PACIFIC groundwater GROUP

SCOUGAL RUBBER FACILITY
FINAL REMEDIATION PLAN

November 2016

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Prepared for:

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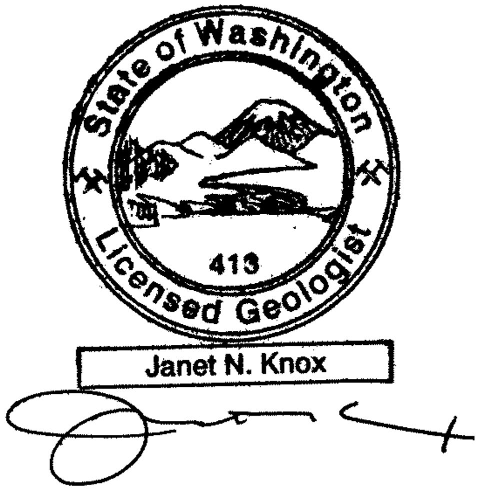
SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



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1.0 INTRODUCTION

This Final Remediation Plan recommends remedial options to address solvent impacts to soil and groundwater in the portion of the Scougal Rubber facility between Michigan Avenue South and the paint booth building, which is referred to as Area A in this report (Figure 1). Previous remedial efforts to address historical trichloroethylene (TCE) contamination of soils and groundwater in the adjacent paint booth, south, and west area at the Scougal Rubber facility have significantly reduced the total amount of contaminant present in the subsurface. However, recent groundwater monitoring data in Area A show residual TCE concentrations that slightly exceed Model Toxics Control Act (MTCA) Method A cleanup levels for groundwater.

1.1 GEOLOGY

The site's geology is based on data reported in a 2002 study by RETEC and by subsequent drilling logs taken during the installation of additional monitoring wells by Pacific Groundwater Group (PGG). The depth to the water table is approximately 7 ft. with silty sand extending down to the characterized saturated zone 20 ft. below ground surface.

The shallow aquifer under Area A is unconfined and comprised primarily of sand and silty sand. Thin (< 0.5 ft) silt layers are present in borings logs. An up-gradient hydraulic boundary exists at the northeastern edge of Area A. It is formed by a zone of gravel used to backfill a buried 50- by 78-inch main sewer line.

Hydraulic parameters at the site estimated by RETEC (2002) include:

- Hydraulic gradient 0.0013 ft/ft
- Transmissivity 4.0 to 4.4 ft^2/min from pump tests
- Transmissivity 10.43 to 14.2 ft^2/min in observation wells
- Hydraulic conductivity 0.37 ft/min (0.19 cm/s)
- Storativity 0.21-0.5

Additional characterizations by PGG, and others, in neighboring geologic units document hydraulic conductivity values ranging from 0.001 to 0.02 cm/s (PGG, 2009).

1.2 SITE CONCEPTUAL MODEL

The site conceptual model presents our understanding of the site and expected fate and transport (Table 1, Figure 1). Low, heterogeneous TCE concentrations are found in groundwater, possibly reflecting low, heterogeneous soil contaminations in the vadose zone. Water percolating through the vadose zone then transported TCE to groundwater forming a dissolved groundwater plume. Concentrations are far too low to indicate the presence of Nonaqueous Phase Liquid at this site. TCE in groundwater migrated in the direction of groundwater flow via advection and dispersion forming a diffuse plume, consistent with the pattern observed in groundwater detections (Figure 1). Subsequent discontinuation of TCE use and later paving of Area A in 2014 reduced loading and leaching to the water table. Residual TCE in vadose and aquifer soil could continue to maintain concentrations above the groundwater cleanup level for an extended period of time.

Measured groundwater TCE concentrations in 2015 (2-19 ug/L) indicate that soil TCE concentrations in some portions of the vadose zone exceed soil concentrations protective groundwater. The likely heterogeneity in soil concentrations limits the value of further soil sampling.

1.3 REMEDIATION OBJECTIVES

The goal of remedial action at the Scougal Facility is to obtain a no further action (NFA) letter under the Washington State Department of Ecology's Voluntary Cleanup Program. Target cleanup levels and remediation levels are summarized in Table 2.

Specific objectives include:

- Reduction of soil concentrations to levels that are protective of groundwater and below screening levels for direct contact. Protection of groundwater may be demonstrated empirically.
- Reduction of groundwater concentrations to levels protective of surface water receptors.

1.4 REMEDIATION LEVELS

This section discusses remediation levels that are protective of receptor pathways. At many sites, potential groundwater receptors include use as drinking water and discharge to surface water at the Duwamish River. The remediation levels in Table 2 are developed to be protective of surface water receptors. In the following section, we discuss why groundwater impacted by the Scougal site is not a practicable drinking water source.

1.4.1 Consideration of Drinking Water

Groundwater in south Seattle-Georgetown is neither a current nor expected to be a future drinking water source. In this section, we indicate that conditions of WAC 173-204-720 (a-c) are met such that groundwater impacted at Scougal is not suitable as a current or probable future source of drinking water.

Potability studies suggest no impact to current drinking water sources. A recent potability study (Amec, 2014) concluded that there are no water supply wells within one mile down or cross-gradient from a Stericycle Georgetown Facility located at 5400 Denver Avenue South, which is 0.5 miles northeast of the Scougal property. The search area used in the Georgetown Facility study encompasses and is applicable to the Scougal property. The study identified the Highline well field, 5 miles to the south, as the nearest municipal groundwater source of drinking water. It was concluded that the Highline well field draws from an aquifer not hydraulically connected to the aquifer underlying the Georgetown Facility.

Groundwater downgradient of Scougal is unlikely to become a future drinking water source. The depth and anticipated yield of groundwater in that vicinity make water recovery technically possible; however, groundwater contains natural background concentrations of organic and inorganic constituents and characteristics that make its use as a drinking water source not practicable.[1] Natural background at this site is likely the same as that found in groundwater upgradient and cross-gradient of the Georgetown Facility, which is upgradient of Scougal. According to recent studies (PSC, 2003; Amec, 2014) groundwater meets neither primary drinking water standards (due to turbidity and coliform levels), nor secondary standards (due to iron, manganese, total dissolved solids, and color criteria).

1.4.2 Protection of Surface Water

The Duwamish River, located 2,200 ft downgradient of Scougal, is a potential surface water receptor of groundwater flow from the Scougal site. The Duwamish River is currently designated unsuitable as a domestic drinking water source per WAC 173-201A.

We used a BIOCHLOR transport model to calculate a remediation level protective of potential discharge to the Duwamish River. BIOCHLOR requires specification of (i) the aquifer's hydraulic conductivity (K-value) and (ii) rate constants for the three steps in the biotransformation of TCE to ethene. The on-site hydraulic conductivity was previously reported as 0.19 cm/s (RETEC, 2002). This value is 1 to 2 orders of magnitude greater than what is expected for the geologic materials (silty sands) observed in site borings (Freeze and Cherry 1979; Fetter 2001). PGG and others have conducted extensive slug testing in equivalent geologic materials near 3rd St and Orcas St. These tests indicated that the K-values for local silty sands more likely fall within the range of 0.001 to 0.017 cm/s. Insufficient data is available to estimate bio transformation rates via plume mass balance methodologies. Therefore, the BIOCHLOR model was implemented using conservative literature reported TCE, DCE, and VC biotransformation kinetics (Newell et al. 2002).

