1,000	85	$85,000
Cap Inspections	1.0	LS	$8,500	$8,500	85	$722,500
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1.0	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	85	$578,000
Ecology Review/Oversight for annual events		5%	$1,700	$1,700	85	$144,500
Other Periodic Costs						
GCL Liner Repair		3%	$190,800	$190,800	yr 15, 45, 75	$572,400
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 50, 90	$663,500
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000
					Subtotal Long Term Costs	**$3,831,900**
					Long Term Cost Contingency[2] (20%)	**$766,380**
					Total Long Term Costs	**$4,598,280**
					Total Construction, Other, and Long Term Costs	**$16,964,280**
					Total Net Present Value[3]	**$12,254,000**

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$162,000	$115,000	$55,400	$332,400	$340,378	$322,633	51	$0	$18,000	$3,600	$21,600	$72,402	$4,719
2	$0	$98,000	$19,600	$117,600	$123,313	$110,790	52	$0	$18,000	$3,600	$21,600	$74,140	$4,581
3	$0	$98,000	$19,600	$117,600	$126,272	$107,535	53	$0	$18,000	$3,600	$21,600	$75,919	$4,446
4	$0	$127,000	$25,400	$152,400	$167,566	$135,262	54	$0	$18,000	$3,600	$21,600	$77,741	$4,315
5	$8,816,000	$98,000	$1,782,800	$10,696,800	$12,043,526	$9,214,916	55	$0	$18,000	$3,600	$21,600	$79,607	$4,189
6	$0	$39,800	$7,960	$47,760	$55,064	$39,935	56	$0	$18,000	$3,600	$21,600	$81,518	$4,065
7	$0	$39,800	$7,960	$47,760	$56,385	$38,761	57	$0	$18,000	$3,600	$21,600	$83,474	$3,946
8	$0	$39,800	$7,960	$47,760	$57,738	$37,622	58	$0	$18,000	$3,600	$21,600	$85,477	$3,830
9	$0	$68,800	$13,760	$82,560	$102,204	$63,124	59	$0	$18,000	$3,600	$21,600	$87,529	$3,718
10	$1,327,000	$39,800	$273,360	$1,640,160	$2,079,150	$1,217,198	60	$0	$18,000	$3,600	$21,600	$89,630	$3,608
11	$0	$39,800	$7,960	$47,760	$61,996	$34,402	61	$0	$18,000	$3,600	$21,600	$91,781	$3,502
12	$0	$39,800	$7,960	$47,760	$63,484	$33,391	62	$0	$18,000	$3,600	$21,600	$93,983	$3,399
13	$0	$39,800	$7,960	$47,760	$65,008	$32,410	63	$0	$18,000	$3,600	$21,600	$96,239	$3,299
14	$0	$39,800	$7,960	$47,760	$66,568	$31,458	64	$0	$18,000	$3,600	$21,600	$98,549	$3,203
15	$190,800	$39,800	$46,120	$276,720	$394,948	$176,910	65	$0	$18,000	$3,600	$21,600	$100,914	$3,108
16	$0	$28,200	$5,640	$33,840	$49,457	$20,999	66	$0	$18,000	$3,600	$21,600	$103,336	$3,017
17	$0	$28,200	$5,640	$33,840	$50,644	$20,382	67	$0	$18,000	$3,600	$21,600	$105,816	$2,928
18	$0	$28,200	$5,640	$33,840	$51,860	$19,783	68	$0	$18,000	$3,600	$21,600	$108,355	$2,842
19	$0	$28,200	$5,640	$33,840	$53,104	$19,201	69	$0	$18,000	$3,600	$21,600	$110,956	$2,759
20	$0	$28,200	$5,640	$33,840	$54,379	$18,637	70	$0	$18,000	$3,600	$21,600	$113,619	$2,678
21	$0	$18,000	$3,600	$21,600	$35,543	$11,547	71	$0	$18,000	$3,600	$21,600	$116,346	$2,599
22	$0	$18,000	$3,600	$21,600	$36,396	$11,207	72	$0	$18,000	$3,600	$21,600	$119,138	$2,523
23	$0	$18,000	$3,600	$21,600	$37,269	$10,878	73	$0	$18,000	$3,600	$21,600	$121,997	$2,449
24	$0	$18,000	$3,600	$21,600	$38,164	$10,558	74	$0	$18,000	$3,600	$21,600	$124,925	$2,377
25	$0	$18,000	$3,600	$21,600	$39,080	$10,248	75	$190,800	$18,000	$41,760	$250,560	$1,483,913	$26,759
26	$0	$18,000	$3,600	$21,600	$40,018	$9,947	76	$0	$18,000	$3,600	$21,600	$130,994	$2,239
27	$0	$18,000	$3,600	$21,600	$40,978	$9,655	77	$0	$18,000	$3,600	$21,600	$134,138	$2,173
28	$0	$18,000	$3,600	$21,600	$41,962	$9,371	78	$0	$18,000	$3,600	$21,600	$137,357	$2,109
29	$0	$18,000	$3,600	$21,600	$42,969	$9,096	79	$0	$18,000	$3,600	$21,600	$140,653	$2,047
30	$0	$18,000	$3,600	$21,600	$44,000	$8,828	80	$0	$18,000	$3,600	$21,600	$144,029	$1,987
31	$0	$18,000	$3,600	$21,600	$45,056	$8,569	81	$0	$18,000	$3,600	$21,600	$147,486	$1,929
32	$0	$18,000	$3,600	$21,600	$46,137	$8,317	82	$0	$18,000	$3,600	$21,600	$151,025	$1,872
33	$0	$18,000	$3,600	$21,600	$47,245	$8,073	83	$0	$18,000	$3,600	$21,600	$154,650	$1,817
34	$0	$18,000	$3,600	$21,600	$48,378	$7,836	84	$0	$18,000	$3,600	$21,600	$158,362	$1,764
35	$0	$18,000	$3,600	$21,600	$49,540	$7,605	85	$0	$18,000	$3,600	$21,600	$162,162	$1,712
36	$0	$18,000	$3,600	$21,600	$50,729	$7,382	86	$0	$18,000	$3,600	$21,600	$166,054	$1,662
37	$0	$18,000	$3,600	$21,600	$51,946	$7,165	87	$0	$18,000	$3,600	$21,600	$170,040	$1,613
38	$0	$18,000	$3,600	$21,600	$53,193	$6,954	88	$0	$18,000	$3,600	$21,600	$174,121	$1,565
39	$0	$18,000	$3,600	$21,600	$54,469	$6,750	89	$0	$18,000	$3,600	$21,600	$178,299	$1,519
40	$0	$18,000	$3,600	$21,600	$55,777	$6,552	90	$331,750	$18,000	$69,950	$419,700	$3,547,603	$28,656
41	$0	$18,000	$3,600	$21,600	$57,115	$6,359	91	$0	$18,000	$3,600	$21,600	$186,960	$1,431
42	$0	$18,000	$3,600	$21,600	$58,486	$6,172	92	$0	$18,000	$3,600	$21,600	$191,448	$1,389
43	$0	$18,000	$3,600	$21,600	$59,890	$5,991	93	$0	$18,000	$3,600	$21,600	$196,042	$1,349
44	$0	$18,000	$3,600	$21,600	$61,327	$5,815	94	$0	$18,000	$3,600	$21,600	$200,747	$1,309
45	$190,800	$18,000	$41,760	$250,560	$728,467	$65,471	95	$0	$18,000	$3,600	$21,600	$205,565	$1,270
46	$0	$18,000	$3,600	$21,600	$64,306	$5,478	96	$0	$18,000	$3,600	$21,600	$210,499	$1,233
47	$0	$18,000	$3,600	$21,600	$65,849	$5,317	97	$0	$18,000	$3,600	$21,600	$215,551	$1,197
48	$0	$18,000	$3,600	$21,600	$67,430	$5,161	98	$0	$18,000	$3,600	$21,600	$220,724	$1,162
49	$0	$18,000	$3,600	$21,600	$69,048	$5,009	99	$0	$18,000	$3,600	$21,600	$226,021	$1,128
50	$331,750	$18,000	$69,950	$419,700	$1,373,842	$94,474	100	$18,000	$18,000	$7,200	$43,200	$462,892	$2,189
												Net Present Value[3]	$12,254,000

Notes:
1. Estimated costs are in 2017 dollars
2. Contingency rates and design/permitting, etc. percentage cost estimates based upon EPA cost estimating guidance (EPA 540-R-00-002). Relative percentages were altered based upon professional judgement.
3. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016 (2.4%) for a discount rate of (3.1%).

