Appendix E

Technical Memorandum: Detailed Evaluation and Comparative Analysis of Non-retained Remedial Alternatives

FINAL TECHNICAL MEMORANDUM

Date: January 29, 2004

Prepared For: Rose Marie Caraway
USEPA Region IX

Prepared By: T N & Associates
Maura Browning, Project Geologist
John Wingate, Project Engineer

Re: Detailed Evaluation and Comparative Analysis of Non-retained Remedial Alternatives

INTRODUCTION

T N & Associates, Inc. (TN&A) has prepared this technical memorandum to report the results of the detailed evaluation and comparative analysis of several preliminary remedial alternatives which were assembled for the *Draft Feasibility Study Report, Pemaco Superfund Site* (TN&A, November 2003), but were not retained for use in the *Final Feasibility Study Report, Pemaco Superfund Site* (TN&A, March 2004).

The two remedial alternatives for the surface and near-surface soil (zero to 3 ft bgs) remediation zone, which were not retained, include:

- Capping/Revegetation
- Excavation/Onsite Treatment/Backfill

The four remedial alternatives for the upper vadose soil and perched groundwater (3 to 35 ft bgs) remediation zone, which were not retained, include:

- Excavation/Onsite Treatment/Backfill
- Electrical Resistance Heating with Vapor Extraction/E*x-situ* Vapor Treatment*
- Pump and Treat/Ultraviolet Oxidation
- Permeable Reactive Barrier

The three remedial alternatives for the lower vadose soil and the Exposition groundwater (35 to 110 ft bgs) remediation zone, which were not retained, include:

- Monitored Natural Attenuation
- Pump and Treat/Ultraviolet Oxidation
- Permeable Reactive Barrier

Descriptions of the remedial alternatives not retained for the Final Feasibility Study (FS) report as well as the detailed evaluations and comparative analyses for the non-retained remedial alternatives will be presented in the following sections. These alternatives were *not* retained for use in the Final FS report due to technical and/or administrative limitations.

It should be noted that the majority of the non-retained remedial alternatives were restructured (i.e., technologies added, updated design) into proficient remedial alternatives for use in the Final FS Report.

* Because this alternative was originally evaluated without a specific *ex-situ* treatment option, Electrical Resistance Heating (ERH) with Vapor Extraction (VE) alternatives, ERH with VE/Flameless Thermal Oxidation/Granular Activated Carbon and ERH with VE/Granular Activated Carbon, will not be treated as separate alternatives in this technical memorandum. Where appropriate, the *ex-situ* treatment options will be discussed.

DESCRIPTIONS OF NON-RETAINED REMEDIAL ALTERNATIVES

SURFACE AND NEAR-SURFACE SOIL REMEDIATION ZONE

Capping/Revegetation *Surface and Near-Surface Soil Remediation Zone*	
Description	
The design of a cap is site specific but typically functions to contain waste or contaminated media and prevents vertical infiltration of water into wastes that would contribute to groundwater contamination. A cap does not treat or destroy the COCs but acts as dry containment and eliminates the pathways to human exposure. Long-term monitoring and maintenance of the cap and vegetative cover is essential to prevent erosion and exposure of the underlying contaminants. Implementation of a cap would be coupled with another process option that would contain or treat groundwater and vadose zone soil. An alternative cap design (relative to RCRA Subtitle C or D) for arid region use would be most applicable. The completed cap and vegetative cover could serve as a recreational area.	
Site Characteristics	
Area To Be Graded and Capped:	
Area of Pemaco Site:	65,000 ft^2
Area of adjacent railway:	22,500 ft^2
Preparation of Subgrade:	
Concrete area to be removed or broken in place:	13,000 ft^2
Thickness:	6 in
Volume:	240 yd^3
Vegetated area to be disposed/composted:	52,000 ft^2
Thickness:	3 in (assumed)
Volume to be hauled/disposed:	480 yd^3
Fence length adjoining railway to be removed:	540 ft
Volume (rough estimate) to be hauled/disposed:	60 yd^3
Impermeable Layer:	
60-mil FML (extra area required for edge):	90,500 ft^2
Liner bedding soil (6 in. thick, 0.19 in. [#4 sieve] max grain size):	2,270 yd^3
Lower bedding soil volume (12 in. thick layer of typical fill):	4,550 yd^3
Drainage Layer:	
Sandy fill volume (12 in. thick, max. K of 1×10^{-3} cm/s):	4,550 yd^3
Screened pipe drains:	1,040 ft
Cover Soil:	
Volume, 1-foot (1.4 x actual volume to account for compaction):	4,550 yd^3
Topsoil volume, 4 in:	1,080 yd^3
Surface Restoration:	
Vegetative cover to be established as needed:	87,500 ft^2

Capping/Revegetation (cont'd) *Surface and Near-Surface Soil Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Preparation of Subgrade: Includes clearing existing vegetation and fixtures such as concrete pads, walls, fencing, rail lines, etc. with the intent of creating a suitable surface for the application of cover soils. Semi-impermeable surfaces, such as concrete pads, promote uneven drainage patterns, ponding, or subsurface erosion, which can lead to slips and cracks in the cover. Therefore, the concrete pads should be removed or broken-up in place and compacted into the subgrade so that drainage is promoted.	• Concrete will be broken-up and left in place; i.e. no hauling. • Well relocation will take place under Maywood Riverfront Park Project. • Removal of fencing except north, east, and south site boundary.
Disposal: Vegetation can be composted or disposed of at a RCRA Subtitle D landfill.	• All vegetation will be hauled to a composting facility. • All concrete will be broken-up and remain in place. • Fencing will be hauled to a recycler.
Earthwork: To strip vegetation, prepare ground surface to receive cover soil, achieve desired control of runon/runoff, accommodate future use, and to apply lower bedding layer (on top of site soil), liner bedding layer (on top of lower bedding), and drainage layer (on top of flexible membrane liner [FML]).	• City of Maywood provides grading plan. • Cuts made into contaminated soil will be used as fill at other areas within the Site. • Adequate compaction is assumed following rough grading.
Cap Construction: FML rolled out, seams heat-sealed. Pipe drains installed in two north-south runs on top of FML. Drainage layer soil placed on top of FML.	• Infrequent drainage will flow to storm sewer. • Assume 12-in drainage layer plus 12-in cover soil plus 4-in topsoil is sufficient to protect FML from root systems.
Cover Soil Application: Lifts should not be greater than 8 inches followed by compaction to 90% of maximum density. Must be capable of supporting vegetative growth such as a sandy loam.	• 1-ft of cover soil • Finish grading - to smooth out surface and apply topsoil • 4 in of topsoil
Surface Restoration: Broadcast seed or sod, install rooted plants, or prepare for landscaping in accordance with City of Maywood Riverfront Park plans. Land surveys will be performed to define new cap elevations and extent.	• The City of Maywood will provide the Park landscaping plans that will determine how the surface is landscaped and vegetation established.
Annual Operation and Maintenance:	• Budget for regular maintenance, irrigation, and repair of cover surface plus regular inspection of the cap.
Additional Remedial Action Required:	• Capping implemented with other remedial process option that addresses vadose zone and groundwater contamination.
Duration Range for Cap Construction:	Approximately 2 to 4 months.
Conceptual Design Considerations	
Residential neighborhoods are located to the south of and adjacent to the Pemaco Site. The City of Maywood intends to accept available grants to convert the Pemaco Site and adjoining properties, including: the railway right-of-way, Precision Arrow, W.W. Henry, Catellus, and Lubrication and Oil Services, to a recreational area named the Maywood Riverfront Park. The park description and economic evaluation of the park plan is described in Section 1.4 of the Feasibility Study.	

Excavation/Onsite Treatment/Backfill *Surface and Near-Surface Soil Remediation Zone*	
Description	
Soil excavation and onsite treatment involves (1) excavation of the impacted surface and near-surface soils, (2) onsite treatment, and (3) backfill of remediated soil to the site. The treatment process would be performance-based and use the Region IX PRGs as treatment criteria. Treatment onsite prevents shipping of contaminants to another location and potential PRP liability. By treating the impacted soil, pathways for human exposure and potential for migration of surface contaminants are eliminated. Following backfill, the site would be regraded and revegetated similar to the soil cover option above. Since the components of excavation and soil cover are discussed above, this section will focus on the onsite treatment phase.	
Site Characteristics	
Contaminated Soil Areas:	25 by 25 ft grid identified in RI
Depths to be Excavated: Refer to the Excavation Volume Calculation Worksheet under the Supporting Documentation Tab.	• 1-ft depth excavated for 0.5 ft sample exceedance • 3-ft depth excavated for 2.5 ft sample exceedance
Volume of soil to be excavated:	2,900 yd^3
Volume of soil to be treated (after expansion x 1.3):	3,770 yd^3 (6,630 tons)
Volume of concrete to be excavated and disposed:	250 yd^3
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Excavation: Conventional backhoe loader or excavator would be used.	• Suggested cleanup criteria is Residential PRGs for SVOCs and Metals (except Iron, which gets cleaned up to background levels) • Excavation rate performed as needed to feed treatment process; therefore no significant stockpiling considerations until post-treatment. • Assume dust suppression will be required.
Treatment Process: Thermal oxidation would not treat metals. Soil solidification/stabilization works well for metals but is not as effective on PAHs. Soil washing works well on a wide range of contaminants (all COCs) and was therefore selected as the most appropriate treatment process for evaluation (via the 9 U.S. EPA criteria) and comparison to the other alternatives.	• Treatment rate 200 c.y./day. • Performance-based treatment subcontract based on treatment criteria • Soil meeting treatment criteria is processed as backfill. Soil that fails to meet the treatment criteria is re-treated.
Stockpiling: Treated soil will be placed on prepared (containment) surface prior to release or re-treatment. Treated soil will be stockpiled on plastic sheeting in 50 c.y. lots and covered until analytical confirmation results received.	• Treated soil is stockpiled until the analytical is evaluated. • Assume 3 day staging requirement (for analytical evaluation) = 4 piles/day x 3 days = 12 pile requirement. • Assume sufficient area for staged soil, treatment equipment, and treated soil stockpile.
Post-treatment Sampling: Grab samples are pulled from treated soil stream and composited at the rate of 1 per 50 c.y. and sampled for VOCs, SVOCs, and metals.	• 24 hr analytical TAT
Backfill: Apply treated soil in 8-in. lifts, compact, and continue to grade. Apply 6 inches of topsoil backfill over entire surface area.	• Treated soil suitable for use as fill (compactable) and capable of supporting vegetative growth • Topsoil backfill required to support vegetative growth.
Surface Restoration: Broadcast seed or sod, install rooted plants, or prepare for landscaping in accordance with City of Maywood Riverfront Park plans. Land surveys will be performed to define new cap elevations and extent.	• The City of Maywood will provide the Park landscaping plans that will determine how the surface is landscaped and vegetation established.

Excavation/Onsite Treatment/Backfill (cont'd) *Surface and Near-Surface Soil Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Annual Operation and Maintenance:	• Budget for regular maintenance, irrigation, and repair of cover surface.
Additional Remedial Action Required:	• Excavation and offsite disposal implemented with other remedial process option that addresses vadose zone and groundwater contamination.
Duration Range for Excavation and Onsite Treatment:	Approximately 2 months.
Conceptual Design Considerations	
Residential neighborhoods are located to the south of and adjacent to the Pemaco Site. The City of Maywood intends to convert the Pemaco Site and adjoining properties into a recreational area named the Maywood Riverfront Park.	

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Excavation/Onsite Treatment/Backfill *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Treatment Description	
Soil excavation under this alternative would incorporate removal of the impacted upper vadose zone soil from 3 feet bgs to approximately 35 feet bgs. It is assumed that the depth and width of the excavation exceeds the capability of most surface excavation equipment, therefore it is assumed that significant additional surface area would be required to build ramps into the removal area. Onsite treatment and reuse of the excavated soil is assumed due to the magnitude of the soil volume (82,500 c.y.) and associated costs with offsite disposal. The treatment process would be performance-based using Site remediation goals for upper vadose soil as treatment criteria. Following soil removal, the site would be regraded and revegetated. Excavating and treating the impacted soil would eliminate the potential for migration of upper vadose zone contaminants to groundwater and the pathways to human exposure to upper vadose zone soil contaminants of concern (COCs). However, pathways to human exposure to COCs in the perched groundwater zone would still need to be addressed. Therefore, excavation would provide only a partial treatment solution to the upper vadose soil and perched groundwater remediation zone.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of the DAF 20 SSLs):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs)
Volume:	82,500 yd^3
Perched Groundwater Area:	168,000 ft^2
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
Maximum concentration of COCs in Upper Vadose Zone soils:	• Benzene (4,100 µg/kg) • DCE (400 µg/kg) • cis-1,2-DCE (3,300 µg/kg) • Ethylbenzene (61,000 µg/kg) • Methylene chloride (530 µg/kg) • PCE (2,000 µg/kg) • Toluene (98,000 µg/kg) • TCE (3,300 µg/kg) • VC (280 µg/kg) • Total xylenes (430,000 µg/kg)

Excavation/Onsite Treatment/Backfill (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Site Characteristics	
Analytical Data:	
Maximum concentration of COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L) • cis-1,2-DCE (780 µg/L) • VC (240 µg/L) • 1,4-dioxane (920 µg/L)
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs.
Direction and gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
Potential Receptors: Residential neighborhoods are adjacent to the south of the site.	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Excavation: Conventional backhoe loader or excavator would be used. Due to depth and width of excavation area, side ramps would be constructed to allow excavators into the removal area. Assume excavation progress will encounter adjoining soil contamination from the W.W. Henry Site and associated liability and disposal issues.	• Suggested cleanup criteria are U.S. EPA Region IX SSLs (DAF 20) for VOCs. • Assume strict air monitoring and engineering controls to protect workers from VOCs. • Assume average progress of 500 yd^3/day
Treatment Process: Soil washing works well on a wide range of contaminants (all COCs) and was therefore selected as the most appropriate treatment.	• Treatment rate 200 yd^3/day • Performance-based treatment subcontract based on treatment criteria • Soil meeting treatment criteria is processed as backfill. Soil that fails to meet the treatment criteria is re-treated.
Stockpiling: Treated soil will be placed on prepared (containment) surface prior to release or re-treatment. Treated soil will be stockpiled on plastic sheeting in 50 c.y. lots and covered until analytical confirmation results received.	• Treated soil is stockpiled until the analytical is evaluated. • Assume 3 day staging requirement (for analytical evaluation) = 4 piles/day x 3 days = 12 pile requirement. • Assume sufficient area for staged soil, treatmen equipment, and treated soil stockpile.
Post-treatment Sampling: Grab samples are pulled from treated soil stream and composited at the rate of 1 per 50 c.y. and sampled for VOCs.	• 24 hr analytical TAT • 1,200 samples collected.
Backfill: Apply treated soil in 8-in. lifts, compact, and continue to grade.	• Treated soil will be suitable for use as fill (compactable). • Backfill required only to fill excavations. No additional cover soil intended.
Additional Remedial Action Required:	• Treatment of perched groundwater required after or in combination with excavation.
Duration Range for Excavation/Onsite Treatment/Backfill:	1 year plus 5 years of monitoring.
Conceptual Design Considerations	
• Excavation of the upper vadose zone soils would disrupt all surface development for the duration of the project and would likely involve use of portions of the adjacent properties. • Significant volatilization of contaminants is to be expected. The emissions would create a pathway for exposure for workers and neighboring residences. The emissions from excavation would trigger permitting requirements and potentially extend the project duration. • A plume of BTEX contaminated soil and groundwater exists on the adjacent W.W. Henry property that would likely be encountered during excavation.	

