7. Detailed Evaluation of Remedial Alternatives

7.1. Criteria and Evaluation Process

This chapter presents our detailed analysis and comparison of the remedial alternatives developed in Chapter 6 for each of the Site 300 OUs. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) identifies nine criteria to be used in the detailed analysis of alternatives:

1. Overall protection of human health and the environment.
2. Compliance with ARARs.
3. Long-term effectiveness and permanence.
4. Reduction of toxicity, mobility, and volume.
5. Short-term effectiveness.
6. Implementability.
7. Cost.
8. State acceptance.
9. Community acceptance.

Each of these criteria is discussed below.

7.1.1. Overall Protection of Human Health and the Environment

This criterion addresses whether the alternative achieves and maintains protection of human health and the environment during implementation and after remediation objectives are achieved.

7.1.2. Compliance with ARARs

Unless a waiver is obtained, the alternative or combination of alternatives that are finally selected must comply with all location-, action-, and chemical-specific ARARs.

7.1.3. Long-Term Effectiveness and Permanence

This criterion is used to evaluate how each alternative maintains protection of human health and the environment. This includes evaluating residual risk and management obligations after meeting the RAOs.

7.1.4. Reduction of Toxicity, Mobility, and Volume

This criterion is used to evaluate if and how well each alternative reduces the toxicity, mobility, and/or volume of contaminants through treatment. It also addresses the amount of contaminants remaining on site after completion of remedial measures.

7.1.5. Short-Term Effectiveness

This criterion addresses the effectiveness of each alternative to protect human health and the environment during construction and implementation of each remedial action. This includes the safety of workers and the public, disruption of site and surrounding land uses, and time necessary to achieve protective measures.

7.1.6. Implementability

This criterion addresses the technical and administrative feasibility of each alternative. Factors considered include:

- Availability of goods and services.
- Flexibility of each alternative to allow additional modified remedial actions.
- Effectiveness of monitoring.
- Generation and disposal of hazardous waste.
- Substantive permitting requirements.

7.1.7. Cost

Capital, operation and maintenance, monitoring, and contingency costs are estimated for each alternative and are presented as 1999 present-worth costs using a 5% discount rate. Costs for all alternatives are presented in Table 7-1. The costs for the modules used to assemble the alternatives are presented in Appendix D.

7.1.8. State Acceptance

The California Department of Toxic Substances Control and Regional Water Quality Control Board-Central Valley Region will review and comment on this document. Analysis of technical and administrative concerns that these agencies may have regarding each of the alternatives will be addressed. The State agencies will participate in the selection of the remedies for the Interim ROD. The State agencies will also participate in the selection of the final remedies and cleanup goals for Site 300 which will be codified in the Site 300 Final ROD.

7.1.9. Community Acceptance

A Public Workshop will be held after the Final SWFS is published to present and receive public input on the proposed remedial alternatives for the Site 300 OUs. A summary of the remedial alternatives and the preferred remedies will be published in the Proposed Plan for the Remediation of Site 300. A Public Meeting will be held during the 30-day comment period for the Proposed Plan to received formal comments from the public. Public comments will be considered in the selection of the remedies for the Site 300 Interim ROD. Public comments made during the Public Meeting and 30-day comment period will be addressed in writing in the Responsiveness Summary of the Site 300 Interim ROD.

7.2. Detailed Analysis of Remedial Alternatives

This section presents evaluations of how each alternative addresses the first seven EPA criteria specified by the NCP. In addition, a comparative evaluation of the characteristics of each alternative against the other alternatives with respect to the first seven criteria is presented for each OU. Presumptive remedies have been identified for a number of OUs. For these OUs, the presumptive remedy is evaluated and compared only to the no action alternative required by EPA guidance. Evaluations of State and community acceptance will be addressed in the ROD following comments on this document and the subsequent Proposed Plan.

7.2.1. Analysis of Remedial Alternatives for the Building 834 OU

This section presents the evaluation of how each of the three alternatives proposed for the Building 834 OU address the first seven EPA criteria.

7.2.1.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all remedial activities in the Building 834 complex would cease.

Alternative 1 may not be protective of human health or the environment because no active measures are taken to reduce contaminant concentrations in ground water or in the vadose zone. No water-supply wells are currently contaminated with VOCs or other contaminants originating from the Building 834 OU. Fate and transport modeling of TCE to the nearest offsite water-supply well (CDF-1) indicated that the TCE ground water plume would not reach the well at concentrations above analytical method detection limits (Webster-Scholten, 1994). The individual risk and additive risk for VOCs modeled to well CDF-1 were below 10^{-6}.

Alternative 1 does not meet the RAO of preventing potential inhalation of VOCs by onsite workers above health-based concentrations inside or in the vicinity of Building 834D. Fencing and full-time security patrols are in place that effectively prevent public access to the onsite portion of the plume and source area.

This alternative meets all ARARs if natural attenuation and dispersion act to reduce contaminant concentrations in ground water to background within a reasonable timeframe. Without natural attenuation and dispersion, ground water concentrations of VOCs and nitrate would remain above MCLs and more stringent WQOs, which have been identified as relevant and appropriate requirements for Site 300 and the requirements of the Basin Plan, or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.1.2. Evaluation of Alternative 2—Monitoring, Exposure Control, and Ground Water and Soil Vapor Extraction and Treatment

The objective of Alternative 2 is to meet RAOs by actively remediating both the vadose zone and ground water to the point where the beneficial uses of ground water are restored and protected and inhalation risk inside and in the vicinity of Building 834D are mitigated.

Alternative 2 uses exposure control methods and administrative controls to provide initial protection to human health and to ecological receptors. This alternative also provides additional protection to human health by restoring and protecting the beneficial uses of the shallow perched aquifer through the active remediation of contaminants in ground water and the vadose zone.

Alternative 2 meets the RAO of preventing potential inhalation of VOCs above health-based concentrations inside and in the vicinity of Building 834D by reducing VOC concentrations through soil vapor extraction.

This alternative also employs ecological surveys and appropriate response actions, if necessary, to protect the environment. By actively reducing VOC concentrations in the vadose zone and ground water, potential future ecological risks are mitigated.

The goal of Alternative 2 is to use active soil vapor and ground water remediation to meet all ARARs. VOC, TBOS/TKEBS, and nitrate concentrations in ground water would be actively reduced to MCLs, any more stringent WQOs, or below. Soil vapor extraction, combined with dewatering in the Building 834D area, removes the source of future contaminant releases to ground water as well as reducing soil vapor VOC concentrations. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

The toxicity and volume of extracted VOCs are eliminated by thermal regeneration of vapor-phase GAC used for soil vapor treatment and treatment of air stripper vapor effluent. The toxicity and volume of extracted nitrate are reduced through phytoremediation. As extracted TBOS/TKEBS would be disposed of offsite, the toxicity and volume of this contaminant would not be reduced. The migration of dissolved VOCs above the cleanup goals would be controlled by ground water extraction. Potential VOC vapor flux would be controlled by the soil vapor extraction system.

Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

Alternative 2 is readily implementable. Equipment, materials, and services necessary for implementing Alternative 2 are available. Ground water and soil vapor extraction systems have been operating at Building 834 for a number of years under an interim ROD for this OU.

The estimated present worth of the life-cycle costs for Alternative 2 is $12,095,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and –30 percent in accordance with EPA guidance (1987).

7.2.1.3. Evaluation of Alternative 3—Monitoring, Exposure Control, and Ground Water and Soil Vapor Extraction and Treatment

Alternative 3 includes the monitoring, exposure control, and ground water and soil vapor extraction and treatment components of Alternative 2 and adds enhanced *in situ* bioremediation of the downgradient portion of the VOC plume. Enhanced *in situ* bioremediation, coupled with ground water and soil vapor extraction, would reduce risk to human health and comply with ARARs by decreasing contaminant concentrations. Non-reversible chemical reactions involved in bioremediation assure long-term effectiveness by permanently reducing VOC concentrations. The reductive dehalogenation of TCE would convert TCE to non-toxic byproducts. Nitrate may be reduced to NO_2 then to the gaseous form (N_2), which would eventually escape from the subsurface, or be chemically bound to microorganisms. The mobility and volume of contaminants would be reduced through ground water and soil vapor extraction, supplemented by bioremediation of the downgradient portion of the plume.

Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during the installation of the bioremediation system and while performing extraction and treatment system operation and maintenance, drilling, or monitoring. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

The ground water and soil vapor extraction and treatment portion of Alternative 3 is readily implementable as ground water and soil vapor extraction and treatment systems are already operating at Building 834. The implementability of the enhanced *in situ* bioremediation component of Alternative 3 is limited by: (1) the ability to find suitable enhancing materials, (2) access to drill sites in the rough terrain, and (3) permitting requirements for injection of enhancing fluids. The operation of the *ex situ* ground water treatment system would require Waste Discharge Requirements (WDRs) from the RWQCB for the discharge of treated effluent. In addition, the enhanced *in situ* bioremediation component may require WDRs designed to ensure that residual materials or byproducts protect beneficial uses of ground water.

The estimated present worth of the life-cycle costs for Alternative 3 is $14,504,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and –30 percent in accordance with EPA guidance (1987).

7.2.2. Comparative Evaluation of Remedial Alternatives for the Building 834 OU

This section presents a comparative evaluation of the characteristics of each alternative against the other Building 834 OU alternatives with respect to the first seven EPA criteria.

7.2.2.1. Overall Protection of Human Health and the Environment

The only human health risks are possible ingestion of ground water with contaminants at concentrations exceeding MCLs, and inhalation of VOC vapors above health-based concentrations in and around Building 834D. There are no existing exposure pathways for ground water with concentrations above MCLs. Fate and transport modeling indicated that contaminants from the Building 834 Complex would not impact offsite water-supply wells.

Alternative 1 would not be protective of human health because no active measures are taken to reduce contaminant concentrations in ground water or in the vadose zone.

Alternatives 2 and 3 both address risk to human health from potential inhalation of VOC vapors above health-based concentrations by reducing soil vapor VOC concentrations through soil vapor extraction. Both alternatives include the same measures to prevent exposure to contamination while contaminant concentrations are being reduced through ground water and soil vapor extraction such as administrative controls to prevent access to contaminated ground water.

Alternatives 2 and 3 use active remediation to reduce contaminant concentrations and mass at the Building 834 source area and at several locations downgradient through dual-phase ground water and soil vapor extraction. Thus, both alternatives would provide long-term protection of human health and restore beneficial uses of ground water.

Alternative 3 provides additional mass removal and plume control by enhanced *in situ* bioremediation of VOCs downgradient of the Building 834 Complex. However, the additional mass removal of TCE through *in situ* bioremediation would provide no significant quantifiable health risk benefit as compared to Alternative 2 because the perched water-bearing zone is not being used for drinking water.

7.2.2.2. Compliance with ARARs

In Alternative 1, concentrations of VOCs and nitrate would remain above MCLs or any more stringent WQOs, which would not meet the requirements of the Basin Plan, or SWRCB Resolutions 68-16 and 92-49.

The goals of Alternatives 2 and 3 are to use active soil vapor and ground water remediation to meet all ARARs. The remedial actions described in Alternative 2 can be designed and implemented in compliance with ARARs. It is not certain at this time whether levels of residual by-products of the enhanced *in situ* bioremediation in Alternative 3 would meet the requirements of SWRCB Resolution 68-16.

7.2.2.3. Long-Term Effectiveness and Permanence

Alternative 1 (no action) does not provide long-term effectiveness in meeting ARARs or permanently reduce COC concentrations. Alternatives 2 and 3 provide long-term effectiveness through mass removal of COCs from the vadose zone and ground water. Ongoing SVE at Building 834 over the past year have demonstrated that SVE is effective in removing VOCs from the subsurface. The dewatering elements of Alternatives 2 and 3 would enhance mass removal in the saturated zone.

7.2.2.4. Reduction of Toxicity, Mobility, and Volume

Alternative 1 does not remove COCs from the subsurface. Therefore, implementation of this alternative would not reduce the toxicity, mobility, or volume of the COCs.

Under Alternatives 2 and 3, remedial actions involve removing VOCs from the vadose zone and ground water by transferring VOCs to an air stream and adsorbing them to carbon. The toxicity and volume of these VOCs are then eliminated through thermal destruction of the VOCs sorbed to carbon. TBOS/TKEBS would be removed from ground water and disposed of offsite as hazardous waste, therefore the toxicity and volume of this contaminant would not be reduced. The toxicity and volume of nitrate would be reduced through phytoremediation. Contaminant volume and mobility in the vadose zone and ground water would be reduced irreversibly by SVE, dewatering, plume control, and contaminant recovery by both Alternatives 2 and 3. Any residual DNAPL would be removed by the dewatering and SVE. If any free-product DNAPL is found, it would be extracted by direct pumping.