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			6%	$4,000
Stormwater System Repair	1	LS	$58,500	$58,500
Design and Permitting			15%	$9,000
Construction Management			10%	$6,000
Project Management			8%	$5,000
Ecology Review/Oversight for Implementation			2%	$1,000
Sales Tax (City of Tacoma)			10.1%	$6,000
			Year 1 Costs Subtotal	**$89,500**
Stormwater System Slip Lining (Year 2) Costs				
Mobilization			6%	$23,000
Stormwater System Repair (Slip Line)	1	LS	$270,000	$270,000
Stormwater System Repair (Vault Replacement)	1	LS	$107,000	$107,000
Design and Permitting			8%	$30,000
Construction Management			4%	$15,000
Project Management			3%	$11,000
Ecology Review/Oversight for Implementation			1%	$4,000
Sales Tax (City of Tacoma)			10.1%	$40,000
			Year 2 Costs Subtotal	**$500,000**
Perched Zone Treatment and Drain (Year 5) Costs				
Mobilization			8%	$27,000
Perched Zone Treatment and Drain Installation (8- 12' bgs, ZVI sumps 12-18'bgs)	1	LS	$342,000	$342,000
Design and Permitting			12%	$41,000
Construction Management			8%	$27,000
Project Management			5%	$17,000
Ecology Review/Oversight for Implementation			2%	$7,000
Sales Tax (City of Tacoma)			10.1%	$37,000
			Year 5 Costs Subtotal	**$498,000**
PRB (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
			Year 10 Costs Subtotal	**$1,327,000**
Cap Improvement Contingency (Year 15) Costs				
Mobilization			4%	$283,000
Low Permeability Cap (GCL, 5" HMA cover)	1	LS	$6,360,000	$6,360,000
Stormwater System Replacement	1	LS	$672,000	$672,000
Monitoring well repairs/replacement	18	EA	$2,500	$45,000
Design and Permitting			4%	$281,000
Construction Management			3%	$211,000
Project Management			2%	$141,000
Ecology Review/Oversight for Implementation			1%	$70,000
Sales Tax (City of Tacoma)			10.1%	$743,000
			Year 15 Costs Subtotal	**$8,806,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
			Initial Construction and Other Costs Subtotal	**$9,403,500**
			Initial Construction Costs Contingency[2] (20%)	**$1,880,700**
			Total Initial Construction and Other Costs	**$11,284,200**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yr 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$5,500	$5,500	5	$27,500
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Cap Inspections	1	LS	$8,500	$8,500	10	$85,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$6,000	$6,000	10	$60,000
Annual Costs - Yrs 16-100						
Maintain Inst. Controls	1	LS	$1,000	$1,000	85	$85,000
Cap Inspections	1	LS	$8,500	$8,500	85	$722,500
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	85	$578,000
Ecology Review/Oversight for annual events		5%	$1,700	$1,700	85	$144,500
Other Periodic Costs						
GCL Liner Repair		3%	$190,800	$190,800	yr 25, 50, 80	$572,400
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 50	$331,750
Perched Zone PRB Maintenance/Repair		10%	$49,800	$49,800	yr 15, 45, 75	$149,400
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$89,500	$115,000	$40,900	$245,400	$251,290	$238,189	51	$0	$18,000	$3,600	$21,600	$72,402	$4,719
2	$500,000	$98,000	$119,600	$717,600	$752,458	$676,048	52	$0	$18,000	$3,600	$21,600	$74,140	$4,581
3	$0	$98,000	$19,600	$117,600	$126,272	$107,535	53	$0	$18,000	$3,600	$21,600	$75,919	$4,446
4	$0	$127,000	$25,400	$152,400	$167,566	$135,262	54	$0	$18,000	$3,600	$21,600	$77,741	$4,315
5	$498,000	$98,000	$119,200	$715,200	$805,244	$616,120	55	$0	$18,000	$3,600	$21,600	$79,607	$4,189
6	$0	$96,500	$19,300	$115,800	$133,508	$96,826	56	$0	$18,000	$3,600	$21,600	$81,518	$4,065
7	$0	$96,500	$19,300	$115,800	$136,713	$93,981	57	$0	$18,000	$3,600	$21,600	$83,474	$3,946
8	$0	$96,500	$19,300	$115,800	$139,994	$91,220	58	$0	$18,000	$3,600	$21,600	$85,477	$3,830
9	$0	$125,500	$25,100	$150,600	$186,434	$115,147	59	$0	$18,000	$3,600	$21,600	$87,529	$3,718
10	$1,327,000	$96,500	$284,700	$1,708,200	$2,165,401	$1,267,692	60	$0	$18,000	$3,600	$21,600	$89,630	$3,608
11	$0	$96,500	$19,300	$115,800	$150,317	$83,412	61	$0	$18,000	$3,600	$21,600	$91,781	$3,502
12	$0	$96,500	$19,300	$115,800	$153,925	$80,961	62	$0	$18,000	$3,600	$21,600	$93,983	$3,399
13	$0	$96,500	$19,300	$115,800	$157,619	$78,583	63	$0	$18,000	$3,600	$21,600	$96,239	$3,299
14	$0	$96,500	$19,300	$115,800	$161,402	$76,273	64	$0	$18,000	$3,600	$21,600	$98,549	$3,203
15	$8,865,800	$96,500	$1,792,460	$10,754,760	$15,349,706	$6,875,641	65	$0	$18,000	$3,600	$21,600	$100,914	$3,108
16	$0	$28,200	$5,640	$33,840	$49,457	$20,999	66	$0	$18,000	$3,600	$21,600	$103,336	$3,017
17	$0	$28,200	$5,640	$33,840	$50,644	$20,382	67	$0	$18,000	$3,600	$21,600	$105,816	$2,928
18	$0	$28,200	$5,640	$33,840	$51,860	$19,783	68	$0	$18,000	$3,600	$21,600	$108,355	$2,842
19	$0	$28,200	$5,640	$33,840	$53,104	$19,201	69	$0	$18,000	$3,600	$21,600	$110,956	$2,759
20	$0	$28,200	$5,640	$33,840	$54,379	$18,637	70	$0	$18,000	$3,600	$21,600	$113,619	$2,678
21	$0	$18,000	$3,600	$21,600	$35,543	$11,547	71	$0	$18,000	$3,600	$21,600	$116,346	$2,599
22	$0	$18,000	$3,600	$21,600	$36,396	$11,207	72	$0	$18,000	$3,600	$21,600	$119,138	$2,523
23	$0	$18,000	$3,600	$21,600	$37,269	$10,878	73	$0	$18,000	$3,600	$21,600	$121,997	$2,449
24	$0	$18,000	$3,600	$21,600	$38,164	$10,558	74	$0	$18,000	$3,600	$21,600	$124,925	$2,377
25	$190,800	$18,000	$41,760	$250,560	$453,326	$118,877	75	$49,800	$18,000	$13,560	$81,360	$481,845	$8,689
26	$0	$18,000	$3,600	$21,600	$40,018	$9,947	76	$0	$18,000	$3,600	$21,600	$130,994	$2,239
27	$0	$18,000	$3,600	$21,600	$40,978	$9,655	77	$0	$18,000	$3,600	$21,600	$134,138	$2,173
28	$0	$18,000	$3,600	$21,600	$41,962	$9,371	78	$0	$18,000	$3,600	$21,600	$137,357	$2,109
29	$0	$18,000	$3,600	$21,600	$42,969	$9,096	79	$0	$18,000	$3,600	$21,600	$140,653	$2,047
30	$0	$18,000	$3,600	$21,600	$44,000	$8,828	80	$190,800	$18,000	$41,760	$250,560	$1,670,738	$23,052
31	$0	$18,000	$3,600	$21,600	$45,056	$8,569	81	$0	$18,000	$3,600	$21,600	$147,486	$1,929
32	$0	$18,000	$3,600	$21,600	$46,137	$8,317	82	$0	$18,000	$3,600	$21,600	$151,025	$1,872
33	$0	$18,000	$3,600	$21,600	$47,245	$8,073	83	$0	$18,000	$3,600	$21,600	$154,650	$1,817
34	$0	$18,000	$3,600	$21,600	$48,378	$7,836	84	$0	$18,000	$3,600	$21,600	$158,362	$1,764
35	$0	$18,000	$3,600	$21,600	$49,540	$7,605	85	$0	$18,000	$3,600	$21,600	$162,162	$1,712
36	$0	$18,000	$3,600	$21,600	$50,729	$7,382	86	$0	$18,000	$3,600	$21,600	$166,054	$1,662
37	$0	$18,000	$3,600	$21,600	$51,946	$7,165	87	$0	$18,000	$3,600	$21,600	$170,040	$1,613
38	$0	$18,000	$3,600	$21,600	$53,193	$6,954	88	$0	$18,000	$3,600	$21,600	$174,121	$1,565
39	$0	$18,000	$3,600	$21,600	$54,469	$6,750	89	$0	$18,000	$3,600	$21,600	$178,299	$1,519
40	$0	$18,000	$3,600	$21,600	$55,777	$6,552	90	$0	$18,000	$3,600	$21,600	$182,579	$1,475
41	$0	$18,000	$3,600	$21,600	$57,115	$6,359	91	$0	$18,000	$3,600	$21,600	$186,960	$1,431
42	$0	$18,000	$3,600	$21,600	$58,486	$6,172	92	$0	$18,000	$3,600	$21,600	$191,448	$1,389
43	$0	$18,000	$3,600	$21,600	$59,890	$5,991	93	$0	$18,000	$3,600	$21,600	$196,042	$1,349
44	$0	$18,000	$3,600	$21,600	$61,327	$5,815	94	$0	$18,000	$3,600	$21,600	$200,747	$1,309
45	$49,800	$18,000	$13,560	$81,360	$236,542	$21,259	95	$0	$18,000	$3,600	$21,600	$205,565	$1,270
46	$0	$18,000	$3,600	$21,600	$64,306	$5,478	96	$0	$18,000	$3,600	$21,600	$210,499	$1,233
47	$0	$18,000	$3,600	$21,600	$65,849	$5,317	97	$0	$18,000	$3,600	$21,600	$215,551	$1,197
48	$0	$18,000	$3,600	$21,600	$67,430	$5,161	98	$0	$18,000	$3,600	$21,600	$220,724	$1,162
49	$0	$18,000	$3,600	$21,600	$69,048	$5,009	99	$0	$18,000	$3,600	$21,600	$226,021	$1,128
50	$522,550	$18,000	$108,110	$648,660	$2,123,318	$146,013	100	$18,000	$18,000	$7,200	$43,200	$462,892	$2,189
												Net Present Value[3]	$11,383,000