<table>
<tr><th colspan="2">Electrical Resistance Heating with Vapor Extraction (ERH with VE)/Ex-Situ Vapor Treatment
Upper Vadose Soil and Perched Groundwater Remediation Zone</th></tr>
<tr><th colspan="2">Treatment Description</th></tr>
<tr><td colspan="2">ERH utilizes an array comprised of six to nine electrodes that are inserted into the ground to the depth of the contamination. The electrodes heat the soil and groundwater to approximately 100 degrees Celsius via resistive current. Contaminants are volatized and removed from the subsurface from the resulting in-situ steam stripping. Volatilized contaminants are collected at the surface via vapor extraction (VE). The soil vapor would most likely be treated using catalytic oxidation or thermal oxidation since the resulting concentrations would quickly overload a carbon treatment system. ERH combined with VE reduces toxicity, mobility, and volume of COCs. ERH with VE would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in both upper vadose soils and the perched groundwater.</td></tr>
<tr><th colspan="2">Site Characteristics</th></tr>
<tr><td>Area of Source control:</td><td></td></tr>
<tr><td>Soil Area (based on exceedances of the SSLs and DAF 20):</td><td>69,600 ft^2</td></tr>
<tr><td>Approximate Thickness:</td><td>32 ft (3 to 35 ft bgs)
37 ft (3 to 40 ft bgs including perching clay)</td></tr>
<tr><td>Volume:</td><td>82,500 yd^3</td></tr>
<tr><td>Perched Groundwater Area:</td><td>168,000 ft^2</td></tr>
<tr><td>Approximate Thickness:</td><td>2 to 3 ft (top of perching clay 25 to 35 ft bgs)</td></tr>
<tr><td>Analytical Data:</td><td></td></tr>
<tr><td>Maximum concentration of COCs in Upper Vadose Zone soils:</td><td>• Benzene (4,100 µg/kg)
• DCE (400 µg/kg)
• Cis-1,2-DCE (3,300 µg/kg)
• Ethylbenzene (61,000 µg/kg)
• Methylene chloride (530 µg/kg)
• PCE (2,000 µg/kg)
• Toluene (98,000 µg/kg)
• TCE (3,300 µg/kg)
• VC (280 µg/kg)
• Total xylenes (430,000 µg/kg)</td></tr>
<tr><td>Maximum concentration of COCs in Perched Zone groundwater:</td><td>• Benzene (1,600 µg/L)
• PCE (1,100 µg/L)
• TCE (680 µg/L),
• cis-1,2-DCE (780 µg/L)
• VC (240 µg/L)
• 1,4-dioxane (920 µg/L)</td></tr>
<tr><td>Hydrogeologic Data:</td><td></td></tr>
<tr><td>Depth to Perched Zone groundwater:</td><td>20 to 30 feet bgs.</td></tr>
<tr><td>Direction and gradient of groundwater flow in Perched Zone:</td><td>Inconsistent due to perching clay</td></tr>
<tr><td colspan="2">Miscellaneous: Residential neighborhoods are situated to the south of the site.</td></tr>
<tr><th colspan="2">Conceptual Design Components and Assumptions</th></tr>
<tr><th>Component</th><th>Assumptions</th></tr>
<tr><td>Treatment Criteria: Same for pilot study and full-scale treatment via ERH. Air treatment criteria to be determined in accordance with South Coast Air Quality Management District discharge permit. Target discharge <25 ppmv at an average total destruction efficiency of 99%.

For water, target discharge based on Site remediation goals for max daily flow of 140,000 gpd of condensed water vapor (approximately 97 gpm).</td><td>• Soil vapor and groundwater influent and effluent to be sampled daily during startup period; weekly after documented stabilization or trend; quarterly or in accordance with discharge permit thereafter.
• Air monitoring via PID performed to supplement sampling data.</td></tr>
</table>

ERH with VE/*Ex-Situ* Vapor Treatment (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Pilot Test: The pilot test would consist of a 12-electrode configuration (2 layers of 6) that would require six boreholes (two in each borehole) and two modular power delivery systems to operate. This will heat a depth interval of approximately 32 feet with a footprint of approximately 2,000 ft^2. The pilot test is recommended to confirm site characteristics (i.e. soil resistivity, electrode diameter, moisture requirements, and radius of influences (for heating and vapor extraction). Surface recovery of soil vapor will be achieved using 3 soil vapor extraction wells screened from approx. 10-50 ft bgs, designed and operated at full scale using a 250-scfm blower. Soil vapor treatment process to be selected from GAC, catalytic oxidation, and thermal oxidation, based on ability to meet treatment criteria and economics. Surface recovery of water (from moisture stripping) will initially amount to approximately 1,400 gpd. Volume will significantly drop off, as perched zone is dehydrated. Treatment process to be ultraviolet (UV) oxidation as it is the most effective commercially available treatment technology used to treat 1,4-dioxane to levels suitable for discharge.	• Pilot study area approx. 1,300 s.f. x 32 feet thick. • Typical HSA drill rig used for drilling 6 electrode borings and three 2-inch VE wells • Assumes one fenced compound for electrical equipment and separate compound for soil vapor and water treatment. • ERH evaluation soil sampling assumes 3 borings to 35 ft bgs with 1 soil sample collected every 5 ft (18 total samples for VOCs analysis). • Pilot study evaluation reporting will make recommendation for suitability of ERH at the site. • Duration of test: 6 months.
Full Scale Source control via ERH: 252 electrodes installed in 126 boreholes would be used to treat source area to a depth of 35 ft bgs. Configuration and power requirements would be increased in scale from the pilot study (same depth interval) with a footprint of approximately 70,000 ft^2 VE will be achieved using 32 wells of same design as pilot study (based on 50 ft ROI). Total blower requirement will be 2,000 scfm. Soil vapor and recovered water treatment process would be same as pilot study.	• Array size, electrode diameter, and installation components are assumed to be the same as pilot scale. • Power supply equipment and connection organized by vendor. • Assume two 1,000-scfm blowers with above ground placement of piping. • ERH confirmation sampling assumes 16 borings to 35 ft bgs with 1 soil sample collected every 5 feet (7 samples per boring (5' to 35' bgs) for a total of 112 samples plus QC.
Monitoring Well Network: Perched Zone water will be boiled off so there will be no perched zone groundwater monitoring requirement.	Install 2 check wells in perched zone to monitor for the return of perched zone groundwater and potential contamination from adjacent sites.
Monitoring/Reporting Frequency: Reporting will be performed in compliance with permits and to document contaminant removal in appropriate frequency to data collection.	Check wells semiannually and sample if possible.
Estimated Project Duration: Based on warm-up (2-months), six months at temperature (100º C), 2-month cool down and soil sampling, and 2 months for data evaluation and reporting.	Approximately 1 year + minimum of 5 years monitoring.
Conceptual Design Considerations	
• Can easily combine with containment design alternative for soil and groundwater from 35 to 110 feet bgs. • Monitoring program can be reevaluated after 5 years for potential of sampling location or frequency reduction.	

Pump and Treat/Ultraviolet Oxidation *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Containment Description	
Pump and treat (groundwater extraction and treatment or P&T) is a method used to gain hydraulic control over the dissolved contaminant plume. Groundwater extraction wells are used to pump groundwater with dissolved phase contaminants to the surface for treatment aboveground. Placement of the groundwater extraction wells is designed to contain the plume and remediate the groundwater over time. An aboveground treatment process would immobilize, treat, or destroy contaminants in the groundwater prior to discharge. The treated groundwater would be disposed by reinjection back into the aquifer, discharged to the sanitary sewer, or discharge to the LA River. Pump and treat systems allow for good control over contaminant mobility and reduction in contaminant volume through extraction of liquid phase contaminants. P&T would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in the perched groundwater. However, the P&T would only provide a partial treatment solution to the upper vadose soil and perched groundwater remediation zone, as pathways to human exposure in upper vadose soils would not be addressed.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of the SSLs and DAF 20):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs) 37 ft (3 to 40 ft bgs including perching clay)
Volume:	82,500 yd^3
Perched Groundwater Area:	168,000 ft^2
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
Maximum concentration of COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L), • cis-1,2-DCE (780 µg/L) • VC (240 µg/L) • 1,4-dioxane (920 µg/L)
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs.
Direction and gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
Miscellaneous: Residential neighborhoods are situated to the south of the site.	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
Groundwater Well Networks: Thirty-two groundwater extraction wells would be installed to provide coverage over the perched groundwater area that exceeds MCLs. The well network conceptual design is based on pump test data. The pump test data demonstrated that without applying a vacuum, anticipated initial flows would be less then 0.5 gpm. Groundwater flow would not be sustainable or be intermittent for long periods of pumping.	• Design ROI of 54 ft • Design GW extraction rate of 0.4 gpm per well • 1/3 Hp pump installed per well • All wells shall be 4-inch diameter, Schedule 40 PVC. • Screened from 20 to 35 ft bgs

Pump and Treat/Ultraviolet Oxidation (cont'd)

Upper Vadose Soil and Perched Groundwater Remediation Zone

Conceptual Design Components and Assumptions

Component	Assumptions
Groundwater treatment system: A fenced and covered treatment compound would be mounted on a 20 ft by 30 ft concrete pad with containment foundation (to be shared with vapor treatment). Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. Treatment process to be UV oxidation as it is the most effective commercially available treatment technology used to treat 1,4-dioxane to levels suitable for discharge. Influent trench and pipe includes 1,200 ft of trench, 600 ft of 2-inch diameter Schedule 80 PVC and 600 ft of 3-inch diameter Schedule 80 PVC. Effluent trench and pipe includes 500 ft of trench and 500 ft of 3-inch diameter Schedule 80 PVC.	• Design flow and influent conc. are 12 gpm and 300 µg/L total VOC. • Treatment criterion is to be based on Site remediation goals. • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system.
Monitoring/Reporting Frequency: Reporting will be performed to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Semiannual sampling events are recommended. • Annual monitoring may be recommended after demonstration of reduction in plume volume and mobility. • QA/QC Program Plan will be instituted for all sampling and treatment.
Estimated Project Duration:	30 years.

Conceptual Design Considerations

- Enhancements: Hydraulic or pneumatic fracturing and VE could be used as enhancements for removal of contaminant from the perched zone.
- P&T does not address vadose zone soil contamination.
- Consider combining with a HVDPE system.

Permeable Reactive Barrier (PRB) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Containment Description	
This conceptual design utilizes a proprietary PRB that is installed across the flow path of the contaminant plume, allowing the groundwater and liquid phase contaminants to be treated as they pass through the wall. The PRB employs zero-valent iron that causes an abiotic dechlorination reaction that has been demonstrated to break down halogenated VOCs into harmless end products. PRB is not practical for use in the upper vadose zone soil since the technology depends on groundwater movement. PRB is not effective for treating compounds (e.g., benzene, toluene) that biodegrade under aerobic conditions; these compounds would have to be addressed aerobically before or after barrier. A proprietary Azimuth Controlled Vertical Hydraulic Fracturing would be used to emplace the PRB throughout the thickness of the perched zone. Groundwater monitoring is used to assess performance of the PRB. PRB works to reduce toxicity, mobility, and volume of halogenated VOC contamination in groundwater. PRB would effectively eliminate the pathways to human exposure and the potential for migration of COCs in perched groundwater. However, the PRB would only provide a partial treatment solution to the upper vadose soil and perched groundwater remediation zone as pathways to human exposure in upper vadose soils would not be addressed.	
Site Characteristics	
Area of Source control:	
Soil Area (based on exceedances of the SSLs and DAF 20):	69,600 ft^2
Approximate Thickness:	32 ft (3 to 35 ft bgs) 37 ft (3 to 40 ft bgs including perching clay)
Volume:	82,500 yd^3
Perched Groundwater Area:	168,000 ft^2.
Approximate Thickness:	2 to 3 ft (top of perching clay 25 to 35 ft bgs)
Analytical Data:	
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Maximum concentration of COCs in Perched Zone groundwater:	• Benzene (1,600 µg/L) • PCE (1,100 µg/L) • TCE (680 µg/L), • cis-1,2-DCE (780 µg/L) • VC (240 µg/L) • 1,4-dioxane (µg/L)
Hydrogeologic Data:	
Depth to Perched Zone groundwater:	20 to 30 feet bgs.
Direction and gradient of groundwater flow in Perched Zone:	Inconsistent due to perching clay
Receptors: Residential neighborhoods are situated to the south of the site.	

Permeable Reactive Barrier (PRB) (cont'd) *Upper Vadose Soil and Perched Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Components	**Assumptions**
General: Design treatment criterion is to reduce plume VOC concentrations outside the PRB to less than 5 µg/L (.05 µg/L for VC). Based on the estimated groundwater velocity, the residence time in the PRB would be a minimum of 12 hours. Also based on the maximum concentration of COCs in the Perched Zone, a 3-inch thick PRB is considered an appropriate wall thickness to treat the contaminants.	▪ Plume maximum travel rate is undetermined due to inconsistent hydraulic gradients and inability to conduct a pump test due to low flows. ▪ 3-in. thick PRB provides sufficient residence time for treatment.
PRB Installation: Based on GeoSierra proprietary iron PRB. Length of P RB wall will be 640 feet. Refer to the Figures Tab for the general conceptual design proposed for Exposition Zone groundwater. Since the perched plume migrates offsite in several directions, an additional 90 feet was added to treat the northern arm of the perched zone plume.	• Plume will be treated prior to it passing beneath residential properties. • Forty-two injection wells required, based on 15-foot spacing. • Depth of wall will be from 20 to 35 feet bgs. • Injection rate: 45 lbs/s.f. of wall • Wall continuity testing and treatment evaluation to be conducted. • Wall lifespan is 30 years. One wall is estimated to be sufficient to meet containment remediation goals.
Monitoring Well Network: Required to track performance of PRB and assure compliance with treatment criteria. Wells situated mostly within plume and along western perimeter since the hydraulic gradient is inconsistent.	• Perched Zone: 8 wells, 2-inch diameter, Schedule 40 PVC, screened 20 to 35 ft bgs.
Monitoring/Reporting Frequency: One PRB wall is estimated to be capable of remediating the plume of chlorinated VOCs at the Pemaco site. This is based on 10 years of performance evaluation testing for PRBs. Based on zero valent iron corrosivity testing, PRB can persist in the environment up to 80 years.[1, 2]	• Semiannual sampling events are recommended. • Annual monitoring may be recommended after demonstration of treatment. • Assume no O&M cost for PRB wall.
Estimated Project Duration:	50 years.
Conceptual Design Considerations	
• PRB technology does not address vadose zone soil contamination or BTEX in perched groundwater. • Preliminary evaluation of geochemistry and hydrogeology is assumed to be suitable for application of zero-valent iron PRB. Vendor will provide additional detail regarding suitability following laboratory bench test. Installation of PRB could be used in conjunction with other treatment options; however, compatibility testing would be required if the geochemistry is altered. • Consider combining with HVDPE. • Due to location of residential properties to the south, monitoring wells will be positioned along public right-of-ways and within the proposed City of Maywood Riverfront Park.	

[1] – Hocking, G., Wells, S.L. and R.I. Ospina (2000). Deep Reactive Barriers for Remediation of VOCs and Heavy Metals. 2nd Int. Conf. On Remediation of Chlorinated and Recalcitrant Compounds, Monterey CA, May.

[2] – Puls, R.W., R. Wilkin, C. Paul, F. Beck, P. Clark and M. McNeil (2002). Six Years of Intensive Monitoring of the 1st PRB to Treat a Mixed Waste Plume: USCG Site in Elizabeth City, NC, RTDF PRB Action Team Meeting, Washington D.C. Nov. 7-6.

Monitored Natural Attenuation[1] (MNA) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Alternative Description	
MNA consists only of collecting and analyzing groundwater samples and hydraulic data to document and/or model the persistence of contaminant concentrations or their natural attenuation. Natural attenuation differs from 'No Action' because it requires that supporting documentation, including groundwater monitoring results and modeling predictions, be supplied to demonstrate that contaminant concentrations can be reduced to cleanup levels in a reasonable timeframe. Chlorinated compounds (Site COCs) are amenable to natural attenuation provided that characteristic environmental conditions and intrinsic microbiological processes are present. The natural attenuation processes include biodegradation, dispersion, dilution, sorption, volatilization, and chemical or biological stabilization, transformation, or destruction of contaminants, i.e. chlorinated solvents. MNA is more practical as a containment option when partnered with a source control option since it does not actively affect mobility, toxicity, or volume. MNA would not eliminate the potential for migration of COCs in this remediation zone nor the pathways to human exposure to COCs without the addition of a more aggressive remedial alternative.	
Site Characteristics	
Area of Containment:	
'A', 'B' and 'C' Exposition groundwater zones:	552,000 ft^2 (within 5 ppb contour)
Analytical Data:	
Maximum concentration of COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)
Maximum concentration of COCs in 'C' Zone:	Assume one to two orders of magnitude less than 'A' and 'B' Zone concentrations
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the 'A' Zone:	0.8 mg/L, 4.1 mg/L, and 157 mg/L, respectively
Average levels of major environmental indicators (oxygen, nitrate, and sulfate) in the 'B' Zone/'C' Zone (assumed):	0.5 mg/L, 0.2 mg/L, and 210 mg/L, respectively
Potential for biodegradation:	Strong[1]
Hydrogeologic Data:	
Depth to groundwater in Exposition Aquifer:	67 ft bgs
Saturated soil thickness:	Approximately 50 ft
Direction and gradient of groundwater flow in 'A' Zone:	0.011 feet/ft, southwest
Direction and gradient of groundwater flow in 'B' Zone:	0.009 feet/ft, west-southwest
Hydraulic conductivity (average for 'A' Zone):	1.46E-03 ft/min
Hydraulic conductivity (average for 'B' Zone):	3.27E-02 ft/min
Hydraulic conductivity (average for 'C' Zone):	Assumed similar to 'B' Zone
Potential Receptors:	
Most shallow well used for domestic production:	Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs
Closest well used for domestic production:	Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs
Residential neighborhoods:	Located to the south and downgradient

Monitored Natural Attenuation (MNA) (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Components	**Assumptions**
General: MNA is only practical as a containment option when partnered with a source control option.	Removal of free product and source areas must be performed.
Monitoring Well Network: To be established to assess potential migration of contaminants and reduction in concentrations. Wells within each network (Exposition 'A', 'B', and 'C' Zones) will be situated to characterize conditions upgradient, downgradient, within the plume, and lateral extent.	• 'A' Zone: eight wells, 2-inch diameter, Schedule 40 PVC, screened 65 to 75 ft bgs. • 'B' Zone: eight wells, 2-inch diameter, Schedule 40 PVC, screened 80 to 95 ft bgs. • 'C' Zone: eight wells, 2-inch diameter, Schedule 40 PVC, screened 100 to 110 ft bgs.
Monitoring/Reporting Frequency: Reporting will be performed to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection. Parameters to be monitored include: COCs (chlorinated ethenes), field parameters (DO, ORP, pH, and temperature), biodegradation parameters (nitrate, sulfate, sulfide, chloride, ferrous iron, and alkalinity), substrate fermentation products (total organic carbon and metabolic acids), and biodegradation end products (carbon dioxide, methane, ethane, and ethene).	• Semiannual sampling events are recommended. • QA/QC Program Plan will be provided for the Sampling Plan.
Estimated Project Duration:	50 years
Conceptual Design Considerations	
• Containment via MNA should consider an aggressive treatment option for the source area. • Monitoring program can be reevaluated after 5 years of sampling locations and frequency reduction.	