The BIOCHLOR model (parameterized with a K-value of 0.02 cm/s and assuming biotransformation of all daughter products) indicates that a TCE concentration of 40 ug/L at Scougal is protective of surface water. Considering a worst-case scenario in which TCE is completely biotransformed to VC with no further transformation of VC to ethene, the BIOCHLOR model indicates that a remediation level of 20 ug/L TCE on-site will avoid groundwater concentrations exceeding those protective of surface water at the point of discharge.

2.0 REMEDIAL ALTERNATIVES

This section describes the common elements of any remediation effort and compares three potential remedial alternatives:

[1] The Model Toxics Control Act (MTCA) defines practicable as "capable of being designed, constructed and implemented in a reliable and effective manner, including consideration of cost. When considering cost under this analysis, an alternative shall not be considered practicable if the incremental cost of the alternative is disproportionate to the incremental degree of benefits provided by the alternative over other lower-cost alternatives" (WAC 173-340-200).

- Alternative 1: Excavation and monitored natural attenuation (1A), or with supplemental groundwater treatment (1B)
- Alternative 2: In situ chemical oxidation (ISCO) by trench infiltration (2A) or in by direct push injection (2B)
- Alternative 3: Enhanced in situ biological (EISB)

Final remediation to cleanup levels is technically challenging at the low levels of TCE and VC concentrations present at Scougal. This is in part because, at these concentrations, in-situ technologies are difficult to implement cost effectively. Technical limitations are discussed in each considered alternative. Regardless of the selected approach, small-scale buried features such as specific soil releases, and buried wood and thin silt layers below the water table are difficult to locate or target and can cause rebound.

Each of the considered remedial options is intended to address remaining contamination, but each has limitations and may not be a complete remedy for the site. Table 3 summarizes the relative benefits of each alternative and planning-level cost estimates for comparison.

2.1 COMMON ELEMENTS

Several elements are common to all remedial alternatives.

- A remedial action report will document the cleanup and results.
- Four quarters groundwater monitoring below cleanup levels protective of surface water.
- ISCO treatment in a residual zone of contamination under the main plant. This is discussed in more detail in the following subsection.
- ISCO treatment in a residual zone of contamination in the adjacent Machinists Inc. property. This is discussed in more detail in the following subsection.

2.1.1 In Situ Chemical Oxidation (ISCO) in the Main Plant Area

The objective of ISCO in the main plant area is to remove TCE, DCE, and VC in the vadose zone under the concrete pad and prevent further leaching to groundwater.

ISCO involves the mineralization of organic contaminants by direct contact with a soluble oxidant such as potassium permanganate ($KMnO_4$). This approach has been successfully used behind the East Warehouse, and in the former UST area.

The preliminary design includes 5 infiltration sumps at locations shown in Figure 1. The delivery depth will be 2 to 5 ft. below ground surface, to deliver oxidant into both the vadose and shallow saturated zones. The primary objective is treatment of groundwater. Three monthly injection rounds of $KMnO_4$ solution will be made, followed by confirmation sampling 6 months after the last injection event. The success of ISCO assumes that the majority of contaminant mass resides in the vadose and shallow saturated zones in close proximity to the installed sumps. It also assumes (i) relatively homogeneous infiltration into the affected soil zone and (ii) a rate of contaminant oxidation, at low TCE concentrations, greater than rate of $KMnO_4$ percolation out of the contaminated zone.

The estimated cost for this remedial element is $15,000. This includes installation of infiltration sumps and oxidant application. We assume that the sumps may be installed and permanganate application can be observed by Scougal personnel if preferred for cost savings.

2.1.2 In Situ Chemical Oxidation (ISCO) in the Adjacent Machinists Inc Building

The objective of ISCO in the adjacent Machinists Inc Building area is to remove TCE, DCE, and VC in groundwater in that vicinity.

The preliminary design includes use of a truck mounted direct push rig to inject permanganate into the saturated zone within the treatment area. The injection interval will extend from 6- to 15-feet below ground surface with a top-down injection pattern. A 5-foot spacing between points in two parallel lines separated by 5 feet will provide a treatment area approximately 10-to 12-feet wide. Subsequent groundwater advection will transport reagents down gradient until depleted. Permanganate can remain active in groundwater for weeks or months depending on the oxidant demand. Therefore, ISCO remediation is expected to reduce contaminant mass tens of feet down gradient from the primary injection area.

Access to the areas between the Mix Room and Machinists Inc. property may be too tight to allow direct push injection. If access to this area is not feasible, then those direct push locations will be replaced with vertical infiltration sumps advanced to 6 feet bgs. They will be constructed with 4 inch slotted PVC and pea gravel backfill.

A bench test may be conducted to see if sodium permanganate solution can be safely used for injections. Sodium permanganate can be mixed to higher concentrations and therefore has both a higher degree of effectiveness, and a higher probability of adverse reactions upon injection.

The estimated cost for this remedial element is $40,000. This includes direct push injections and sumps, and oxidant application. We assume that the sumps may be installed and permanganate application can be observed by Scougal personnel if preferred for cost savings.

2.2 ALTERNATIVE 1A. EXCAVATION AND MONITORED NATURAL ATTENUATION

Alternative 1A involves the mechanical removal of the asphalt cover and soils comprising the vadose zone under Area A. Clean gravel fill would replace the excavated soil. The excavation area is dictated by the site boundaries (e.g. road, sewer line, paint house). Approximately 780 cubic yards of soil would be removed. Maintaining safe shoring angles during pit excavation near these boundaries renders potentially contaminated soils at the pit edges inaccessible to direct removal.

The objective of Alternative 1A is to remove contaminated soil that would otherwise serve as a long-term source of TCE leaching to groundwater. If TCE in soil is removed, the potential impacts to groundwater and surface water receptors will be diminished.

The cost estimate associated with Alternative 1A assumes that TCE levels in excavated soil will be sufficiently low to be disposed of in Subtitle D landfill. Pre-cleanup soil sampling will be performed to adjust the extent of excavation. After excavation, grab soil samples at 20 ft. linear intervals along the excavation boundaries will be analyzed for TCE.

The major costs associated with Alternative 1A include the removal of the asphalt cover, vadose zone excavation, soil stockpile screening, and disposal at a Subtitle D landfill facility, estimated within the range of $80,000-$100,000. The total remedial cost is estimated at $250,000.

2.3 ALTERNATIVE 1B. EXCAVATION AND GROUNDWATER TREATMENT

Alternative 1B involves the excavation components of Alternative 1A plus targeted ISCO groundwater treatment of the shallow saturated zone. Following excavation, rows of perforated PVC piping would be installed in the excavation as a permanganate delivery system to further reduce groundwater concentrations through ISCO. These delivery lines would be installed approximately 6 ft. apart and perpendicular to groundwater flow direction.

The objective of Alternative 1B is to provide a contingency for efficient oxidant delivery once the excavated soil has been backfilled with clean gravel. This will allow for delivery of oxidant directly to the interface of the vadose and saturated zones, if residual TCE remains above cleanup levels in shallow groundwater after soil excavation.

Alternative 1B assumes that residual TCE will be present in the shallow groundwater interval (i.e. the first 1-5 ft. of the saturated zone) accessible to oxidant solution traveling by passive seepage. It also assumes that the rate of contaminant oxidation, at low TCE concentrations, will be greater than the rate of $KMnO_4$ percolation out of the contaminated zone.

The costs associated with Alternative 1B are similar to Alternative 1A, but with the addition of ISCO in the excavation and Machinists Inc. areas. The total costs for Alternative 1B are estimated at $270,000.