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			6%	$19,000
Stormwater System Repair	1	LS	$314,000	$314,000
Design and Permitting			15%	$47,000
Construction Management			10%	$31,000
Project Management			8%	$25,000
Ecology Review/Oversight for Implementation			2%	$6,000
Sales Tax (City of Tacoma)			10.1%	$34,000
			Year 1 Costs Subtotal	**$476,000**
Cap Improvement (Year 5) Costs				
Mobilization			4%	$93,000
Cap Resurfacing (4" HMA Overlay)	1	LS	$2,292,412	$2,292,412
Monitoring well repairs/replacement	18	EA	$2,500	$45,000
Design and Permitting			4%	$97,000
Construction Management			3%	$69,000
Project Management			2%	$51,000
Ecology Review/Oversight for Implementation			1%	$25,000
Sales Tax (City of Tacoma)			10.1%	$245,000
			Year 5 Costs Subtotal	**$2,917,000**
Perched Water Ex Situ Treatment (Year 5) Costs				
Mobilization			6%	$35,000
Ex Situ Treatment System (French Drains) Install	1	LS	$587,000	$587,000
Design and Permitting			8%	$47,000
Construction Management			4%	$23,000
Project Management			3%	$18,000
Ecology Review/Oversight for Implementation			1%	$6,000
Sales Tax (City of Tacoma)			10.1%	$63,000
			Year 5 Costs Subtotal	**$779,000**
PRB Contingency (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
			Year 10 Costs Subtotal	**$1,327,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
			Initial Construction and Other Costs Subtotal	**$4,182,000**
			Initial Construction Costs Contingency[2] (20%)	**$836,400**
			Total Initial Construction and Other Costs	**$5,018,400**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yrs 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ex Situ Treatment Maintenance	1	LS	$31,000	$31,000	5	$155,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$6,200	$6,200	5	$31,000
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Cap Inspections	1	LS	$8,500	$8,500	10	$85,000
Ex Situ Treatment Maintenance	1	LS	$31,000	$31,000	10	$310,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$3,400	$3,400	10	$34,000
Annual Costs - Yrs 16-100						
Maintain Inst. Controls	1	LS	$1,000	$1,000	85	$85,000
Cap Inspections	1	LS	$8,500	$8,500	85	$722,500
Ex Situ Treatment Maintenance	1	LS	$31,000	$31,000	85	$2,635,000
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	85	$578,000
Ecology Review/Oversight for annual events		5%	$2,400	$2,400	85	$204,000
Other Periodic Costs						
Cap Resurfacing (Grinding and 3"HMA)	1	LS	$2,058,000	$2,058,000	yr 25, 45, 65, 85	$8,232,000
Cap Repairs	1	LS	$54,000	$54,000	yr 15, 35, 55, 75, 95	$270,000
Ex Situ Treatment Maintenance (periodic)	1	LS	$30,000	$30,000	yr 10, 15, 20, 25…	$570,000
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 50, 90	$663,500
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000
					Subtotal Long Term Costs	**$15,495,500**
					Long Term Cost Contingency[2] (20%)	**$3,099,100**
					Total Long Term Costs	**$18,594,600**
					Total Construction, Other, and Long Term Costs	**$23,613,000**
					Total Net Present Value[3]	**$10,921,000**

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (20%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$476,000	$146,700	$124,540	$747,240	$765,174	$725,283	51	$0	$49,700	$9,940	$59,640	$199,910	$13,030
2	$0	$129,700	$25,940	$155,640	$163,200	$146,628	52	$0	$49,700	$9,940	$59,640	$204,708	$12,648
3	$0	$129,700	$25,940	$155,640	$167,117	$142,319	53	$0	$49,700	$9,940	$59,640	$209,621	$12,276
4	$0	$158,700	$31,740	$190,440	$209,391	$169,024	54	$0	$49,700	$9,940	$59,640	$214,652	$11,915
5	$3,696,000	$129,700	$765,140	$4,590,840	$5,168,826	$3,954,847	55	$84,000	$49,700	$26,740	$160,440	$591,303	$31,112
6	$0	$70,900	$14,180	$85,080	$98,091	$71,140	56	$0	$49,700	$9,940	$59,640	$225,079	$11,225
7	$0	$70,900	$14,180	$85,080	$100,445	$69,049	57	$0	$49,700	$9,940	$59,640	$230,481	$10,895
8	$0	$70,900	$14,180	$85,080	$102,855	$67,020	58	$0	$49,700	$9,940	$59,640	$236,013	$10,575
9	$0	$99,900	$19,980	$119,880	$148,404	$91,659	59	$0	$49,700	$9,940	$59,640	$241,677	$10,265
10	$1,357,000	$70,900	$285,580	$1,713,480	$2,172,094	$1,271,610	60	$30,000	$49,700	$15,940	$95,640	$396,860	$15,977
11	$0	$70,900	$14,180	$85,080	$110,440	$61,284	61	$0	$49,700	$9,940	$59,640	$253,417	$9,670
12	$0	$70,900	$14,180	$85,080	$113,091	$59,484	62	$0	$49,700	$9,940	$59,640	$259,499	$9,386
13	$0	$70,900	$14,180	$85,080	$115,805	$57,736	63	$0	$49,700	$9,940	$59,640	$265,727	$9,110
14	$0	$70,900	$14,180	$85,080	$118,584	$56,039	64	$0	$49,700	$9,940	$59,640	$272,104	$8,843
15	$84,000	$70,900	$30,980	$185,880	$265,297	$118,835	65	$2,088,000	$49,700	$427,540	$2,565,240	$11,984,645	$369,161
16	$0	$59,900	$11,980	$71,880	$105,053	$44,603	66	$0	$49,700	$9,940	$59,640	$285,322	$8,331
17	$0	$59,900	$11,980	$71,880	$107,574	$43,293	67	$0	$49,700	$9,940	$59,640	$292,169	$8,086
18	$0	$59,900	$11,980	$71,880	$110,156	$42,021	68	$0	$49,700	$9,940	$59,640	$299,181	$7,848
19	$0	$59,900	$11,980	$71,880	$112,800	$40,786	69	$0	$49,700	$9,940	$59,640	$306,362	$7,618
20	$30,000	$59,900	$17,980	$107,880	$173,356	$59,414	70	$30,000	$49,700	$15,940	$95,640	$503,079	$11,857
21	$0	$49,700	$9,940	$59,640	$98,138	$31,881	71	$0	$49,700	$9,940	$59,640	$321,244	$7,176
22	$0	$49,700	$9,940	$59,640	$100,493	$30,944	72	$0	$49,700	$9,940	$59,640	$328,954	$6,966
23	$0	$49,700	$9,940	$59,640	$102,905	$30,035	73	$0	$49,700	$9,940	$59,640	$336,848	$6,761
24	$0	$49,700	$9,940	$59,640	$105,375	$29,153	74	$0	$49,700	$9,940	$59,640	$344,933	$6,562
25	$2,088,000	$49,700	$427,540	$2,565,240	$4,641,164	$1,217,070	75	$84,000	$49,700	$26,740	$160,440	$950,188	$17,135
26	$0	$49,700	$9,940	$59,640	$110,493	$27,465	76	$0	$49,700	$9,940	$59,640	$361,688	$6,182
27	$0	$49,700	$9,940	$59,640	$113,145	$26,658	77	$0	$49,700	$9,940	$59,640	$370,369	$6,001
28	$0	$49,700	$9,940	$59,640	$115,861	$25,874	78	$0	$49,700	$9,940	$59,640	$379,258	$5,824
29	$0	$49,700	$9,940	$59,640	$118,641	$25,114	79	$0	$49,700	$9,940	$59,640	$388,360	$5,653
30	$30,000	$49,700	$15,940	$95,640	$194,822	$39,090	80	$30,000	$49,700	$15,940	$95,640	$637,729	$8,799
31	$0	$49,700	$9,940	$59,640	$124,405	$23,660	81	$0	$49,700	$9,940	$59,640	$407,225	$5,326
32	$0	$49,700	$9,940	$59,640	$127,390	$22,965	82	$0	$49,700	$9,940	$59,640	$416,998	$5,169
33	$0	$49,700	$9,940	$59,640	$130,448	$22,290	83	$0	$49,700	$9,940	$59,640	$427,006	$5,017
34	$0	$49,700	$9,940	$59,640	$133,578	$21,635	84	$0	$49,700	$9,940	$59,640	$437,254	$4,870
35	$84,000	$49,700	$26,740	$160,440	$367,969	$56,490	85	$2,088,000	$49,700	$427,540	$2,565,240	$19,258,582	$203,313
36	$0	$49,700	$9,940	$59,640	$140,067	$20,382	86	$0	$49,700	$9,940	$59,640	$458,494	$4,588
37	$0	$49,700	$9,940	$59,640	$143,429	$19,783	87	$0	$49,700	$9,940	$59,640	$469,498	$4,453
38	$0	$49,700	$9,940	$59,640	$146,871	$19,202	88	$0	$49,700	$9,940	$59,640	$480,766	$4,322
39	$0	$49,700	$9,940	$59,640	$150,396	$18,638	89	$0	$49,700	$9,940	$59,640	$492,304	$4,195
40	$30,000	$49,700	$15,940	$95,640	$246,966	$29,009	90	$361,750	$49,700	$82,290	$493,740	$4,173,442	$33,711
41	$0	$49,700	$9,940	$59,640	$157,702	$17,558	91	$0	$49,700	$9,940	$59,640	$516,219	$3,952
42	$0	$49,700	$9,940	$59,640	$161,486	$17,042	92	$0	$49,700	$9,940	$59,640	$528,608	$3,836
43	$0	$49,700	$9,940	$59,640	$165,362	$16,542	93	$0	$49,700	$9,940	$59,640	$541,294	$3,724
44	$0	$49,700	$9,940	$59,640	$169,331	$16,056	94	$0	$49,700	$9,940	$59,640	$554,286	$3,614
45	$2,088,000	$49,700	$427,540	$2,565,240	$7,458,063	$670,294	95	$84,000	$49,700	$26,740	$160,440	$1,526,893	$9,437
46	$0	$49,700	$9,940	$59,640	$177,556	$15,126	96	$0	$49,700	$9,940	$59,640	$581,211	$3,405
47	$0	$49,700	$9,940	$59,640	$181,817	$14,681	97	$0	$49,700	$9,940	$59,640	$595,160	$3,305
48	$0	$49,700	$9,940	$59,640	$186,181	$14,250	98	$0	$49,700	$9,940	$59,640	$609,443	$3,208
49	$0	$49,700	$9,940	$59,640	$190,649	$13,831	99	$0	$49,700	$9,940	$59,640	$624,070	$3,113
50	$361,750	$49,700	$82,290	$493,740	$1,616,204	$111,141	100	$48,000	$49,700	$19,540	$117,240	$1,256,237	$5,941
												Net Present Value[3]	$10,921,000

