SECTION 5

Development of Corrective Action Alternatives

The technologies presented in Section 4.2 are viable for use in the remediation and/or closure of the POL Hill AST-2 Area, and have been proven effective at sites with similar site-specific conditions and contaminants. The purpose of this section is to present the combinations of candidate technologies which were assembled into specific corrective action alternatives to provide integrated solutions for remediation to meet the stated corrective action objectives for the POL Hill AST-2 Area. The following sub-sections present the alternatives for contaminated soil and groundwater sites.

5.1 Corrective Action Alternatives for Soil

The sole alternative proposed for soil is the no further action alternative. This alternative entails leaving the site in its current condition. As identified in Section 4.1, contaminant concentrations in the soil at the POL Hill AST-2 Area are essentially below required the cleanup goals, except for soils within shallow bedrock fractures beneath the former AST-2.

Because no other alternatives are developed for the soil, further discussion or analysis using the evaluation criteria will not be conducted in this report.

5.2 Corrective Action Alternatives for Groundwater

The POL Hill AST-2 Area groundwater was extensively sampled during previous and current investigations (as described in Section 2.0 and summarized in Table 2-1). Based on these investigative results, TPH measured as JP-4 was detected at concentrations above its associated cleanup goal in one well. Consequently, JP-4 has been established as a COC for groundwater.

Petroleum hydrocarbons are present in the groundwater in the POL Hill AST-2 Area but appear to be limited to the vicinity of the former location of AST-2. The highest concentrations in groundwater were reported in samples collected from well PL-MW-101, located immediately adjacent to the location of former AST-2. Additionally, evidence supports the conclusion that the area of petroleum-hydrocarbon contamination in the groundwater within bedrock fractures at the POL Hill AST-2 Area is static or is shrinking, and that natural attenuation is occurring.

Corrective action technologies identified in Section 4.2 are refined into corrective action alternatives specific to the POL Hill AST-2 Area groundwater in the following subsections.

5.2.1 No Action

The National Contingency Plan (NCP) (USEPA, 1990) requires retaining a no action alternative to serve as a baseline for evaluating remedial action measures. Under the no action alternative, no corrective or monitoring actions would be implemented. Because the no action alternative entails leaving the site in its current condition, no cost is associated with this alternative.

5.2.2 Institutional Controls

Access restrictions and land-use controls could be implemented for the POL Hill AST-2 Area. Deed restrictions that limit the kind of future development that can take place or that prevent groundwater use are other types of institutional controls.

This alternative can be used to complement the chosen groundwater remediation strategy. It is anticipated that a deed restriction will be put in place to preclude the use of groundwater at the site and to prevent the property from being developed for residential purposes. Institutional controls alone were not considered a reasonable long-term solution for the POL Hill AST-2 Area because of the potential future development restrictions for the property. From this standpoint, it was considered more advantageous to seek an alternative that leads to attainment of the RCGs for groundwater and permits development of the site once closure status with regulatory agencies has been achieved.

5.2.3 In Situ Biodegradation

The in situ biodegradation alternative involves remediation of the contaminated groundwater by the addition of nutrients and oxygen to stimulate microorganisms that destroy the contaminants. Under this alternative, a system consisting of approximately 400 ft. of infiltration trenches would be installed at the upgradient periphery of the contaminated groundwater area. These trenches would be used to apply nutrients by infiltration into the subsurface and the groundwater. Because of the low hydraulic conductivity (approximately 2.6×10^{-7} centimeters per second [cm/sec]), the infiltration rate would likely be low. The infiltration trenches would be piped to a 50-gal holding tank and a 0.3-milliliter per minute (ml/min) injection pump[1]. A fence would be erected around the site to preclude inadvertent trespass onto the site and to protect equipment from vandalism.