As the rate of degradation through enhanced *in situ* biodegradation is unknown, the ability of this Alternative 3 component to provide additional reductions in the mobility and volume of contaminants above that attained through pumping and treating in Alternative 2 is not certain. Ongoing studies would provide data on the viability of *in situ* biodegradation to provide additional reduction in the mobility and volume of contaminants.

7.2.2.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors.

Due to the remoteness of the site and the distance between the perched water-bearing zone and the regional aquifer, remedial actions under Alternatives 2 and 3 would have minimal impact on the public during the construction and subsequent operation of the remedial systems. A health and safety plan would be developed prior to implementation of the selected remedial action to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks.

It is unlikely that risk protection would be achieved significantly faster under Alternative 3 than under Alternative 2. For both, the ground water and soil vapor extraction will reduce concentrations. Concentration trends indicate that DNAPLs, if present, have been significantly reduced and continued ground water and soil vapor extraction will complete the remediation in about 30 years. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

7.2.2.6. Implementability

Each of the alternatives can be implemented. However, implementation becomes more complicated with each alternative. Alternative 1 can be implemented easily by shutting down the existing treatment facilities.

The treatment technologies incorporated into Alternative 2 are well proven and have been identified as presumptive technologies for VOCs in soil vapor and ground water**,** and are already in-place and operating. To fully implement this alternative, additional extraction wells would be connected to the treatment systems.

For Alternative 3, the implementability of the enhanced *in situ* bioremediation component of the alternative is limited by: (1) the ability to find suitable enhancing materials, (2) access to drill sites in the rough terrain, and (3) permitting requirements for injection of enhancing fluids. This technology is otherwise well established. The operation of the *ex situ* ground water treatment system for Alternative 3 would require WDRs from the RWQCB for the discharge of treated effluent. In addition, the enhanced *in situ* bioremediation component of Alternative 3 may require WDRs designed to ensure that residual materials or byproducts protect beneficial uses of ground water.

7.2.2.7. Cost

The estimated present worth of the life-cycle costs for the Building 834 alternatives range from no cost for Alternative 1 to $14,504,000 for Alternative 3. Costs for each alternative are summarized in Table 7-1. Capital, operation and maintenance (O&M), monitoring, and risk and hazard management costs were developed for Alternatives 2 and 3.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 has a cost of $12,095,000, which consists primarily of wellfield expansion and O&M for the existing treatment facility. The majority of the capital construction costs have already been incurred.
- Alternative 3 costs exceed the costs of Alternative 2 by $2.4 million, which includes the capital and O&M costs for the enhanced *in situ* bioremediation system.

7.2.3. Analysis of Remedial Alternatives for the Pit 6 Landfill OU

This section presents the evaluation of how each of the three alternatives proposed for the Pit 6 Landfill OU address the first seven EPA criteria.

7.2.3.1. Evaluation of Alternative—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Pit 6 Landfill OU, such as monitoring, would cease.

Alternative 1 may not be protective of human health or the environment, in that without monitoring of the ground water plumes, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with VOCs or other contaminants originating from the Pit 6 Landfill OU. Fate and transport modeling of VOCs to the nearest offsite water-supply well (CARNRW2) indicated that the TCE ground water plume would not reach the well at concentrations above analytical method detection limits (Webster-Scholten, 1994). The individual and additive risks for VOCs modeled to well CARNRW2 were below 10^{-6}.

The installation of the landfill cap in 1997 met the RAO of preventing potential inhalation of VOCs by onsite workers above health-based concentrations in the vicinity of the Pit 6 Landfill. Fencing and full-time security patrols are in place that effectively prevent public access to the onsite portion of the plume and the landfill.

This alternative meets all ARARs if natural attenuation and dispersion act to reduce contaminant concentrations in ground water to background within a reasonable timeframe. Without natural attenuation and dispersion, concentrations of VOCs and tritium would remain above MCLs or any more stringent WQOs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.3.2. Evaluation of Alternative 2—Monitoring, Exposure Control, and Monitored Natural Attenuation of VOCs and Tritium in Ground Water

The Pit 6 Landfill cap was installed in 1997 to mitigate the inhalation risk to onsite workers from VOCs volatilizing from subsurface soil in the vicinity of Pit 6 and to prevent further leaching of contaminants from the pit waste to ground water. In addition, the cap was designed to prevent animals from burrowing into the pits thus preventing exposure to ground squirrels and kit foxes to contaminants in the pit.

Tritium naturally decays with a 12.3 year half-life. The maximum tritium activity measured in ground water at the Pit 6 Landfill in 1998 is 1,600 pCi/L, an order of magnitude below the State MCL of 20,000 pCi/L. VOCs also degrade through irreversible chemical reactions largely brought about by microbial action. The only VOCs reported in the last two years of observations have been TCE (maximum 1998 concentration of 15 µg/L) and cis-1,2-DCE, a known breakdown product of TCE (maximum 1998 concentration of 4.4 µg/L). TCE has exhibited a downward trend in concentration over time, with an initial increase in cis-1,2-DCE. As TCE concentrations have diminished, cis-1,2-DCE concentrations are now also declining. Published half-lives of TCE range from 0.27 µg/L to 4.5 years (Howard et al., 1987; Buchanan, 1996). Data indicate that natural degradation of TCE is occurring and the declining data trends suggest that the concentrations in ground water will be below MCLs, WQOs, and possibly detection limits within several years, well before any exposure pathways are encountered.

The water-bearing zone affected by the contamination is not currently a drinking water source. Because the affected ground waters are unlikely to have any exposure pathways for one or more half-lives of both TCE and tritium, natural degradation and decay should be protective of human health and the environment. Risk and hazard management would be applied to prevent health impacts until ARARs are met. TCE concentrations in Spring 7 have declined to levels slightly above background indicating that exposure controls are not necessary at this time. The spring would be monitored for changes in TCE concentrations that could affect human health.

Alternative 2 relies on natural attenuation to reduce concentrations of VOCs and tritium in ground water to meet ARARs. As demonstrated by the data presented above, natural attenuation should lead to full compliance with ARARs in a reasonable timeframe. Monitoring of these contaminants in ground water provides a tool for: (1) demonstrating the existence and effectiveness of the natural degradation of VOCs and decay of tritium to meet ARARs, (2) detecting if any new releases have occurred, and (3) verifying attainment of ARARs. In addition, fate and transport modeling would be performed as part of this alternative to predict the spatial distribution of tritium over time and demonstrate the efficacy of monitored natural attenuation in meeting RAOs and ARARs within a reasonable timeframe.

As ground water monitoring data for nitrate and perchlorate are limited and they have been detected in only one well each to date, the monitoring of these compounds would continue to determine if and when an active remedy for these contaminants might be necessary.

The Site 300 Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs.

The radioactive decay of tritium and degradation of TCE are irreversible and hence effective in the long term and permanent. Monitoring would be continued after ARARs have been achieved to ensure long-term effectiveness and permanence.

The toxicity and volume of VOCs and tritium are reduced by natural degradation and decay, and there would be no impacts on the community or onsite workers from allowing these processes to occur. Monitoring would be conducted to identify any potentially toxic transformation products resulting from the biodegradation of TCE and to ensure the plumes do not migrate and impact downgradient receptors.

There are no remediation-related construction activities included in this alternative, therefore there would be no impact to human or ecological receptors from the implementation of this alternative and therefore it would be effective in the short-term.

This alternative is readily implementable and post-closure monitoring is already in place which would support the monitored natural attenuation component of this alternative. A detection monitoring program is included as part of the post-closure monitoring program, to provide for the early detection of future releases of contaminants from the Pit 6 Landfill.

The estimated present worth of the life-cycle costs for Alternative 2 is $2,377,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble this alternative are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.3.3. Evaluation of Alternative 3—Monitoring, Exposure Control, Monitored Natural Attenuation of Tritium in Ground Water, and Extraction and Treatment of VOCs, Perchlorate, and Nitrate in Ground Water.

Alternative 3 includes the monitoring, exposure control, and monitored natural attenuation of tritium components of Alternative 2 and adds the extraction and treatment of VOCs, perchlorate, and nitrate.

The extraction and treatment of VOCs, perchlorate, and nitrate in ground water, coupled with the natural attenuation of tritium, would reduce the risk of ground water ingestion to human health and reduce contaminant concentrations to comply with ARARs within a reasonable timeframe. Ground water extraction is a demonstrated technology to effectively reduce the mass and concentrations of contaminants in the subsurface. However, the low concentrations of VOCs in ground water may limit mass removal rates.

The overall protection of human health and the environment is ensured by the removal of contaminants, proper handling of separated products and wastes, effluent controls, and operational safety procedures.

Removal of contaminants from the subsurface reduces toxicity and volume, as well as preventing migration of contaminant plumes, to the maximum extent feasible. The radioactive decay of tritium would reduce the toxicity and volume of this contaminant. The toxicity and volume of extracted VOCs and perchlorate are eliminated during the thermal regeneration of the GAC. Biochemical processes in the bioreactor would eliminate the toxicity and volume of extracted nitrate.

In the short term, emission controls on surface treatment facilities would prevent any impact to the general public. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during the installation of the treatment system and while performing treatment system operation and maintenance, drilling, or monitoring. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. This alternative poses additional short-term exposure risks if tritiated water is brought to the surface during ground water extraction. Workers could be exposed during the operation and maintenance of the ground water treatment facility.

Alternative 3 is implementable although provisions would need to be made to avoid impacting the integrity of the landfill cap during construction, as well as for worker safety during treatment system construction and operation, as an active small firearms shooting range is located in the vicinity.

The estimated present worth of the life-cycle costs for Alternative 3 is $5,939,000. Costs are summarized and compared in Table 7-1. The costs of the modules used to assemble this alternative are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.4. Comparative Evaluation of Remedial Alternatives for the Pit 6 Landfill OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Pit 6 Landfill OU with respect to the first seven EPA criteria.

7.2.4.1. Overall Protection of Human Health and the Environment

In the baseline risk assessment, an inhalation risk of 5×10^{-5} for onsite workers was identified for VOCs volatilizing from subsurface soil in the vicinity of the Pit 6 Landfill. A landfill cap was installed in 1997 which prevents exposure to VOCs fluxing from the landfill, mitigating this risk. An inhalation risk of 4×10^{-5} and HI of 1.5 for onsite workers was also identified for VOCs volatilizing from Spring 7 to ambient air. The risk and hazard numbers were based on an exposure to maximum historical concentrations of VOCs detected in Spring 7 (110 µg/L). However, in 1998, only TCE was detected in Spring 7 at a concentration of 0.77 µg/L. There are no existing exposure pathways for ground water with concentrations above MCLs. A hazard of greater than 1 was identified for exposure of kit foxes to contaminants in soil in the vicinity of the pit. The landfill cap was designed to prevent burrowing, and thus exposure by animals, to the pit contents.

Alternative 1 (No further action) may not be protective of human health and the environment. Although contaminant concentrations may be reduced to health- and environmentally-protective levels through natural attenuation, potential changes in plume concentrations/activities and size that could result in impacts to downgradient receptors would not be monitored or detected.

Alternatives 2 and 3 both address risk to human health from potential ingestion of contaminated ground water. Ground water contaminant levels may be reduced to health-protective levels more rapidly through extraction and treatment in Alternative 3 than by natural attenuation of contaminants in Alternative 2. Both alternatives include the same measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced, such as administrative controls to prevent access to contaminated ground water.

Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

Alternative 3 provides for more rapid contaminant mass removal and concentration reduction through the extraction and treatment of contaminated ground water. However, the additional mass removal provided in Alternative 3 would provide no significant quantifiable health risk benefit as compared to Alternative 2, because ground water in this area is not used for drinking water.

7.2.4.2. Compliance with ARARs

Alternative 1 (no action) may meet all ARARs if natural attenuation acts to reduce contaminant concentrations to MCLs or lower within a reasonable timeframe. However, there are no provisions in this alternative to monitor the progress of natural attenuation toward meeting ARARs or determining when these goals are met.

Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water to meet all ARARs. Data indicate that some COCs are naturally attenuating and will achieve ARARs in a reasonable timeframe as proposed in Alternative 2. However, ARARs may be achieved in shorter timeframe through the active remediation presented in Alternative 3.

7.2.4.3. Long-Term Effectiveness and Permanence

Alternative 1 may provide long-term effectiveness in meeting ARARs and permanently reduce COC concentrations, however there are no mechanisms included in this alternative for establishing the achievement of these goals.