Notes:
1. Estimated costs are in 2017 dollars
2. Contingency rates and design/permitting, etc. percentage cost estimates based upon EPA cost estimating guidance (EPA 540-R-00-002). Relative percentages were altered based upon professional judgement.
3. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016 (2.4%) for a discount rate of (3.1%).

Initial and Annual Costs[1]

Item	Quantity	Unit	Rate/ %	Total
Initial (Year 1) Costs				
Mobilization			10%	$10,000
Stormwater System Repair (no slip line)	1	LS	$104,000	$104,000
Design and Permitting			15%	$16,000
Construction Management			10%	$10,000
Project Management			8%	$8,000
Ecology Review/Oversight for Implementation			2%	$2,000
Sales Tax (City of Tacoma)			10.1%	$12,000
			Year 1 Costs Subtotal	**$162,000**
Excavation, Removal, Repave (Year 5) Costs				
Mobilization			1.0%	$214,000
Excavation to Cleanup Level & Offsite Disposal	1	LS	$17,963,000	$17,963,000
Repave Site (Alt 2 Cap)	1	LS	$3,424,000	$3,424,000
Design and Permitting			1.0%	$214,000
Construction Management			1.5%	$321,000
Project Management			0.5%	$107,000
Ecology Review/Oversight for Implementation			0.1%	$21,000
Sales Tax (City of Tacoma)			10.1%	$2,182,000
			Removal (Year 5) Costs Subtotal	**$24,446,000**
Stormwater System Replacement (Year 5) Costs				
Mobilization			10%	$55,000
Stormwater System Replacement	1	LS	$553,000	$553,000
Design and Permitting			12%	$66,000
Construction Management			8%	$44,000
Project Management			6%	$33,000
Ecology Review/Oversight for Implementation			2%	$11,000
Sales Tax (City of Tacoma)			10.1%	$61,000
			Stormwater (Year 5) Costs Subtotal	**$823,000**
PRB Contingency (Year 10) Costs				
Mobilization			6%	$60,000
PRB Installation (10% ZVI @ 25'-10'bgs)	1,000	LF	$1,000	$1,000,000
Design and Permitting			8%	$80,000
Construction Management			4%	$40,000
Project Management			3%	$30,000
Ecology Review/Oversight for Implementation			1%	$10,000
Sales Tax (City of Tacoma)			10.1%	$107,000
			Year 10 Costs Subtotal	**$1,327,000**
Initial Other Costs				
Institutional controls	1	LS	$10,000	$10,000
			Initial Construction and Other Costs Subtotal	**$26,606,000**
			Initial Construction Costs Contingency[2] (30%)	**$7,981,800**
			Total Initial Construction and Other Costs	**$34,587,800**

Annual Long Term Costs	No. of Events	Unit	Rate/ %	Annual Total	Years	Total
Annual Costs - Yrs 1-5						
Maintain Inst. Controls	1	LS	$1,000	$1,000	5	$5,000
Cap Inspections	1	LS	$8,500	$8,500	5	$42,500
Cap Repairs	1	LS	$54,000	$54,000	5	$270,000
Ground/Surface Water Sampling & Annual Reporting (YR 1)	4	LS	$11,500	$46,000	1	$46,000
Ground/Surface Water Sampling & Annual Reporting	2	LS	$14,500	$29,000	4	$116,000
Porewater Sampling (YR 4)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$5,200	$5,200	5	$26,000
Annual Costs - Yrs 6-15						
Maintain Inst. Controls	1	LS	$1,000	$1,000	10	$10,000
Groundwater Sampling and Annual Reporting	2	LS	$13,500	$27,000	10	$270,000
Porewater Sampling (YR 9)	2	LS	$14,500	$29,000	1	$29,000
Ecology Review/Oversight for annual events		5%	$1,500	$1,500	10	$15,000
Annual Costs - Yrs 16-30						
Maintain Inst. Controls	1	LS	$1,000	$1,000	15	$15,000
Reduced Groundwater Sampling & Reporting (YRs 16-21)	1.0	LS	$17,000	$17,000	5	$85,000
Reduced Groundwater Sampling & Reporting (Twice/5YR)	0.4	LS	$17,000	$6,800	10	$68,000
Ecology Review/Oversight for annual events		5%	$1,800	$1,800	15	$27,000
Annual Costs - Yrs 30-100						
Maintain Inst. Controls	1	LS	$1,000	$1,000	70	$70,000
Other Periodic Costs						
PRB Maintenance/Repair		25%	$331,750	$331,750	yr 60	$331,750
Abandon wells	12	EA	$1,500	$18,000	yr 100	$18,000
					Subtotal Long Term Costs	**$1,473,250**
					Long Term Cost Contingency[2] (30%)	**$441,975**
					Total Long Term Costs	**$1,915,225**
					Total Construction, Other, and Long Term Costs	**$36,503,025**
					Total Net Present Value[3]	**$30,964,000**

Notes:
1. Estimated costs are in 2017 dollars
2. Contingency rates and design/permitting, etc. percentage cost estimates based upon EPA cost estimating guidance (EPA 540-R-00-002). Relative percentages were altered based upon professional judgement.
3. Net present value (NPV) based on reasonable return on investment (ROI) estimate (5.5%) subtracted from average City of Tacoma consumer price index (CPI) between 1998 and 2016