2.4 ALTERNATIVE 2. VADOSE ZONE IN SITU CHEMICAL OXIDATION (ISCO)

PGG considered vadose zone in situ chemical oxidation (ISCO). ISCO is appealing because it rapidly degrades contaminants to CO_2 in place, and has been successfully applied in targeted applications at the Scougal site. Natural oxidant demand, the amount of chemical used by native materials instead of the target contaminant, is a limiting design factor in ISCO applications. In the target area, either large quantities of chemicals would be required to treat the vadose zone or injection methods would be used to treat groundwater and leave soil contamination in place. These options have similar estimated costs to excavation, but are more difficult to implement and have a less certain outcome. The cost for Alternative 2 is estimated at $270,000.

2.5 ALTERNATIVE 3. ENHANCED IN SITU BIOLOGICAL (EISB) REMOVAL

Biostimulants are commonly used to reduce groundwater chloroethene (TCE, DCE, VC) concentrations. However, at low concentrations, such as those observed at Scougal, the chloroethene concentrations are not high enough to sustain the necessary microbial communities (as a food source) and remediation progress is often very slow. Therefore, this approach is not considered further as it is unlikely to effectively remediate concentrations beyond existing natural attenuation rates. The cost for Alternative 3 is estimated at $170,000.

3.0 RECOMMENDATIONS

We recommend Alternative 1B as the approach most likely to achieve successful site closure. Excavation will permanently remove the majority of remaining soil contamination from Area A while providing direct access to the saturated zone for supplemental oxidant treatment. Targeted oxidant applications in the Main Plant and the adjacent Machinists Inc. property will reduce contaminant mass in areas with difficult access. Excavation is cost-competitive with ISCO (Alternative 2) and provides a more certain outcome. Overall, in situ treatment technologies can reduce the mass of contamination, but often have limitations in removing low levels of contaminants to achieve cleanup levels over larger areas.

Current chloroethene concentrations in groundwater are low, and – by preventing further TCE leaching from the vadose zone – they should not increase. Oxidant application will reduce chloroethene mass in the saturated zone, further reducing the potential for rebound. TCE is expected to dissipate and be degraded naturally before posing a threat to potential surface or drinking water receptors. Targeted permanganate injections may also be used to expedite remediation in areas that may experience rebound. Attenuation to cleanup levels will be more rapid without further loading from the vadose zone.

We assume 4 quarters of compliance groundwater monitoring with concentrations below remediation levels for the groundwater discharging to surface water pathway and thus protective of surface water. Soil concentrations will be protective of direct contact. Compliance groundwater monitoring will be conducted at MW-11, MW-12, MW-13, MW-14, and MW-17; three of these wells are located downgradient on the south-adjacent property.

3.1 NEXT STEPS

The suggested next steps to move forward include:

1. Conduct soil sampling in the North Yard Area A to refine excavation quantities and provide data to support soil excavation dimensions and disposal profiling.

2. Develop a more accurate cost estimate for implementation based on quotes from contractors and other vendors, including details such as asphalt recycling.

3. Coordinate with contractors and vendors to implement the selected remedy.

4.0 REFERENCES

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Table 1. Groundwater Sampling Result Summary
Scougal Rubber Corporation, Seattle, Washington

Sample Location	Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride
Pre-Permanganate Concentrations					
MW-11	8/3/2006	0.3	**9.4**	8.7	U 0.2
MW-12	8/3/2006	U 1	0.2	0.4	**0.7**
MW-13	8/3/2006	U 1	**46**	11	**2.6**
MW-14	8/3/2006	4.1	**110**	26	**33**
MW-4	8/3/2006	0.2	3.3	U 1	U 0.2
OW-10	8/3/2006	U 1	**9.6**	18	**3.5**
Post-Permanganate Concentrations					
MW-11	6/10/2008	U 1	**10**	3.7	U 0.2
MW-12	6/10/2008	U 1	U 1	U 1	U 0.2
MW-14	6/10/2008	U 1	**13**	3.7	**15**
MW-11	9/5/2008	U 1	**13**	2.9	U 0.2
MW-12	9/5/2008	U 1	U 1	U 1	**1**
MW-14	9/5/2008	U 1	**14**	3.4	**25**
Ozone Install Reconnaissance Samples					
OP-10	6/29/2010	U 1	U 1	U 1	U 0.2
OP-11	6/29/2010	U 1	U 1	U 1	**0.51**
OP-9	6/29/2010	U 1	U 1	U 1	**0.7**
Ozone Operational Data					
MW-11	1/23/2009	U 1	**12**	U 1	U 0.2
MW-12	1/23/2009	U 1	U 1	U 1	U 0.2
MW-14	1/23/2009	1.6	**41**	1.3	**13**
MW-14	7/20/2009	0.8	**19**	5.8	**9.2**
MW-14	9/23/2009	U 0.2	4	1.7	1.9
MW-14	12/4/2009	0.3	3.7	1.3	**0.5**
MW-14	1/22/2010	0	1.4	1.8	**1**
MW-14	3/10/2010	0	2.3	2.3	**5.7**
MW-14	4/22/2010	U 1	1.6	U 1	U 0.2
MW-11	5/24/2010	U 1	U 1	U 1	U 0.2
MW-12	5/24/2010	U 1	U 1	U 1	U 0.2
MW-14	5/24/2010	U 1	3.1	U 1	**1.5**
MW-14	9/15/2010	U 1	U 1	U 1	U 0.2
MW-14	10/14/2010	U 1	0.89 J	U 1	**1.1**
MW-14	3/9/2011	0.39 J	1.6	0.12 J	0.08 J
MW-14	5/6/2011	0.18 J	1.9	0.34 J	0.15 J
MW-14	7/15/2011	U 0.11	0.49 J	U 1	0.1 UJ
MW-11	9/16/2011	U 0.5	2.6	U 1	U 0.2
MW-12	9/16/2011	U 0.5	U 0.5	U 1	**0.89**
MW-14	9/16/2011	U 0.5	2.8	U 1	**0.69**
MW-11	11/23/2011	U 0.12	2.5	U 1	**U 0.2**
MW-12	11/23/2011	U 0.12	0.22 J	U 1	**0.32**
MW-13	11/23/2011	0.24 J	**8.4**	3.3	**0.6**
MW-14	11/23/2011	0.3 J	4.2	1.5	**2.1**
MW-11	6/14/2013	U 1	**6.8**	U 1	U 0.2
MW-12	6/14/2013	U 1	U 1	U 1	U 0.2
MW-13	6/14/2013	U 1	**11**	U 1	**0.32**
MW-14	6/14/2013	U 1	**5**	U 1	**0.44**
MW-11	11/25/2014	U 1	U 1	U 1	U 0.2
MW-12	11/25/2014	U 1	U 1	U 1	U 0.2
MW-13	11/25/2014	U 1	**6.2**	2.8	**0.29**