Alternatives 2 and 3 both provide long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs. Alternative 2 would effectively and permanently reduce contamination in ground water through irreversible chemical degradation and radioactive decay (natural attenuation). In Alternative 3, contaminants are actively removed from ground water through extraction and treatment. Alternatives 2 and 3 provide monitoring to determine the long-term effectiveness and permanence of the remedies.

7.2.4.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, natural attenuation of contaminants may result in the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. However there are no mechanisms included in this alternative for establishing the achievement of these goals.

Alternative 2 relies on natural attenuation to achieve the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. Alternative 3 actively removes contaminants from the subsurface and may reduce the volume and mobility of contaminants more rapidly. Both alternatives provide a monitoring component to ensure that contaminants in the subsurface are addressed.

7.2.4.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors. In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment system component of Alternative 3 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

Alternative 3 poses additional short-term exposure risks if tritiated water is brought to the surface during ground water extraction. Workers could be exposed during the operation and maintenance of the ground water treatment facility.

VOC concentrations may decrease below MCLs within 2-4 years through natural attenuation, regardless of other actions taken. Alternative 3 may lessen the time to reach MCLs. Tritium activities are well below MCLs. There are no MCLs for perchlorate, but concentrations currently exceed the State Action Level of 18 ppb. Because of the small size of the plume, dispersion alone may decrease the concentration of perchlorate to less than the Action Level within 15 years. Additional monitoring data will be presented in the Remedial Design report to refine this estimate.

7.2.4.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs and continuing administrative controls to prevent exposure.

Alternative 3 can be readily implemented although additional time, labor and expense would be necessary both in the short- and long-term to construct, operate and monitor the treatment system. Operation of the treatment system would require Waste Discharge Requirements (WDRs) from the RWQCB. In addition, provisions would need to be made to avoid impacting the integrity of the landfill cap during construction, as well as for worker safety during treatment system construction and operation, as an active small firearms shooting range is located in the vicinity.

7.2.4.7. Cost

The estimated present worth of the life-cycle costs for the Pit 6 Landfill OU alternatives range from no cost for Alternative 1 to $5,939,000 for Alternative 3. Costs are summarized in Table 7-1. Monitoring, modeling, and risk and hazard management costs were developed for Alternative 2. Capital and operation and maintenance (O&M) costs for the extraction and treatment facility, as wells as monitoring, and risk and hazard management costs, were developed for Alternative 3.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $2,377,000, which includes the cost to monitor and model the natural attenuation of contaminants in ground water to document the effectiveness of remedy in meeting RAOs and ARARs and determine when these goals are met.
- Alternative 3 costs exceed the costs of Alternative 2 by $3.6 million, which includes the capital and O&M costs for the ground water extraction and treatment system.

7.2.5. Analysis of Remedial Alternatives for the HE Process Area OU

This section presents the evaluation of how each of the two alternatives proposed for the HE Process Area OU address the first seven EPA criteria.

7.2.5.1. Evaluation of Alternative 1 – No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the HE Process Area OU, including monitoring and active remediation, would cease.

Alternative 1 may not be protective of human health or the environment because no active measures are taken to reduce contaminant concentrations in ground water within a reasonable timeframe. No water-supply wells are currently contaminated with VOCs, HE compounds, nitrate, or perchlorate originating from the HE Process Area.

Without active remediation, contaminant concentrations may remain above MCLs and any more stringent WQOs which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water, which may not be achieved in a reasonable timeframe.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.5.2. Evaluation of Alternative 2—No Further Action for VOCs and HE Compounds in Soil and Bedrock, Monitoring, Exposure Control, and Ground Water Extraction and Treatment

The objective of Alternative 2 is to meet RAOs by actively remediating ground water to the point where the beneficial uses of surface water (Spring 5) and ground water are restored and protected.

Alternative 2 uses exposure control methods and administrative controls to provide initial protection to human health and to ecological receptors. This alternative also provides additional protection to human health by restoring and protecting the beneficial uses of surface water in Spring 5 and ground water in the Tps, $Tnbs_1$, and $Tnbs_2$ water-bearing units through active remediation of contaminants in ground water.

Although no further action of VOCs and HE compounds in surface soil and subsurface soil and bedrock is proposed under Alternative 2, source control measures have already been implemented at the HE rinse water lagoons and HE Burn Pits to prevent further releases of contaminants to ground water. There is no risk or hazard to human health or ecological receptors posed by these contaminants in surface soil and subsurface soil/rock. VOCs and HE compounds released to ground water are addressed through extraction and treatment.

The baseline risk assessment identified a potential inhalation risk for VOCs in subsurface soil above health-based concentrations (1.4×10^{-6}) in the vicinity of Building 815. The risk calculation was based on soil concentrations nine to twelve years ago. The risk and hazard management component of Alternative 2 would prevent exposure by implementing construction restrictions in the vicinity of Building 815. In addition, risk and hazard models would be updated using current data to verify this assumption.

As there is no standing water present in Spring 5, risk and hazard management measures are not necessary at this time. Well W-817-03A, a shallow well located adjacent to Spring 5, would be sampled to monitor VOC concentrations and Spring 5 would be surveyed periodically for standing water. Risk and hazard management measures would be implemented if exposure risk and hazard becomes a problem in the future. As this spring is fed by ground water, the extraction and treatment of ground water would reduce contaminant concentrations in ground water and therefore, in the spring as well.

There are no existing exposure pathways for ground water with concentrations above MCLs. Ground water extraction at the site boundary is designed to prevent migration of the VOC plume into offsite water-supply wells.

A HI exceeding one for oral intake and inhalation for individual ground squirrels and deer was identified in the baseline risk assessment, however there is no unacceptable risk to the ground squirrel or deer populations as described in Sections 1.5.3.1 and 1.5.3.2.

The goal of Alternative 2 is to use active ground water remediation to meet all ARARs within a reasonable timeframe. The requirements of the Basin Plan, and SWRCB Resolutions 68-16 and 92-49 would be met by actively reducing VOC, HE compounds, perchlorate, and nitrate concentrations in ground water to MCLs, or WQOs, or below. Ground water extraction and treatment would be implemented at the Building 815, HE rinsewater lagoons, and HE Burn Pit source areas to reduce source mass. In addition, the ground water extraction and treatment system currently operating at the site boundary would continue to operate to control the offsite migration of the VOC plume. Carbon disulfide concentrations in ground water are currently below the analytical method detection limits. Monitoring for carbon disulfide would be continued to ensure continued compliance with ARARs. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence of the remedy.

The toxicity and volume of extracted VOCs, RDX, and perchlorate are eliminated by thermal regeneration of the aqueous-phase GAC. Biochemical processes in the bioreactor would reduce the toxicity and volume of nitrate. The migration of dissolved VOCs, RDX, nitrate, and perchlorate above the cleanup goals would be controlled by ground water extraction.

Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

Alternative 2 is implementable. Equipment, materials, and services necessary for implementing Alternative 2 are available. A ground water extraction and treatment system is currently operating at the site boundary as part of the Building 815 Removal Action. The operation of the ground water treatment systems for Alternative 2 would require WDRs from the RWQCB for the discharge of treated effluent.

The estimated present worth of the life-cycle costs for Alternative 2 is $27,621,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.6. Comparative Evaluation of Remedial Alternatives for the HE Process Area OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives presented for remediation of the HE Process Area OU with respect to the first seven EPA criteria.

7.2.6.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may not be protective of human health and the environment because no active measures are taken to reduce contaminant concentrations in ground water to health- and environmentally-protective levels. In addition, potential changes in plume concentration and size that could result in impacts to downgradient receptors would not be monitored or detected.

In Alternative 2, human health is protected from exposure to VOCs volatilizing from subsurface soil at Building 815 through the implementation of construction and/or use restrictions. Risk and hazard would be reevaluated using current data. Alternative 2 also provides measures to prevent exposure to VOCs volatilizing from Spring 5 until concentrations in the spring are reduced to health-protective levels through the extraction and treatment of ground water.

Alternative 2 mitigates risk to human health from potential ingestion of contaminated ground water through extraction and treatment of contaminated ground water at the Building 815, HE rinsewater lagoon, and HE Burn Pit source areas and in the downgradient portion of the plume. This alternative also includes measures to prevent exposure to contamination by human and ecological receptors while contaminant concentrations are being reduced, such as administrative controls to prevent access to contaminated ground water.

Alternative 2 includes measures to reduce contaminant concentrations and mass in ground water and surface water and prevent migration of the contaminant plumes, therefore would provide long-term and effective protection of human health and the environment.

7.2.6.2. Compliance with ARARs

In Alternative 1 (no action), concentrations of VOCs, HE compounds, nitrate, and perchlorate may remain above MCLs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

Alternative 2 includes active measures to reduce contaminant concentrations and mass in ground water and surface water to meet all ARARs within a reasonable timeframe. The remedial actions described in Alternative 2 can be designed and implemented in compliance with ARARs.

7.2.6.3. Long-Term Effectiveness and Permanence

Alternative 1 (no action) does not provide long-term effectiveness in meeting ARARs or permanently reduce COC concentrations.

Alternative 2 provides long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs through active remediation. This alternative also provides monitoring to determine the long-term effectiveness and permanence of the remedies.

7.2.6.4. Reduction of Toxicity, Mobility, and Volume

Alternative 1 does not remove COCs from the subsurface. Therefore, implementation of this alternative would not reduce the toxicity, mobility, or volume of the COCs.

In Alternative 2, remedial actions involve removing contaminants from ground water and adsorbing them to carbon. The toxicity of the contaminants would be reduced through the thermal destruction of these contaminants sorbed to GAC. Contaminant volume and mobility in ground water would be reduced irreversibly by source mass removal, contaminant concentration reduction, and plume control.

7.2.6.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors.

In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment system component of Alternative 2 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

Ground water and soil vapor extraction will reduce contaminant concentrations. Based on historic trends and expected effectiveness of pump and treat technology, it may take between 25 and 30 years for ground water contaminants to fall below MCLs or any more stringent WQOs. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

7.2.6.6. Implementability

No actions would be necessary to implement Alternative 1.

The treatment technologies incorporated into Alternative 2 are well proven and have been identified as presumptive technologies for VOCs in ground water. The implementation of this alternative would require the construction and operation of extraction and treatment systems at the Building 815, HE rinsewater lagoon, and HE Burn Pit source areas. The ground water extraction and treatment system at the site boundary to control offsite plume migration is already in place and operating. The operation of the ground water treatment systems for Alternative 2 would require WDRs from the RWQCB for the discharge of treated effluent.

7.2.6.7. Cost

The estimated present worth of the life-cycle costs for the HE Process Area OU alternatives range from no cost for Alternative 1 to $27,621,000 for Alternative 2. Costs are summarized in Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs exceed the costs of Alternative 1 by $27.6 million which includes the costs for monitoring, risk and hazard management, and the capital and operation and maintenance (O&M) costs for the extraction and treatment facilities.

7.2.7. Analysis of Remedial Alternatives for the Pit 7 Complex Subarea, Building 850/Pits 3 & 5 OU

This section presents the evaluation of how each of the three alternatives proposed for the Pit 7 Complex address the first seven EPA criteria. The Pit 7 Complex subarea includes Pits 3, 4, 5, and 7.

7.2.7.1. Evaluation of Alternative 1 – No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Pit 7 Complex subarea, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment as without monitoring of the ground water COC plumes, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with VOCs, tritium, uranium-238, nitrate, or perchlorate originating from the Pit 7 Complex.

Alternative 1 does not meet the RAO of preventing potential inhalation of tritium by onsite workers above health-based concentrations in the vicinity of Pit 3. Fencing and full-time security patrols are in place that effectively prevent public access to the plume and source areas. There was no unacceptable risk or hazard to ecological receptors in the Pit 7 complex identified in the baseline risk assessment.

This alternative may meet State and Federal chemical-specific ARARs if natural attenuation acts to reduce contaminant concentrations in ground water to MCLs, any more stringent WQOs, or below within a reasonable timeframe. Without source control for Pits 3 and 5, contaminant concentrations may remain above MCLs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water. It is possible that without source control measures for Pits 3 and 5, this may not be achieved in a reasonable timeframe.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.7.2. Evaluation of Alternative 2—No Further Action for Tritium and Uranium-238 in Surface Soils outside of Pits 3 and 5, Monitoring, Exposure Prevention, Monitored Natural Attenuation of Tritium and Uranium in Ground Water, Waste Characterization with Contingent Monitoring, Capping, and/or Excavation, and Optional Plume Migration Control (option 2b)

Alternative 2 has two options: (1) Alternative 2a, which does not include the plume migration control; and (2) Alternative 2b, which provides plume migration control by installing a subsurface reactive barrier. The objective of Alternative 2a is to meet RAOs and ARARs by:

1. Providing risk and hazard management measures to prevent exposure of humans and ecological receptors in the short-term,
2. Monitoring COCs in ground water to: (a) track changes in plume concentrations/activities to evaluate the effectiveness of source control measures and the natural attenuation of contaminants in ground water to health- and environmentally protective levels, (b) to ensure there is no impact to downgradient receptors, and (c) ensure that State and Federal chemical-specific ARARs are met within a reasonable timeframe.
3. Evaluating potential impacts to human health and the environment through characterization of the pit waste, and
4. Providing for active source control measures for Pits 3 and 5 to prevent further releases of contaminants from the pits and mitigate inhalation risk to onsite workers.