Net Present Value Calculation

Year	Initial/One Time Costs	Annual	Contingency (30%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)	Year	Initial/One Time Costs	Annual	Contingency (30%)	Total	Inflated Cost (2.4%)	NPV Cost (ROI 5.5%)
1	$162,000	$114,700	$83,010	$359,710	$368,343	$349,140	51	$0	$1,000	$300	$1,300	$4,358	$284
2	$0	$97,700	$29,310	$127,010	$133,180	$119,656	52	$0	$1,000	$300	$1,300	$4,462	$276
3	$0	$97,700	$29,310	$127,010	$136,376	$116,140	53	$0	$1,000	$300	$1,300	$4,569	$268
4	$0	$126,700	$38,010	$164,710	$181,101	$146,187	54	$0	$1,000	$300	$1,300	$4,679	$260
5	$25,279,000	$97,700	$7,613,010	$32,989,710	$37,143,111	$28,419,471	55	$0	$1,000	$300	$1,300	$4,791	$252
6	$0	$29,500	$8,850	$38,350	$44,215	$32,066	56	$0	$1,000	$300	$1,300	$4,906	$245
7	$0	$29,500	$8,850	$38,350	$45,276	$31,124	57	$0	$1,000	$300	$1,300	$5,024	$237
8	$0	$29,500	$8,850	$38,350	$46,362	$30,210	58	$0	$1,000	$300	$1,300	$5,144	$231
9	$0	$58,500	$17,550	$76,050	$94,145	$58,147	59	$0	$1,000	$300	$1,300	$5,268	$224
10	$1,327,000	$29,500	$406,950	$1,763,450	$2,235,438	$1,308,694	60	$331,750	$1,000	$99,825	$432,575	$1,794,977	$72,262
11	$0	$29,500	$8,850	$38,350	$49,781	$27,624	61	$0	$1,000	$300	$1,300	$5,524	$211
12	$0	$29,500	$8,850	$38,350	$50,976	$26,812	62	$0	$1,000	$300	$1,300	$5,656	$205
13	$0	$29,500	$8,850	$38,350	$52,199	$26,025	63	$0	$1,000	$300	$1,300	$5,792	$199
14	$0	$29,500	$8,850	$38,350	$53,452	$25,260	64	$0	$1,000	$300	$1,300	$5,931	$193
15	$0	$29,500	$8,850	$38,350	$54,735	$24,518	65	$0	$1,000	$300	$1,300	$6,074	$187
16	$0	$19,800	$5,940	$25,740	$37,619	$15,972	66	$0	$1,000	$300	$1,300	$6,219	$182
17	$0	$19,800	$5,940	$25,740	$38,522	$15,503	67	$0	$1,000	$300	$1,300	$6,369	$176
18	$0	$19,800	$5,940	$25,740	$39,446	$15,047	68	$0	$1,000	$300	$1,300	$6,521	$171
19	$0	$19,800	$5,940	$25,740	$40,393	$14,605	69	$0	$1,000	$300	$1,300	$6,678	$166
20	$0	$19,800	$5,940	$25,740	$41,363	$14,176	70	$0	$1,000	$300	$1,300	$6,838	$161
21	$0	$9,600	$2,880	$12,480	$20,536	$6,671	71	$0	$1,000	$300	$1,300	$7,002	$156
22	$0	$9,600	$2,880	$12,480	$21,029	$6,475	72	$0	$1,000	$300	$1,300	$7,170	$152
23	$0	$9,600	$2,880	$12,480	$21,533	$6,285	73	$0	$1,000	$300	$1,300	$7,342	$147
24	$0	$9,600	$2,880	$12,480	$22,050	$6,100	74	$0	$1,000	$300	$1,300	$7,519	$143
25	$0	$9,600	$2,880	$12,480	$22,579	$5,921	75	$0	$1,000	$300	$1,300	$7,699	$139
26	$0	$9,600	$2,880	$12,480	$23,121	$5,747	76	$0	$1,000	$300	$1,300	$7,884	$135
27	$0	$9,600	$2,880	$12,480	$23,676	$5,578	77	$0	$1,000	$300	$1,300	$8,073	$131
28	$0	$9,600	$2,880	$12,480	$24,245	$5,414	78	$0	$1,000	$300	$1,300	$8,267	$127
29	$0	$9,600	$2,880	$12,480	$24,826	$5,255	79	$0	$1,000	$300	$1,300	$8,465	$123
30	$0	$9,600	$2,880	$12,480	$25,422	$5,101	80	$0	$1,000	$300	$1,300	$8,668	$120
31	$0	$1,000	$300	$1,300	$2,712	$516	81	$0	$1,000	$300	$1,300	$8,876	$116
32	$0	$1,000	$300	$1,300	$2,777	$501	82	$0	$1,000	$300	$1,300	$9,089	$113
33	$0	$1,000	$300	$1,300	$2,843	$486	83	$0	$1,000	$300	$1,300	$9,308	$109
34	$0	$1,000	$300	$1,300	$2,912	$472	84	$0	$1,000	$300	$1,300	$9,531	$106
35	$0	$1,000	$300	$1,300	$2,982	$458	85	$0	$1,000	$300	$1,300	$9,760	$103
36	$0	$1,000	$300	$1,300	$3,053	$444	86	$0	$1,000	$300	$1,300	$9,994	$100
37	$0	$1,000	$300	$1,300	$3,126	$431	87	$0	$1,000	$300	$1,300	$10,234	$97
38	$0	$1,000	$300	$1,300	$3,201	$419	88	$0	$1,000	$300	$1,300	$10,479	$94
39	$0	$1,000	$300	$1,300	$3,278	$406	89	$0	$1,000	$300	$1,300	$10,731	$91
40	$0	$1,000	$300	$1,300	$3,357	$394	90	$0	$1,000	$300	$1,300	$10,989	$89
41	$0	$1,000	$300	$1,300	$3,437	$383	91	$0	$1,000	$300	$1,300	$11,252	$86
42	$0	$1,000	$300	$1,300	$3,520	$371	92	$0	$1,000	$300	$1,300	$11,522	$84
43	$0	$1,000	$300	$1,300	$3,604	$361	93	$0	$1,000	$300	$1,300	$11,799	$81
44	$0	$1,000	$300	$1,300	$3,691	$350	94	$0	$1,000	$300	$1,300	$12,082	$79
45	$0	$1,000	$300	$1,300	$3,780	$340	95	$0	$1,000	$300	$1,300	$12,372	$76
46	$0	$1,000	$300	$1,300	$3,870	$330	96	$0	$1,000	$300	$1,300	$12,669	$74
47	$0	$1,000	$300	$1,300	$3,963	$320	97	$0	$1,000	$300	$1,300	$12,973	$72
48	$0	$1,000	$300	$1,300	$4,058	$311	98	$0	$1,000	$300	$1,300	$13,284	$70
49	$0	$1,000	$300	$1,300	$4,156	$301	99	$0	$1,000	$300	$1,300	$13,603	$68
50	$0	$1,000	$300	$1,300	$4,255	$293	100	$18,000	$1,000	$5,700	$24,700	$264,663	$1,252
												Net Present Value[3]	$30,964,000