[1] Reference Technical Memorandum: Pemaco Data Evaluation for Natural Attenuation and Biodegradation of Chlorinated Ethenes (TN&A, January 2003), which is provided as Appendix D.

Pump and Treat/Ultraviolet Oxidation *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Description	
Pump and treat (groundwater extraction and treatment or P&T) is a method used to gain hydraulic control over the dissolved contaminant plume. Groundwater extraction wells are used to pump the dissolved phase contaminants to the surface and treat them aboveground. Placement of the groundwater extraction wells is designed to contain the plume and remediate the groundwater over time. An aboveground treatment process would immobilize, treat, or destroy contaminants in the groundwater prior to discharge. The treated groundwater would be disposed by reinjection back into the aquifer, discharged to the sanitary sewer, or discharge to the LA River. Pump and treat systems allow for good control over contaminant mobility and reduction in contaminant volume through extraction of liquid phase contaminants. P&T would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in the Exposition groundwater zones. However, the P&T would only provide a partial treatment solution to the remediation zone, as COCs in lower vadose soils would act as a continuing source of contamination to the Exposition groundwater zones.	
Site Characteristics	
Area of Containment:	
'A', 'B' and 'C' Exposition groundwater zones:	552,000 ft^2 (within 5 ppb contour)
Analytical Data:	
Maximum concentration of COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)
Maximum concentration of COCs in 'C' Zone:	Assume one to two orders of magnitude less than 'A' and 'B' Zone concentrations
Hydrogeologic Data:	
Depth to groundwater in Exposition Aquifer:	67 ft bgs
Saturated soil thickness:	Approximately 50 ft
Direction and gradient of groundwater flow in 'A' Zone:	0.011 feet/ft, southwest
Direction and gradient of groundwater flow in 'B' Zone:	0.009 feet/ft, west-southwest
Hydraulic conductivity (average for 'A' Zone):	1.46E-03 ft/min
Hydraulic conductivity (average for 'B' Zone):	3.27E-02 ft/min
Hydraulic conductivity (average for 'C' Zone):	Assumed similar to 'B' Zone
Pump Test Data:	Average width of capture of 45 ft along downgradient axis; average width of capture of 69 ft along cross-gradient axis.
Boundary conditions:	No documented recharge from LA River along eastern site boundary
Potential Receptors:	
Most shallow well used for domestic production:	Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs
Closest well used for domestic production:	Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs
Residential neighborhoods:	Located to the south and downgradient

Pump and Treat/Ultraviolet Oxidation (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Components	Assumptions
Groundwater Well Networks: Fifty-five extraction wells will be installed in four networks: wells screened in the 'A' Zone, wells screened in the 'B' Zone, wells screened continuously through the 'A' and 'B' Zones, and wells screened in the 'C' Zone. Well network design is based on pump test data (average downgradient axis width of capture of 45 ft; average cross-gradient width of capture of 69 ft). To prevent the potential for cross contamination between the different Exposition Zones, the wells screened continuously through the 'A' and 'B' Zones are located outside the 100 ppb plume contour line. Refer to the Figures Tab for the proposed P&T extraction well locations.	• Wells to be situated predominantly in the source area and along public right-of-ways. • Groundwater extraction rate is 2 gpm for 'A' and 'B' Zones and 4 gpm for 'C' Zone. • Total system flow of 168 gpm (2.0 gpm x 34 'A' and 'B' wells; 4.0 gpm x 21 'C' wells). • All wells shall be 6-inch diameter, Schedule 80 PVC. A .5 hp submersible pump will be installed in each well. • 'A' Zone: 13 wells, Schedule 80 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 13 wells, Schedule 80 PVC, screened 80 to 95 ft bgs. • 'A' and 'B' Zone: 8 wells Schedule 80 PVC, screened 65 to 95 ft bgs. • 'C' Zone: 21 wells, Schedule 80 PVC, screened 100 to 110 ft bgs.
Groundwater Treatment System: Treatment process to be UV oxidation. A fenced and covered treatment compound would be mounted on a 20 ft by 20 ft concrete pad with containment foundation. Electrical service and remote monitoring communication system would be tied into local services with possible back-up power generation. Influent trench and pipe would include 3,800 ft of trench, 2,200 ft of 4-inch diameter Schedule 80 PVC and 1,600 ft of 6-inch diameter Schedule 80 PVC. Effluent trench and pipe would include 500 ft of trench and 500 ft of 6-inch diameter Schedule 80 PVC.	• Design flow and influent conc. are 170 gpm and 3.0 ppm total VOC • Max VOC effluent conc. 5 ppb. • Treatment system influent and effluent to be sampled daily during 7-day startup; quarterly after documented stabilization; semiannually after established trend or continued stabilization. Effluent sampling frequency would be determined by discharge permit. • Long-term O&M plan to be implemented for treatment system.
Monitoring/Reporting Frequency: Reporting will be performed to document contaminant removal rates, flows, cleanup forecasts, and groundwater gradient maps, in appropriate frequency to data collection.	• Semiannual sampling events are recommended. • Annual monitoring may be recommended after demonstration of reduction in plume volume and mobility. • QA/QC Program Plan will be instituted for all sampling and treatment.
Estimated Project Duration:	30 years
Conceptual Design Considerations	
• Containment via P&T should consider an aggressive treatment option for the source area, particularly the perching clay (28 to 40 feet bgs). • Enhancements: Hydraulic or pneumatic fracturing and VE could be used as an enhancement for removal of contaminant from source area.	

Permeable Reactive Barrier (PRB) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Description	
This conceptual design utilizes a proprietary PRB that is installed across the flow path of the contaminant plume, allowing the groundwater and liquid phase contaminants to be treated as they pass through the wall. The PRB employs zero-valent iron that causes an abiotic dechlorination reaction that has been demonstrated to break down VOC COCs into harmless end products. Metal COCs would also be remediated through precipitation reactions. A proprietary Azimuth Controlled Vertical Hydraulic Fracturing is used to emplace the PRB to a depth of 110 feet bgs. Groundwater monitoring is used to assess performance of the PRB. PRB works to reduce toxicity, mobility, and volume of contamination. PRB would effectively eliminate the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in the Exposition groundwater zones. However, the PRB would only provide a partial treatment solution to the remediation zone, as COCs in lower vadose soils would act as a continuing source of contamination to the Exposition groundwater zones.	
Site Characteristics	
Area of Containment:	
'A', 'B' and 'C' Exposition groundwater zones:	552,000 ft^2 (within 5 ppb contour)
Analytical Data:	
Maximum concentration of COCs in 'A' Zone:	TCE (27,000 µg/L), cis-1,2-DCE (2,600 µg/L) and VC (100 µg/L)
Maximum concentration of COCs in 'B' Zone:	TCE (21,000 µg/L), cis-1,2-DCE (14,000 µg/L) and VC (780 µg/L)
Maximum concentration of COCs in 'C' Zone:	Assume one to two orders of magnitude less than 'A' and 'B' Zone concentrations
Hydrogeologic Data:	
Depth to groundwater in Exposition Aquifer:	67 feet bgs
Saturated soil thickness:	Approximately 50 ft
Direction and gradient of groundwater flow in 'A' Zone:	0.011 feet/ft, southwest
Direction and gradient of groundwater flow in 'B' Zone:	0.009 feet/ft, west-southwest
Estimated interstitial velocity (average for 'A' Zone):	0.04 ft/day
Estimated interstitial velocity (average for 'B' Zone):	0.5 ft/day
Estimated interstitial velocity (average for 'C' Zone):	Assumed similar to 'B' Zone
Receptors:	
Most shallow well used for domestic production:	Located approx. 4,000 ft southwest of site; screen interval begins at 350 feet bgs.
Closest well used for domestic production:	Located approx. 2,600 ft southwest of site; screen interval begins at 610 feet bgs.
Residential neighborhoods:	located to the south and downgradient
Conceptual Design Components and Assumptions	
Component	**Assumptions**
General: Design treatment criterion is to reduce plume concentrations outside the PRB to less than 5 µg/L. Average residence time in 3-inch thick PRB based on 'B' Zone average interstitial velocity is 12 hours. Estimated residence time required to reduce maximum concentrations is 'B' Zone to <5 µg/L is 6 hours.	Plume maximum travel rate is 0.5 ft/day 3 in thick PRB provides sufficient residence time for treatment

Permeable Reactive Barrier (PRB) (cont'd) *Lower Vadose Soil and Exposition Groundwater Remediation Zone*	
Conceptual Design Components and Assumptions	
Component	**Assumptions**
PRB Installation: Based on GeoSierra proprietary iron PRB. Length of PRB wall will be 550 feet. Refer to the Figures Tab for the proposed location of the PRB and associated well network.	• Plume will be treated prior to it passing beneath residential properties. • Thirty-seven injection wells required, based on 15-foot spacing. • Depth of wall will be from 55 feet to 110 feet bgs. • Injection rate: 45 lbs/s.f. of wall • Wall continuity testing and treatment evaluation to be conducted. • Wall lifespan is 30 years. One wall is estimated to be sufficient to meet remediation goals.
Monitoring Well Network: Required to track performance of PRB and assure compliance with treatment criteria. Wells within each network (Exposition 'A', 'B', and 'C' Zones) will be situated to characterize conditions upgradient and downgradient of the PRB wall; and upgradient, downgradient, within the plume, and lateral extent of the plume.	• 'A' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 65 to 75 ft bgs. • 'B' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 80 to 95 ft bgs. • 'C' Zone: 10 wells, 2-inch diameter, Schedule 40 PVC, screened 100 to 110 ft bgs.
Monitoring/Reporting Frequency: One PRB wall is estimated to be capable of remediating the plume of chlorinated VOCs at the Pemaco site. This is based on 10 years of performance evaluation testing for PRBs. Based on zero valent iron corrosivity testing, PRB can persist in the environment up to 80 years.[1,2]	• Semiannual sampling events are recommended. • Annual monitoring may be recommended after demonstration of treatment. • Assume no O&M cost for PRB wall.
Estimated Project Duration:	50 years
Conceptual Design Considerations	
• Preliminary evaluation of geochemistry and hydrogeology is assumed to be suitable for application of zero-valent iron PRB. Vendor will provide additional detail regarding suitability following laboratory bench test. • Installation of PRB could be used in conjunction with source control options; however, compatibility testing would be required if the geochemistry is altered. • Due to location of residential properties to the south, monitoring wells will be positioned along public right-of-ways and within the proposed City of Maywood Riverfront Park.	

DETAILED EVALUATION OF NON-RETAINED REMEDIALTERNATIVES

The detailed evaluation of the remedial alternatives presents a comparison of relevant information needed to allow decision makers to select a site remedy(s). As part of the National Contingency Plan (40 CFR 300.430(e)(9)), each alternative is assessed against the nine evaluation criteria. The U.S. EPA developed the nine criteria to address CERCLA statutory considerations for remedial actions that must be addressed in the Record of Decision (ROD) as well as technical and policy considerations that have proven to be important for selecting among remedial alternatives.

The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the evaluation is mostly based. The final two criteria are referred to as modifying criteria and are applied, following the public comment period, to evaluate state and community acceptance. The evaluation of alternatives reflects the scope and complexity of site problems and alternatives being evaluated and considers the relative significance of the factors within each criterion. The nine evaluation criteria are as follows:

Threshold Criteria

1. Overall protection of human health and the environment
2. Compliance with ARARs/TBCs (applicable or relevant and appropriate standards/to be considered documents)

Primary Balancing Criteria

3. Long-term effectiveness and permanence
4. Reduction of toxicity, mobility or volume
5. Short-term effectiveness
6. Implementability
7. Cost

Modifying Criteria

8. State acceptance
9. Community acceptance

SURFACE AND NEAR-SURFACE SOIL REMEDIATION ZONE

The two remedial alternatives for the surface soil and near-surface soil groundwater (zero to 3 ft bgs) remediation zone, which were not retained, include:

- Capping/Revegetation
- Excavation/Onsite Treatment/Backfill

These two alternatives were evaluated in detail to the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period.

The detailed evaluations are presented in Table 1.0. Detailed cost estimates for each alternative are presented in Tables 1.1 and 1.2 and are summarized in Table 1.0.

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

The four remedial alternatives for the upper vadose soil and perched groundwater (3 to 35 ft bgs) remediation zone, which were not retained, include:

- Excavation/Onsite Treatment/Backfill
- Electrical Resistance Heating with Vapor Extraction/*Ex-Situ* Vapor Treatment
- Pump and Treat/Ultraviolet Oxidation
- Permeable Reactive Barrier

These four alternatives were evaluated in detail to the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period. The detailed evaluations are presented in Table 2.0. Detailed cost estimates for each alternative are presented in Tables 2.1 through 2.4 and are summarized in Table 2.0.

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

The three remedial alternatives for the lower vadose soil and the Exposition groundwater (35 to 110 ft bgs) remediation zone, which were not retained, include:

- Monitored Natural Attenuation
- Pump and Treat/Ultraviolet Oxidation
- Permeable Reactive Barrier

These three alternatives were evaluated in detail to the nine evaluation criteria described above. Note that additional evaluation of two of the criteria, state acceptance and community acceptance, will be performed following the public comment period. The detailed evaluations are presented in Table 3.0. Detailed cost estimates for each alternative are presented in Tables 3.1 through 3.3 and are summarized in Table 3.0.

COMPARATIVE ANALYSIS OF NON-RETAINED REMEDIAL ALTERNATIVES

The purpose of the comparative analysis is to identify the relative advantages and disadvantages of each alternative. A comparative analysis of the non-retained remedial alternatives is presented in separate sections below. The remedial alternatives selected for detailed evaluation in the Final FS document are not included in this comparative analysis.

SURFACE AND NEAR-SURFACE SOIL REMEDIATION ZONE

The comparative analysis of the non-retained remediation alternatives for the surface and near-surface soil remediation zone is provided below, organized by evaluation criterion.

Overall Protection of Human Health and the Environment

Both of the surface and near-surface soil remediation zone alternatives would reduce current baseline risks and would provide some level of protection to human health and the environment.

The Capping/Revegetation alternative would reduce the likelihood of surficial exposure pathways to potential human and ecological receptors. However, this alternative includes a design (cap) that substantially reduces infiltration of surface water, which would reduce the potential for migration of COCs to groundwater through percolation. The characteristic immobility of the COCs in this remediation zone diminishes this benefit. In addition, by restricting the percolation of oxygenated water through the near surface zone soils, the potential for natural attenuation of the organic contaminants would be greatly reduced.

Excavation/Onsite Treatment/Backfill alternative would reduce COCs, and therefore, reduce potential pathways to human health and environment and the potential migration of COCs to groundwater. This alternative would significantly reduce risks for exposure if the site were ever redeveloped or if a significant erosion event were to occur. However, some uncertainty exists regarding the permanence of the remedy and how successful the soil treatment process would be. Several soil treatments may be required to effectively reduce both PAHs and metals in this zone. This alternative may require the addition of a vegetative soil cover to ensure protection of human health and the environment.

Compliance with the ARARs/TBCs

The evaluation of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of the *Feasibility Study Report, Pemaco Superfund Site* (TN&A, March 2003). of this report. There are no known location-specific ARARs/TBCs for this site.

The Capping/Revegetation alternative would likely meet ARARs/TBCs through the elimination of potential exposure pathways. The Excavation/Onsite Treatment/Backfill alternative would likely meet ARARs/TBCs through soil treatment, although there is some uncertainty about the ability of the treatment processes to meet ARARs/TBCs and regarding the permanence of treatment.

Long-Term Effectiveness and Permanence

The Excavation/Onsite Treatment/Backfill alternative would provide good long-term effectiveness and permanence, because COCs within this remediation zone would be destroyed or stabilized. However, the use of treated soil as backfill would introduce some uncertainty depending on the success and permanence of the treatment process applied to this alternative. This uncertainty would be minimized through quality control during post-treatment soil analysis and through the addition of a vegetative soil cover.

The Capping/Revegetation alternative is considered adequate and reliable in eliminating exposure risk and preventing migration (via erosion). This alternative would require indefinite surface inspections and implementation of corrective actions (e.g., maintenance and/or repair of their surfaces in order to address erosion and surface wear) to remain effective.

Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

The Excavation/Onsite Treatment/Backfill alternative would provide a degree of TMV reduction depending on the success of the onsite treatment. Due to the uncertainty associated with treating fine-grained soils and creating a soil-washing reagent that treats both organic and inorganic contaminants, the potential exists for additional monitoring after treatment in order to be assured of compliance with ARARs and TBCs.

The Capping/Revegetation alternative would not reduce the toxicity or volume of COCs within this remediation zone; however, this alternative would provide significant reductions in contaminant mobility. The lack of reduction in toxicity and volume would be compensated for by the elimination of potential exposure routes. This alternative would provide an increased reduction in mobility with respect to leaching of contaminants to groundwater. As previously discussed, the immobility of COCs within this remediation zone diminishes this benefit. Additionally, the lack of percolation because of the cap design would slow down the potential reduction in toxicity and volume of COCs via natural attenuation and degradation processes which depend upon water.

Short-Term Effectiveness

This evaluation criterion is two-fold. One aspect addresses the time until remedial action objectives are met and the other addresses the effects of the alternative during the construction and implementation phase of the alternative.

The Capping/Revegetation alternative is anticipated to have the good short-term effectiveness for quickly achieving RAOs (1 – 2 months for construction of soil cover and 2 – 4 months for construction of cap) with minimal impact to remedial construction workers, the community, and the environment. Potential short-term risks consist of dust emissions, which could be mitigated through engineering controls (dust suppression), air monitoring, and PPE.

The Excavation/Onsite Treatment/Backfill alternative offers less short-term effectiveness than the capping alternative because it would require the excavation, handling, and mixing of contaminated soil. Excavation and soil movement operations have the potential to generate significant amounts of dust that could be a threat to construction workers, the community, and the environment but which could be mitigated through engineering controls (dust suppression), air monitoring, and PPE. The operation of a soil treatment plant at the Site would extend the duration of potential dust releases and construction related disturbances. The dust, noise, and traffic could be mitigated with proper planning and suitable health and safety measures, such as engineering controls (dust suppression), air monitoring, PPE, and traffic control, but not to the degree typical of soil cover and capping alternatives.

Implementability

The Capping/Revegetation alternative would require administrative efforts to modify land deeds to prevent future development of the property and indefinite monitoring and maintenance programs. Technically, the cap would be more difficult to implement than the retained Soil Cover/Revegetation alternative because of the impermeable membrane feature and the construction methods involved. Construction services and materials would be readily available for either alternative.

The Excavation/Onsite Treatment/Backfill alternative would involve a similar degree of administrative effort and an additional degree of technical effort to the retained Excavation and Offsite Disposal alternative since a soil treatment system would be operated onsite. Some of the technical considerations associated with the plant operations include the mixing of reagents and soil, timing process rates to achieve the RAOs, post treatment testing, and disposal of waste liquids or treatment byproducts. Engineering and construction services and materials would be readily available for excavation and onsite treatment.

Estimated Cost

A summary of the estimated costs for each of the surface and near-surface soil remediation zone remedial alternatives is presented in Table 1.0. A more detailed cost estimate for each alternative is provided in Tables 1.1 and 1.2. The cost estimates presented in Table 1.0 and in Tables 1.1 and 1.2 have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are "order-of-magnitude" estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all screening criteria are considered in preparation of the ROD.

The Capping/Revegetation alternative has a total present worth of $1.2 million, primarily because of the addition of the impermeable liner. The Excavation/Onsite Treatment/Backfill alternative has a total present worth of $1.5 million. A major cost uncertainty associated with this alternative is with the degree of treatment the soil will require to meet the RAOs.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

The comparative analysis of remedial alternatives for the upper vadose soil and perched groundwater remediation zone is presented below, organized by evaluation criterion.

Overall Protection of Human Health and the Environment

All of the non-retained remedial alternatives would reduce current baseline risks and would provide some level of protection to human health and the environment. The ERH with VE alternative would be expected to reduce COCs to remediation goals within both the soil column and the perched groundwater zone, thereby providing a high level of protection to human health and the environment. The removal of COCs in both media would achieve remediation goals and eliminate exposure pathways for all potential receptors.

The Excavation/Onsite Treatment/Backfill alternative would provide adequate protection of human health and the environment through reduction of COCs in upper vadose soils to a depth of 25 ft, but would not address COCs in perched groundwater. While this alternative would reduce COC concentrations and address potential pathways to contaminated upper vadose soils (e.g., vapor phase migration of VOCs to the surface), VOCs may still volatilize to the surface from saturated soils (25 to 35 ft bgs) and the perched groundwater, as well as migrate to deeper saturated zones.

The Permeable Reactive Barrier (PRB) alternative provides a reactive barrier to lateral contaminant migration in groundwater through the placement of reactive materials in the subsurface that are designed to intercept contaminated groundwater and chemically reduce the contaminants into environmentally acceptable forms. The PRB alternative would achieve protection for offsite receptors by preventing exposure to COCs downgradient of the perched groundwater plumes. However, PRB would not be protective for future onsite receptors (park users, potential future residents) because COCs upgradient of the PRB would not be mitigated. Additionally, COCs that have already migrated downgradient and may be exposing receptors to possible vapor phase contamination would not be addressed.

The Pump and Treat (P&T) alternative would be protective of human health and the environment (through reduction of COCs) in some capacity, but would not address all receptor pathways. Pump and Treat would provide a long-term solution to the reduction of COCs in perched groundwater and to the mobility of COCs in saturated soils, but would not address upper vadose zone soils and the potential for vapor phase migration to the surface.

Compliance with the ARARs/TBCs

The evaluation of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of the *Feasibility Study Report, Pemaco Superfund Site* (TN&A, March 2004). There are no known location-specific ARARs/TBCs for this site.

The ERH with VE alternative would meet ARARs/TBCs for both soil and groundwater.

The PRB alternative would effectively achieve groundwater ARARs downgradient of the PRB, but TBCs for upper vadose soils throughout the site and groundwater ARARs upgradient of the PRB would not be achieved within a reasonable timeframe.

The Excavation/Onsite Treatment/Backfill alternative would meet subsurface soil TBCs for soils between 3 and 25 feet bgs; however, saturated soils between 25 and 35 feet bgs would not meet TBCs and the perched groundwater would not meet ARARs.

The P&T alternative would directly address groundwater contamination and be generally compliant with groundwater ARARs over time, but upper vadose soil TBCs would not be achieved.

Long-Term Effectiveness and Permanence

The ERH with VE alternative would be expected to provide the highest degree of long-term effectiveness and permanence because this alternative uses a technology that would reduce concentrations of known COCs to concentrations that meet remedial goals and baseline risks within this zone. Removal of contaminants within perched groundwater and upper vadose soils would be permanent with no treatment residuals and no untreated residual risks. Although ERH with VE is not in widespread use, it has been proven to be effective in several full-scale demonstration projects. This alternative would require monitoring of the remediation area to assure effectiveness over the duration of system operation.

The PRB and Excavation/Onsite Treatment/Backfill alternatives only address one medium within the upper vadose and perched groundwater remediation zone.

The PRB alternative would only reduce COCs in groundwater that migrates through and react with the zero-valent iron within the PRB. While the PRB would reduce risks to downgradient receptors, COCs in groundwater upgradient of the PRB and in upper vadose soils throughout the remediation zone would remain as untreated residual contamination. Although zero-valent iron is a well-established treatment method for chlorinated VOCs in groundwater, there are several issues which render uncertainty to the alternative at Pemaco: 1) the installation method of the PRB (via a series of injection points) could be impractical because of complex stratigraphy; 2) perched groundwater may not flow consistently through the PRB (technology requires groundwater movement); 3) the perched groundwater gradient is irregular because of undulations in the perching clay surface so there is no clear "downgradient" location; and, 4) the lifespan of the PRB can not be accurately predicted. Downgradient monitoring would be required to assure removal of contaminants as the perched groundwater travels through the PRB and to assure effectiveness over time.

The Excavation/Onsite Treatment/Backfill alternative would eliminate COCs in upper vadose soils between 3 and 25 feet bgs, but COCs within saturated soils (25 to 35 feet bgs) and perched groundwater would be remaining risks to potential receptors.

P&T would provide only a partial long-term solution to the reduction of COCs in perched groundwater and to the mobility of COCs in saturated soils since the nature of the perched zone will not allow for all groundwater to be extracted by traditional pumping methods (i.e., no flow to wells without vacuum assistance). The P&T alternative would require a long period of time to achieve remediation goals within the perched groundwater zone. The alternative would not address upper vadose zone soils 3 to 25 feet bgs. Finer-grained soils within the saturated zone would also be incompletely treated due to permeability differences relative to the sand/silt layers, which would allow them to act as continuing sources.

Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

The ERH with VE alternative uses a technology that increases the rate of COC evaporation and mass transfer and enhances the physical removal of the COCs in both perched groundwater and upper vadose zone soils. This alternative would effectively reduce the TMV of COCs within both upper vadose soils and the perched groundwater. Extracted vapor would require *ex-situ* treatment.

The PRB alternative would not physically remove COCs from the subsurface nor would it address COCs in upper vadose soils. However, as contaminants in groundwater would pass through the zero-valent iron in the PRB the toxicity of chlorinated VOCs would be reduced through dechlorination. In turn, the volume of COCs would be reduced as COCs are diluted from the source area and moved through the reactive wall by through-flowing groundwater and infiltrating precipitation. Because COCs are reduced as they travel through the PRB, the mobility of chlorinated VOCs would also be reduced. However, PRB would not be effective for treating non-chlorinated organic compounds because these compounds do not degrade by reaction with the iron in the PRB.

The Excavation/Onsite Treatment/Backfill alternative physically removes COCs in upper vadose soils between the depths of 3 and 25 feet bgs through soil excavation, onsite soil treatment, and replacement of treated soil and/or clean fill to the excavated area. The likelihood of exposure to COCs in these soils (approximately 56,700 cubic yards) would be reduced, but a significant volume of contamination within this remediation zone would be untreated, because this alternative does not address saturated soils between 25 and 35 feet bgs (approximately 25,800 cubic yards) or the perched groundwater.

The P&T alternative would address the reduction of TMV of COCs in perched groundwater and the mobility of COCs in saturated soils, but would not address upper vadose zone soils 3 to 25 ft bgs. P&T systems create positive hydraulic control over contaminant migration and reduction in plume volume through extraction of dissolved phase contaminants. It is through this hydraulic control of groundwater flow that the mobility of contaminants (including free product) in saturated soils would be reduced. The toxicity and volume of COCs in the saturated soils, however, would not be reduced. Extracted groundwater would require *ex-situ* treatment via UV oxidation. As described above, complex stratigraphy would inhibit the recovery of perched groundwater using traditional pumping methods; vacuum assistance would be required to capture COC-containing groundwater.

Short-Term Effectiveness

This evaluation criterion is two-fold. One aspect addresses the time until remedial action objectives (RAOs) are met; the other addresses the effects of the alternative during the construction and implementation phase of the alternative.

The ERH with VE alternative is anticipated to be very effective in the short-term with respect to meeting RAOs. RAOs for both upper vadose soil and perched groundwater would likely be met within 1 year under this alternative. The ERH with VE alternative presents potential risks to workers, the community, and the environment during construction and implementation (approximately 2 months for both alternatives). This alternative would involve installation of 32 soil vapor extraction wells, installation of 252 electrodes in 126 boreholes, and construction of an aboveground soil vapor treatment system and a small power station. Risks associated with construction and implementation activities of these alternatives include: increased traffic, particulate emissions, and high voltage hazards. All of these risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, worker PPE, air monitoring, and restricted access to the aboveground treatment systems and power station.

The project duration of the PRB alternative is expected to be long (approximately 50 years). It is anticipated that within this timeframe, the majority of contaminated groundwater within the perched zone will travel through and react with the iron in the PRB (based on zero-valent iron corrosivity testing, the PRB can persist in the environment for up to 80 years). Although this alternative is projected to take a long time to reach perched groundwater RAOs, it only requires a 2-month implementation period, because no aboveground treatment systems are necessary. Short-term risks to the community, workers, and environment during remedial actions are limited to those associated with drilling activities, such as worker safety and traffic issues. (This alternative necessitates the installation of 42 injection wells, which together make up the 640-ft-long PRB.) These risks can be mitigated with proper planning and suitable health and safety measures/controls. Baseline risks to the community associated with contaminants in upper vadose soils would remain.

The Soil Excavation/Onsite Treatment/Backfill alternative would take about 1 year to implement and reach RAOs for upper vadose soils between the depths of 3 and 25 feet bgs. Baseline risks to the community associated with contaminants in saturated soils (25 to 35 feet bgs) and perched groundwater would remain. Short-term risks to the community and environment associated with excavation activities include increased traffic and particulate emissions with a high frequency. In addition, workers could be potentially exposed to upper vadose soil contaminants through direct contact. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, dust suppression, air monitoring, and worker PPE.

The P&T alternative is projected to take approximately 2 months to implement/construct and 30 years of operations to achieve perched groundwater RAOs. Baseline risks to the community associated with contaminants in upper vadose soils would remain. Short-term physical risks associated with P&T would arise from the installation of 32 extraction wells, a groundwater treatment system, and approximately 1,700 feet of trenching. Short-term risks to the community and environment associated with drilling, construction, and trenching activities include increased traffic and particulate emissions; potential worker exposure to upper vadose soils would be a short-term risk. These risks could be mitigated with proper planning and suitable health and safety measures, such as traffic control, dust suppression, air monitoring, and worker PPE.

Implementability

The Soil Excavation/Onsite Treatment/Backfill alternative is challenging to implement technically because of engineering controls required for excavations to this depth. However, this alternative involves conventional, well proven, and implementable technologies and personnel, equipment, and materials are readily available. This alternative would require administration of an excavation and endpoint-sampling plan as well as institutional controls to prevent future development. In addition, close administrative cooperation with the City of Maywood is required to reroute utilities during excavation. Partial closure of the Maywood Riverfront Park would be required for about a 1-year period during excavation, onsite treatment, and backfill activities.

The PRB alternative is not an innovative technology but the reliability of the installation method (via a series of injection points) is not well established. In addition, perched groundwater may not flow consistently through the PRB because of the irregular groundwater flow direction caused by undulations in the perching clay surface. Without groundwater movement, this technology would not be functional. Modifications (640-foot length, 35 foot depth and 42 injection points based on 15-foot spacing) could be warranted based on performance of the installation method and the effectiveness of the technology through groundwater monitoring data. Personnel, equipment, and materials are generally available for implementation and operation. The Maywood Riverfront Park would be disrupted for an approximate 2-month period.

The ERH with VE alternative is a complex alternative to construct and, during implementation, to operate. Although ERH with VE is no longer considered an innovative technology, it is a relatively new technology that requires sophisticated specialized equipment and skilled technical operators. As such, relatively few vendors offer ERH with VE and personnel, equipment, and materials have limited availability. A pilot test would be needed to establish suitability of the method at the site and to obtain additional design information. System modifications to the suggested 32 soil vapor extraction wells and 252 electrodes could be warranted based on performance and monitoring data. The southwest portion of the Pemaco property and adjacent area of the Maywood Riverfront Park would be disrupted for approximately 1-year. The partial park closure would need to be coordinated in cooperation with the City of Maywood.

The P&T alternative consists of a generally conventional, well proven, and implementable technology and is expected to be highly reliable when adequately operated, maintained and monitored. Personnel, equipment, and materials are also readily available for implementation/operation. However, the perched groundwater zone has limited pumping capabilities as demonstrated during quarterly groundwater sampling events where several wells screened within the perched zone were unable to sustain pumping rates of 50 mL/min. The perched zone is often limited or sometimes even absent where it is replaced by “high points” of the underlying “perching” clay. Groundwater flow direction and hydraulic communication between the different localities of the perched zone is dependent upon the geometry of the underlying perching clay. In short, the limited yield of the perched zone may limit the technical feasibility of a P&T system for the perched groundwater zone. Implementation of this alternative is projected to last for approximately 2 months, during which time portions of the Maywood Riverfront Park would be disrupted. Revision of the pumping system may be required following evaluation of performance monitoring of the system as initially installed. A discharge permit of treated groundwater to either the surface or subsurface would also be required.

Estimated Cost

A summary of the estimated costs for each of the upper vadose soil and perched groundwater remediation zone non-retained remedial alternatives is presented in Table 2.0. A more detailed cost estimate for each alternative is provided in Tables 2.1 through 2.4. The cost estimates presented in Table 2.0 and in Tables 2.1 through 2.4 have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are “order-of-magnitude” estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all evaluation criteria are considered in preparation of the ROD.

The PRB alternative provides a total present worth cost at approximately $3.5 million. Contaminants in the perched zone could continue migrating to the Exposition groundwater zones, however, thereby increasing the cost to cleanup the deeper zone. Therefore, PRB is not is not considered cost effective for the perched zone.