Table 1. Groundwater Sampling Result Summary

Scougal Rubber Corporation, Seattle, Washington

Sample Location	Date	Tetrachloroethene	Trichloroethene	cis-1,2-Dichloroethene	Vinyl Chloride
MW-14	11/25/2014	U 1	3.9	U 1	U 0.2
East Warehouse Reconnaissance Samples					
SR-18	5/1/2009	U 1	U 1	U 1	U 0.2
SR-19	5/1/2009	U 1	U 1	U 1	U 0.2
SR-20	5/1/2009	U 1	U 1	U 1	U 0.2
SR-21	5/1/2009	U 1	1.1	U 1	U 0.2
SR-22	5/1/2009	U 1	1.1	U 1	U 0.2
SR-23	5/1/2009	U 1	U 1	1.4	U 0.2
Paint Booth Building Reconnaissance Samples					
SR-27	5/14/2013	U 1	2.7	U 1	U 0.2
SR-28	5/14/2013	U 1	**5.9**	U 1	U 0.2
SR-31	5/14/2013	U 1	3.5	U 1	U 0.2
2015 Extent Investigations					
SR-32	3/6/2015	U 1	**6.7**	U 1	U 0.2
SR-33	3/6/2015	U 1	1.9	1.9	U 0.2
SR-35	3/6/2015	U 1	2.3	U 1	U 0.2
SR-36	3/6/2015	U 1	2.9	U 1	U 0.2
SR-37	3/6/2015	U 1	**5.4**	1.1	U 0.2
SR-38	3/6/2015	U 1	1.2	1.1	U 0.2
SR-39-W	5/1/2015	U 1	**13**	1	U 0.2
SR-40-W	5/1/2015	U 1	**7.8**	3.2	U 0.2
SR-41-W	5/1/2015	U 1	**19**	3.1	U 0.2
SR-42-W	5/1/2015	U 1	**5.4**	U 1	U 0.2
SR-43-W	5/1/2015	U 1	4.7	3.4	U 0.2
SR-44-W	5/1/2015	U 1	**12**	U 1	U 0.2
SR-45-W	5/1/2015	U 1	4	1.6	U 0.2
SR-46-W	5/1/2015	U 1	3.3	4	U 0.2
SR-47-W	5/1/2015	U 1	2.6	U 1	U 0.2
SR-48-W	5/1/2015	U 1	3.7	4.3	U 0.2
SR-52	7/28/2015	U 1	**19**	2.4	U 0.2
SR-53	7/28/2015	U 1	**6.3**	1.7	U 0.2
SR-54	7/28/2015	U 1	U 1	U 1	U 0.2
SR-55	7/28/2015	1.5	U 1	U 1	U 0.2
SR-56	7/28/2015	**5**	U 1	U 1	U 0.2
MW-18	7/28/2015	U 1	1	U 1	U 0.2
MTCA Method A table values		*5*	*5*	*80*	*0.2*

Bold indicates exceedance of MTCA Method A table value.

U indicates non-detect at the shown reporting limit.

J indicates an estimated value. J-flag values occur where concentrations are reported between the method detection limit and reporting limit.

All Results ug/L.

* MTCA Method B Value

Table 2: Soil and Groundwater Screening Levels for Contaminants of Potential Concern

Scougal Rubber Corporation, Seattle, Washington

Constituent of Concern		Groundwater Cleanup Level Protective of Surface Water	Groundwater Remediation Level Protective of Surface Water	Soil Cleanup Level Protective of Direct Contact Pathway (Unrestricted Land Use)[1]	Soil Cleanup Level Protective of Direct Contact Pathway (Industrial Land Use)[1]	Soil Cleanup Level Protective of Groundwater Concentrations Protective of Surface Water Quality[2]
		ug/L	ug/L	mg/kg	mg/kg	mg/kg
Tetrachloroethene	PCE	29	NE	476	21,000	0.44
Trichloroethene	TCE	7	20	12	1,750	0.057
cis-1,2-Dichloroethene	cDCE	--	15	160	7,000	--
trans-1,2-Dichloroethene	tDCE	4,000	NE	1,600	70,000	62
1,1-Dichloroethene	1,1-DCE	3.2	NE	4,000	175,000	0.025
Vinyl Chloride	VC	1.6	8	0.67	87.5	0.01

[1] Cleanup level is based on standard Washington State Model Toxics Control Act Cleanup Regulation (MTCA) Method B (unrestricted land use) or Method C (industrial land use) values from

[2] Soil cleanup levels for protection of surface water quality are calculated using MTCA Equation 747-1 where the groundwater cleanup level protective of surface water in this table was used as Cw.

NE: Not Evaluated

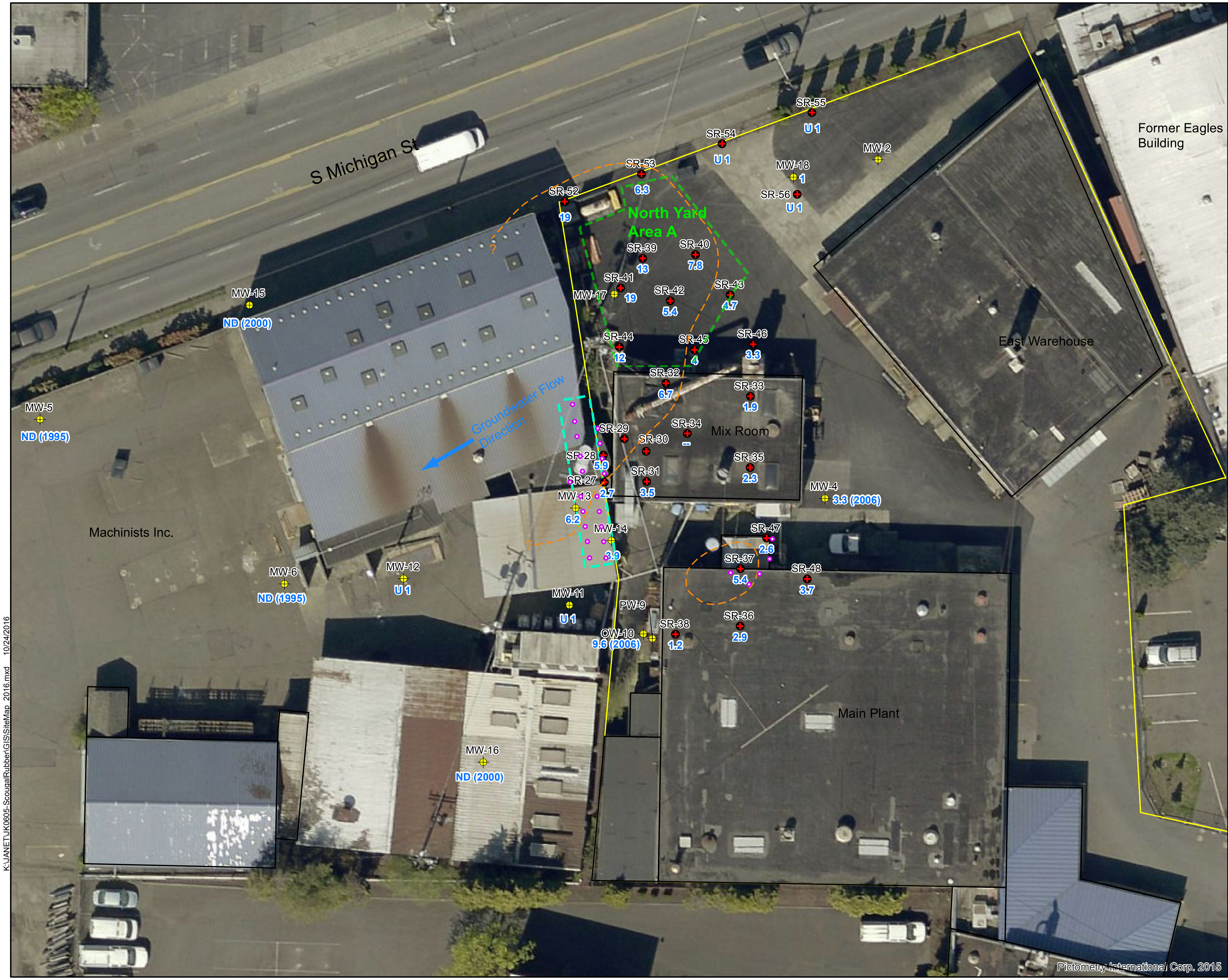
PCE, TCE and VC are based on constituent as a carcinogen.