Unit Costs Item	Unit Cost ($)	Units	# of Units		Source/Notes
Discount Rate	3.1	%			
Consumer Price Index (CPI) Rate	2.4	%			1998-2016 average CPI in Seattle
Return on Investment (ROI) Rate	5.5	%			
Permeable Reactive Barrier (Contingency)				*Sub-totals*	
Zero valent iron (ZVI)	$1,125	CY	0	*$0*	$0.30 - $0.45/lb of coarse ZVI, from ITRC, June 2011: http://www.itrcweb.org/GuidanceDocuments/PRB-5-1.pdf. Not escalated to 2017, assumed cost competition.
ZVI Delivery	$143	TN	833	*$119,048*	From 2010 cost estimating at $3000/21tons in container shipment
Sand Purchase	$7.00	TN	0	*$0*	Dickson Company (Waller Road Gravel Pit): January 2017 price list
Sand Transport and Place	$11.40	CY	0	*$0*	2016 RS Means (Tacoma, WA): Hauling - Line #312323200134 assuming haul from Dickson @ 5mi/1-way; Backfill - Line #312323170020
Trenching w/single pass continuous trenching (25' depth)	$350	LF	1000	*$350,000*	Escalated from 2005 PRB installation cost, from ITRC, June 2011: http://www.itrcweb.org/GuidanceDocuments/PRB-5-1.pdf.
ZVI Backfill Mixture	$132	CY	1667	*$220,350*	Assumes 15' of ZVI sand mixture at 10/90 ZVI to Sand. Unit costs above.
Low Perm Backfill Mixture	$145	CY	1111	*$161,111*	Assumes CDF is used from 10'bgs to surface. Contractor bid price on similar project
Media and Cover Placement	$4	CY	2778	*$11,500*	Contractor bid on similar project
Cold Mix Asphalt	$100	TN	56	*$5,556*	Assumes 3" asphalt patch over 4' x 1500'
Pavement Repair	$62	SY	444	*$27,733*	Assumes 3" asphalt patch over 4' x 1500' , costs from G&O below
Subtitle D Trucking and Disposal	$54	CY	1667	*$90,634*	From cost below, assumes all native material removed and disposed
Permeable Reactive Barrier Installation (rolled up as LF)	$985.93	LF		*$985,932*	Assumes a 25' deep trench, 3' wide, 1000' long. Assumes a 50/50 ZVI & fine sand mix.
Perched Water Treatment and Drain (3A)					
New Pipeline Excavation	$12	CY	2400	*$28,800*	From estimate below. Assumes excavator loading trucks, from Stratus 2017 estimate. Assumes 12' deep by 1200' long. plus 50% bulking factor
Sawcut Pavement	$5	LF	5280	*$23,760*	From Port of Tacoma bid. Assumes double the sawcut for thick RCC
Pavement Demolition	$20	SY	1067	*$21,333*	From Port of Tacoma bid. Assumes double the sawcut and demolition for thick RCC
Dewatering	$17,200	LS	1	*$17,200*	From Caltrans, assumes dewatering approximatley 40K gallons (perched water) for storage and sediment removal. Discharge water into reactive sumps at completion. $60/d per tank, $1000 sediment disposal, $3k tank delivery and mod, $50/d for pumps
Reactive Media Sumps Excavation	$12	CY	360	*$4,320*	Assumes 18' deep by 10' long by 3' wide sumps will be dug at 6 locations to provide drainage and treatment. Backfilled with reactive ZVI media (see above)
Reactive Media Sumps Backfill	$132	CY	240	*$31,730*	See above for cost estimating. Assumes 8' of reacdtive media fill below drain pipe and bedding.
Trench Safety Equipment	$1,950	LS	2	*$3,900*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
12" Drain Pipe and Fittings Install	$85	LF	1200	*$102,000*	Assumes french drain line installs per FS TM. Use 12" HDPE costs per Tacoma area bids
Drain Rock/Gravel Base Puchase and Place	$25	CY	667	*$16,600*	Dickson's rates for materials with RS Means for delivery and placement = $24.90 total for drain rock
Backfill and Compaction	$2.35	CY	1,853	*$4,355*	Assuming this is placement and compaction of on-site materials; units were revised to match RS Means; if import is required we recomment Gravel Borrow from Dickson
HMA (conventional) Pavement (5-inch)	$100	TN	139	*$13,889*	From Port of Tacoma on call rate. Assumes 5" repave over 5' wide area through full length of excavation. Asphalt at 2tn/1cy
Waste Disposal Haul and Disposal	$54	CY	1360	*$73,958*	Assumes drain rock volume is equivalent to waste plus 50% bulking and wasting factor, slag left in place otherwise and recapped. Disposal costs below.
Perched Water Treatment and Drain Total		LS		*$341,846*	
Stormwater System Replacement				*Sub-totals*	
Removing drainage structure	$800	EA	4	*$3,200*	WSDOT Cost Database (bid dated 4/2017) $500-$800 for 4 units in project, $700 for 9 unit project (1/2016)
Removing manhole	$1,400	EA	8	*$11,200*	WSDOT Cost Database (bid dated 8/2014) 1 unit in project
Abandon existing stormwater system	$17	LF	2400	*$40,492*	Assumes existing stormwater system would be plugged and filled with CDF at a cost of $145/cy, 2400 LF of stormline, and an average diameter of 24".
Sawcut Pavement	$5	LF	5280	*$23,760*	From Port of Tacoma bid
Pavement Demolition	$20	SY	1067	*$21,333*	From Port of Tacoma bid
New Pipeline Excavation	$12	CY	1800	*$21,600*	From estimate below, assumes 4' wide and 4' to 7' excavation for 2 x 1200lf runs.Assumes excavator loading trucks, from Stratus 2017 estimate
Type II Catch Basin	$3,250	EA	4	*$13,000*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
12" HDPE Install	$85	LF	600	*$51,000*	Average of Tacoma area bids for similar projects
18" HDPE Install	$135	LF	600	*$81,000*	Average of Tacoma area bids for similar projects
24" HDPE Install	$145	LF	600	*$87,000*	Average of Tacoma area bids for similar projects
36" HDPE Install	$200	LF	600	*$120,000*	Average of Tacoma area bids for similar projects
Connections to Existing Catch Basins	$1,300	EA	8	*$10,400*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
Pipe Bedding (6")	$50	CY	180	*$9,000*	Seattle Public Utilities. 2014.
Trench Backfill and Pavement Base Course	$40	TN	1080	*$43,200*	Port of Tacoma 2016 bid.
HMA Paving	$100	TN	296	*$29,630*	From Port of Tacoma on call rate. Assumes 5" repave over 5' wide area through full length of excavation. Asphalt at 2tn/1cy
Trench Safey System	$8,600	LS	1	*$8,600*	Port of Tacoma 2016 bid.
Waste Disposal Haul and Disposal	$54	CY	1800	*$97,885*	From estimate below.
Stormwater System Replacement (Rolled up to LF)	$280	LF	1	*$672,300*	

Stormwater System Replacement (post removal action)	$230	LF	1	*$553,081*	Assumes no offsite disposal
Stormwater System Repair (Characterization and Incremental Improvement)				*Sub-totals*	
Initial Characterization (Workplan, SAP, Sampling)	$39,000	LS	1	*$39,000*	Assumes $10k for SAP/Work Plan, 15 samples for Diss/Total Metals ($200/s), 2 staff x 40hrs for collection, $10k for reporting with 20% contingency
Storm System Sediment Cleaning	$8	LF	2500	*$20,000*	Port of Tacoma contractor verbal estimate
Sediment Disposal	$54	CY	46	*$2,502*	Assumes 3" x 2' x 2500LF of sediment throughout system. Cost from estimate below.
Slip line (assume 36") with HDPE	$350	LF	600	*$210,000*	Verbal quote from a Vancouver, WA ($200/lf) and a Tacoma, WA contractor ($700/lf). City of Olympia cost of ~$150/lf for 32".
Seal Vaults	$21,000	LS	1	*$21,000*	Assumes 40 hrs of labor x 4 staff at $125/hr + $1000 materials
Verification Sampling and Report	$21,000	LS	1	*$21,000*	Assume 8 samples for Diss/Total Metals ($200/s), 2 staff x 24 hrs for collection, $10k for reporting with 20% contingency
Stormwater Improvement Total	$314,000	LS	1	*$314,000*	
Stormwater System Repair - no slip line (Alt 3 and 5)				*Sub-totals*	
Initial Characterization (Workplan, SAP, Sampling)	$39,000	LS	1	*$39,000*	Assumes $10k for SAP/Work Plan, 15 samples for Diss/Total Metals ($200/s), 2 staff x 40hrs for collection, $10k for reporting with 20% contingency
Storm System Sediment Cleaning	$8	LF	2500	*$20,000*	Port of Tacoma contractor verbal estimate
Sediment Disposal	$54	CY	46	*$2,502*	Assumes 3" x 2' x 2500LF of sediment throughout system. Cost from estimate below.
Seal Vaults	$21,000	LS	1	*$21,000*	Assumes 40 hrs of labor x 4 staff at $125/hr + $1000 materials
Verification Sampling and Report	$21,000	LS	1	*$21,000*	Assume 8 samples for Diss/Total Metals ($200/s), 2 staff x 24 hrs for collection, $10k for reporting with 20% contingency
Stormwater Improvement Total	$104,000	LS	1	*$104,000*	
Stormwater System Repair ALT3A - tide gates (yr 1) , vault removal (yr 3), slip line (yr 5)				*Sub-totals*	
Year 1 Improvements				***$58,502***	
Tide Gate Installation	$18,000	LS	2	*$36,000*	Port of Tacoma similar projects. Antec quote for 36" slip on check valve @ ~$10K-$15k each. Budget of $3k for port time installation at each outfall.
Storm System Sediment Cleaning	$8	LF	2500	*$20,000*	Port of Tacoma contractor verbal estimate
Sediment Disposal	$54	CY	46	*$2,502*	Assumes 3" x 2' x 2500LF of sediment throughout system. Cost from estimate below.
Remove vaults, place new vaults				***$107,063***	
Sawcut Pavement	$5	LF	320	*$1,440*	From Port of Tacoma bid
Pavement Demolition	$20	SY	89	*$1,778*	From Port of Tacoma bid. Double for thick RCC.
New Excavation	$12	CY	667	*$8,000*	From estimate below, assumes 20' wide and 20' to 15' excavation with 50% bulking factor. Assumes excavator loading trucks, from Stratus 2017 estimate
New Vaults and Install	$21,000	EA	2	*$42,000*	Assume $7500 for each Port specified inlet with 3K for install labor each.
Vault Bedding (6")	$50	CY	6	*$296*	Seattle Public Utilities. 2014.
Backfill and Pavement Base Course	$28	TN	667	*$18,667*	Port of Tacoma 2016 bid. Assumes 1/2 of excvation volume will need to be backfilled.
Connections to Existing Catch Basins	$1,300	EA	2	*$2,600*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
HMA Paving	$100	TN	56	*$5,556*	From Port of Tacoma on call rate. Assumes 5" repave over 5' wide area through full length of excavation. Asphalt at 2tn/1cy
Trench Safey System	$8,600	LS	1	*$8,600*	Port of Tacoma 2016 bid.
Waste Disposal Haul and Disposal	$54	CY	333	*$18,127*	From estimate below. Assume only 1/2 of excavated volume is disposable matieral
Slip line (assume 36") with HDPE				***$270,000***	
Initial Characterization (Workplan, SAP, Sampling)	$39,000	LS	1	*$39,000*	Assumes $10k for SAP/Work Plan, 15 samples for Diss/Total Metals ($200/s), 2 staff x 40hrs for collection, $10k for reporting with 20% contingency
Slip line (assume 36") with HDPE	$350	LF	600	*$210,000*	Verbal quote from a Vancouver, WA ($200/lf) and a Tacoma, WA contractor ($700/lf). City of Olympia cost of ~$150/lf for 32".
Verification Sampling and Report	$21,000	LS	1	*$21,000*	Assume 8 samples for Diss/Total Metals ($200/s), 2 staff x 24 hrs for collection, $10k for reporting with 20% contingency
Stormwater Improvement Total				***$435,565***	
Perched Water Ex Situ Treatment (ALT 4 French Drains)					
New Pipeline Excavation	$12	CY	4250	*$51,000*	From estimate below, assumes 15' deep x3' wide excavation for 1700lf with 50% bulking factor.Assumes excavator loading trucks, from Stratus 2017 estimate
Sawcut Pavement	$5	LF	7480	*$33,660*	From Port of Tacoma bid. Assumes double the sawcut for thick RCC
Pavement Demolition	$20	SY	1511	*$30,222*	From Port of Tacoma bid. Assumes double the sawcut and demolition for thick RCC
Dewatering	$17,200	LS	1	*$17,200*	From Caltrans, assumes dewatering approximatley 40K gallons (perched water) for storage and sediment removal. Discharge water into reactive sumps at completion. $60/d per tank, $1000 sediment disposal, $3k tank delivery and mod, $50/d for pumps
Trench Safety Equipment	$1,950	LS	2	*$3,900*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
12" Drain Pipe and Fittings Install	$85	LF	1700	*$144,500*	Assumes 3 french drain line installs per FS TM. Use 12" HDPE costs per Tacoma area bids
Connections to Existing Catch Basins	$1,300	EA	8	*$10,400*	Escalated from 2005 Gray and Osborne unit costs for Friday Harbor, WA. CCI 8194.11 (2005) to 10699 (April, 2017).
Drain Rock/Gravel Base Puchase and Place	$25	CY	944	*$23,517*	Dickson's rates for materials with RS Means for delivery and placement = $24.90 total for drain rock
Backfill and Compaction	$2.35	CY	3,306	*$7,768*	Assuming this is placement and compaction of on-site materials; units were revised to match RS Means; if import is required we recomment Gravel Borrow from Dickson.