Seven monitoring wells would be sampled semi-annually (PL-MW-101, -103, -104, -114, -115, and -116, and MW-POLA-121) to monitor the groundwater for contaminant migration and concentration changes. When the concentration of JP-4 is reduced to the cleanup goal (i.e., 1,200 µg/L), treatment would be considered complete. Compliance with corrective action objectives would be demonstrated before the system operation is terminated.

Once contaminant concentrations have been reduced to the corrective action objectives, treatment would be terminated. The treatment system (i.e., fencing, tank, pump, and piping) would be removed and the infiltration trenches would be abandoned in-place by backfilling with clean fill to the ground surface.

The in situ biodegradation alternative was excluded due to the following considerations:

- The alternative was not likely to address suspended/trapped JP-4 contamination in the discontinuous bedrock fractures due to very low permeability.
- Uncertainties are high and effects are dubious without extensive and costly studies.

[1] Calculations of the infiltration rate result in a rate of approximately 1.95×10^{-3} gallons per day. Adjusting the calculation for a 10-ft-wide interface between the soil and bedrock leads to an application rate of 1.7×10^{-2} gallons per day. Because it is impossible to estimate the actual interface width, the larger width will be assumed with the understanding that the actual width, and thus the application rate, may be much smaller.

- The addition of nutrient would require adding fluids that have the potential to mobilize contamination and potentially lead to slope stability problems.
- A review of the geochemical parameters indicate that site conditions are favorable for biodegradation.
- This option would require additional permitting and monitoring, thereby increasing project costs.
- The need to exclude the public from infiltration trenches and equipment would preclude development of the site for open space.

5.2.4 Monitored Natural Attenuation

Under the natural attenuation alternative, no active remediation would be implemented; however, institutional controls (deed restrictions) and a groundwater-monitoring program would be instituted until natural attenuation reduces groundwater contamination to acceptable levels.

A preliminary field test was conducted to confirm that biodegradation is occurring and to try to estimate biodegradation rates (SOTA, 2002). Groundwater samples were collected and analyzed to quantify the natural-attenuation indicator parameters and determine the contribution of intrinsic biodegradation to the attenuation process. Additionally, the groundwater geochemistry, specifically respiratory substrates and products, were examined in contaminated and uncontaminated areas to confirm the occurrence of intrinsic biodegradation. The TPH contamination in bedrock fractures appears to be relatively stable in the area of the former AST-2 and geochemical parameters indicate natural attenuation is occurring at the site (SOTA, 2002).

An annual groundwater-sampling program has been initiated to collect samples from selected existing monitoring wells (PL-MW-101, -103, -104, -106, -107, -114, -115, and -116, and MW-POLA-121). The data from the monitoring wells would be used to delineate contaminant migration and concentration changes within the impacted area.

Deed restrictions would be used to ensure that unauthorized use of the groundwater does not occur prior to completion of remedial actions. Because the groundwater contaminants occur at approximately 25 ft bgs and are located in bedrock, inadvertent access to the contaminants is judged to be unlikely.

When monitoring data indicate that groundwater contamination is below the TPH measured as JP-4 cleanup goal (i.e., 1,200 μg/L) deed restrictions would be removed, and the monitoring wells would be abandoned in compliance with applicable State of California requirements.

5.3 Analysis of Alternatives

Three criteria, effectiveness, implementability, and cost, were used to conduct an evaluation of the corrective action alternatives for the impacted groundwater. The analysis compared the corrective action alternatives to one another to assess the advantages and disadvantages relative to each alternative and to select a preferred alternative. The evaluation criteria are described in further detail below.

- **Effectiveness**—each corrective action alternative was evaluated with respect to its ability to protect human health and the environment and to reduce contaminant toxicity, mobility, and volume. More specifically, the following factors were addressed:
  - Protection of workers during implementation
  - Environmental impacts that may result from implementation
  - Protection of the public from any potential risk resulting from implementation
  - How well the alternative achieves the corrective action objectives
- **Implementability**—this criteria addresses the technical and administrative feasibility of implementing a corrective action alternative and the availability of various services and materials needed during implementation.
- **Cost**—cost estimates include both direct and indirect costs. Direct costs consist of the following:
  - Materials
  - Labor
  - Equipment purchase or rental
  - Health and safety measures
  - Sampling and analysis.