Table 3. Summary of Alternatives
Scougal Rubber Corporation, Seattle, Washington

	Alternative 1A	Alternative 1B	Alternative 2	Alternative 3
	Excavation and Monitored Natural Attenuation	**Excavation and Groundwater Treatment**	**Saturated Zone In Situ Chemical Oxidation (ISCO) by Direct Push Injection**	**Enhanced In Situ Biological (EISB) Removal**
Cost Estimate (including 25% cost contingency)	$250,000	$270,000	$270,000	$170,000
Outcome	**Outcome Likelihood**			
Vadose Zone TCE Removal	Low	High	Low	Low
Local Groundwater TCE Removal	Low	Low	Moderate	Low
Downgradient TCE Migration in Groundwatre	High	Moderate	Moderate	High
Protective of Surface Water Receptor	Moderate	High	Moderate	Moderate

Figure 1
Site Map

PgG



Monitoring Well

Sample Locations

Proposed Injection Area

Building Outlines

Scougal Parcel

3.9 Most Recent TCE Concentrations (Sample from 2014, 2015, 2016 unless otherwise noted) (ug/L)

Approximate Area A Excavation Extent *(subject to adjustement based on field conditions)*

ISCO Injection Location *(subject to adjustement based on field conditions)*

Approximate Extent of TCE Exceedances in Groundwater

0 Feet 30

N

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APPENDIX A
EPA BIOCHLOR MODEL

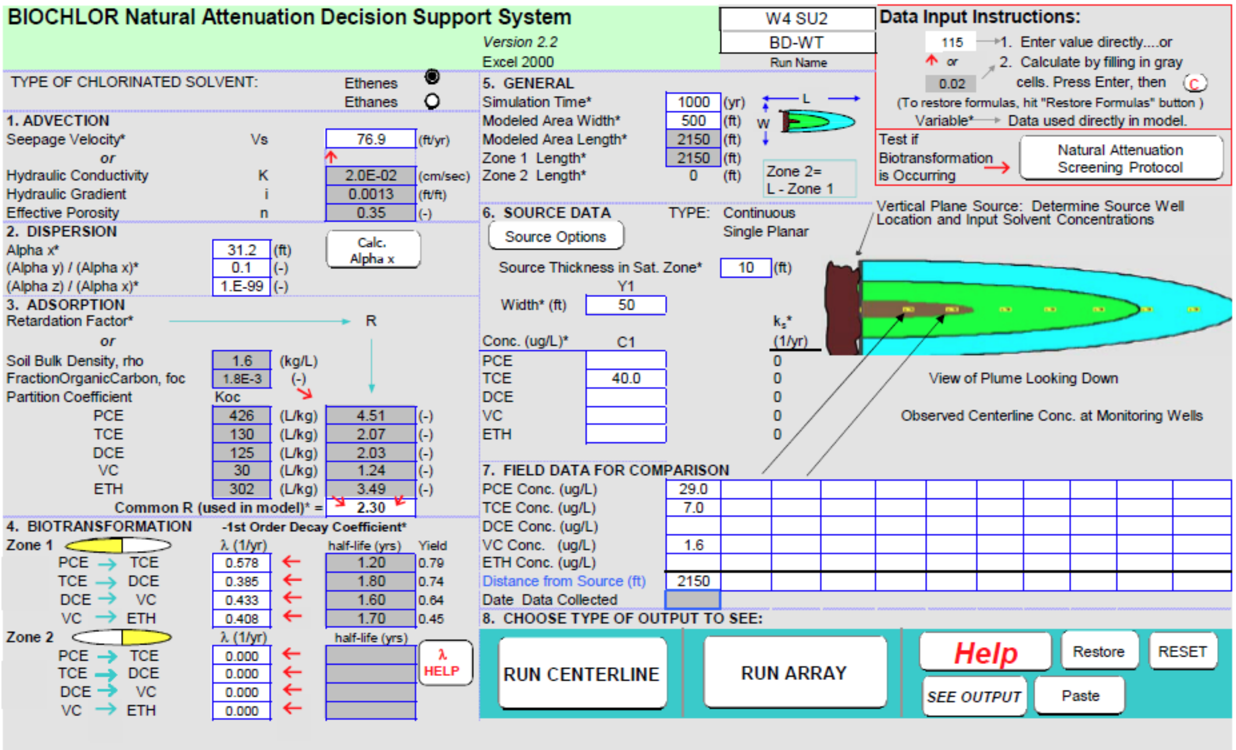

Figure A1: BIOCHLOR Model Inputs. Under this model run TCE, DCE, and VC transformation kinetics were specified using conservative literature values (Newell et al 2002). The constant source TCE concentration was specified as 40 ug/L.

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (ug/L) at Z=0

TCE	Distance from Source (ft)										
	0	215	430	645	860	1075	1290	1505	1720	1935	2150
No Degradation	40.000	20.204	14.826	12.259	10.684	9.593	8.779	8.143	7.628	7.199	6.835
Biotransformation	40.0000	7.838	2.231	0.716	0.242	0.084	0.030	0.011	0.004	0.001	0.001
	Monitoring Well Locations (ft)										
	2150										
Field Data from Site	7.000										

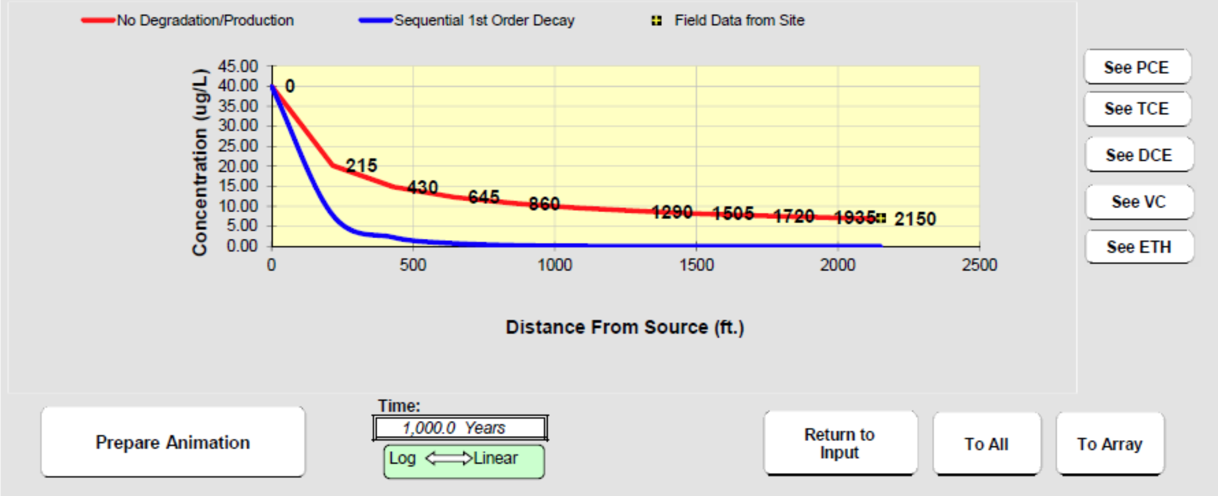

Figure A2: BIOCHLOR Model Output for TCE. Under this model run TCE, DCE, and VC transformation kinetics were specified using conservative literature values (Newell et al 2002). TCE groundwater concentration is predicted to be protective of surface water at the location of discharge 2150 ft. from the Scougal site.