Prior to adding on the costs of *ex-situ* treatment (approximately $3.5 million), the P&T alternative provides a total present worth cost of approximately $6.1 million. This alternative is relatively expensive considering that only the saturated portion of the perched zone would receive treatment, and then only for as long as water could be pumped. Since P&T would take a long time and only affects the saturated portion of the perched zone, it is not considered cost effective.

Prior to adding on the costs of *ex-situ* treatment (approximately $2 to $3 million), the ERH with VE alternative provides a total present worth cost of approximately $7.5 million. ERH is estimated to be an effective and expedient alternative at remediating both the saturated and unsaturated portions of the perched zone and is also capable of remediating the contaminants trapped in the impermeable clay layers. Although it is an expensive alternative, it is estimated to be very effective in its potential to remove contaminants and achieve the Site remediation goals in a relatively short period of time, and is therefore cost effective.

The Excavation/Onsite Treatment/Backfill alternative is a very expensive alternative with a total present worth cost of $18.4 million. The high cost of this alternative is a result of excavating below the normal operating range of standard equipment. Also of significant cost would be a pilot test to determine the treatability of both saturated and unsaturated soils. This alternative has the highest potential for cost overruns due to technical constraints and is, therefore, not considered cost effective.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

The comparative analysis for the lower vadose soil and Exposition groundwater remediation zone alternatives is presented below, organized by evaluation criterion.

Overall Protection of Human Health and the Environment

All of the non-retained remedial alternatives would reduce current baseline risks and would provide some level of protection to human health and the environment. The P&T alternative would be protective of human health and the environment by reducing contaminant volume and limiting migration of contaminants. P&T provides long-term protection of human health and the environment, but it would be more effective and require less time to achieve remediation goals if combined with more aggressive technologies, such as vacuum extraction, *in-situ* bioremediation, or ERH.

The PRB alternative provides a reactive barrier to lateral contaminant migration in groundwater through the placement of reactive materials in the subsurface that are designed to intercept contaminated groundwater and chemically reduce the contaminants into environmentally acceptable forms. A PRB could effectively reduce chlorinated solvents in groundwater, which would reduce the potential exposure pathways to residents via migration of COCs in groundwater to local domestic production wells.

The MNA alternative is protective of human health and the environment in some capacity by monitoring natural restoration of groundwater quality along plume fringes to that of drinking water standards over time. However, remediation in this zone through attenuation and degradation processes alone is estimated to take greater than 100 years and does not remediate receptor pathways within a reasonable timeframe. MNA would only be valuable in conjunction with an effective source reduction technology such as vacuum extraction or *in-situ* bioremediation.

Compliance with the ARARs/TBCs

The evaluation of the ability of alternatives to comply with ARARs/TBCs included a review of chemical-specific and action-specific ARARs/TBCs that was presented in Section 2.0 of the *Feasibility Study Report, Pemaco Superfund Site* (TN&A, March 2004). There are no known location-specific ARARs/TBCs for this site.

The P&T alternative would directly address groundwater contamination and would generally comply with groundwater ARARs over time in conjunction with a source reduction technology. Industry case histories indicate that P&T alone is limited by contaminant desorption rates from fine-grained units and natural attenuation rates within those units. With the potential contaminant mass present within the fine-grained units at Pemaco, achieving ARARs in the source area with P&T alone would be unlikely, although ARARs could be met in non-source (diluted-phase) areas. Lower vadose soil remediation goals would not be achieved.

The PRB alternative would likely achieve groundwater ARARs downgradient of the PRB, but TBCs for lower vadose soils throughout the plume and groundwater ARARs upgradient of the PRB would not be achieved. Fugitive COCs that already exist downgradient of the proposed PRB location are expected to attenuate if the source area is treated with a more aggressive technology.

The MNA alternative would not achieve ARARs and TBCs within a reasonable timeframe, because MNA would not actively address contaminants. However, if used in conjunction with an effective source reduction technology, MNA would be useful to demonstrate containment or plume recession.

Long-Term Effectiveness and Permanence

The P&T alternative consists of conventional and well-proven technologies and is expected to be highly reliable when properly operated and maintained. The placement of groundwater extraction wells would be designed to contain the plume through hydraulic control and to remediate the contamination over time through groundwater extraction. P&T would effectively minimize the potential for migration of COCs in this remediation zone and the pathways to human exposure to COCs in the Exposition groundwater zones. The removal of contaminants from groundwater through P&T would be permanent, although impacted lower vadose soils may act as a continual, long-term source of contamination to the Exposition groundwater zones. Monitoring of the remediation zone would be required to maintain effectiveness over time.

The PRB alternative would reduce COCs that migrate through and react with the zero-valent iron within the PRB, which would reduce risks to downgradient receptors. Although zero-valent iron is a well-established treatment method for chlorinated VOCs in groundwater, there are issues which render uncertainty to the long-term effectiveness of this alternative at Pemaco: (1) the installation method of the PRB (via a series of injection points) could be impractical because of the complex stratigraphy at the site, and (2) the lifespan of the PRB can not be accurately predicted. Downgradient monitoring would be required to assure adequate removal of contaminants and to assure effectiveness over time.

The effectiveness of the MNA alternative in restoring groundwater quality to RAOs within a reasonable timeframe without pro-active source reduction is very low. In combination with an effective source reduction technology; however, long-term effectiveness may be achieved by natural attenuation.

Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment

The PRB alternative is not a barrier to groundwater flow, rather, as dissolved contaminants in Exposition groundwater pass through the reactive barrier, the toxicity of chlorinated VOCs would be reduced through in-situ dechlorination. In turn, plume volume and COC mass would be reduced. Additionally, the mobility of chlorinated VOCs would be reduced since COCs would be limited to the area upgradient of the PRB.

The P&T alternative addresses the reduction of TMV of COCs in Exposition groundwater and the mobility of COCs in saturated soils. Groundwater P&T systems allow for positive hydraulic control over contaminant migration and reduction in plume volume through extraction of dissolved phase contaminants. It is through this hydraulic control of groundwater flow that the mobility of contaminants (including NAPL) in saturated soils would be reduced. The toxicity and volume of COCs in the saturated soils, however, would not be reduced. *Ex-situ* treatment of groundwater via UV oxidation would be required.

The MNA alternative would not reduce TMV within a reasonable timeframe without an effective source reduction technology.

Short-Term Effectiveness

The P&T alternative is projected to take approximately 2 months to implement/construct and over 30^{+} years of operations to achieve Exposition groundwater RAOs. Baseline risks to the community associated with contaminants in upper vadose soils would remain. Short-term risks associated with this alternative are related to the installation of 55 extraction wells, a groundwater treatment system, and approximately 4,200 feet of trenching. Short-term risks to the community and environment associated with drilling, construction, and trenching activities include increased traffic and particulate emissions; potential worker exposure to lower vadose soils is also a risk. These risks can be mitigated with proper planning and suitable health and safety measures, such as traffic control, dust suppression, air monitoring, and worker PPE.

The project duration of the PRB alternative is expected to be approximately 50 years. It is anticipated that within this timeframe, the majority of contaminated groundwater within the Exposition zone would travel through and react with the PRB (based on zero-valent iron corrosivity testing, PRB can persist in the environment for up to 80 years). Although PRB is projected to take a long time to reach Exposition groundwater RAOs, it only requires a 2-month implementation period, because no aboveground treatment systems are necessary. Short-term risks to the community, workers, and environment during remedial actions are limited to those associated with drilling activities, such as worker safety and traffic issues. (This alternative necessitates the installation of 37 injection wells, which make up the 550-ft-long PRB.) These risks can be mitigated with proper planning and suitable health and safety measures/controls. It should be noted that baseline risks to the community associated with contaminants in lower vadose soils would remain.

The MNA alternative is not expected to achieve RAOs within a reasonable timeframe without an effective source control alternative. Short-term risks are limited to workers performing monitoring activities, which are relatively minimal and can be controlled with proper health and safety measures (e.g., PPE).

Implementability

The MNA alternative would be a simple alternative to implement. Personnel, equipment, and materials are also readily available for implementation.

The P&T alternative consists of a generally conventional, well proven, and implementable technology and is expected to be highly reliable when adequately operated and maintained. Personnel, equipment, and materials are also readily available for implementation/operation. Implementation of this alternative is projected to last for approximately 2 months, during which time portions of the Maywood Riverfront Park would be disrupted. A discharge permit of treated groundwater to either the surface or subsurface would be required.

The PRB alternative is not an innovative technology, but the reliability of the installation method (via a series of injection points) is not completely certain. System modifications (550-feet length, 110 feet depth, 47 injection points based on 15-foot spacing) could be warranted based on performance of the installation method and groundwater monitoring data. Personnel, equipment, and materials are generally available for implementation/operation. The Maywood Riverfront Park would be disrupted for an approximate 2-month period.

Estimated Cost

A summary of estimated costs for each of the lower vadose zone soils and Exposition groundwater remediation zone alternatives is presented in Table 3.0. A more detailed cost estimate for each alternative associated with this remediation zone is provided in Tables 3.1 through 3.3. The cost estimates summarized in Table 3.0 and detailed in Tables 3.1 through 3.3 have been developed strictly for comparing the alternatives. The final costs of the treatment alternatives will depend on competitive bids, actual market conditions, actual site conditions, final project scope, and implementation schedules. Because of these factors and those unforeseen, project feasibility and requirements must be reviewed carefully to adequately address the decisions related to project funding.

The cost estimates are “order-of-magnitude” estimates having an intended accuracy range of +50% to –30%. They are not intended to limit the flexibility in the selection of the remedial design but to provide a basis for evaluating cost in light of the other modifying criteria. The specific details of the remedial actions and cost estimates would be refined once all evaluation criteria are considered in preparation of the ROD.

The MNA alternative is a passive remedy that provides a low total present worth cost of approximately $3 million. This passive containment alternative would be cost effective under a scenario where the contaminant plume is receding, which may be the case if an aggressive source control alternative is implemented.

The PRB alternative provides a total present worth cost of approximately $4.8 million. This alternative requires a large outlay of direct capital costs (approximately $3.8 million), but low annual O&M costs (approximately $0.05 million). This alternative may be considered cost effective depending on the desired cleanup time frame required. The present worth O&M costs (approximately $1.0 million) represents 50 years of groundwater monitoring. If the plume can be shown to be receding as a result of the PRB, then a significant savings in O&M may result.

Prior to adding on the costs of *ex-situ* treatment (approximately $3 million), the P&T alternative has a high total present worth cost of approximately $5.4 million. P&T is expensive and may not represent the best value because of the high costs of pumping for 30 years, as represented by an O&M present worth of approximately $4.0 million.

State Acceptance

To be addressed in the ROD.

Community Acceptance

To be addressed in the ROD.

TABLES

TABLES

Table 1.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Surface and Near-Surface Soil Remediation
Pemaco Superfund Site, Maywood, California

Criterion	REMEDIAL ALTERNATIVES	
	Capping/Revegetation	**Excavation/Onsite Treatment/Backfill**
1. Overall Protection of Human Health and the Environment.	• A cap does not treat or destroy the COCs but acts as a dry containment and eliminates the pathways to human exposure. • Through monitoring and maintenance of the cap and associated vegetative cover, environmental and ecological exposure pathways would be eliminated. • The cap would prevent percolation of precipitation and irrigation water into the subsurface, thereby eliminating any potential pathway for migration to groundwater, however unlikely. • Due to the lack of moisture, the potential for natural attenuation of the organic contaminants would be greatly reduced. So the concentrations of both SVOCs and metals would persist. • The completed cap is consistent with the planned future use as a recreational area.	• Soil excavation and onsite disposal would eliminate the pathways to human and ecological exposure, and the potential for migration of the COCs to groundwater. • The contaminated soil would be treated onsite to eliminate the pathways to human exposure via soil washing. • The treated soil would remain onsite in the sub-base and soil additives would be added to support vegetative growth. Depending on the success of the treatment in meeting the RAOs and the demonstrated permanence of the treatment, some additional monitoring for COCs may be required. • The treatment/disposal area and vegetative cover is consistent with the planned future use as a recreational area.

Table 1.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Surface and Near-Surface Soil Remediation
Pemaco Superfund Site, Maywood, California

Criterion	**REMEDIAL ALTERNATIVES**	
	Capping/Revegetation	**Excavation/Onsite Treatment/Backfill**
2. Compliance With ARARs and TBCs	• A cap would eliminate exposure pathways, thereby complying with health based ARARs and TBCs. • Monitoring and maintenance of the cap would be performed to assure exposure pathways remain closed and compliance with health-based ARARs and TBCs is maintained. • The cap would prevent percolation of precipitation and irrigation water into the subsurface, thereby eliminating any potential pathway for migration to groundwater, however unlikely.	• Soil excavation and onsite treatment would eliminate exposure pathways, thereby complying with health based ARARs and TBCs. • Due to the uncertainty associated with treating fine-grained soils and creating a soil washing reagent that treats both organic and inorganic contaminants, the potential exists for additional monitoring after treatment in order to be assured of compliance with ARARs and TBCs. • The treatment processes would also have to comply with water discharge and air emissions standards.

Table 1.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Surface and Near-Surface Soil Remediation
Pemaco Superfund Site, Maywood, California

Criterion	REMEDIAL ALTERNATIVES	
	Capping/Revegetation	**Excavation/Onsite Treatment/Backfill**
3. Long-Term Effectiveness And Permanence	• Once the cap is in place all risks related to surface and near surface soil would be eliminated. • Requires reliance on continued maintenance of cap and vegetative cover. The reliance will be reduced once vegetation is allowed to grow and sustain the surface soil. • Deed restrictions or institutional controls are necessary to assure that potential future development does not disturb the integrity of the cap. • Erosional processes associated with future planned use as a recreational area would be counteracted by regular maintenance. • Ecological receptors that burrow to depths greater than two-feet in the areas of contamination would contact contaminants and would have to be controlled via the maintenance plan.	• Soil excavation and onsite treatment would eliminate all risks related to surface and near surface soil. • Placement of the treated soil back on site introduces some uncertainty related to the effectiveness of treatment. This uncertainty can be minimized through quality control during post-treatment soil analysis. • Ecological receptors that burrow to depths greater than one-foot in the areas of contamination would contact treated soil; regardless, habitat would be poor and control would be instituted through the maintenance plan. • Deed restrictions or institutional controls may be necessary to assure that potential future development does not disturb the treated soil. • Erosional processes especially associated with future planned use as a recreational area would be counteracted by regular maintenance.
4. Reduction of Toxicity, Mobility or Volume (TMV) through Treatment	• No reduction in TMV of metals; however, they are not considered mobile in the environment, particularly after placement of a cap. • The lack of percolation due to the cap design would eliminate the potential for a reduction in TMV via natural attenuation. • Capping does not address statutory preference for remedies that employ treatment as a principal element.	• Excavation and onsite treatment would reduce TMV. • Some contaminants that are not destroyed onsite would be transferred to an approved facility for disposal. • Excavation and onsite treatment meets the statutory preference for remedies under the NCP. • The degree of reduction in TMV would depend on the batch reactions and mixing process.

Table 1.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Surface and Near-Surface Soil Remediation
Pemaco Superfund Site, Maywood, California

Criterion	**REMEDIAL ALTERNATIVES**	
	Capping/Revegetation	**Excavation/Onsite Treatment/Backfill**
5. Short-term Effectiveness	• Although a cap would not treat the COCs it would eliminate the risk of exposure; thus demonstrating good short term effectiveness. • Potential short-term impacts to remedial construction workers, the community, or the environment would be from dust emissions. These impacts would be minimal since the contaminated soil would be left in place. • Dust emissions would be mitigated through engineering controls (dust suppression), air monitoring, and PPE.	• Soil excavation and onsite treatment would eliminate all risk once the soil is treated and returned to the ground. • Excavation and onsite treatment would have the longest duration for the generation of dust and potential for exposure. • Potential short-term impacts to remedial construction workers, the community, or the environment would be from dust emissions. These impacts would be mitigated through engineering controls (dust suppression), air monitoring, and PPE. • Additional engineering controls would be required to mitigate dust and emissions from treatment processes.
6. Implementability	• No technical constraints. • May require regulatory waivers for leaving soil in place that exceeds PRGs and SSRGs. • Action would require administration of institutional controls to prevent future development. • Action would require administration of long-term cap monitoring and maintenance program. • The engineering services and materials would be readily available for constructing a cap.	• Minor technical constraints that could be eliminated through proper pilot testing. • Action will require administration of an excavation and endpoint sampling plan. • Action will require administration of a treatment and post-treatment sampling plan. • Action would require administration of institutional controls to prevent future development. • The engineering services and materials would be readily available for excavation and onsite treatment.