Alternative 2b has the additional objective of limiting the migration of uranium.

No risk or hazard associated with tritium and uranium in surface soil in the Pit 7 Complex has been identified. VOC concentrations in ground water have steadily decreased to near or below MCLs and continue to decline. The monitoring of VOCs in ground water would continue to detect any changes that could impact human health or the environment.

Given the short half-life of tritium, once the tritium source has been quantified and controlled, monitored natural attenuation of tritium may reduce activities in ground water and surface water to meet RAOs and achieve State and Federal chemical-specific ARARs within a reasonable timeframe as discussed in Section 6.4.1.2.4 of Chapter 6. Ground water in this area is not used as a drinking water supply. Modeling of tritium fate and transport in ground water from the Pits 3 and 5 area predicted that without further releases from the pits, tritium activities would decrease to the drinking water standard of 20,000 pCi/L after 46 years without impacting ground water offsite above background activities. Monitored natural attenuation for tritium would also prevent incurring risks associated with extracting tritiated ground water and bringing it to the surface for treatment. As discussed in Chapter 3, there are currently no effective or reasonable technologies available to remediate tritiated ground water.

If further releases of uranium are prevented through source control measures, natural attenuation would eventually reduce uranium activities in ground water to below the MCL of 20 pCi/L. There is currently no risk associated with uranium in ground water, as there are no existing receptors.

Although uranium has an extremely long half-life, it sorbs readily to subsurface material, reducing its mobility. Uranium fate and transport were modeled in the SWRI Addendum, demonstrating that uranium would not reach the site boundary at concentrations greater than the MCL. DOE/LLNL has recently updated the model using the current highest activities recorded to evaluate the possible migration of uranium along the alluvial channel (the pathway with the greatest concern). Modeling predicts that the 20 pCi/L contour will not extend more than about 600 feet beyond its present extent, and all uranium activities in the area may diminish to below 20 pCi/L in about 60 years. Attenuation results primarily from sorption and dispersion. Modeling will be updated and discussed in the Remedial Design report.

The monitoring and continued modeling of tritium and uranium in ground water would help to determine any changes in tritium or uranium activities or plume size that could impact human health and warrant more active remedial measures.

In the baseline risk assessment, an inhalation risk of 4×10^{-6} to adult onsite workers was identified for tritium evaporating from subsurface soil to the ambient air in the vicinity of the Pit 3 Landfill. There are currently no active facilities located in the vicinity and the landfill was closed to use in 1967. Since there are no manned facilities in this area, there is no exposure pathway for tritium volatilizing from subsurface soil into air to affect workers. In addition, in 1992, a landfill cover was installed on Pit 7 which is adjacent to Pit 3. Approximately 40% of the Pit 3 landfill was covered during the capping of Pit 7. Air sampling for tritium will be conducted for at least two years until measured activities are determined to cause no significant risk. Exposure control measures would be implemented in the area to prevent inhalation risk in the event that land usage changes occur in the vicinity of Pit 3 that would result in exposure to onsite workers.

No risk or hazard to ecological receptors has been identified in the Pit 7 Complex area.

The remedial measures presented in Alternative 2a should provide adequate protection of human health and the environment by preventing exposure to contaminants while source control measures prevent future impacts to the environment, and natural attenuation of tritium and uranium-238 reduces activities in ground water to health-protective levels. Monitoring would be used to detect changes that could impact human health and the environment and demonstrate the effectiveness of the remedial measures in reducing contaminant levels to meet State and Federal chemical-specific ARARs in a reasonable timeframe. The Site 300 Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs. Monitoring would be continued after State and Federal chemical-specific ARARs are achieved to ensure long-term effectiveness and permanence.

Alternative 2b includes all of the protections of Alternative 2a, and adds an *in situ* reactive barrier to limit the migration of uranium in ground water.

The natural attenuation of tritium and uranium-238 in ground water would achieve a long-term reduction in toxicity, mobility, and volume of tritium and uranium in the subsurface. The excavation component of Alternatives 2a and 2b would reduce the mobility of the contaminants by removing any waste constituting a significant source, thus preventing further leaching of contaminants to the subsurface. It would not reduce the toxicity or volume of the contaminants as the waste would be redeposited at a different location. Source control measures have already been implemented at Pits 4 and 7 through the installation of a pit cap and drainage diversion system in 1992.

The *in situ* reactive barrier included in Alternative 2b would reduce the mobility of uranium by sorbing it onto reactive materials within the barrier which can be removed, as necessary. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during the installation of the *in situ* barrier. Additional short-term, and possibly long-term exposure risks are posed by the handling and storage or disposal of uranium-contaminated materials. Exposure control measures would be needed to prevent exposure during off-site disposal.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. There would be minimal impact to onsite workers during characterization and monitoring activities. Workers would follow Site 300 operational procedures to mitigate potential risks that may be posed in the course of characterization and monitoring activities. A much higher level of exposure controls would be necessary to prevent short-term exposure of onsite workers and ecological receptors during excavation. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location. This would likely increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Disposal off-site would entail transportation on public highways, and the associated risks. DOE/LLNL would employ its hazardous waste transportation procedures to mitigate those risks.

A health and safety plan would be developed prior to excavation of the pit waste to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during pit excavation. Biological resource surveys are conducted prior to any ground disturbing activities at Site 300 to ensure there are no impacts to ecological receptors.

All of the Alternatives 2a and 2b remedial components for the Pit 7 Complex can be implemented. Many of the exposure control methods are already in place. Monitoring can be implemented easily, although the installation of additional monitor wells may be necessary. The implementability of the *in situ* reactive barrier component of Alternative 2b is limited by: (1) significant engineering challenges to install the barrier in unconsolidated alluvium and bedrock, (2) the removal and replacement of spent materials in the subsurface barriers, and (3) permitting requirements for the long-term storage or disposal of uranium-contaminated materials.

Characterization can be fairly easily implemented depending on the extent of characterization required. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste, as well as resolution of potential disposal issues.

The costs to implement either Alternative 2a or 2b are dependent on the characterization results and remedial measure selected. The estimated present worth of the life-cycle costs for the remedial measures presented in Alternative 2a ranges from $3,186,000 if the excavation option is not implemented to $50,282,000, which includes total excavation of the pit waste and disposal at a commercial off-site facility. The estimated present worth of the life-cycle costs for the remedial measures presented in Alternative 2b ranges from $7,527,000 if the excavation option is not implemented to $54,623,000.

Characterization data may indicate that only partial excavation of the waste would be necessary to protect human health and the environment and prevent further impacts to ground water. The costs of partial excavation are presented in Appendix D. If large volumes of waste are excavated, placement of the waste in an on-site engineered containment unit may be more cost-effective than off-site disposal. Siting, design, and approval issues, discussed in Section C-2.7 of Appendix C may significantly impact the time, resources, and cost necessary to implement an on-site disposal option.

The upcoming Focused Feasibility Study for this subarea shall include the evaluation of *in situ* stabilization which may mitigate or eliminate all or most of the negative impacts discussed above.

The costs to implement Alternatives 2a and 2b are summarized in Table 7-1. The costs of the modules used to assemble Alternatives 2a and 2b are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.7.3. Evaluation of Alternative 3—No Further Action for Tritium and Uranium-238 in Surface Soils, Monitoring, Exposure Prevention, Monitored Natural Attenuation of Tritium in Ground Water, Plume Migration Control, and/or Waste Characterization with Contingent Monitoring, Capping, or Excavation

The objective of Alternative 3 is to meet RAOs and ARARs by:

1. Providing risk and hazard management measures to prevent exposure of humans and ecological receptors in the short-term,
2. Monitoring COCs in ground water to track changes in plume concentrations/activities to evaluate the effectiveness of the natural attenuation of tritium in ground water to health- and environmentally protective levels and to ensure there is no impact to downgradient receptors,
3. Extracting and treating ground water to reduce the concentrations/activities of VOCs, uranium, and nitrate to levels protective of human health and the environment,

4. Installing an *in situ* permeable reactive barrier to prevent further migration of the uranium plume in ground water and remove contaminants trapped by iron filings or other reactive materials,
5. Providing for active source control measures for Pits 3 and 5 to prevent further releases of contaminants from the pits and mitigate inhalation risk to onsite workers.

No risk or hazard associated with tritium and uranium in surface soil in the Pit 7 complex has been identified. Ground water in this area is not currently used as a drinking water supply. No risk or hazard to ecological receptor populations has been identified in the Pit 7 Complex area.

The remedial measures presented in Alternative 3 should provide adequate protection of human health and the environment by preventing exposure to contaminants while the natural attenuation of tritium and extraction and/or treatment of VOCs, uranium, and nitrate reduces concentrations/activities in ground water to health-protective and ARAR-compliant levels. Monitoring would be used to demonstrate the effectiveness of the remedial measures in reducing contaminant levels to meet State and Federal chemical-specific ARARs in a reasonable timeframe. The Site 300 Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs. Monitoring would be continued after ARARs are achieved to ensure long-term effectiveness and permanence.

The irreversible decay of tritium in ground water would achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. The extraction and treatment of ground water would reduce the volume and mobility of VOCs, uranium, and nitrate in ground water. The thermal regeneration of the aqueous-phase GAC would permanently reduce the toxicity and volume of VOCs. The toxicity and volume of nitrate would be reduced through biochemical processes in the bioreactor. Because the uranium collected in the resins used for ion exchange is not destroyed, radioactive decay would be relied upon to reduce the toxicity and volume of the uranium removed from ground water. Use of an *in situ* reactive barrier would limit the migration of uranium, and allow for removal of contaminants collected in the barrier material.

If further releases of uranium are prevented through source control measures, natural attenuation would eventually reduce uranium activities in ground water to below the MCL of 20 pCi/L. Although uranium has an extremely long half-life, it sorbs readily to subsurface material, reducing its mobility. As described in Section 7.2.7.2. modeling results predict that the 20 pCi/L contour will not extend more than about 600 feet beyond its present extent, even without the *in situ* reactive barrier, and all uranium activities in the area should diminish to below 20 pCi/L in about 60 years. Modeling will be updated and discussed in the Remedial Design report.

The excavation component of Alternative 3 would reduce the mobility of the contaminants by removing any waste constituting a significant source, thus preventing further leaching of contaminants to the subsurface. It would not reduce the toxicity or volume of the contaminants as the waste would be redeposited at a different location. Source control measures have already been implemented at Pits 4 and 7 through the installation of a pit cap and drainage diversion system in 1992.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during the installation of the extraction and treatment system and the *in situ* barrier, and while performing system operation and maintenance, drilling, or monitoring. Additional short-term, and possibly long-term exposure risks are posed by the handling and storage or disposal of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until uranium activities decayed to health-protective levels. Short-term exposure risk would also increase if tritiated ground waters were brought to the surface during ground water extraction.

There would be minimal impact to onsite workers not involved in the actual restoration work during characterization and monitoring activities. Restoration workers would follow Site 300 operational procedures to mitigate potential risks that may be posed in the course of characterization and excavation activities. Additional short-term exposure risks to on-site restoration workers are posed by the characterization and excavation activities. Extensive exposure control measures would be needed to prevent exposure of restoration workers during characterization and excavation activities. Additional exposure controls may be necessary to prevent short-term exposure of all onsite workers and ecological receptors during excavation. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location. This would likely increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Disposal off-site would entail transportation on public highways, and the associated risks. DOE/LLNL would employ its hazardous waste transportation procedures to mitigate those risks.

Prior to excavation of the pit waste, a health and safety plan would be developed to protect the health of restoration workers who will enter the exclusion zone or be nearby during the excavation. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during pit excavation. Biological resource surveys are conducted prior to any ground disturbing activities at Site 300 to ensure there are no impacts to ecological receptors.