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (ug/L) at Z=0

VC	Distance from Source (ft)										
	0	215	430	645	860	1075	1290	1505	1720	1935	2150
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	1.702	1.674	1.110	0.624	0.320	0.155	0.072	0.032	0.014	0.006
	Monitoring Well Locations (ft)										
	2150										
Field Data from Site	1.600										

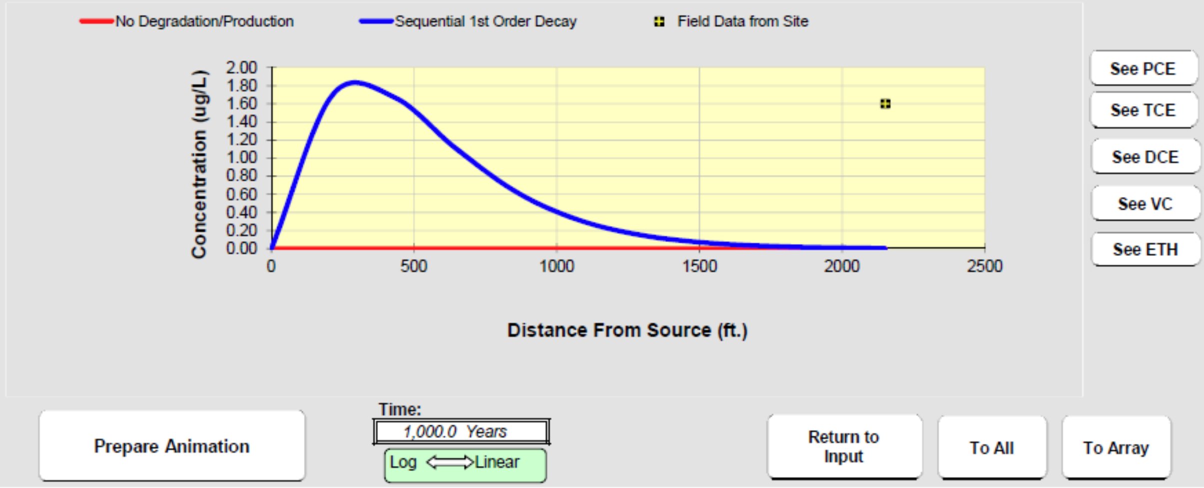

Figure A3: BIOCHLOR Model Output for VC. Under this model run TCE, DCE, and VC transformation kinetics were specified using conservative literature values (Newell et al 2002). The VC groundwater concentration is predicted to be protective of surface water at the location of discharge 2150 ft. from the Scougal site.

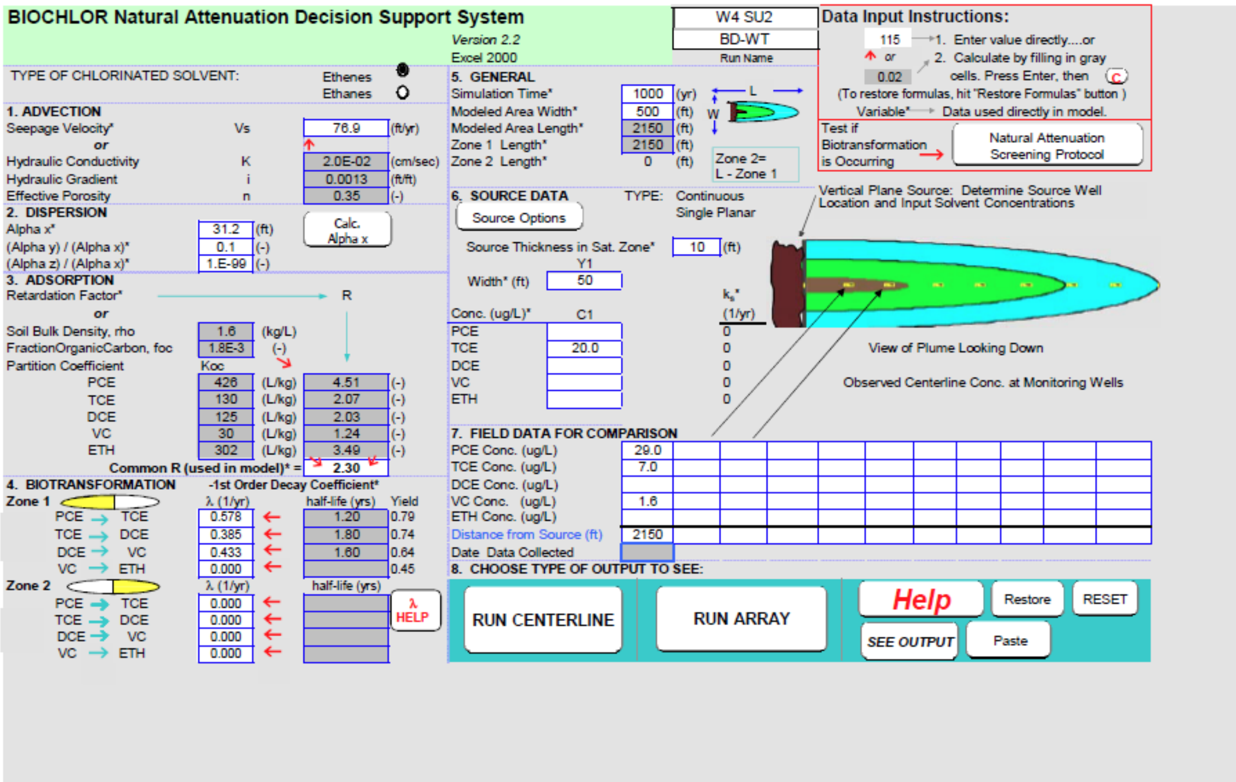

Figure A4: BIOCHLOR Model Inputs. Under this model run TCE, DCE, transformation kinetics were specified using conservative literature values (Newell et al 2002) and no VC transformation capacity was assumed. The constant-source TCE concentration was specified as 20 ug/L.

TCE	Distance from Source (ft)										
	0	215	430	645	860	1075	1290	1505	1720	1935	2150
No Degradation	20.000	10.102	7.413	6.129	5.342	4.796	4.390	4.071	3.814	3.600	3.418
Biotransformation	20.0000	3.919	1.116	0.358	0.121	0.042	0.015	0.005	0.002	0.001	0.000
	Monitoring Well Locations (ft)										
	2150										
Field Data from Site	7.000										

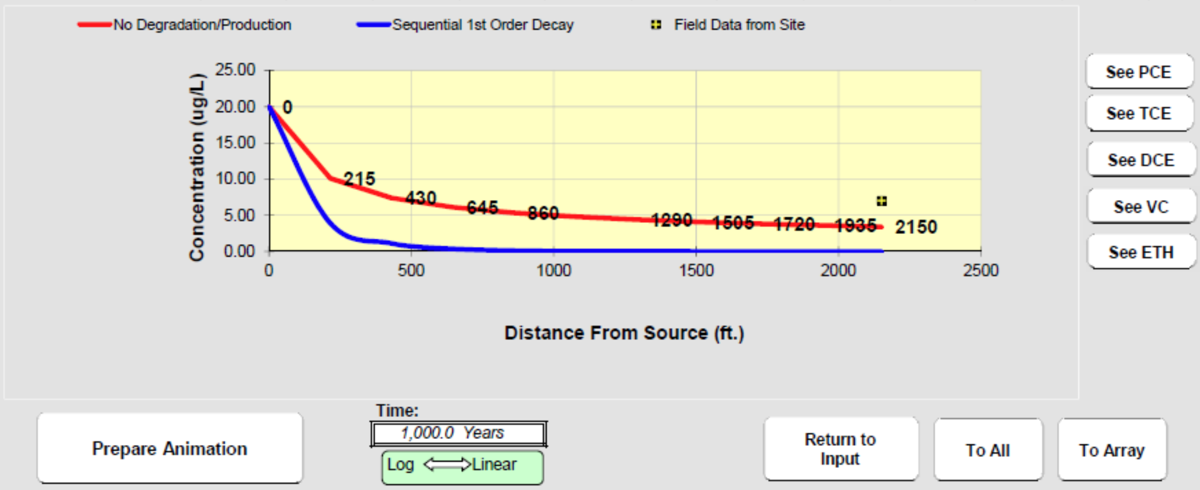

Figure A5: BIOCHLOR Model Output for TCE. Under this model run TCE, DCE, transformation kinetics were specified using conservative literature values (Newell et al 2002) and no VC transformation capacity was assumed. The constant source TCE concentration was specified as 20 ug/L. The TCE groundwater concentration is predicted to be protective of surface water at the location of discharge 2150 ft. from the Scougal site.