Media Treatment (below grade) Vault and Install	$52,629	EA	3	*$157,888*	Escalated from 2008 City of Tacoma evaluation. Contech syle concrete vault with heavy traffic load rating.
Treatment Media Replacement (Initial)	$651	CY	5	*$3,257*	From PRB calcs costs above. Assumes 50/50 ZVI/sand mixture.
HMA (conventional) Pavement (5-inch)	$100	TN	262	*$26,235*	From Port of Tacoma on call rate. Assumes 5" repave over 5' wide area through full length of excavation. Asphalt at 2tn/1cy
Waste Disposal Haul and Disposal	$54	CY	1417	*$77,039*	Assumes drain rock volume is equivalent to waste, slag left in place otherwise and recapped. With 50% bulking factor. Disposal costs below.
French Drain and Ex Situ Treatment Vault Total		LS		*$586,585*	
Ex Situ Treatment Maintenance (Annual)					
ZVI/Sand Mix Replacement	$651	CY	5	*$3,257.14*	From PRB calcs costs above. Assumes 50/50 ZVI/sand mixture.
Spent Media Disposal	$54	CY	5	*$1,000*	Estimate below or minimum of $1000, assumes media is non-haz
Vac Truck - Media Removal	$3,272	LS	1	*$3,272*	From Port of Tacoma's stormline jetting verbal estimate
3 submersible pump power usage	6,000	kW-h/yr	0.07	*$420*	Assume 2000 kWh/a per pump (Grunfos .5HP pump at 20'and 5gpm)
2 2HP transfer pumps at 20% service	2,000	kW-h/yr	0.07	*$140*	Assume 5000 kWh/a per pump
NPDES Annual Sampling Cost	1	LS	$8,000	*$8,000*	Costs from ALS, only metals analysis ($166/sample). Assumes monthly samples. Assumes 4hrs labor x $120/hr per sampling.
Operations Labor	1	LS	$6,500	*$6,500*	Estimate for 1hr/wk @ $125/hr operations and monitoring.
NPDES Monthly Reporting	1	LS	$6,000	*$6,000*	Assumes 4hrs labor/month @ $125/hr
NPDES Annual Reporting	1	LS	$2,500	*$2,500*	Est. 20hrs at $125/hr
Annual Ex Situ Treatment Maintenance O&M total				*$31,089*	
Ex Situ Treatment Maintenance (periodic, 5-yr)					
NPDES Permit Re-Application	1	LS	$7,500	*$7,500*	Estimate from 2014/15 GSI permit re-application effort. Assume re-appication every 5 years
NPDES Permit Remewal Fee	1	LS	$5,200	*$5,200*	Assumes individaul water plant permit fee schedule. http://apps.leg.wa.gov/wac/default.aspx?cite=173-224-040
Quarterly Samples for Renewal	1	LS	$2,987	*$2,987*	NPDES renewal analytical costs (assumes 4 quarterly samples) from Eugene Project. Costs from Test America.
.5HP submersible pump replacement	1	EA	$1,250	*$1,250*	Est. for a grundfos 0.5HP submersible pump. Assume 1 one replacement every 5 yrs
Valve, pipe, and controls replacements	1	LS	$3,000	*$3,000*	Budget for miscellaneous replacements
O&M Labor	1	LS	$10,000	*$10,000*	Budget for miscellaneous repair
Periodic Ex Situ Treatment Maintenance O&M total				*$29,937*	
Subtitle D Disposal (no stabilization)					
Haul to LRI in Graham WA	$15	TN	1		Assume $125/hr per truck, 4 turns at 10 hr days. Assume 14cy trucks.
Disposal at LRI	$21	TN	1		From Port of Tacoma 2015 contract rates, add 3.6% for WA waste tax.
	$36.25	TN			Assumes excavation and disposal takes 6 days for 1800cy
Disposal (rolled up as CY)	$54.38	CY			Assumes waste density of 1.5 ton/CY
Source Removal (Alternative 5)				*Sub-totals*	
Rubbilize existing RCC	$2	SY	142,780	*$285,560*	Assumes 13" average of RCC (from RI) across property (30ac). $2/SY value provided by Jerry Thayer (Mat-Con) via email April to June 2017
Excavation	$12	CY	337,119	*$4,045,433*	Assumes excavator loading trucks, from contractor bid on similar project.
Haul and Subtitle D Disposal (no stabilization)	$54	CY	237,967	*$12,940,770*	From above, assumes disposal w/LRI
Import gravel layer (purchase/place)	$25	CY	27,763	*$691,293*	Assumes placement of equivalent excavated material minus rubbilized concrete. Dickson's rates for materials with RS Means for delivery and placement = $24.90 total for drain rock
Total Removal Cost				$17,963,056	
Repave Site (Alt 2)	$116,056.52	Ac	29.5	*$3,423,667*	Repave site as Alt 2, minus gravel layer. Includes compaction, HMA, and triaxial grid over 29.5 ac
Total Construction Cost				*$21,386,723*	
Cap Resurfacing/Asphalt Overlay (Alt 1)				*Sub-totals*	
HMA (conventional) Pavement (4-inch)	$70	TN	31,729	*$2,221,022*	Averaged price of WSDOT 2016 state average HMA cost and local vendor quote. 29.5 acres, HMA = 2tns/CY
Asphalt Tack Coat	$0.50	SY	142,780	*$71,390*	Jerry Thayer (Mat-Con) via email April to June 2017
Total Construction Cost				$2,292,412	
Enhanced Cap (Alt 2)				*Sub-totals*	
HMA (conventional) Pavement (5-inch)	$70	TN	39,661	*$2,776,278*	Averaged price of WSDOT 2016 state average HMA cost and local vendor quote. 29.5 acres, HMA = 2tns/CY
Import 12 inch gravel layer (purchase/place)	$25	CY	47,593	*$1,185,074*	Dickson's rates for materials with RS Means for delivery and placement = $24.90 total for drain rock
Compact gravel (2passes)	$0.30	CY	47,593	*$14,278*	2016 RS Means (Tacoma, WA): Line #312323235050 - compaction, riding, vibrating roller, 8-in lifts, 2 passes
Stripdrain for drainage layer over RCC	$215.00	Roll	30	*$6,450*	Rolls are 150' long; Vendor quote @$215/roll