The monitoring component of Alternative 3 is readily implementable, as most of the monitoring network is already in place. Site control measures are also in place, but additional exposure controls would need to be evaluated and implemented, as necessary. The ground water and soil vapor extraction and treatment portion of Alternative 3 is implementable. The operation of the *ex situ* ground water treatment system would require WDRs from the RWQCB for the discharge of treated effluent. The implementability of the *in situ* reactive barrier component of Alternative 3 is limited by: (1) significant engineering challenges to install the barrier in unconsolidated alluvium and bedrock, and 2) the removal and replacement of spent materials in the subsurface barriers.

Characterization can be implemented but extensive provisions to ensure restoration worker safety would be required. Excavation of landfill waste would require additional provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste, as well as resolution of potential disposal issues.

The upcoming Focused Feasibility Study for this subarea shall include the evaluation of *in situ* stabilization which may mitigate or eliminate all or most of the negative impacts discussed above.

The estimated present worth of the life-cycle costs for Alternative 3 ranges from $16,655,000, to $64,748,000, depending on the amount of excavation. The costs to implement Alternative 3 are summarized in Table 7-1. The cost of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.8. Comparative Evaluation of Remedial Alternatives for the Pit 7 Complex Subarea, Building 850/Pits 3&5 OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Pit 7 Complex with respect to the first seven EPA criteria.

7.2.8.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may not be protective of human health or the environment as without monitoring of the ground water COC plumes, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with VOCs, tritium, uranium-238, nitrate, or perchlorate originating from the Pit 7 Complex.

Alternative 1 does not met the RAO of preventing potential inhalation of tritium by onsite workers above health-based concentrations in the vicinity of Pit 3. Fencing and full-time security patrols are in place that effectively prevent public access to the plume and source areas, but there are currently no controls in-place to prevent exposure to onsite workers. However, because the Pit 3 Landfill is relatively remote and there are no people routinely working at or near the landfill, exposure controls are not necessary at this time. There was no unacceptable risk or hazard to ecological receptors in the Pit 7 complex identified in the baseline risk assessment.

Alternatives 2 (a and b) and 3 address risk to human health from potential ingestion of contaminated ground water and inhalation of tritium fluxing from subsurface soil/rock. Both alternatives include the same measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced, such as administrative controls to prevent access to contaminated ground water.

Alternatives 2 (a and b) and 3 include measures to reduce contaminant concentrations and mass in ground water and monitor for changes that could impact human health and the environment. The monitored natural attenuation component of Alternatives 2 (a and b) and 3 includes monitoring and modeling of contaminant fate and transport in ground water that would help to determine any changes in contaminant activities or plume size that could impact human health and warrant more active remedial measures. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

The excavation component of Alternatives 2 (a and b) and 3 would provide additional long-term protection for human health and the environment by removing the contaminant source thereby mitigating tritium inhalation risk and reducing the chances of further releases to ground water. Exposure potential for workers will increase during excavation and disposal. Off-site disposal would entail risks associated with transport of potentially hazardous materials on public roads. If on-site disposal is chosen, delays in siting, design, and approval would potentially allow further releases during the extra time required for the process.

7.2.8.2. Compliance with ARARs

Alternative 1 (no action) may not meet ARARs. Natural attenuation would act to reduce contaminant concentrations, however without source control or active remediation, contaminant concentrations may not be reduced to MCLs or lower.

Alternatives 2 (a and b) and 3 include measures to meet State and Federal ground water chemical-specific ARARs by reducing contaminant concentrations/activities to MCLs, any more stringent WQOs, or below. These alternatives provide for source control measures to prevent further releases of contaminants to the subsurface. Alternative 2a relies entirely on natural attenuation to reduce the concentrations/activities and mass of existing contaminants in ground water to meet State and Federal chemical-specific ARARs within a reasonable timeframe. Alternative 2b prevents further migration of uranium above the MCL, reducing the future extent of their plumes in ground water. Data indicate that tritium is naturally attenuating and should meet ARARs in a reasonable timeframe if source control measures are implemented.

Alternative 3 provides measures to actively reduce contaminant concentrations/activities and mass in ground water to meet ARARs. Both Alternatives 2 and 3 include source control, however Alternative 3 may reduce the migration pathway in ground water by as much as 500 feet.

7.2.8.3. Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness in meeting ARARs or permanently reducing contaminant concentrations. Alternatives 2 (a and b) and 3 provide long-term effectiveness through the control of the contaminant source and the natural attenuation of contaminants in ground water. Alternative 2b and 3 would also control the migration of uranium and, as barrier materials with sorbed uranium are removed, reduce the mass of uranium in the ground water. Alternative 3 would additionally reduce contaminant mass and concentrations in ground water by active pumping.

7.2.8.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, the natural attenuation of contaminants may result in the long-term reduction of toxicity, mobility, and volume of contaminants if further releases do not occur.

Alternatives 2 (a and b) and 3 rely on the monitored natural attenuation of tritium in ground water to achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. Alternative 2a relies on degradation and decay to reduce the toxicity, mobility, and volume of VOCs and uranium in ground water. Alternative 2b employs an *in situ* reactive barrier to limit the mobility of uranium by sorbing it onto the barrier materials. Removal of the spent barrier materials would reduce the volume of uranium in the subsurface. The excavation component of Alternatives 2 (a and b) and 3 would reduce the mobility of the contaminants by removing the waste, thus preventing further leaching of contaminants to the subsurface.

Excavation would not reduce the toxicity or volume of the contaminants, as the waste would be redeposited at a different location.

The extraction and treatment of VOCs, uranium, and nitrate in ground water of uranium in Alternative 3 would reduce the volume and mobility of the contaminants in ground water. The thermal regeneration of the aqueous-phase GAC would permanently reduce the toxicity and volume of VOCs. Biochemical processes in the bioreactor would reduce the toxicity and volume of nitrate. Because the uranium collected in the resins used for ion exchange are not destroyed, radioactive decay would be relied upon to reduce the toxicity and volume of the uranium removed from ground water.

7.2.8.5. Short-Term Effectiveness

Since there would be no remediation-related construction or monitoring occurring in Alternative 1, there would be no short-term impact to human or ecological receptors.

Alternatives 2 (a and b) and 3 have the potential for short-term exposure for onsite workers during implementation of the remedial measures.

In Alternative 2 (a and b) and 3, there would be minimal impact to onsite workers during characterization and monitoring activities. The potential for short-term exposure for onsite workers and ecological receptors would be possible in the excavation component. This is likely to increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Off-site disposal would require transport of potentially hazardous materials over public roads, whereas disposal of waste in an on-site containment unit would only involve movement of this material within the site boundaries. Construction of an on-site containment unit may impact ecological habitat and its inhabitants.

Alternatives 2b and 3 slightly increase the exposure risks for workers while installing the *in situ* reactive barrier and removing contaminated barrier materials. Operational safety plans would minimize those risks, however exposure control measures may be needed to prevent exposure to materials containing uranium until they are safely disposed.

Alternative 3 poses short-term and possibly long-term exposure risk to onsite workers as contaminants, including VOCs, uranium, and potentially tritium, would be brought to the surface. Workers could be exposed during the installation, operation and maintenance of the treatment systems and the handling and storage of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the uranium is safely disposed.

The waste characterization component of Alternatives 2 (a and b) and 3 would determine if residual tritium in the vadose zone constitutes a significant continuing source, or locate the potential sources which could be excavated to actively reduce tritium activities. Without an active source, MNA should reduce tritium to below MCLs in less than 90 years assuming no additional releases. Other factors (dispersion, dilution) may reduce activities more rapidly. Tritium activities would not be reduced significantly faster by employing a pumping and re-injection strategy. VOCs are already below MCLs and perchlorate is below the State Action Level. Modeling will be updated and discussed in the Remedial Design report.

Uranium-238 sorbs readily to subsurface soil particles. This means that the potential for significant migration in the ground water is reduced, so that MCLs may be attained through sorption and dispersion. Modeling predicts that all uranium activities will be below the MCL in about 60 years. The use of an *in situ* reactive barrier (Alternatives 2b and 3) may not significantly reduce the time to reach MCLs, but should reduce the extent of the plume.

The high sorption of uranium also reduces the efficiency and time for attaining MCLs by ground water extraction (Alternative 3), as much of the uranium will sorb onto the geologic materials, delaying complete cleanup. Active pumping is likely to achieve MCLs somewhat faster, but in neither case are uranium activities greater than MCLs predicted to extend off site or to any known exposure pathway.

7.2.8.6. Implementability

No actions would be necessary to implement Alternative 1.

The monitoring components of Alternatives 2 (a and b) and 3 can be implemented easily. Most of the monitoring network is already in-place, although the installation of additional monitor wells may be necessary. Site control measures are also in-place but additional exposure controls would need to be evaluated and implemented, as necessary.

The waste characterization component of Alternatives 2 (a and b) and 3 can be fairly easily implemented depending on the extent of characterization required. The excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste, as well as resolution of potential disposal issues. Waste disposal in an on-site containment unit would further require a siting, design, and approval process, with stakeholder input, which could significantly impact time, resources, and cost to implement on on-site disposal option.

The implementability of the *in situ* reactive barrier component of Alternatives 2b and 3 is limited by: (1) significant engineering challenges to install the barrier in unconsolidated alluvium and bedrock, (2) the removal and replacement of spent materials in the subsurface barriers, and (3) permitting requirements for the long-term storage of uranium-contaminated materials. The *in situ* reactive barrier may require WDRs designed to ensure that residual materials or byproducts protect beneficial uses of ground water.

The implementation of ground water extraction and treatment (Alternative 3) is limited by the likelihood of extracting tritium along with the other contaminants. The operation of the *ex situ* ground water treatment system for Alternative 3 would require WDRs from the RWQCB for the discharge of treated effluent. Reinjection would require assurance that it would not increase the plume migration or enlarge the plume.

7.2.8.7. Cost

The estimated present worth of the life-cycle costs for the Pit 7 Complex alternatives range**s** from no cost for Alternative 1 to $64,748,000 for Alternative 3. Costs are summarized in Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.

- Alternative 2a costs range from $3,189,000 for exposure controls**,** monitoring of the pits, and characterization, to $50,282,000 for the exposure controls, characterization, monitoring, and total excavation and off-site disposal of the waste in both pits. Selective removal of a portion of the waste, and/or on-site consolidation (as opposed to off-site disposal) could reduce the actual costs substantially.
- Alternative 2b costs range from $7,530,000 for exposure controls, monitoring of the pits, *in situ* reactive barrier, and characterization, to $54,623,000 for the exposure controls, *in situ* reactive barrier, characterization, monitoring, and total excavation and off-site disposal of the waste in both pits. Selective removal of a portion of the waste, and/or on-site consolidation (as opposed to off-site disposal) could reduce the actual costs substantially.
- Alternative 3 costs range from $16,655,000, which includes the costs for: (1) monitoring and modeling, (2) risk and hazard management, (3) the extraction and treatment of VOCs, nitrate, and uranium in ground water, (4) an *in situ* permeable reactive barrier wall to remove uranium from ground water, and (5) waste characterization, to $64,748,000, for all of the above plus total excavation and off-site disposal of the waste in both pits.

7.2.9. Analysis of Remedial Alternatives for the Building 850 Subarea, Building 850/Pits 3&5 OU

This section presents the evaluation of how each of the four alternatives proposed for the Building 850 subarea address the first seven EPA criteria.

7.2.9.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 850 subarea, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment, for without monitoring of the ground water COC plumes, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with tritium, uranium-238, or nitrate originating from the Building 850 area.

Alternative 1 does not meet the RAO of preventing potential incidental ingestion and direct dermal contact with surface soils contaminated with PCBs, dioxins, and furans by onsite workers above health-based concentrations in the vicinity of the Building 850 firing table. Fencing and full-time security patrols are in place that effectively prevent public access to the plume and source areas. Alternative 1 may be protective of ecological receptors, as the baseline risk assessment determined that there was no unacceptable risk or hazard to the plants or animal populations in the area.

This alternative may meet ARARs if natural attenuation acts to reduce contaminant concentrations in ground water to MCLs, WQOs, or below thus meeting the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49. Tritium activities in ground water may naturally attenuate to meet ARARs in a reasonable timeframe.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.9.2. Evaluation of Alternative 2—Monitoring, Exposure Prevention, Monitored Natural Attenuation of Tritium, and Sandpile/Soil Removal

The objective of Alternative 2 is to meet RAOs and ARARs by:

1. Providing risk and hazard management measures to prevent exposure of humans and ecological receptors in the short-term,
2. Monitoring COCs in ground water to track changes in plume concentrations/activities to evaluate the effectiveness of source control measures and the natural attenuation of contaminants in ground water and surface water to health- and environmentally protective levels, as well as to ensure there is no impact to downgradient receptors,
3. Mitigating risk to onsite workers through the removal of PCB, dioxin, and furan-contaminated surface soil, and
4. Removal of the tritium-contaminated sandpile in the vicinity of Building 850 to prevent further releases to ground water.