Table 1.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Surface and Near-Surface Soil Remediation
Pemaco Superfund Site, Maywood, California

Criterion	**REMEDIAL ALTERNATIVES**	
	Capping/Revegetation	**Excavation/Onsite Treatment/Backfill**
7. Estimated Cost[1]		
Direct Capital Cost	$769,000	$1,463,000
Annual O&M Cost	$25,000	No O&M would be required.
O&M Present Worth	$415,000 (30 yr term at 4.25% interest)	No O&M would be required.
Total Present Worth	$1,184,000	$1,463,000
8. State Acceptance	• Capping would meet state acceptance because it is protective of human health and the environment and there are no administrative or technical limitations to implementation.	• Excavation and onsite treatment would meet state acceptance (administratively) because it is protective of human health and the environment. Technically there are uncertainties associated with the treatment process that make this alternative relatively less acceptable. Much of the uncertainty could be resolved through pilot testing.
9. Community Acceptance	• Capping would meet community acceptance because it is protective of human health and the environment and is complimentary to planned use of the land for the City of Maywood Riverfront Park.	• Excavation and onsite treatment would meet community acceptance because it is protective of human health and the environment and is complimentary to planned use of the land for the City of Maywood Riverfront Park. Certain aspects of aboveground treatment, such as fugitive dusts, noise, and visible treatment equipment would be less acceptable.

1. Cost estimates and present worth values are rounded to three significant figures and are considered order-of-magnitude with an expected accuracy of plus 50 to minus 30 percent.

TABLE 1.1 - DETAILED COST SUMMARY FOR CAPPING/REMEDIATION

SURFACE AND NEAR-SURFACE SOIL REMEDIAITON ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Geophysical Clearance	1	lump sum	$2,200.00	$2,200	Spectrum Geophysics
2	Fence Demolition and Haul (445 linear feet)	1	lump sum	$2,144.00	$2,144	RS Means
3	Concrete Demolition, leave in place	1,450	square yard	$13.95	$20,228	RS Means
4	Concrete Pulverizing and Blending w/Existing Base	1,450	square yard	$3.33	$4,829	RS Means
5	Vegetative Stripping, Subgrade Prep., and Haul	481	cubic yard	$5.08	$2,443	RS Means
6	Dust Control, light	5	day	$755.00	$3,775	RS Means
7	HDPE Liner 60-mil thick	90,450	square foot	$1.46	$132,057	RS Means
8	Geotextile Drainage Layer	90,450	square foot	$1.25	$113,063	RS Means
9	Soil - base liner, lower bedding, and cover	11,375	cubic yard	$22.50	$255,938	TN&A - quote for similar work
10	Dozer spread and compact 6-12 in lifts, vibrat. roller	11,375	cubic yard	$2.50	$28,438	RS Means
11	Finish Grading (Added Day Mob cost)	4,550	cubic yard	$0.30	$1,365	RS Means
12	Surveying 2 crew, estab. grade, slope & cap thickness	8	day	$2,000.00	$16,000	RS Means
13	Top Soil - deliver/spread (4-in. depth)	1,080	cubic yard	$22.50	$24,300	TN&A - quote for similar work
14	Temp. Subsurface Irrigation System - 1spr. hd./ 225 s.f.	388	per head	$38.00	$14,744	RS Means
15	Grass Cover - via hydroseeding	87,454	square feet	$0.07	$6,122	RS Means
16	Misc. Landscaping and Erosion Control	1	lump sum	$25,153	$25,153	RS Means
17	Heavy Equipment Mob/Demob	4	each	$250.00	$1,000	TN&A - quote for similar work
18	Handling Fees (3%)	1	lump sum	$19,613.90	$19,614	T N & Associates
19	Contingency (10%)	1	lump sum	$65,379.68	$65,380	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$738,790**	
TN&A Labor						
20	Construction Management	450	hour	$85.00	$38,250	T N & Associates
21	Engineering, Design and Inspection	680	hour	$100.00	$68,000	T N & Associates
22	Project Management	225	hour	$110.00	$24,750	T N & Associates
	Subtotal (TN&A Labor)				**$30,553**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$769,343**	

Assumptions:

1. There will be no disposal costs for fencing since it can be sold to recycler or re-used by the City of Maywood.
3. There will be no disposal costs for stripped vegetation, since it can be composted and re-used by the City of Maywood.
4. Hydroseeding was selected over sod for an estimated savings of approximately $35,000.

TABLE 1.1 - DETAILED COST SUMMARY FOR CAPPING/REMEDIATION

SURFACE AND NEAR-SURFACE SOIL REMEDIAITON ZONE

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Vegetative Cover Maintenance and Repair	1	lump sum	$3,148.00	$3,148	RS Means
2	Brush Clearing - medium density	4	each	$1,100.00	$4,400	RS Means
3	Handling Fees (3%)	1	lump sum	$226.44	$226	T N & Associates
4	Contingency (10%)	1	lump sum	$754.80	$755	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$8,529**	
TN&A Labor						
8	Quarterly Inspection	80	hours	$85.00	$6,800	T N & Associates
9	Monitoring and Reporting	50	hours	$100.00	$5,000	T N & Associates
10	Management of O&M	40	hours	$110.00	$4,400	T N & Associates
	Subtotal (TN&A Labor)				**$16,200**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$24,729**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$24,729	4.25%	30	**$414,953**	Calculated using uniform series present worth factor.

Assumptions:

1. Establishment of native vegetative cover is included in installation. Long-term irrigation is not planned.
2. Assumes that 5% of the cover surface (approx. 4,400 s.f.) will require fill and replanting (annually) due to erosional forces. Backfill for the repair area at a three inch depth is assumed (40 c.y.).
3. Brush cutting is assumed to take place quarterly.
4. Quarterly inspections would be performed and reported in conjunction with well monitoring. A memo report identifying areas of wear or erosion would be issued.
5. A 30-year project term was assumed for comparison purposes. The interest rate of 4.25% is the reported Prime Rate (Nov. 2002). Backfill for the repair area at a three inch depth is assumed (40 c.y.).

TABLE 1.2 - DETAILED COST SUMMARY FOR EXCAVATION/ONSITE TREATMENT/BACKFILL

SURFACE AND NEAR-SURFACE SOIL REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Geophysical Clearance	1	lump sum	$2,200.00	$2,200	Spectrum Geophysics
2	Concrete Demo, Haul, and Disposal	250	c.y.	$160.00	$40,000	Advance Industrial Recycling
3	Fence Demolition and Haul (445 linear feet)	1	lump sum	$2,144.00	$2,144	RS Means
4	Vegetative Stripping, Subgrade Prep., and Haul.	481	cubic yard	$5.08	$2,443	RS Means
5	Ex-Situ Soil Washing Incl. Excavation and QA Sampling	3,770	tons	$200.00	$754,000	DOD Env. Tech. Transfer Committee
6	Dust Control, light	10	day	$755.00	$7,550	RS Means
7	Post-Excav. Confirmation Sampling (1 per 25' x 25' grid)	37	sample suite	$562.00	$20,794	Calscience
9	Grading - spread from pile to finish grade	3,000	cubic yard	$4.33	$12,990	RS Means
12	Surveying Grade Checker	4	day	$500.00	$2,000	RS Means
11	Top Soil - deliver/spread (6-in. depth)	856	cubic yard	$22.50	$19,271	RS Means
12	Subsurface Irrigation System - auto, 1spr. hd./ 225 s.f.	388	per head	$38.00	$14,744	RS Means
13	Grass Cover- via hydroseeding	43,727	square feet	$0.07	$3,061	RS Means
14	Heavy Equipment Mob/Demob	4	each	$250.00	$1,000	T N & A - quote for similar work
15	Handling Fees (3%)	1	lump sum	$26,465.92	$26,466	T N & Associates
16	Contingency (10%)	1	lump sum	$88,219.72	$88,220	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$ 996,883**	
TN&A Labor						
17	Construction Management	800	hour	$85.00	$68,000	T N & Associates
18	Engineering, Design, and Inspection	520	hour	$100.00	$52,000	T N & Associates
19	Project Management	500	hour	$110.00	$55,000	T N & Associates
	Subtotal (TN&A Labor)				**$ 175,000**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$ 1,462,568**	

Assumptions:

1. There will be no disposal costs for fencing since it can be sold to recycler or re-used by the City of Maywood.
2. There will be no disposal costs for stripped vegetation, since it can be composted and re-used by the City of Maywood.
3. Six inches of cover soil and 6 in. of top soil will be required over the treated soil to establish vegetative growth.
4. Hydroseeding was selected over sod for an estimated savings of approximately $35,000.
5. Annual O&M is not included with Alternative N5, since the obligation to maintain surface cover would be eliminated once the contaminants are treated.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction[1]**	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
1. Overall Protection of Human Health and the Environment	• Soil removal of the majority of the upper vadose zone soils (3 to 25 ft bgs) would eliminate the potential pathways for human exposure via inhalation, ingestion, or dermal contact in the event that these soils would be exposed (i.e., site redevelopment). By removing the impacted soil, the potential for migration of upper vadose zone COCs to the perched groundwater and deeper viable aquifers is also eliminated. • Because excavation of saturated soil in the perched zone (25 to 35 ft bgs) is not feasible, soil excavation under this alternative would only provide a partial treatment solution to upper vadose zone soils. • Without groundwater extraction or treatment, a pathway for human exposure to contaminated groundwater may eventually exist if contamination spreads towards domestic production wells. • Potential impacts to remedial construction workers, nearby residences, or the environment from dust emissions would be mitigated through engineering controls (dust suppression), air monitoring, and PPE.	• ERH combined with soil vapor extraction reduces toxicity, mobility, and volume of contamination. In turn, potential exposure pathways to future construction workers (to contaminated soil via inhalation, ingestion, and dermal contact) and to local residents (to contaminated groundwater via migration of COCs in groundwater to domestic production wells) are eliminated. • Extracted vapor would require *ex-situ* treatment.	• The extraction and treatment alternative provides long-term protection of human health and the environment by reducing contaminant volume and limiting migration of contaminants to viable aquifers. • The mobility of contaminants in saturated soils (25 to 35 ft bgs) would also be reduced as the perched groundwater zone was stabilized. However, the toxicity and volume of contaminants in upper vadose zone soils would not be reduced through groundwater extraction and treatment alone. • In conjunction with an effective source treatment alternative, extraction and treatment is protective of human health and the environment by restoring groundwater quality along plume fringes to that of drinking water standards over time. • This alternative does not provide protection of human health of future excavation workers that may be exposed to contaminated subsurface soils.	• The PRB provides a barrier to contaminant migration through the placement of reactive materials in the subsurface that are designed to intercept a plume of chlorinated VOC-contaminated groundwater and convert contaminants into environmentally acceptable compounds. • PRBs could effectively reduce chlorinated VOCs in groundwater, which would eliminate exposure pathways to residents via migration of COCs in groundwater to domestic production wells. • However, because this alternative does not reduce TMV of contaminants within upper vadose zone soils, future excavation workers may be exposed to contaminated subsurface soils.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction[1]**	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
2. Compliance With ARARs and TBCs	• Would not meet ARARs and TBCs because soil between 25 and 35 feet bgs and perched groundwater would not be addressed. • Potential exposure pathways would exist for future excavation workers (via dermal contact, inhalation and ingestion) and for community residents (via migration of COCs to viable aquifers). • Due to uncertainty associated with the available treatment processes (soil washing), the potential exists for additional monitoring of backfilled area after treatment to assure compliance with ARARs and TBCs. • The treatment processes would also have to comply with water discharge and air emission standards.	• Reduction of COCs would eliminate exposure pathways, thereby complying with ARARs and TBCs. • Monitoring of remediation area required to assure compliance with ARARs and TBCs. • The soil vapor treatment processes would have to comply with air emission standards. • Potentially effective soil and groundwater treatment method that could potentially achieve ARARs and TBCs.	• Directly addresses groundwater contamination, and would generally comply with groundwater ARARs and TBCs. • Monitoring of remediation area required to assure compliance with ARARs and TBCs. • Would not address subsurface soil remedial objectives. P&T would not meet ARARs and TBCs for subsurface soil because subsurface soil contaminants would not be mitigated. • During system construction and O&M, air pollution regulations would be complied met (fugitive dust and VOC emission control). Discharge of treated groundwater would be compliant for discharge to groundwater/surface water.	• Directly addresses groundwater contamination, and hence, is generally compliant with groundwater ARARs and TBCs. • PRB alternative would not address subsurface soil remedial objectives. ARARs and TBCs subsurface soil contaminants would not be mitigated.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction[1]**	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
3. Long-Term Effectiveness And Permanence	• Soil excavation and on-site treatment would eliminate risks related to the soils 3 to 25 ft bgs, assuming quality control of post-treatment soil analyses. • Deed restrictions or institutional controls may be necessary to assure that potential future development does not disturb treated soil. • This remedial action would not eliminate potential exposure pathways associated with the saturated and unsaturated soils (25 to 35 ft bgs) or the perched groundwater zone. Thus, PSSRGs would not be met.	• Long-term effectiveness would be achieved through active groundwater and vapor extraction and treatment. • Monitoring of the remediation area required to assure effectiveness over time. • Removal of contaminants within the perched groundwater zone and upper vadose zone from the Site would be permanent. • Pilot test recommended to confirm site characteristics. • Although this process is not in widespread use, it has proven to be very effective in several full-scale demonstration projects.	• Long-term effectiveness would be achieved through active groundwater extraction and treatment. • Pump and treat consists of generally conventional and well-proven technologies and is expected to be highly effective when adequately operated and maintained. • Monitoring of the remediation area required to assure effectiveness over time. • Removal of COCs within the perched groundwater zone would be permanent. • Subsurface soil contamination would not be reduced.	• Zero-valent iron PRB is potentially effective method for treatment of chlorinated VOCs in groundwater. • Zero-valent iron PRB is a potentially effective method for treatment of chlorinated VOCs. A treatability study is required to determine the effectiveness of PRB under Site conditions. • Monitoring of remediation area required to assure effectiveness over time. • Removal of contaminants within perched groundwater zone would be permanent. • Subsurface soil contamination would not be reduced.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction**[1]	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
4. Reduction of Toxicity, Mobility or Volume (TMV) through Treatment	• Excavation and onsite treatment of soil would reduce TMV. • Onsite treatment does not transfer the contamination to another site. • There is some uncertainty regarding the degree of reduction in toxicity, which would depend on the selected treatment process and its success in achieving the RAOs. • Excavating and treating impacted soils eliminates the potential migration of upper vadose zone contamination to the perched groundwater and to deeper viable aquifers. • TMV of saturated and unsaturated soils 25-35 ft bgs are not addressed; these soils contain the highest concentrations of COCs. • Estimated treatment rate is 200 cubic yards per day. The total estimated contaminated soil volume of 56,700 cubic yards.	• ERH allows for good control over contaminant mobility and a reduction in contaminant volume for both soil and groundwater. • UV oxidation required during treatment process, because it addresses treatment of 1,4-dioxane. • Estimated area of soil exceeding ARARs is 69,600 square feet; estimated area of groundwater exceeding ARARs is 168,000 square feet. • Extracted vapor would require *ex-situ* treatment.	• Groundwater pump and treat systems allow for positive hydraulic control over contaminant migration and reduction in plume volume through extraction of dissolved phase contaminants. • Because P&T hydraulically controls groundwater flow, the migration of contaminants in upper vadose zone soils would be reduced. However, toxicity and volume of contamination in subsurface soils would not be reduced. • An aboveground treatment process would immobilize, treat, or destroy contaminants in groundwater prior to discharge. • UV oxidation required during treatment process, because it addresses treatment of 1,4-dioxane. • Estimated area of soil exceeding ARARs is 69,600 square feet; estimated area of groundwater exceeding ARARs is 168,000 square feet.	• PRBs are not barriers to groundwater flow. However, as the dissolved contaminants pass through the reactive barrier, the toxicity, mobility, and volume of the chlorinated VOCs is reduced by reductive dechlorination. In turn plume volume and COC mass would be reduced. • PRB only addresses chlorinated VOC contamination; BTEX contaminants in groundwater are not treated by this technology. • The PRB alternative is not applicable for use in the upper vadose zone soil because the technology requires groundwater movement. • Estimated area of soil exceeding ARARs is 69,600 square feet; estimated area of groundwater exceeding ARARs is 168,000 square feet.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction**[1]	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
5. Short-term Effectiveness	• Excavation and onsite treatment would have the longest duration for the generation of dust and potential for exposure to future excavation workers (via dermal contact, inhalation and ingestion) and neighboring residents (via inhalation). • Fugitive dust produced during excavation activities may create an exposure pathway via inhalation to construction workers and neighboring residences. This could be reduced through engineering controls such as dust suppression and air monitoring. • Construction workers exposed to contaminated upper vadose zone soils during site redevelopment may also be exposed to COCs via ingestion and dermal contact. These pathways could be reduced through appropriate personal protection equipment (PPE). • Estimated project duration is 1 year plus 5 years of monitoring; PSSRGs will not be met.	• Air emissions from vapor treatment would comply with air emission standards. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 1 year plus a minimum of 5 years of monitoring; PSSRGs will likely be met.	• Community risks during system construction activities include fugitive dust and increased traffic of construction vehicles. Engineering controls (i.e., dust suppression) and appropriate traffic control would reduce these risks, respectively. • Risks to workers performing monitoring activities are relatively minimal and can be controlled and mitigated with proper health and safety measures (e.g. PPE). • Estimated project duration is 30 years; PSSPRGs will likely be met.	• Community risks during PRB installation include fugitive dust and increased vehicular traffic. Engineering controls (i.e., dust suppression) and appropriate traffic control would reduce these risks, respectively. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 50 years; PSSPRGs will likely be met.