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (ug/L) at Z=0

VC	Distance from Source (ft)										
	0	215	430	645	860	1075	1290	1505	1720	1935	2150
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	1.463	2.195	2.379	2.326	2.196	2.054	1.923	1.809	1.710	1.625

	Monitoring Well Locations (ft)										
	2150										
Field Data from Site	1.600										

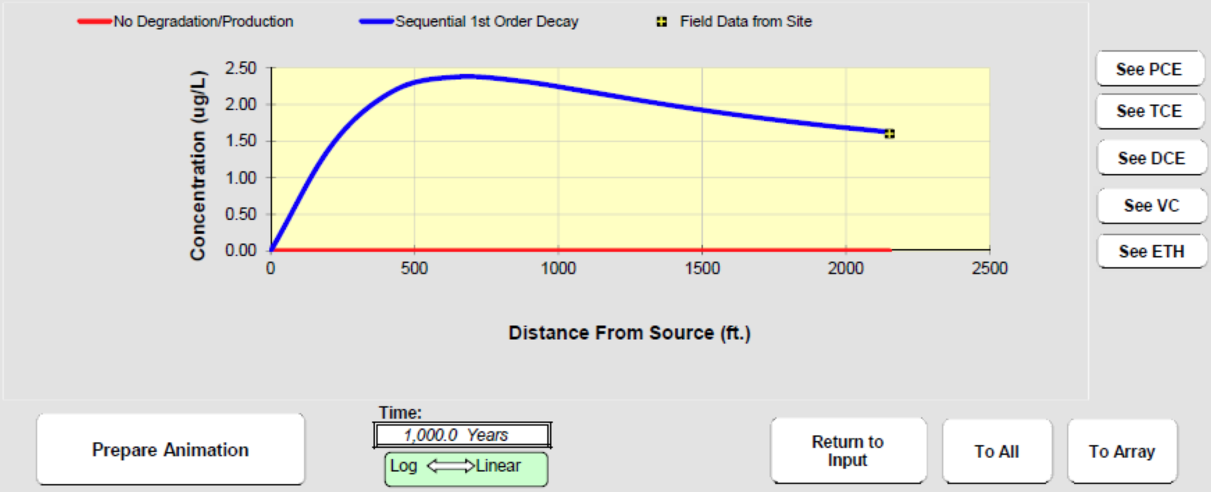

Figure A6: BIOCHLOR Model Output for VC. Under this model run TCE, DCE, transformation kinetics were specified using conservative literature values (Newell et al 2002) and no VC transformation capacity was assumed. The constant source TCE concentration was specified as 20 ug/L. The VC groundwater concentration is predicted to be protective of surface water at the location of discharge 2150 ft. from the Scougal Site.

DISSOLVED CHLORINATED SOLVENT CONCENTRATIONS ALONG PLUME CENTERLINE (ug/L) at Z=0

VC	Distance from Source (ft)										
	0	215	430	645	860	1075	1290	1505	1720	1935	2150
No Degradation	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Biotransformation	0.0000	1.463	2.195	2.379	2.326	2.196	2.054	1.923	1.809	1.710	1.625

	Monitoring Well Locations (ft)										
	2150										
Field Data from Site	1.600										

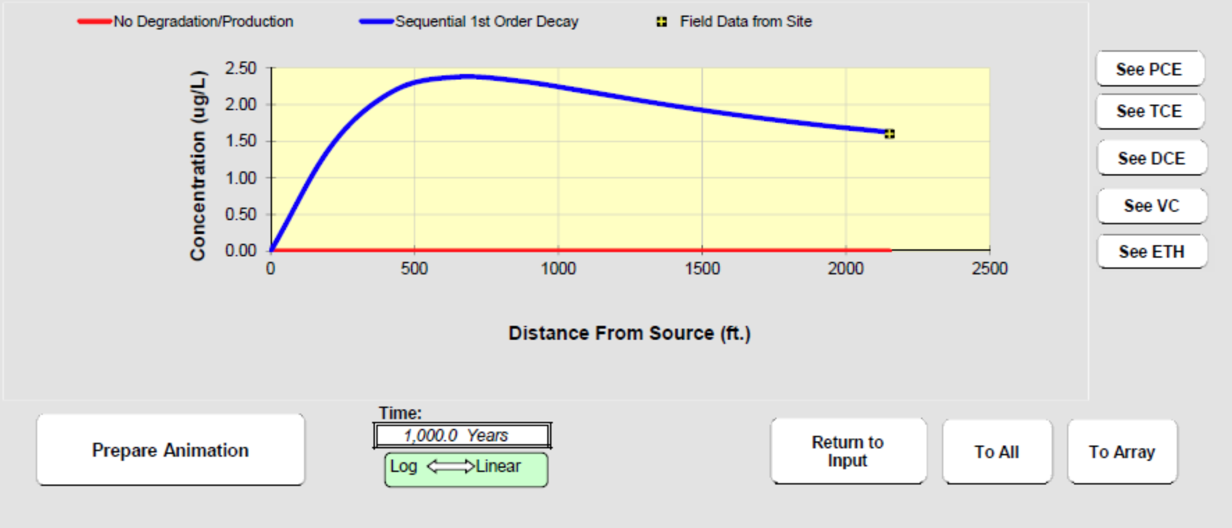

Figure A6: BIOCHLOR Model Output for VC. Under this model run TCE, DCE, transformation kinetics were specified using conservative literature values (Newell et al 2002) and no VC transformation capacity was assumed. The constant source TCE concentration was specified as 20 ug/L. The VC groundwater concentration is predicted to be protective of surface water at the location of discharge 2150 ft. from the Scougal Site.