No risk or hazard associated with tritium and uranium in subsurface soil/rock in the Building 850 area has been identified. Ground water in this area is not used as a drinking water supply therefore there is no current risk from ingestion of contaminated ground water. Modeling of tritium fate and transport in ground water from Building 850 predicted that tritium activities will decrease to the drinking water standard of 20,000 pCi/L after 45 years without impacting ground water offsite above the MCL. The modeling results were based on health-conservative assumptions assuming a continuous tritium point source located beneath the Building 850 firing table. Data indicate that a diminishing source is present at Building 850, and the continuing decay of tritium may result in the attainment of ARARs in a reasonable timeframe.

The maximum uranium-238 activity in ground water at Building 850 in 1998 was 3.96 pCi/L, which is below the MCL and background levels for total uranium. Uranium activities in ground water would continue to be monitored to detect any changes in activities that could impact human health or the environment.

The remedial measures presented in Alternative 2 should provide adequate protection of human health and the environment by preventing exposure to contaminants while source control measures prevent future impacts to the environment, and natural attenuation of tritium reduces activities in ground water to health-protective levels. Monitoring would be used to detect changes that could impact human health and the environment and demonstrate the effectiveness of the remedial measures in reducing contaminant levels to meet ARARs. The Site 300

Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs.

The radioactive decay of tritium is irreversible and hence effective in the long-term and permanent. The removal of contaminated surface soil and the sandpile would permanently prevent further releases of COCs to ground water, and provide long-term prevention of exposure to surface soils containing PCBs, dioxins, and furans. Monitoring would be conducted after ARARs have been achieved to ensure long-term effectiveness and permanence.

The monitored natural attenuation of tritium in ground water would achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. Historical data also indicated that the toxicity, mobility, and volume of uranium in ground water is decreasing over time. The steadily declining activities of tritium and uranium in ground water indicate that the toxicity, mobility, and volume of tritium and uranium in subsurface soil has been reduced over time. The removal of contaminated soil and the sandpile would reduce the mobility of contaminants, but would not affect the toxicity or volume of the contaminants.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. There would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures and use personal protective equipment and clothing, if necessary, to mitigate potential risks that may be posed in the course of the surface soil and sandpile removal. Access control measures would be implemented, if necessary, to prevent inhalation exposure at Well 8 Spring until tritium activities attenuate to health-protective levels. Biological resource surveys would be conducted prior to any removal activities to ensure there are no impacts to ecological receptors.

All of the Alternative 2 remedial components for the Building 850 subarea can be implemented. Many of the exposure control methods are already in place. Monitoring can be implemented easily as the monitoring network already exists. As the volume of contaminated soil and sandpile to be removed is relatively small (1,260 yd^3), this component should be fairly easy to implement. Significant deviations from this estimated volume would affect the degree of difficulty in implementing this component of Alternative 2. As the material to be removed is assumed to be mixed waste, a suitable, permitted disposal facility would need to be located or obtained.

The estimated present worth cost of the life-cycle costs for Alternative 2 is $4,029,000. The costs to implement Alternative 2 are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.9.3. Evaluation of Alternative 3—Monitoring, Exposure Prevention, Monitored Natural Attenuation of Tritium, Sandpile/Soil Removal, and Soil/Rock Excavation

Alternative 3 includes the following components of Alternative 2 to meet RAOs and ARARs:

1. Providing risk and hazard management measures to prevent exposure of humans and ecological receptors in the short-term,

2. Monitoring COCs in ground water to track changes in plume concentrations/activities to evaluate the effectiveness of source control measures and the natural attenuation of contaminants in ground water and surface water to health- and environmentally protective levels, as well as to ensure there is no impact to downgradient receptors,
3. Mitigating risk to onsite workers through the removal of PCB, dioxin, and furan-contaminated surface soil, and
4. Removal of the tritium-contaminated sandpile in the vicinity of Building 850 to prevent further releases to ground water.

In addition, Alternative 3 includes excavation of subsurface soil and bedrock contaminated with tritium and uranium in the vicinity of the Building 850 firing table. Although no risk or hazard has been identified associated with these contaminants in subsurface soil or rock, this action may prevent future releases to ground water.

The remedial measures presented in Alternative 3 should provide protection of human health and the environment by preventing exposure to contaminants while source control measures prevent future impacts to the environment, and natural attenuation of tritium reduces activities in ground water to health-protective levels. Monitoring would be used to detect changes that could impact human health and the environment and demonstrate the effectiveness of the remedial measures in reducing contaminant levels to meet ARARs. The Site 300 Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs.

The radioactive decay of tritium is irreversible and hence effective in the long-term and permanent. The removal of contaminated surface soil, subsurface soil/rock and the sandpile would permanently prevent further releases of COCs to ground water, and provide long-term prevention of exposure to surface soils containing PCBs, dioxins, and furans. Monitoring would be conducted after ARARs have been achieved to ensure long-term effectiveness and permanence.

The monitored natural attenuation of tritium in ground water would achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. Historical data also indicated that the toxicity, mobility, and volume of uranium in ground water is decreasing over time. The steadily declining concentrations of tritium and uranium in ground water indicate that the toxicity, mobility, and volume of tritium and uranium in subsurface soil have been reduced over time. The removal of contaminated surface soil, subsurface soil/rock and the sandpile would reduce the mobility of contaminants, but would not affect the toxicity or volume of the contaminants.

All exposure controls described in Alternative 2, would be applied during the implementation of Alternative 3 to prevent exposure of onsite workers and ecological receptors in the short-term. Additional short-term exposure risks to onsite workers posed by the subsurface soil/rock excavation component of Alternative 3, would require a higher level of exposure control measures to be implemented.

All of the Alternative 3 remedial components for the Building 850 subarea can be implemented. Many of the exposure control methods and the monitoring network are already in place. As discussed in Alternative 2, the removal of contaminated soil and sandpile should be fairly easy to implement. Additional engineering and logistical difficulties are posed by the excavation of subsurface soil and bedrock at Building 850. The primary difficulties in excavating beneath the Building 850 Firing Table are: (1) excavating bedrock in areas of steep terrain is extremely difficult, (2) this firing table is currently active and in use for high explosive experiments, and (3) there are a number of subsurface conduits for diagnostic equipment that would have to be avoided or removed/replaced during excavation.

The estimated present worth cost of the life-cycle costs for Alternative 3 is $8,264,000. The costs to implement Alternative 3 are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.9.4. Evaluation of Alternative 4—Monitoring, Exposure Prevention, Monitored Natural Attenuation of Tritium, Ground Water Extraction and Treatment, Uranium Plume Migration Control, Sandpile/Soil Removal, and Soil/Rock Excavation

Alternative 4 includes the following components of Alternative 3 to meet RAOs and ARARs:

1. Providing risk and hazard management measures to prevent exposure of humans and ecological receptors in the short-term,
2. Monitoring COCs in ground water to track changes in plume concentrations/activities to evaluate the effectiveness of source control measures and the natural attenuation of tritium in ground water and surface water to health- and environmentally protective levels, as well as to ensure there is no impact to downgradient receptors,
3. Mitigating risk to onsite workers through the removal of PCB, dioxin, and furan-contaminated surface soil,
4. Removing tritium-contaminated sandpile in the vicinity of Building 850 to prevent further releases to ground water, and
5. Excavating subsurface soil and bedrock contaminated with tritium and uranium to prevent further releases to ground water.

Alternative 4 also includes the extraction and treatment of uranium and nitrate in ground water at the source area and downgradient of Building 850 and the installation of an *in situ* reactive permeable barrier to reduce contaminant concentrations and mass to meet RAOs and achieve compliance with ARARs.

Alternative 4 should provide protection of human health and the environment by preventing exposure to contaminants while source control measures prevent future impacts to the environment, and natural attenuation of tritium, extraction/treatment and *in situ* treatment of uranium reduces activities in ground water to health-protective levels and to meet ARARs within a reasonable timeframe. Monitoring would be used to detect changes that could impact human health and the environment and demonstrate the effectiveness of the remedial measures in reducing contaminant levels to meet ARARs. The Site 300 Contingency Plan will include actions to be implemented in the event that these measures do not achieve RAOs or compliance with ARARs.

In situ treatment, coupled with ground water extraction, would provide long-term effectiveness by permanently removing uranium and nitrate from ground water. The radioactive decay of tritium is irreversible and hence effective in the long-term and permanent. The removal of contaminated surface soil, subsurface soil/rock and the sandpile would permanently prevent further releases of COCs to ground water, and provide long-term prevention of exposure to surface soils containing PCBs, dioxins, and furans. Monitoring would be conducted after ARARs have been achieved to ensure long-term effectiveness and permanence.

The irreversible decay of tritium in ground water would achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. The extraction and treatment of ground water and *in situ* treatment would reduce the volume and mobility of the contaminants in ground water. The thermal regeneration of the aqueous-phase GAC would permanently reduce the toxicity and volume of VOCs. The toxicity and volume of nitrate would be reduced through biochemical processes in the bioreactor. Because the uranium collected in the resins used for ion exchange are not destroyed, radioactive decay would be relied upon to reduce the toxicity and volume of the uranium removed from ground water.

All exposure controls described in Alternative 3 would be applied during the implementation of Alternative 4 to prevent exposure of onsite workers and ecological receptors in the short-term. Workers would use appropriate protective procedures, clothing and equipment to prevent the possibility of exposure during the installation of the treatment system and reactive barrier and while performing treatment system operation and maintenance. The extraction and treatment and *in situ* treatment of contaminants in Alternative 4 could significantly increase short-term exposure risk as uranium-contaminated, and potentially tritiated, ground water would be brought to the surface. Additional short-term, and possibly, long-term exposure risks are posed by the handling and storage or disposal of uranium-contaminated resins. Workers could be exposed during the installation, operation and maintenance of the treatment systems and the handling and storage of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the resin is safely disposed.

All of the Alternative 4 remedial components for the Building 850 subarea can be implemented. Many of the exposure control methods and the monitoring network are already in place. As discussed in Alternative 2, the removal of contaminated soil and sandpile should be fairly easy to implement. Additional engineering and logistical difficulties are posed by the excavation of subsurface soil. The ground water extraction and treatment portion of Alternative 4 is implementable. The operation of the *ex situ* ground water treatment system for Alternative 4 would require WDRs from the RWQCB for the discharge of treated effluent. The implementability of the *in situ* reactive barrier component of Alternative 4 is limited by: (1) significant engineering challenges to install the barrier in unconsolidated alluvium and bedrock, and (2) the removal and replacement of spent resins in the subsurface barriers. The *in situ* reactive barrier may require WDRs designed to ensure that residual materials or by products protect beneficial uses of ground water.

The estimated present worth cost of the life-cycle costs for Alternative 4 is $16,097,000. The costs to implement Alternative 4 are summarized in Table 7-1. The costs of the modules used to assemble Alternative 4 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.10. Comparative Evaluation of Remedial Alternatives for the Building 850 Subarea, Building 850/Pits 3 & 5 OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Building 850 subarea with respect to the first seven EPA criteria.

7.2.10.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may not be protective of human health or the environment as without monitoring of the ground water COC plumes, there would be no means of determining changes in plume size and location that could impact downgradient receptors. Alternative 1 does not meet the RAOs of preventing potential incidental ingestion and direct dermal contact with contaminated surface soils or the inhalation of tritium volatilizing from Well 8 Spring.

Alternatives 2, 3, and 4 all address risk to human health from potential incidental ingestion and direct dermal contact with contaminated surface soils, and ingestion of contaminated ground water. These three alternatives include the same measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced.

Alternatives 2 and 3 both include source control measures and rely on natural attenuation of contaminants in ground water and surface water to health- and environmentally protective levels, as well as to prevent further releases to ground water. In addition to these measures provided by Alternatives 2 and 3, Alternative 4 includes active extraction and *in situ* treatment of uranium and nitrate to reduce concentrations/activities of these contaminants to levels protective of human health and the environment.

Data indicate that there is not an ongoing source of tritium and uranium to ground water and there is no risk or hazard associated with tritium and uranium in subsurface soil in the vicinity of the firing table. Therefore, Alternative 3 and 4 may not provide a significant increase of the level of protection to human health and the environment posed by contaminated subsurface soil/rock over Alternative 2.