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction[1]**	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
6. Implementability	• Technical constraints are considered minor and could be eliminated through pilot testing. • Action would require administration of an excavation and endpoint-sampling plan. • Action would require administration of institutional controls to prevent future development. • The engineering services and materials would be readily available for excavation and onsite treatment. • Administratively feasible. • Construction difficulties with MRP; partial park closure required for 1-year period.	• System modifications may be added if warranted based on performance and monitoring data. • Groundwater and soil vapor monitoring would provide indication of effectiveness of treatment system and status of contaminant plumes. • Personnel, equipment, and materials generally available for implementation/operation of ERH. • Requires sophisticated equipment and skilled technical personnel; relatively few vendors offer ERH. • Pilot test needed to establish suitability of method and to obtain additional design information. • Administratively feasible. • Construction difficulties with MRP; partial park closure required for 1-year period.	• P&T generally consists of proven and reliable methods and components generally well-established technology. • Modifications to the system may be made if warranted based on system performance and monitoring data. • Discharge permit of treated groundwater required as part of this alternative. • Groundwater monitoring would indicate effectiveness of P&T as well as plume status. • Personnel, equipment, and materials generally available for implementation/operation of P&T. • Administratively feasible. • Construction difficulties with P&T; partial park closure required for 2-month period.	• System modifications may be warranted based on performance and monitoring data. • Groundwater monitoring would provide indication of effectiveness of PRB and status of contaminant plume. • Personnel, equipment, and materials generally available for implementation of PRB. • Administratively feasible. • Construction requirements with MRP would cause partial park closure for about 2-month period.
7. Estimated Cost[2]				
Direct Capital Cost	$18,000,000	$7,140,000[3]	$414,000[3]	$2,440,000
Annual O&M Cost	$86,000	$86,000[3]	$191,000[3]	$51,000
O&M Present Worth	$379,000 (5 yr term at 4.25% interest)	$379,000[3] (5 yr term at 4.25% interest)	$3,200,000[3] (30 yr term at 4.25% interest)	$1,050,000 (50 yr term at 4.25% interest)
Total Present Worth	$18,400,000	$10,900,000 (FTO/GAC) $9,830,000 (GAC)	$9,570,000 (P&T/UV oxidation)	$3,490,000

Table 2.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Upper Vadose Soil and Perched Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternative			
	Soil Excavation and Onsite Treatment	**Electrical Resistance Heating with Vapor Extraction[1]**	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
8. State and Support Agency Acceptance	• Statewide acceptance under CalEPA on numerous projects. • Further comments will be addressed in the ROD after public comment period.	• Innovative technology that has shown pilot-scale acceptance. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • Generally accepted as “containment alternative”. • Further comments will be addressed in the ROD after public comment period.	• Generally accepted as “containment alternative”. • Further comments will be addressed in the ROD after public comment period.
9. Community Acceptance	• Potential conflict/interference with future park activities. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999. • Further comments will be addressed in the ROD after public comment period.	• Potential conflict/interference with future park activities. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999. • Further comments will be addressed in the ROD after public comment period.	• To be determined during public comment period. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999.	• To be determined during public comment period.

1 ERH with VE alternatives (ERH with VE/FTO/GAC and ERH with VE/GAC) treated as same alternative, as difference between alternatives is limited to *ex-situ* treatment.
2 Cost estimates and present worth values are rounded to three significant figures. Refer to Tables 2.1 though 2.4 for a detailed analysis of capital estimates, O&M cost estimates, and present worth assumptions. Cost estimates are considered order-of-magnitude with an expected accuracy of plus 50 to minus 30 percent.
3 Does not include *ex-situ* treatment cost estimates (only total present worth estimates include *ex-situ* treatment costs).

ARARs	applicable and relevant and appropriate requirements	MRP	Maywood Riverfront Park	P&T	pump and treat
COCs	Contaminants of concern	O&M	operation and maintenance	ROD	record of decision
GAC	granular activated carbon	PPE	personal protective equipment	TBCs	to be considered ARARs
EPA	Environmental Protection Agency	SVE	soil vapor extraction	TMV	toxicity, mobility, and volume
ERH	electrical resistance heating	PRB	permeable reactive barrier	VOCs	volatile organic compounds
FTO	flameless thermal oxidation	PSSRGs	preliminary site-specific remediation goals	UV	ultraviolet

TABLE 2.1 - DETAILED COST SUMMARY FOR EXCAVATION AND ONSITE TREATMENT

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Heavy Equipment Mob/Demob	2	each	$4,500.00	$9,000	TN&A - quote for similar work
2	Excavation	82,500	c.y.	$30.00	$2,475,000	Advanced Industrial Recycling
3	Ex-Situ Soil Washing & Sampling	74,800	tons	$170.00	$12,716,000	DOD Env. Tech. Transfer Committee
4	Grading - soil replacement	82,500	cubic yard	$4.33	$357,225	RS Means
5	Restoration - grass cover via hydroseeding	69,620	square feet	$0.07	$4,873	RS Means
6	Handling Fees (3%)	1	lump sum	$466,862.95	$466,863	TN& Associates
7	Contingency (10%)	1	lump sum	$1,556,209.84	$1,556,210	RS Means
8	**Subtotal (Equipment, Materials, and Subs)**				**$17,585,171**	
TN&A Labor						
9	Construction Management	2,520	hour	$85.00	$214,200	TN& Associates
10	Engineering, Design, and Inspection	504	hour	$100.00	$50,400	TN& Associates
11	Project Management	1,260	hour	$110.00	$138,600	TN& Associates
	Subtotal (TN&A Labor)				**$403,200**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$17,988,371**	

Assumptions:

1. Treatability study would be required to ensure soil washing is an effective method for *ex-situ* soil treatment.
   suitable technologies. Soil washing was selected to appear above because it is a likely scenario and provides a conservative representation of costs.
2. The actual soil volume being excavated is 82,500 c.y. (x 1.36 tons/c.y.) = 112,200 tons. It is assumed that 1/3 of the excavated soil (37,400 tons) would be identified as "clean" and would not require treatment.
3. Confirmation sampling is included in the ex-situ soil washing unit cost of $170 per ton.
4. Based on an average treatment rate of 200 c.y./day. The project duration would be approximately 1 year followed by 5 years of required monitoring.
5. It is assumed that the excavation will not require dewatering.

TABLE 2.1 - DETAILED COST SUMMARY FOR EXCAVATION AND ONSITE TREATMENT

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	(2) Semiannual GW Sampling Events, Incl. QC	72	each	$227.20	$16,358	Calscience Labs
2	Handling Fees (3%)	1	lump sum	$490.75	$491	TN& Associates
3	Contingency (10%)	1	lump sum	$1,635.84	$1,636	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$18,485**	
TN&A Labor						
4	Inspection and Monitoring	320	hours	$85.00	$27,200	TN & Associates
5	Data Processing and Reporting	280	hours	$100.00	$28,000	TN & Associates
6	Management of O&M	110	hours	$110.00	$12,100	TN & Associates
	Subtotal (TN&A Labor)				**$67,300**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$85,785**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$85,785	4.25%	5	**$379,255**	Calculated using uniform series present worth factor.

Assumptions:

1. Semiannual groundwater sampling would be performed on 30 wells and the analysis would be for VOCs via EPA Methods 8260B.
2. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 2.2 - DETAILED COST SUMMARY FOR ELECTRICAL RESISTANCE HEATING

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections (electric, water, and sewer)	1	lump sum	$13,610.00	$13,610	RS Means
3	Mobilization/Demob.	1	each	$20,000.00	$20,000	McMillan-McGee
4	Preliminary Resistivity Testing & Design	1	lump sum	$16,573.00	$16,573	McMillan-McGee
5	Pilot Study - 12 electrode, install, monitor, report, trmt.	1	lump sum	$318,953.00	$318,953	McMillan-McGee
6	Full Scale Ops. - 408 elec., 204 borings, utils., controls	1	lump sum	$5,445,160.00	$5,445,160	McMillan-McGee and Greg Drilling
	SVE Extraction System - 32 wells, 4 in., piping, trench.	1	lump sum	$274,809.76	$274,810	Harrington Plastics & Gregg Drilling
7	Confirmation Soil and GW Sampling after Treatment	1	lump sum	$34,574.00	$34,574	T N & Associates
8	Handling Fees (3%)	1	lump sum	$184,036.31	$184,036	T N & Associates
9	Contingency (10%)	1	lump sum	$613,454.38	$613,454	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$6,932,034**	
TN&A Labor						
10	Construction Management	1,040	hour	$85	$88,400	T N & Associates
11	Engineering, Design, and Inspection	600	hour	$100	$60,000	T N & Associates
12	Project Management	520	hour	$110	$57,200	T N & Associates
	Subtotal (TN&A Labor)				**$205,600**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$7,137,634**	

Assumptions:

1. The pilot scale and full scale operations include all drilling, power modules, utility costs, O&M, data collection, and reporting.
2. The confirmation soil borings would be spaced one boring per 100' x 100' foot grid for 16 boring locations for the perched zone. Seven samples would be collected per boring at approximate five-foot intervals to a depth of 35 feet bgs (5' to 35' bgs).
3. Costs associated with treatment of groundwater and vapor are included with the treatment scenarios. Since 1,4 Dioxane was detected in the perched zone and does not adsorb to carbon and is not amenable to air stripping, oxidation technologies were selected for treatment of groundwater and vapor.
4. Estimated duration for the pilot scale plus full scale in perched zone is approximately 1 year plus a minimum of 5 years additional monitoring.

TABLE 2.2 - DETAILED COST SUMMARY FOR ELECTRICAL RESISTANCE HEATING

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	(2) Semiannual GW Sampling Events, Incl. QC	72	each	$227.20	$16,358	Calscience Labs
2	Handling Fees (3%)	1	lump sum	$490.75	$491	T N & Associates
3	Contingency (10%)	1	lump sum	$1,635.84	$1,636	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$18,485**	
TN&A Labor						
4	Inspection and Monitoring	320	hours	$85.00	$27,200	T N & Associates
5	Data Processing and Reporting	280	hours	$100.00	$28,000	T N & Associates
6	Management of O&M	110	hours	$110.00	$12,100	T N & Associates
	Subtotal (TN&A Labor)				**$67,300**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$85,785**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$85,785	4.25%	5	**$379,255**	Calculated using uniform series present worth factor.

Assumptions:

1. Semiannual groundwater sampling would be performed at 30 wells and the analysis would be for VOCs via EPA Methods 8260B.
2. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

TABLE 2.3 - DETAILED COST SUMMARY PUMP & TREAT

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections	1	lump sum	$10,755.00	$10,755	RS Means
3	Mobilization/Demobilization	2	each	$2,400.00	$4,800	Gregg Drilling
5	Well Installation, 4" dia.	32	each	$3,500.00	$112,000	Gregg Drilling
6	Piping Network, Manifold, Valves	1	lump sum	$26,880.32	$26,880	Harrington Industrial Plastics
7	Trenching and Backfill, 8" wide trench, 24" deep	4,500	linear feet	$2.18	$9,810	RS Means
8	Grundfos Rediflo 3, 1/3 Hp, 50 ft. Lead, Controllers	32	each	$1,490.00	$47,680	Grundfos
9	Site Restoration/Well Destruction	32	lump sum	$950.00	$30,400	Gregg Drilling
10	Confirmation Soil and GW Sampling after Treatment	1	lump sum	$34,574	$34,574	Gregg Drilling and Calscience
11	Handling Fees (3%)	1	lump sum	$8,632.90	$8,633	T N & Associates
12	Contingency (10%)	1	lump sum	$28,776.33	$28,776	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$325,173**	
TN&A Labor						
13	Construction Management and Sampling	620	hour	$85.00	$52,700	T N & Associates
14	Planning and Design	240	hour	$100.00	$24,000	T N & Associates
15	Project Management	110	hour	$110.00	$12,100	T N & Associates
	Subtotal (TN&A Labor)				**$88,800**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$413,973**	

Assumptions:

1. It is assumed that 32 new perched zone wells would be required complete the containment network.
2. Costs associated with treatment of groundwater and vapor are included with the treatment scenarios. Since 1,4 Dioxane was detected in the perched zone and does not adsorb to carbon and is not amenable to air stripping, oxidation technologies were selected for treatment of groundwater and vapor.
3. The confirmation soil borings would be spaced one boring per 100' x 100' foot grid for 16 boring locations for the perched zone. Seven samples would be collected per boring at approximate five-foot intervals to a depth of 35 feet bgs (5' to 35' bgs).
4. Pump and treat does not address vadose zone soil contamination and requires partnering with a source treatment alternative.
5. The estimated duration for pump and treat is 30 years.

TABLE 2.3 - DETAILED COST SUMMARY PUMP & TREAT

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	367318	kWH	$0.18	$66,117	S.C. Edison
2	Maintenance and Service (Average)	1	lump sum	$2,200.00	$2,200	T N & Associates
3	Mechanical, Pipe, Valves, Parts (Average)	1	lump sum	$1,728.70	$1,729	Assume 5% of Network Cost
4	(2) Semiannual GW Sampling Events, Incl. Some soil	85	each	$227.20	$19,312	Calscience Labs
5	Handling Fees (3%)	1	lump sum	$2,680.74	$2,681	T N & Associates
6	Contingency (10%)	1	lump sum	$8,935.79	$8,936	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$100,974**	
TN&A Labor						
7	Weekly Inspection and Monitoring	520	hours	$85.00	$44,200	T N & Associates
8	Data Processing and Reporting	280	hours	$100.00	$28,000	T N & Associates
9	Management of O&M	160	hours	$110.00	$17,600	T N & Associates
	Subtotal (TN&A Labor)				**$89,800**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$190,774**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$190,774	4.25%	30	**$3,201,196**	Calculated using uniform series present worth factor.

Assumptions:

1. Costs associated with treatment of water and vapor discharge are included with the treatment scenarios.
2. Electrical rate for small business were provided by Southern California Edison (Los Angeles) and range from $.14 - $.21/kWH.
3. Semiannual groundwater sampling would be performed on 32 wells (plus QC) and the analysis would be for VOCs via EPA Methods 8260B.
4. Weekly inspections would be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
5. The interest rate used in the present worth calculation (4.25%) is reported Prime Rate (Nov. 2002).

TABLE 2.4 - DETAILED COST SUMMARY FOR PERMEABLE REACTIVE BARRIER

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Pre-Design Treatability Study	1	lump sum	$31,920.00	$31,920	GeoSierra
2	Mobilization/Demobilization	2	each	$13,000.00	$26,000	GeoSierra
3	PRB Construction & Verification Testing	1	lump sum	$1,756,992.00	$1,756,992	GeoSierra
4	Monitoring Well Installation	8	each	$3,500.00	$28,000	Gregg Drilling
5	Confirmation Soil and GW Sampling (16 borings)	1	lump sum	$34,574	$34,574	Gregg Drilling and Calscience
6	Handling Fees (3%)	1	lump sum	$56,324.58	$56,325	T N & Associates
7	Contingency (10%)	1	lump sum	$187,748.60	$187,749	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$2,121,559**	
TN&A Labor						
8	Construction Management	1,035	hour	$85.00	$87,975	
9	Engineering, Design, and Inspection	1,570	hour	$100.00	$157,000	
10	Project Management	650	hour	$110.00	$71,500	
	Subtotal (TN&A Labor)				**$316,475**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$2,438,034**	

Assumptions:

1. Confirmation sampling is based on 16 borings along length of wall, one sample per five foot interval (soil), plus 16 groundwater samples, plus QC.
2. The estimated duration of the prb is 50 years. Reduced monitoring requirements are likely following several 5-year reviews.

TABLE 2.4 - DETAILED COST SUMMARY FOR PERMEABLE REACTIVE BARRIER

UPPER VADOSE SOIL AND PERCHED GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance (Monitoring)

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Annual GW Sampling Events, Incl. QC.	36	each	$227.20	$8,179	Calscience Labs
2	Handling Fees (3%)	1	lump sum	$245.38	$245	T N & Associates
3	Contingency (10%)	1	lump sum	$817.92	$818	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$9,242**	
TN&A Labor						
4	Sampling and Monitoring	160	hours	$85.00	$13,600	T N & Associates
5	Data Processing and Reporting	140	hours	$100.00	$14,000	T N & Associates
6	Management of O&M	130	hours	$110.00	$14,300	T N & Associates
	Subtotal (TN&A Labor)				**$41,900**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$51,142**	

Present Worth of Annual Operation and Maintenance (Monitoring)

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$51,142	4.25%	50	**$1,053,024**	Calculated using uniform series present worth factor.

Assumptions:

1. Annual groundwater sampling at 30 well locations includes analysis for VOCs via EPA Methods 8260B.
2. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).