Triaxial Grid (purchase/deliver/install)	$3.99	SY	157,058	*$626,661*	Jordan Rabin & Garrett Fountain (Tensar Corp) via email 7/27/17 , 29.5 acres plus 10%
Total Construction Cost				$4,608,741	
Enhanced Cap (Alt 3)				*Sub-totals*	
HMA (conventional) Pavement (5-inch)	$70	TN	39,661	*$2,776,278*	Averaged price of WSDOT 2016 state average HMA cost and local vendor quote. 29.5 acres, HMA = 2tns/CY
Triaxial Grid (purchase/deliver/install)	$3.99	SY	157,058	*$626,661*	Jordan Rabin & Garrett Fountain (Tensar Corp) via email 7/27/17
Sand Purchase (above and below GCL layer)	$7.00	TN	41,938	*$293,566*	Dickson Company (Waller Road Gravel Pit): January 2017 price list
Sand Transport and Place	$11.40	CY	23,828	*$271,639*	2016 RS Means (Tacoma, WA): Hauling - Line #312323200134 assuming haul from Dickson @ 5mi/1-way; Backfill - Line #312323170020
GCL Liner @ k =10^-8 to 10^-9 cm/s	$0.63	SF	1,413,522	*$890,519*	Jeff Boys (ACF West) via email 6/15/17
Rubbilize existing RCC	$2	SY	142,780	*$285,560*	Assumes 13" average of RCC (from RI) across property (30ac). $2/SY value provided by Jerry Thayer (Mat-Con) via email April to June 2017
Stripdrain for drainage layer over GCL	$215	Roll	30	*$6,450*	Rolls are 150' long; Vendor quote @$215/roll
Excavate 13" thick existing RCC and 18" gravel (stockpile)	$6.62	CY	122,949	*$813,925*	2016 RS Means (Tacoma, WA): Line #312316464400 dozer excavation, 300-ft haul, sand & gravel
Construct Stockpile area (labor, geosynthetic, ecology block)	$42,000	LS	1	*$42,000*	BTL Liner (liner materials), 48Barriers (ecology blocks), and RS Means 2016 (Tacoma, WA) for labor & equipment
Backfill placement w/stockpiled RCC and Gravel	$2.56	CY	122,949	*$314,751*	2016 RS Means (Tacoma, WA): Line #312323144400 - backfill, structural, 300'haul sand & gravel from existing stockpile, 200HP, B10B crew
RCC and Gravel Compaction (2 passes)	$0.30	CY	122,949	*$36,885*	2016 RS Means (Tacoma, WA): Line #312323235050 - compaction, riding, vibrating roller, 8-in lifts, 2 passes
Total Construction Cost				$6,358,234	
Conventional HMA Resurfacing (3" HMA)				*Sub-totals*	
HMA (conventional) Pavement (3-inch)	$70	TN	23,797	*$1,665,767*	Averaged price of WSDOT 2016 state average HMA cost and local vendor quote. 29.5 acres, HMA = 2tns/CY
Asphalt Tack Coat	$0.50	SY	142,780	*$71,390*	Jerry Thayer (Mat-Con) via email April to June 2017
Planing Bitumious Pavement	$2.25	SY	142,780	*$320,855*	Average WSDOT first bid price between 2013-2017 for projects greater than 100K SY.
Total Construction Cost				$2,058,012	
Sawmill Bioremediation (Alt 2) Enhanced Bio	thickness (ft)				
Treatment Area Volume & Weight Calculation	5	LB	427,606		5' thick "target zone" (see FS TM Figure 5) at 35' radius. Assume 5' of crushed recycle concrete is being neutralized at 20% pure CaCO3.
Benchscale Test	$31,000	LS	1	*$31,000*	Assumes 8 core field samples composite for 3 for bio & oxidant benchscale testing. Samples collected @$1500 ea, tests at $3000/ea + Report @ $10k
Injection Well Points by Geoprobe	$7,700	Day	2	*$15,400*	From contractor bid cost on similar project. 2 days to perform injections on 22 points. Assume oversight cost of $115/staff/hr @12hr days.
Ammonia Sulfate	$0.20	LB	3,887	*$777*	From SC 2017 AG report for dry bulk pricing $310/ton. Assume $400/ton. Assume neutralization potential of 110 lb pure CaCO3 per Purdue Extension Doc.
Chemical Mixing Equipment Materials and Ops	$800	point	15	*$12,000*	From 2016 cost estimating, Washington PCP chemox injection project
Water	$4.00	CCF	44	*$176*	From 2016 cost estimating, Washington PCP chemox injection project
Oversight	$3,000	Day	2	*$6,000*	Assumes 2 staff oversight at $125/hr@ 12hr day.
Bioremediation Injection Cost				$65,353	
Sawmill Excavation (Alt 3)	thickness (ft)				
Treatment Area Volume Calculation	12	CY	1,780		Per FS TM Figure 13 assume excavation around historical dig area. Approximately 15' beyond former extent to a maximum depth of 12'
Extract Well Installation (6", 20' deep)	$2,500	per well	3	*$7,500*	From contractor 2016 bid, includes mob fee ($500), stard card ($65), vault ($375), drilling at $35/ft. Assumes consultant oversight at $500/well. Assumes 1 solid and 1 liquid drum disposal ($175 + $185)
Excavation	$12	CY	1,780	*$21,363*	From contractor bid on similar project.
Haul and Subtitle D Disposal (no stabilization)	$54	CY	1,780	*$96,810*	From above, assumes disposal with LRI
Import gravel layer (purchase/place)	$25	CY	1,780	*$44,322*	Assumes placement of equivalent excavated material minus rubbilized concrete. Dickson's rates for materials with RS Means for delivery and placement = $24.90 total for drain rock
Carbon Treatment Unit Rental (dewatering)	$2,000	week	2	*$4,000*	Assumed cost for rental carbon units, https://clearcreeksystems.com/services/system-rentals/
Total Removal Cost				$173,995	
Periodic Maintenance and Costs				*Sub-totals*	
Well Installation (2", 20' deep)	$2,500	ea	1		From contractor 2016 bid, includes mob fee ($500), stard card ($65), vault ($375), drilling at $35/ft. Assumes consultant oversight at $500/well. Assumes 1 solid and 1 liquid drum disposal ($175 + $185)
Well Abandonment	$1,500	ea	1		From contractor bid on similar project.
Cap Inspections	$8,500	ea	1		From Port of Tacoma 2017 costs. $6.5K contract, $2k Port staff
Cap Repairs (crack repairs)	$3.40	LF	16000	$54,400.00	Assumes crack repair at 10x the width of the property . Approximate WSDOT Bid Item Database Low Bid Average for 2015-2017, range from $2.20 to $4.60
GCL Liner Repair	3	%	1	$190,747.02	Assumes 3% cap liner repair at 3% installation cost (see above)
Monitoring and Characterization					
Sampling mobilization	$4,140	per event	1		Assumes an 6hr mob/demob + 12hr prep x 2 staff at $115/hr
Groundwater sampling (labor)	$270	per well	1		Assumes 2.5hr per well x 1 staff @ $115/hr + equipment surcharge of $40/well (assuming $160 day rate/ 4 wells)

Surface/OF Surface Water Sampling (labor)	$98	per location	1	Assumes 0.5hr per well x 1 staff @ $115/hr + equipment surcharge of $40/location
NMDS Porewater Sampling (labor)	$3,500	per location	1	Assumes up to 14 jars planted at each transect. Based on RI budgeting.
Analytical (Sawmill)	$300	per well	1	Assumes PCP (8270D) $225/sample and total metals analysis (6020A) $75/sample from ALS 2017 quote
Analytical (Log Yard)	$75	per well	1	Assumes total metals analysis (6020A) $75/sample from ALS 2017 quote
Annual data reporting	$10,000	per event	1	From inccurred costs on similar projects.
Annual GW Sampling Event (Sawmill)	$16,420	yr	1	Assumes 4 wells and unit costs above
Semi-Annual GW Sampling Event (Sawmill)	$22,840	yr	1	Assumes 4 wells and unit costs above
Quarterly GW Sampling Event (Sawmill)	$35,680	yr	1	Assumes 4 wells and unit costs above
Bi-Annual GW Sampling Event (Log Yard) - 9 Wells	$6,898	yr	1	Assumes 9 wells and unit costs above . Annualized on 5yr review periods or 2/5's annual monitoring cost.
Annual GW Sampling Event (Log Yard) - 12 Wells	$18,280	yr	1	Assumes 12 wells and unit costs above
Semi-Annual GW, SW, and Porewater Sampling Event (Log Yard)	$42,893	yr	1	Assumes 12 wells + 4 SW locations, + 3 OF locations, + 4 porewater sampling locations, and unit costs above
Quarterly GW and SW Sampling Event (Log Yard)	$45,903	yr	1	Assumes 12 wells + 4 SW locations, + 3 OF locations, and unit costs above
Maintain Institutional Controls	$1,000	LS	1	Budget for annual controls maintenance.
Semi-annual SW and OF sampling - 7 locations	$2,415	yr	1	Assumes 7 sample locations, unit costs above
Semi-annual Porewater NMDS Sampling - 4 Locations	$28,600	yr	1	Assumes 4 sample locations, unit costs above
Reduced Annual GW Sampling Event (Log Yard) - 9 Wells	$17,245	yr	1	Assumes 9 wells and unit costs above