APPENDIX B
COST BASIS TABLES

Table B1. Alternative 1A: Excavation and Monitored Natural Attenuation
Scougal Rubber Facility Remediation Alternatives

Excavation and Off-Site Disposal General Cost

Description	Unit	Value	Details
Excavation and Off-Site Disposal General Cost			
Typical Cost per Cubic Yard	$/cy	$100	$35 disposal, $40 handling, $25 backfill
Landfill Suitability Sampling	lump	$2,500	
Area A			
Treatment Area Length	ft.	70	
Treatment Area Depth (thickness)	ft.	6	
Treatment Area Width	ft.	50	
Treatment Volume	cy	778	
Total	**$**	**$80,278**	

Soil Sampling

Description	Unit	Value	Details
Perimeter Confirmation Samples	**$**	**$2,640**	Based on 240 ft perimeter and 12 samples
Disposal Characterization Sampling	**$**	**$5,000**	7 soil samples incl. driller

Common Remedial Elements (Table B5)

Description	Unit	Value	Details
Common ISCO elements	$	**$90,000**	From B5

Monitoring Natural Attenuation

Description	Unit	Value	Details
Years of Quarterly Sampling	y	2	
Sampling Event Cost	$	$2,500	Assumes 5 wells.
Total	$	$20,000	

Cost Summary

Description	Unit	Value	Details
Sum of Direct Expenses	$	$197,918	
Contingency	%	25%	Contingency applies to uncertainty in costs above and does not include contingency for additional remedial action
Contingency Amount	$	$49,479	
Total Estimated Alternative Cost	**$**	**$250,000**	Rounded to nearest ten thousand dollars

Table B2. Alternative 1B: Excavation and Groundwater Treatment

Scougal Rubber Facility Remediation Alternatives

Groundwater Treatment

Description	Unit	Value	Details
Excavation and Off-Site Disposal General Cost			
Typical Cost per Cubic Yard	$/cy	$100	$35 disposal, $40 handling, $25 backfill
Landfill Suitability Sampling	lump	$2,500	
Area A Excavation			
Treatment Area Length	ft.	70	
Treatment Area Depth (thickness)	ft.	6	
Treatment Area Width	ft.	50	
Treatment Volume	cy	778	
Total	**$**	**$80,278**	

Perimeter Sampling

Description	Unit	Value	Details
Perimeter	ft	240	
Perimeter Samples	samples	12	
Total	**$**	**$2,640**	

Oxidant Delivery System

Description	Unit	Value	Details
Area A Excavation			
Distance Between Trench	ft	6	
Number of Lines	#	10	
Line Length	ft	50	
Total Line Length	ft	750	
PVC Line	$	$1,500	
Valves	$	$1,125	
Labor	$	$1,000	
KMnO4 5% Solution	$/cy	$73	
Treatments	#	1.00	
Treatment Volume	cy	259	
Oxidant Cost	$	$18,926	
Total	$	**$22,551**	

Common Remedial Elements (Table B5)

Description	Unit	Value	Details
Common ISCO elements	$	**$90,000**	From B5

Monitoring Natural Attenuation

Description	Unit	Value	Details
Years of Quarterly Sampling	y	2	
Sampling Event Cost	$	$2,500	
Total	$	**$20,000**	

Cost Summary

Description	Unit	Value	Details
Sum of Direct Expenses	$	$215,469	
Contingency	%	25%	Contingency applies to uncertainty in costs above and does not include contingency for additional remedial action
Contingency Amount	$	$53,867	
Total Estimated Alternative Cost	**$**	**$270,000**	Rounded to nearest ten thousand dollars

** Permanaganate formulation pending health and safety review.*

Table B3. Alternative 2: Saturated Zone In Situ Chemical Oxidation (ISCO) by Direct Push Injection

Scougal Rubber Facility Remediation Alternatives

Groundwater Treatment

Description	Unit	Value	Details
Implementation Parameters			
Number of Points		12	Assuming 12 ft radius of influence
Number of points per day		6	
Number of days		2	
Rates			
Oxidant Preparation	$/event	2000	
Labor Rate for Equipment Setup and Removal	$/event	800	
Daily DPT Equipment and Operator	$/day	3000	
Oxidant Solution			
0.05 % KMgO4 Solution	lbs/cy	29.20	
	$/lb	$2.5	
	lbs/cy	$73	
Site A **Saturated Zone**			
Treatment Area Length	ft.	70	
Treatment Area Depth (thickness)	ft.	**10**	
Treatment Area Width	ft.	50	
Treatment Volume	cy	1296	
Site Specific Logistical Costs	lump	$0	
Injection Costs	$	$8,800	
Chemical Oxidant Cost	$	$94,630	
Total Cost single event)	$	**$103,430**	

Common Remedial Elements (Table B5)

Description	Unit	Value	Details
Common ISCO elements	$	**$90,000**	From B5

Post-Treatment Monitoring

Description	Unit	Value	Details
Years of Annual Sampling	y	0	
Years of Quarterly Sampling	y	2	
Sampling Event Cost	$	$2,500	
Total	$	**$20,000**	

Cost Summary

Description	Unit	Value	Details
Sum of Direct Expenses	$	$213,430	
Contingency	%	25%	Contingency applies to uncertainty in costs above and does not include contingency for additional remedial action
Contingency Amount	$	$53,357	
Total Estimated Alternative Cost	**$**	**$270,000**	Rounded to nearest ten thousand dollars

Table B4. Alternative 3: Enhanced In Situ Biological (EISB) Removal

Scougal Rubber Facility Remediation Alternatives

Groundwater Treatment

Description	Unit	Value	Details
Rates			
Biostimulant	$/cy	$20	
Direct Push Injections	$/event	$3,000	
Site A			
Treatment Area Length	ft.	70	
Treatment Area Depth (thickness)	ft.	**9**	
Treatment Area Width	ft.	50	
Treatment Volume	cy	1167	
Biostimulation events	events	1	
Biostimulation Costs	$	$26,333.33	

Common Remedial Elements (Table B5)

Description	Unit	Value	Details
Common ISCO elements	$	**$90,000**	From B5

Post-Treatment Monitoring

Description	Unit	Value	Details
Years of Annual Sampling	y	0	
Years of Quarterly Sampling	y	2	
Sampling Event Cost	$	$2,500	
Total	$	**$20,000**	

Cost Summary

Description	Unit	Value	Details
Sum of Direct Expenses	$	$136,333	
Contingency	%	25%	Contingency applies to uncertainty in costs above and does not include contingency for additional remedial action
Contingency Amount	$	$34,083	
Total Estimated Alternative Cost	**$**	**$170,000**	Rounded to nearest ten thousand dollars

Table B5. Common Remedial Elements

Scougal Rubber Facility Remediation Alternatives

Reporting Elements

Description	Unit	Value	Details
Design Report	lump	$15,000	includes soil profiling
Remedial Action Report	lump	$10,000	
Annual Reports (3)	lump	$10,000	
Reporting Total		**$35,000**	

Groundwater Treatment

Description	Unit	Value	Details
Main Plant ISCO Sumps			
Number of Locations	holes	5	
KMnO4 Loading per hole (40% solution)	gallons	60	3 x 20 gallon injections
NaMnO4Cost per gallon (40% solution) *	$/gallon	$17.90	Cascade Columbia mix and deliver in 240 gallon totes
Permanganate Cost	$	$5,370	
Installation Costs	$/day	$6,000	
Direct push hotspot confirmation	$	$3,500	
Cost	$	**$14,870**	
Adjacent Machinists Inc. Injections			
Number of Locations	holes	25	
NaMnO4 Loading per hole (40% solution)	gallons	50	
NaMnO4Cost per gallon (40% solution) *	$/gallon	$17.90	Cascade Columbia mix and deliver in 240 gallon totes
Permanganate Cost	$	$22,375	
Driller Cost per Day	$/day	$2,700	includes rig, pumps, personnel
Holes per day	holes/day	5	
Driller Days	days	6	Includes 1 contingency day
Driller Cost	$	$16,200	
Concrete coring	lump	$1,500	2 inch hole through 12 inch slab; Cascade Concrete Cutting
Cost	$	**$40,075**	
Total Estimated Cost	**$**	**$90,000**	Rounded to nearest thousand dollars

Contingency is not included in the values in this table. Contingnecy is included in the specific Alternative tables.

** Permanaganate formulation pending health and safety review.*

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