Table 3.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Lower Vadose Soil and Exposition Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternatives		
	Monitored Natural Attenuation	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
1. Overall Protection of Human Health and the Environment.	• The MNA alternative may passively reduce contamination, however, remediation of this zone through attenuation/degradation processes is estimated to take greater than 50 years. • In conjunction with an effective source treatment alternative, MNA is protective of human health and the environment by monitoring natural restoration of groundwater quality along plume fringes to that of drinking water standards over time.	• The pump and treat alternative provides long-term protection of human health and the environment by reducing contaminant volume and limiting migration of contaminants to viable aquifers. • Pump and treat would be more effective and require less time for cleanup if combined with a source treatment alternative.	• The PRB alternative provides a barrier to contaminant migration through the placement of reactive materials in the subsurface which are designed to intercept a plume of contaminated groundwater and convert the contaminants into environmentally acceptable forms. • A PRB could effectively reduce chlorinated solvents in groundwater, which would eliminate exposure pathways to residents via migration of COCs in groundwater to domestic production wells. • Monitoring of the groundwater downgradient of the PRB would be required for the life of the alternative to assure long-term effectiveness.
2. Compliance With ARARs and TBCs	• MNA would not actively address contaminants in the groundwater zone and therefore does not comply with applicable ARARs and TBCs. • If combined with a source treatment alternative, MNA would be useful to demonstrate containment or recession of the plume.	• Directly addresses groundwater contamination, and hence, is generally compliant with groundwater ARARs and TBCs. • Monitoring of remediation area required to assure compliance with ARARs and TBCs. • Design of the pump and treat system would be compliant with discharge requirements for treated groundwater and air emissions.	• Directly addresses groundwater contamination, and hence, is generally compliant with groundwater ARARs and TBCs. • The PRB alternative does not address fugitive COCs that would exist downgradient of the proposed PRB location. These fugitive COC concentrations are generally at the same order of magnitude as the groundwater MCLs and are expected to diminish once the source is treated. • Monitoring of the containment area would be required to assure compliance with ARARs and TBCs.

Table 3.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Lower Vadose Soil and Exposition Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternatives		
	Monitored Natural Attenuation	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
3. Long-Term Effectiveness And Permanence	• The effectiveness of natural attenuation in restoring groundwater quality to PSSRGs in a reasonable timeframe without a pro-active source treatment alternative is very low. • In combination with an effective source control alternative, long-term effectiveness may be achieved by natural attenuation. • Monitoring of the remediation zone and plume fringes would be required to assure effectiveness over time.	• Long-term effectiveness would be achieved through active groundwater extraction and treatment. • Pump and treat consists of generally conventional and well-proven technologies and is expected to be highly reliable when adequately operated and maintained. • Monitoring of the remediation zone is required to assure effectiveness over time. • Removal of contaminants from the deep groundwater zone would be permanent.	• Zero-valent iron PRB is a potentially effective method for treatment of chlorinated VOCs. A treatability study is required to determine the effectiveness of PRB under site conditions. • Monitoring of the remediation zone is required to assure effectiveness over time. • Removal of contaminants within the deep groundwater zone would be permanent.
4. . Reduction of Toxicity, Mobility or Volume (TMV) through Treatment	• There would be no active reduction in TMV under the MNA Alternative. • MNA is only practical as a containment option when partnered with a source treatment alternative that actively reduces TMV.	• Groundwater pump and treat systems allow for positive hydraulic control over contaminant migration and reduction in plume volume through extraction of dissolved phase contaminants. • Because P&T hydraulically controls groundwater flow, the pathways for exposure to groundwater could be eliminated. • An aboveground treatment process would immobilize, treat, or destroy contaminants in groundwater prior to discharge.	• PRBs are not barriers to groundwater flow. However, as the dissolved contaminants pass through the reactive barrier, the toxicity, mobility, and volume of the chlorinated VOCs is reduced by reductive dechlorination. In turn plume volume and COC mass would be reduced. • PRB only addresses chlorinated VOC contamination.

Table 3.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Lower Vadose Soil and Exposition Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternatives		
	Monitored Natural Attenuation	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
5. Short-term Effectiveness	• No additional risks beyond those posed by current conditions. • Risks to workers performing monitoring activities are relatively minimal and can be controlled and mitigated with proper health and safety measures (e.g. PPE). • Estimated project duration is 50+ years; with source control measures, PSSRGs will likely be met.	• Community risks during system construction activities include fugitive dust and increased traffic of construction vehicles. Engineering controls (i.e., dust suppression) and appropriate traffic control would reduce these risks. • Risks to workers performing monitoring activities are relatively minimal and can be controlled and mitigated with proper health and safety measures (e.g. PPE). • Estimated project duration is 30 years; PSSRGs will likely be met.	• Community risks during PRB installation include fugitive dust and increased vehicular traffic. Engineering controls (i.e., dust suppression) and appropriate traffic control would reduce these risks. • Risks to workers performing remedial and monitoring activities can be controlled and mitigated with proper health and safety measures (e.g. air monitoring, PPE). • Estimated project duration is 50 years; PSSRGs will likely be met.
6. Implementability	• Modifications to the system may be warranted based on system performance and monitoring data. • Groundwater monitoring would provide indication of status of contaminant plume. • Personnel, equipment, and materials generally available for implementation/operation MNA. • Administratively feasible.	• P&T generally consists of proven and reliable methods and components generally well-established technology. • Modifications to the system may be made if warranted based on system performance and monitoring data. • Discharge permit of treated groundwater to either surface or subsurface required as part of this alternative. • Groundwater monitoring would indicate effectiveness of P&T as well as status of contaminant plume. • Personnel, equipment, and materials generally available for implementation/operation of P&T. • Administratively feasible. • Construction difficulties with P&T; partial park closure required for 2-month period.	• System modifications may be warranted based on performance and monitoring data. • Groundwater monitoring would provide indication of effectiveness of PRB and status of contaminant plume. • Personnel, equipment, and materials generally available for implementation of PRB. • Administratively feasible. • Construction requirements for a PRB would cause partial park closure for about 2-month period.

Table 3.0
Detailed Evaluation of Non-Retained Remedial Alternatives – Lower Vadose Soil and Exposition Groundwater Remediation Zone
Pemaco Superfund Site, Maywood, California

Criterion	Remedial Alternatives		
	Monitored Natural Attenuation	**Pump and Treat/Ultraviolet Oxidation**	**Permeable Reactive Barrier**
7. Estimated Cost[1]			
Direct Capital Cost	$290,000	$1,360,000[2]	$3,790,000
Annual O&M Cost	$130,000	$238,000[2]	$51,000
O&M Present Worth	$2,690,000 (50 yr term at 4.25% interest)	$3,990,000[2] (30 yr term at 4.25% interest)	$1,050,000 (50 yr term at 4.25% interest)
Total Present Worth	$2,980,000	$8,830,000	$4,840,000
8. State and Support Agency Acceptance	• Statewide acceptance under CalEPA on numerous projects. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • Further comments will be addressed in the ROD after public comment period.	• Statewide acceptance under CalEPA on numerous projects. • State approval of injection permits would be required. • Further comments will be addressed in the ROD after public comment period.
9. Community Acceptance	• To be determined during public comment period.	• To be determined during public comment period. • Certain members of public opposed thermal vapor abatement associated with operation of SVE system in 1999.	• To be determined during public comment period.

1 Cost estimates and present worth values are rounded to three significant figures. Refer to Tables 3.1 though 3.3 for a detailed analysis of capital estimates, O&M cost estimates, and present worth assumptions. Cost estimates are considered order-of-magnitude with an expected accuracy of plus 50 to minus 30 percent.
2 Does not include *ex-situ* treatment cost estimates (only total present worth estimate includes *ex-situ* treatment costs).

ARARs applicable and relevant and appropriate requirements
COCs Contaminants of concern
EPA Environmental Protection Agency
ERH electrical resistance heating
MRP Maywood Riverfront Park
O&M operation and maintenance
PPE personal protective equipment
PRB permeable reactive barrier
PSSRGs preliminary site-specific remediation goals
P&T pump and treat
ROD record of decision
SVE soil vapor extraction
TBCs to be considered ARARs
TMV toxicity, mobility, and volume
VOCs volatile organic compounds
UV ultraviolet

TABLE 3.1 - DETAILED COST SUMMARY FOR MONITORED NATURAL ATTENUATION

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Mobilization/Demobilization	2	each	$1,500.00	$3,000	Gregg Drilling
2	Monitoring Well Installation	8	per well	$15,785.00	$126,280	Gregg Drilling
3	1st Yr Sampling (2 events; 8 new + 35 existing wells)+QC	94	lump sum	$546.40	$51,220	Calscience
4	Handling Fees (3%)	1	lump sum	$5,414.99	$5,415	T N & Associates
5	Contingency (10%)	1	lump sum	$18,049.95	$18,050	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$203,964**	
TN&A Labor						
6	Well Installation/Sampling	536	hour	$85.00	$45,560	T N & Associates
7	Engineering, Design, Planning	260	hour	$100.00	$26,000	T N & Associates
8	Project Management	130	hour	$110.00	$14,300	T N & Associates
	Subtotal (TN&A Labor)				**$85,860**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$289,824**	

Assumptions:

1. It is assumed that 35 of the existing Exposition groundwater zone(s) wells would be utilized and 8 new wells would be required in the same zone.
2. Monitored natural attenuation is only practical as a containment option when partnered with a source treatment option.

TABLE 3.1 - DETAILED COST SUMMARY FOR MONITORED NATURAL ATTENUATION

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance (Monitoring)

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	(2) Semiannual GW Sampling Events, Incl. QC	94	each	$546.40	$51,220	Calscience Labs
2	Handling Fees (3%)	1	lump sum	$1,536.59	$1,537	T N & Associates
3	Contingency (10%)	1	lump sum	$5,121.95	$5,122	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$57,878**	
TN&A Labor						
4	Sampling/ Monitoring	396	hours	$85.00	$33,660	T N & Associates
5	Data Processing and Reporting	270	hours	$100.00	$27,000	T N & Associates
6	Management of O&M	108	hours	$110.00	$11,880	T N & Associates
	Subtotal (TN&A Labor)				**$72,540**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$130,418**	

Present Worth of Annual Operation and Maintenance (Monitoring)

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$130,418	4.25%	50	**$2,685,308**	Calculated using uniform series present worth factor.

Assumptions:

1. Semiannual groundwater sampling at 43 well locations includes analysis for VOCs and natural attenuation parameters.
2. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).
3. The assumed project duration for monitored natural attenuation is 50 years.

TABLE 3.2 - DETAILED COST SUMMARY FOR PUMP & TREAT

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Treatment Compound - Concrete Pad, Fencing, Lights	1	lump sum	$10,864.00	$10,864	RS Means
2	Utility Connections	1	lump sum	$12,906.00	$12,906	RS Means
3	Mobilization/Demobilization	2	each	$2,400.00	$4,800	Gregg Drilling
4	Well Installation, 6" dia.	55	each	$15,785.00	$868,175	Gregg Drilling
5	Piping Network, Manifold, Valves	1	lump sum	$32,256.38	$32,256	Harrington Industrial Plastics
6	Trenching and Backfill, 8" wide trench, 24" deep	4,500	linear feet	$2.18	$9,810	RS Means
7	Grundfos Rediflo 3, 1/3 Hp, 120 ft. Lead, Controllers	55	each	$1,788.00	$98,340	Grundfos
8	Site Restoration/Well Destruction	55	lump sum	$950.00	$52,250	Gregg Drilling
9	Handling Fees (3%)	1	lump sum	$32,682.04	$32,682	T N & Associates
10	Contingency (10%)	1	lump sum	$108,940.14	$108,940	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$1,231,024**	
TN&A Labor						
11	Construction Management and Sampling	930	hour	$85.00	$79,050	T N & Associates
12	Planning and Design	360	hour	$100.00	$36,000	T N & Associates
13	Project Management	165	hour	$110.00	$18,150	T N & Associates
	Subtotal (TN&A Labor)				**$133,200**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$1,364,224**	

Assumptions:

1. It is estimated that 55 extraction wells (6-in.) will be required to complete the containment network. An additional 20 existing wells will be used for monitoring.
2. Costs associated with treatment of water are included with the treatment scenarios.
3. Containment via pump and treat would be most effective if partnered with an aggressive treatment option for the source area.
4. The estimated duration for this alternative is 30 years.

TABLE 3.2 - DETAILED COST SUMMARY FOR PUMP & TREAT

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Electrical Consumption	429651	kWH	$0.18	$77,337	S.C. Edison
2	Maintenance and Service (Average)	1	lump sum	$2,200.00	$2,200	T N & Associates
3	Mechanical, Pipe, Valves, Parts (Average)	1	lump sum	$2,420.18	$2,420	Assume 5% of Network Cost
4	(2) Semiannual GW Sampling Events, Incl. QC	90	each	$227.20	$20,448	Calscience Labs
5	Handling Fees (3%)	1	lump sum	$3,072.16	$3,072	T N & Associates
6	Contingency (10%)	1	lump sum	$10,240.53	$10,241	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$115,718**	
TN&A Labor						
7	Weekly Inspection and Monitoring	728	hours	$85.00	$61,880	T N & Associates
8	Data Processing and Reporting	392	hours	$100.00	$39,200	T N & Associates
9	Management of O&M	192	hours	$110.00	$21,120	T N & Associates
	Subtotal (TN&A Labor)				**$122,200**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$237,918**	

Present Worth of Annual Operation and Maintenance

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$237,918	4.25%	30	**$3,992,264**	Calculated using uniform series present worth factor.

Assumptions:

1. Costs associated with treatment of water are included with the treatment scenarios.
2. Electrical rate for small business were provided by Southern California Edison (Los Angeles) and range from $.14 - $.21/kWH.
3. Semiannual groundwater sampling would be performed on 75 wells (plus QC) and the analysis would be for VOCs via EPA Methods 8260B.
4. Weekly inspections would be performed and reported in conjunction with the remediation system monitoring and compliance sampling.
5. The interest rate used in the present worth calculation (4.25%) is reported Prime Rate (Nov. 2002).

TABLE 3.3 - DETAILED COST SUMMARY FOR PERMEABLE REACTIVE BARRIER

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Treatment System Equipment and Installation

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
Equipment, Materials, and Subcontractors						
1	Pre-Design Treatability Study	1	lump sum	$31,920.00	$31,920	GeoSierra
2	Mobilization/Demobilization	2	each	$13,000.00	$26,000	GeoSierra
3	PRB Construction & Verification Testing	1	lump sum	$2,646,073.00	$2,646,073	GeoSierra
4	Monitoring Well Installation	30	each	$11,690.00	$350,700	Gregg Drilling
5	Confirmation Soil and GW Sampling (16 borings)	1	lump sum	$34,574	$34,574	Gregg Drilling and Calscience
6	Handling Fees (3%)	1	lump sum	$92,678.01	$92,678	T N & Associates
7	Contingency (10%)	1	lump sum	$308,926.70	$308,927	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$3,490,872**	
TN&A Labor						
8	Construction Management	1,000	hour	$85.00	$85,000	
9	Engineering, Design, and Inspection	1,410	hour	$100.00	$141,000	
10	Project Management	650	hour	$110.00	$71,500	
	Subtotal (TN&A Labor)				**$297,500**	
TOTAL TREATMENT SYSTEM EQUIPMENT AND INSTALLATION:					**$3,788,372**	

Assumptions:

1. Confirmation sampling is based on 16 borings along length of wall, one sample per five foot interval (soil), plus 16 groundwater samples, plus QC.
2. The estimated duration of this alternative is 50 years. Reduced monitoring requirements are likely following several 5-year reviews.

TABLE 3.3 - DETAILED COST SUMMARY FOR PERMEABLE REACTIVE BARRIER

LOWER VADOSE SOIL AND EXPOSITION GROUNDWATER REMEDIATION ZONE

Annual Operation and Maintenance (Monitoring)

Item No.	Description	Quantity	Unit	Unit Rate	Total Cost	Source
O&M - Utilities, Materials, and Subs						
1	Annual GW Sampling Events, Incl. QC.	36	each	$227.20	$8,179	Calscience Labs
2	Handling Fees (3%)	1	lump sum	$245.38	$245	T N & Associates
3	Contingency (10%)	1	lump sum	$817.92	$818	RS Means
	Subtotal (Equipment, Materials, and Subs)				**$9,242**	
TN&A Labor						
4	Sampling and Monitoring	160	hours	$85.00	$13,600	T N & Associates
5	Data Processing and Reporting	140	hours	$100.00	$14,000	T N & Associates
6	Management of O&M	130	hours	$110.00	$14,300	T N & Associates
	Subtotal (TN&A Labor)				**$41,900**	
TOTAL ANNUAL OPERATION AND MAINTENANCE					**$51,142**	

Present Worth of Annual Operation and Maintenance (Monitoring)

	Cost	Interest Rate	Years	Present Worth	
Total Present Worth of Annual O&M	$51,142	4.25%	50	**$1,053,024**	Calculated using uniform series present worth factor.

Assumptions:

1. Annual groundwater sampling at 30 well locations includes analysis for VOCs via EPA Methods 8260B.
2. The interest rate used in the present worth calculation (4.25%) is the reported Prime Rate (Nov. 2002).