Alternatives 2, 3, and 4 provide similar levels of protection to human health for preventing the ingestion of contaminated ground water as: 1) the tritium and uranium plumes are contained onsite, 2) uranium activities in ground water are below the MCL and background levels for total uranium, and 3) ground water is not currently used for drinking water.

7.2.10.2. Compliance with ARARs

Alternative 1 may meet ARARs if natural attenuation acts to reduce contaminant concentrations in ground water to MCLs, any more stringent WQOs, or below. However, without monitoring, there is no means of establishing achievement of these goals.

Alternatives 2, 3, and 4 all include source control measures to prevent further releases of tritium and uranium to ground water. Alternatives 2, 3, and 4 all rely on natural attenuation to reduce tritium activities in ground water to meet ARARs. Data indicate that a diminishing source is present at Building 850, and the continuing decay of tritium and uranium may result in the attainment of ARARs in a reasonable timeframe.

7.2.10.3. Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of Alternative 1 relies solely on natural attenuation to reduce contaminant concentrations in ground water. It does not provide long-term or permanent protection of human health as contaminated surface soils are left in place.

Alternatives 2 and 3 provide long-term effectiveness by removing contaminant sources to prevent future releases to ground water, permanently mitigating exposure risk by removing contaminated surface soils, and through natural attenuation of contaminants in ground water. In addition, Alternative 4, provides long-term effectiveness by permanently removing uranium and nitrate from ground water.

In Alternatives 2, 3, and 4, monitoring would be conducted after ARARs have been achieved to ensure long-term effectiveness and permanence.

7.2.10.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, the natural attenuation of contaminants may result in the long-term reduction of toxicity, mobility, and volume of contaminants if further releases do not occur.

Alternatives 2, 3, and 4 rely on the monitored natural attenuation of tritium in ground water to achieve a long-term reduction in toxicity, mobility, and volume of tritium in the subsurface. Alternatives 2 and 3 rely on degradation and decay to reduce the toxicity, mobility, and volume of uranium and nitrate in ground water. The excavation component of Alternative 2 would reduce the mobility of the contaminants by removing the waste, thus preventing further leaching of contaminants to the subsurface. It would not reduce the toxicity or volume of the contaminants as the waste would be redeposited at a different location.

By adding the additional soil/bedrock excavation component, Alternative 3 may provide additional reduction in contaminant mobility over Alternative 2. However, none of the removal components of Alternative 2 or 3 would reduce contaminant toxicity and volume.

The extraction and treatment of uranium, and nitrate in ground water and *in situ* treatment of uranium in Alternative 4 would reduce the volume and mobility of the contaminants in ground water.

7.2.10.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term.

Alternatives 2, 3 and 4 have the potential for short-term exposure for onsite workers during the removal of contaminated soil and the sandpile. Short-term exposure risk may be higher for Alternatives 3 and 4 than for Alternative 2 as workers would be exposed to a much larger volume of contaminated media which was previously buried and posed no risk. The excavation component of Alternatives 3 and 4 is likely to increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment.

Alternative 4 also poses short-term and possibly long-term exposure risk to onsite workers as uranium and potentially tritium, would be brought to the surface during the extraction of ground water. Workers could be exposed during the installation, operation and maintenance of the treatment systems and the handling and storage of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the uranium is safely disposed.

Alternative 2 would reduce the source rapidly by removal, actively reducing the tritium activities. Ground water data trends indicate that little tritium remains in the vadose zone; hence the excavation of deeper soil and bedrock included in Alternative 3 and 4 may not reduce activities more rapidly. Without an active source, MNA may reduce tritium activities to below MCLs within a few decades. By decay alone (Alternative 2), tritium activities in ground water would decrease to less than MCLs in under 40 years. Other factors (dispersion, dilution) will likely contribute to reducing measured activities more quickly. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

Tritium activities would not be significantly reduced by the ground water extraction for uranium and nitrate. Uranium-238 is already below the MCL for uranium.

7.2.10.6. Implementability

No action would be necessary to implement Alternative 1.

The monitoring and exposure control components of Alternatives 2, 3, and 4 can be easily implemented as many of the exposure control methods and the monitoring network are already in place. The removal of contaminated soil and sandpile in Alternatives 2, 3, and 4 should be fairly easy to implement but deviations from the estimated volume to be removed, would affect the degree of difficulty of implementation. Additional engineering and logistical difficulties are posed by the excavation of subsurface soil in Alternatives 3 and 4. The primary difficulties in excavating beneath the Building 850 Firing Table are: (1) excavating bedrock in areas of steep terrain is extremely difficult, (2) this firing table is currently active and in use for high explosive experiments, and (3) there are a number of subsurface conduits for diagnostic equipment that would have to be avoided or removed/replaced during excavation.

The ground water extraction and treatment portion of Alternative 4 is fairly easy to implement. The operation of the *ex situ* ground water treatment system for Alternative 4 would require WDRs from the RWQCB for the discharge of treated effluent. The implementability of the *in situ* reactive barrier component of Alternative 4 is limited by (1) significant engineering challenges to install the barrier in unconsolidated alluvium and bedrock, and (2) the removal and replacement of spent resins in the subsurface barriers. The *in situ* reactive barrier may require WDRs designed to ensure that residual materials or by-products protect beneficial uses of ground water.

7.2.10.7. Cost

The estimated present worth of the life-cycle costs for the Building 850 alternatives range from no cost for Alternative 1 to $16,097,000 for Alternative 4. Costs are summarized in Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $4,029,000, and includes: (1) monitoring, (2) exposure controls, (3) monitored natural attenuation, modeling, and risk assessment, and (4) removal of contaminated surface soil and the sandpile.
- Alternative 3 costs $8,246,000, and includes: (1) monitoring, (2) exposure controls, (3) monitored natural attenuation, modeling, and risk assessment, (4) removal of contaminated surface soil and the sandpile, (5) the excavation of contaminated subsurface soil/rock**,** and (6) off-site disposal of waste.
- Alternative 4 costs $16,097,000, which includes the costs for: (1) monitoring and modeling, (2) exposure controls, (3) monitored natural attenuation, modeling, and risk assessment, (4) removal of contaminated surface soil and the sandpile, (5) the excavation of contaminated subsurface soil/rock, (6) off-site disposal of waste, (7) the extraction and treatment of nitrate and uranium in ground water, and (8) the installation and maintenance of an *in situ* permeable reactive barrier wall to remove uranium from ground water.

7.2.11. Analysis of Remedial Alternatives for the Pit 2 Landfill Subarea, Building 850/Pits 3 & 5 OU

This section presents the evaluation of how each of the three alternatives proposed for the Pit 2 Landfill subarea address the first seven EPA criteria.

7.2.11.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Pit 2 Landfill subarea, including monitoring, would cease.

VOCs were detected in ground water in 1989 but have not been detected since that time. Although tritium has been detected in subsurface soil/rock, the depth of maximum detection indicate that the tritium is likely to be from the transport of ground water from the Building 850 area. No COCs have been identified in any environmental media in the vicinity of the Pit 2 Landfill and no risk or hazard to human health or ecological receptors was identified in the baseline risk assessment. Therefore, Alternative 1 may be protective of human health or the environment if contaminants are not identified in the pit waste that could impact ground water. This alternative currently meets all ARARs.

Without the monitoring of ground water to detect potential future releases from the landfill, Alternative 1 may not provide long-term effectiveness and permanence in the protection of human health and the environment. As there are no COCs identified in any media identified for the Pit 2 Landfill area, the criteria for reduction in toxicity, mobility, and volume of contaminants are not applicable.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.11.2. Evaluation of Alternative 2—Monitoring

As discussed in Section 7.2.11.1 above, no COCs have been identified in any environmental media emanating from the Pit 2 Landfill and no risk or hazard to human health or ecological receptors was identified in the baseline risk assessment. The depth to ground water below Pit 2 (>65 ft) indicates there is no risk of inundation of the pit that could result in releases. Data indicate there is no evidence of significant releases from the Pit 2 Landfill in the past that have impacted environmental media. The monitoring of ground water in the vicinity of the Pit 2 Landfill would indicate if contamination is released from the landfill that would impact human health or the environment. For these reasons, the monitoring of ground water for contaminants that may be present in the pit waste should be protective of human health and the environment.

As indicated in the information presented in Section 7.2.11.1 above, the Pit 2 Landfill is currently in compliance with ARARs. Monitoring of these contaminants in ground water provides a tool for: (1) demonstrating the continued compliance with ARARs, and (2) assuring that no releases from the Pit 2 Landfill occur that could pose a risk or hazard to human health or ecological receptors or impact ground water. Monitoring would also provide long-term effectiveness and permanence in protecting human health and the environment.

As there are no COCs identified in any media identified for the Pit 2 Landfill area, the criteria for reduction in toxicity, mobility, and volume of contaminants are not applicable.

In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential exposure risks during monitoring and would therefore be effective in the short-term.

This alternative is readily implementable. It may be necessary to install additional ground water monitor wells in order to provide complete detection monitoring for the Pit 2 Landfill.

The estimated present worth of the life-cycle costs for Alternative 2 is $515,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.11.3. Evaluation of Alternative 3—Monitoring and Waste Characterization with Contingent Monitoring, Capping, or Excavation of Pit 2 Landfill

Alternative 3 includes the monitoring component of Alternative 2 and adds waste characterization with contingent monitoring, capping, or excavation of Pit 2 Landfill.

Alternative 3 ensures compliance with RAOs and ARARs by monitoring for potential contaminants that may be present in Pit 2 waste, as discussed in Section 7.2.9.2 above.

If characterization of the waste in the Pit 2 Landfill indicates that the contaminants in the pit pose an unacceptable risk or hazard to human health and the environment and/or a significant threat to ground water, it may be necessary to cap or excavate the landfill to protect human health and/or beneficial uses of ground water. Both capping and excavation provide long-term protection of human health and the environment and ensure compliance with ARARs. As the depth to ground water below Pit 2 is 65 ft bgs or more, there is no risk of inundation of the pit that could result in contaminant releases. Therefore, the excavation of the waste may not provide a significant increase in protection to human health or the environment over that provided by capping.

Monitoring may be adequate if characterization determines that the pit waste does not pose an unacceptable risk or hazard, or a threat to ground water. Either monitoring, capping, or excavation/disposal may be effective in the long-term protection of human health and the environment.

Neither capping nor removal of contaminants from the landfill would reduce the toxicity and volume. These remedial measures are only capable of reducing the mobility of contaminants in the waste. Monitoring does not reduce the toxicity, mobility, or volume of contaminants in the waste but provides a mechanism for detecting the migration of the contaminants into ground water.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. There would be minimal impact to onsite workers during characterization and monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks that may be posed in the course of characterization and monitoring activities. A higher level of exposure controls would be necessary to prevent short-term exposure of onsite workers and ecological receptors during capping. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during cap installation or waste excavation.

Excavation activities pose the highest short-term risk of exposure and potential impact to human and ecological receptors. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location. Excavation and disposal could increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Off-site disposal would require transport of potentially hazardous materials over public roads, whereas disposal of waste in an on-site containment unit would only involve movement of this material within site boundaries. Construction of an on-site containment unit may impact ecological habitat and its inhabitants.

A health and safety plan would be developed prior to installation of the pit cap or waste excavation to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during these activities. Biological resource surveys are conducted prior to any construction or ground disturbing activities at Site 300 to ensure there are no impacts to ecological receptors.

Each of the remedial options for Alternative 3 can be implemented. However, implementation becomes more complicated with each alternative. Characterization can be fairly easily implemented depending on the extent of characterization required. Monitoring can be implemented easily although the installation of additional monitor wells may be necessary. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected. The estimated present worth of the life-cycle costs for the remedial measures presented in Alternative 3 are:

Monitoring: $515,000.

Characterization and capping: $1,432,000.

Characterization with total excavation and off-site disposal: $22,250,000.

The costs for partial excavation of the landfill are contained in Appendix D. If large volumes of waste are excavated, placement of the waste in an on-site engineered containment unit may be more cost-effective than for off-site disposal. Siting, design, and approval issues, discussed in Section C-2.7 of Appendix C, could significantly impact the time, resources, and costs necessary to implement an on-site disposal option.

Costs for this alternative are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.12. Comparative Evaluation of Remedial Alternatives for the Pit 2 Landfill, Building 850/Pits 3 & 5 OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Pit 2 Landfill with respect to the first seven EPA criteria.

7.2.12.1. Overall Protection of Human Health and the Environment

Alternative 1 (No further action) may be protective of human health and the environment for the following reasons: (1) no risk or hazard to human health or ecological receptors in the vicinity of the Pit 2 Landfill was identified, (2) ground water has not been impacted by contamination in the Pit 2 Landfill area, and 3) no COCs were identified in any media for the Pit 2 Landfill. Although there is no known risk or hazard associated with the Pit 2 Landfill, potential impacts to ground water would not be monitored or detected in Alternative 1.