  Indirect costs included the following items:
  - Engineering studies
  - Permits/deed restrictions
  - Startup costs
  - Contingency allowances.

A detailed cost analysis of both capital costs and annual operation and maintenance costs, which presents the estimated expenditures required to complete each interim measure, is presented in Appendix G. The cost estimates were prepared based on a conceptual design for the alternatives and are expected to be accurate within +50 percent and -30 percent.

Table 5-1 presents a summary of the alternatives evaluation relative to the three criteria. Based on this evaluation, the recommended corrective action alternative is selected and presented in Section 6.

TABLE 5-1
Corrective Action Alternative Analysis

Evaluation Criteria	No Action	Monitored/Natural Attenuation	In Situ Biodegradation
Effectiveness	The no action alternative currently meets the corrective action objective of preventing human exposure through ingestion of groundwater since the groundwater contamination is essentially inaccessible and groundwater at the site does not meet the recovery rate requirement for designation as a drinking water source per California State Water Resources Board Resolution 88-63. This alternative is the least effective alternative since it does not provide a means for remediation of the present contamination and does not prevent further migration of contaminants or a monitoring program to delineate future contaminant migration or contaminant concentration increases. In addition, this alternative does not effectively prevent unauthorized use of the groundwater in the future (i.e., no deed restrictions).	Natural attenuation, dependent upon time and conditions, effectively reduces hydrocarbon contamination to acceptable levels; however, this alternative is not as effective in achieving the stated objective (based on time to achieve cleanup goals) as in situ biodegradation. Groundwater monitoring is required for delineating contaminant extent, migration, or concentration changes. Current estimates using half-life calculations suggest that cleanup goals would be achieved within 4 to 10 years. In addition, obtaining a deed restriction reduces the potential risk of unauthorized use of the groundwater in the future. Such activities, when coupled together, effectively provide protection of human health and the environment from contact with contaminants while contaminants are attenuating. However, if contaminant migration is discovered, development of an applicable remedial action may be warranted.	In situ biodegradation is a proven technology that has been implemented at sites with hydrocarbon-contaminated groundwater. This alternative would be the most effective to reduce toxicity, mobility, and volume of the contaminants because the addition of nutrients would accelerate natural degradation of the contaminants, expediting the process of contaminant reduction to acceptable levels and thus mitigating risk of potential exposure. However, due to the low hydraulic conductivity of the contaminated aquifer, injection of the liquid nutrients may cause mounding that would promote contaminant migration, rather than reduce contaminant levels. The low flow rates may also promote microbial accumulation directly along the infiltration pipe, which may result in fouling of the line and a decrease in infiltration effectiveness.
Implementability	Acceptance may not be expected since the groundwater may be inadvertently accessed by unauthorized users in the future, contaminants are not reduced, and migration of contaminant would potentially occur. Therefore, this alternative is the least implementable.	This alternative is the easiest to implement as groundwater monitoring was previously conducted at the existing monitoring wells on site. In addition, deed restrictions to prevent groundwater usage may be necessary. No adverse effects are anticipated to human health or the environment during implementation.	This alternative is not as implementable as the monitored/natural attenuation alternative. An in-situ system could be implemented using existing resources and technologies. However, site characteristics (i.e., bedrock layer) may affect implementability due to the length of and depth at which an infiltration trench would be required to meet design objectives. In addition, due to the low hydraulic conductivity of the contaminated aquifer, application of the liquid nutrients may not be easily implemented. It is also possible that addition of liquid nutrients could mobilize contaminants in groundwater within bedrock fractures or lead to slope instability.
Present Worth Cost[a]	$0	$174,613	$383,015

[a] Present worth is calculated using a discount rate of 5 percent.

Source: IT, 1997c.