Alternatives 2 and 3 both include the same measures to monitor for potential future impacts to ground water and any associated changes in risk or hazard that could affect human health and the environment. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

If the characterization data for the Pit 2 Landfill waste indicate that contaminants associated with the waste could impact human health and/or the environment, the capping and/or excavation components of Alternative 3 would provide additional long-term protection for human health and the environment. If the waste characterization results indicate that human health and the environment would not be impacted by contaminants in the landfill waste, Alternative 3 would provide no significant quantifiable health risk benefit as compared to Alternative 2.

7.2.12.2. Compliance with ARARs

Alternative 1 (no action) currently meet all ARARs. However, there are no provisions in this alternative to monitor for continued compliance with ARARs.

Alternatives 2 and 3 both include measures to monitor for continued compliance with ARARs.

7.2.12.3. Long-Term Effectiveness and Permanence

Alternative 1 may provide long-term effectiveness in meeting ARARs, however there are no mechanisms included in this alternative for establishing the continued compliance in meeting these goals.

Alternatives 2 and 3 provide monitoring to determine the long-term effectiveness and permanence of the remedies.

If the characterization data for the Pit 2 Landfill waste provide evidence that contaminants associated with the waste could impact human health and/or the environment, the capping and/or excavation components of Alternative 3 would add additional long-term and permanent protection for human health and the environment.

7.2.12.4. Reduction of Toxicity, Mobility, and Volume

As there are no COCs identified in any media identified for the Pit 2 Landfill area, the criteria for reduction in toxicity, mobility, and volume of contaminants are not applicable unless pit waste characterization indicates the potential for impacts to human health and the environment. Both Alternatives 2 and 3 provide a monitoring component to determine if contaminants in the pit waste impact ground water in the future.

If waste characterization data indicate that contaminants were present in the waste that could impact human health or the environment, the capping and excavation components of Alternative 3 would reduce the mobility of the contaminants in the waste. These components would not reduce the toxicity or volume of the contaminants. Excavation might increase the potential for airborne releases of volatile or dust-borne contaminants during disruption, but proper disposal should lower long-term mobility. The monitoring component of Alternatives 2 and 3 does not reduce the toxicity, mobility, or volume of contaminants in the waste, but provides a mechanism for detecting the migration of contaminants into ground water.

7.2.12.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors. In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring. As there are no contaminants of concern from the Pit 2 landfill, protection is already achieved.

There would not be a significant difference in the short-term effectiveness of Alternatives 2 and 3, if only the characterization and monitoring components of Alternative 3 were implemented. The risk of exposure for onsite workers and ecological receptors in the short-term increases if the capping component of Alternative 3 is implemented. The excavation component of Alternative 3 poses the highest short-term risk of exposure and potential impact to human and ecological receptors during implementation of the remedy. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location, which increases the number of exposure pathways and may disrupt plant and animal habitat. A high level of exposure control measures would need to be implemented to prevent the exposure of onsite workers, transport personnel, the public, and ecological receptors to contaminants.

7.2.12.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs and continuing administrative controls to prevent exposure.

The implementability of Alternative 3 would be significantly more difficult than Alternative 2 if the pit capping or waste excavation options are selected. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

7.2.12.7. Cost

The estimated present worth of the life-cycle costs for the Pit 2 Landfill alternatives range from no cost for Alternative 1 to a maximum of $22,250,000 for Alternative 3. Costs are summarized in Table 7-1. Monitoring costs were developed for Alternative 2. For Alternative 3, costs were developed for: (1) waste characterization, (2) monitoring, (3) installation and maintenance of a pit cap, and (4) total excavation of the pit waste with off-site disposal. The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $515,000, as the objectives of this remedy are to: (1) monitor for continued compliance with RAOs and ARARs, and (2) monitor for potential future leaks from the Pit 2 Landfill which could impact ground water.
- The maximum Alternative 3 costs exceed those of Alternative 2 by over $20 million, which includes the costs for: (1) waste characterization, (2) monitoring, (3) total excavation of the pit waste, and (4) off-site disposal. Actual costs could be significantly

reduced if only partial excavation is necessary, or if excavation is total but on-site consolidation or re-consolidation in place is feasible.

7.2.13. Analysis of Remedial Alternatives for the Building 854 OU

This section presents the evaluation of how each of the two alternatives proposed for the Building 854 OU address the first seven EPA criteria.

7.2.13.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 854 OU, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment because no active measures are taken to reduce contaminant concentrations in the vadose zone or ground water within a reasonable timeframe. No water-supply wells are currently contaminated with VOCs, tritium, uranium-238, nitrate, or perchlorate originating from the Building 854.

Alternative 1 does not met the RAO of preventing potential inhalation of VOCs by onsite workers above health-based concentrations in the vicinity of Buildings 854A and 854F. Fencing and full-time security patrols are in place that effectively prevent public access to the plume and source areas. There are no exposure pathways for ecological receptors, as the affected portions of the Building 854 area are paved and do not provide sufficient ecological habitat.

Without active remediation, contaminant concentrations may remain above MCLs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water, which may not be achieved in a reasonable timeframe.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.13.2. Evaluation of Alternative 2—No Further Action for Metals, HMX, PCBs, and Tritium in Surface Soils, Monitoring, Exposure Control, and Ground Water Extraction and Treatment

The objective of Alternative 2 is to meet RAOs by actively remediating ground water to the point where the beneficial uses of ground water are restored and protected and inhalation risk in the vicinity of Buildings 854A and 854F are mitigated.

Alternative 2 uses exposure control methods and administrative controls to provide initial protection to human health and to ecological receptors. This alternative also provides additional protection to human health by restoring and protecting the beneficial uses of ground water in the shallow $Tnbs_1$ and Tmss water-bearing units through active remediation of contaminants in ground water and the vadose zone.

Alternative 2 meets the RAO of preventing potential inhalation of VOCs above health-based concentrations in the vicinity of Buildings 854A and 854F by reducing VOC concentrations in subsurface soil through soil vapor extraction.

Although no further action of metals, HMX, and tritium in surface soil is proposed under Alternative 2, there are no risk or hazard to human health or ecological receptors posed by these contaminants in surface soil, and no significant impact to ground water indicated by modeling of these contaminants. There is no current exposure pathway present or potential impact to ground water posed by PCBs in surface soils as discussed in Section 6.5.2.1 of Chapter 6.

No hazard for exposure of ecological receptors to contaminants present in environmental media at Building 854 has been identified.

The goal of Alternative 2 is to use active ground water and soil vapor remediation to meet all ARARs. The requirements of the Basin Plan and SWRCB Resolutions 68-16 and 92-49 would be met by actively reducing VOC, perchlorate, and nitrate concentrations in ground water to MCLs, any more stringent WQOs, or below. Ground water and soil vapor extraction and treatment would be implemented at the Building 854 source areas to reduce source mass. In addition, a second ground water extraction and treatment system would be installed downgradient of Building 854 to prevent the migration of the VOC plume. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

The toxicity and volume of extracted VOCs and perchlorate are eliminated by thermal regeneration of the aqueous-phase GAC. Biochemical processes in the bioreactor would reduce the toxicity and volume of nitrate. Migration of dissolved VOCs above the cleanup goals would be controlled by ground water extraction.

Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

Alternative 2 is implementable. Equipment, materials, and services necessary for implementing Alternative 2 are available. The operation of the treatment systems for Alternative 2 would require WDRs from the RWQCB for the discharge of treated effluent and obtaining air permits from the local air board.

The estimated present worth of the life-cycle costs for Alternative 2 is $9,150,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.14. Comparative Evaluation of Remedial Alternatives for the Building 854 OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives presented for remediation of the Building 854 OU with respect to the first seven EPA criteria. As a presumptive remedy has been identified for this OU, only one alternative (Alternative 2), has been compared against the no action alternative required by EPA guidance.

7.2.14.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may not be protective of human health and the environment because no active measures are taken to reduce contaminant concentrations in the vadose zone or ground water to health- and environmentally-protective levels. In addition, potential changes in plume concentration and size that could result in impacts to downgradient receptors would not be monitored or detected.

Alternative 2 mitigates risk to human health from potential ingestion of contaminated ground water and inhalation of VOC vapors through extraction and treatment of contaminated soil vapor and ground water at the Building 854 source area, and ground water extraction and treatment in the downgradient portion of the plume. This alternative also includes measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced, such as administrative controls to prevent access to contaminated ground water and access restrictions for Springs 10 and 11, if necessary.

Alternative 2 includes measures to reduce contaminant concentrations and mass in ground water and therefore would provide long-term and effective protection of human health and the environment.

7.2.14.2. Compliance with ARARs

In Alternative 1 (no action), concentrations of VOCs and nitrate may remain above MCLs, any more stringent WQOs, or below in the foreseeable future, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

Alternative 2 includes active measures to reduce contaminant concentrations and mass in ground water and subsurface soil to meet all ARARs within a reasonable timeframe. The remedial actions described in Alternative 2 can be designed and implemented in compliance with ARARs.

7.2.14.3. Long-Term Effectiveness and Permanence

Alternative 1 (no action) does not provide long-term effectiveness in meeting ARARs or permanently reduce COC concentrations.

Alternative 2 provides long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs through active remediation. This alternative also provides monitoring to determine the long-term effectiveness and permanence of the remedies.

7.2.14.4. Reduction of Toxicity, Mobility, and Volume

Alternative 1 does not remove COCs from the subsurface. Therefore, implementation of this alternative would not reduce the toxicity, mobility, or volume of the COCs.

In Alternative 2, remedial actions involve removing contaminants from soil and ground water and adsorbing them to carbon. The toxicity and volume of extracted VOCs and perchlorate would be reduced through the thermal destruction of these contaminants sorbed to GAC. The toxicity and volume of nitrate would be reduced through biochemical processes in the bioreactor. Contaminant volume and mobility in ground water would be reduced irreversibly by source mass removal, contaminant concentration reduction, and plume control.

7.2.14.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors.

In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment systems in Alternative 2 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

The ground water and soil vapor extraction of Alternative 2 should reduce TCE concentrations to below MCLs. Based on current concentration trends, and the known effectiveness of ground water and soil vapor extraction on localized perched aquifers, concentrations of TCE may fall below its MCL within 25 years. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

7.2.14.6. Implementability.

No actions would be necessary to implement Alternative 1.

The treatment technologies incorporated into Alternative 2 are well proven and have been identified as presumptive technologies for VOCs. The implementation of this alternative would require the construction and operation of soil vapor and ground water extraction and treatment systems at the Building 854 source area. A ground water extraction and treatment system would also be installed downgradient of Building 854 to control plume migration. Operation of the treatment system for Alternative 2 would require obtaining WDRs from the RWQCB and a permit from the local air board.

7.2.14.7. Cost

The estimated present worth of the life-cycle costs for the Building 854 OU alternatives range from no cost for Alternative 1 to $9,150,000 for Alternative 2. Costs are summarized in

Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs exceed the costs of Alternative 1 by $9.1 million, which includes the costs for monitoring, risk and hazard management, and the capital and operation and maintenance (O&M) costs for the extraction and treatment facilities.

7.2.15. Analysis of Remedial Alternatives for the Building 832 Canyon OU

This section presents the evaluation of how each of the two alternatives proposed for the Building 832 Canyon OU address the first seven EPA criteria.

7.2.15.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 832 Canyon OU, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment because no active measures are taken to reduce contaminant concentrations in the vadose zone or ground water within a reasonable timeframe. No water-supply wells are currently contaminated with VOCs, nitrate, or perchlorate originating from the Building 830 or 832.

Alternative 1 does not meet the RAO of preventing potential inhalation of VOCs by onsite workers above health-based concentrations in the vicinity of Building 830. Fencing and full-time security patrols are in place that effectively prevent public access to the plume and source areas.

In the baseline risk assessment, it was determined that there were no impacts to ecological receptors from COCs in environmental media at Buildings 830 or 832.

Without active remediation, contaminant concentrations may remain above MCLs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies solely on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs, nitrate, and perchlorate in ground water which, may not be achieved in a reasonable timeframe.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.15.2. Evaluation of Alternative 2—No Further Action for Non-VOC Contaminants in Surface Soil and Subsurface Soil and Rock, Monitoring, Exposure Control, and Ground Water and Soil Vapor Extraction and Treatment

The objective of Alternative 2 is to meet RAOs by actively remediating ground water to the point where the beneficial uses of ground water and surface water are restored and protected and inhalation risk in the vicinity of Building 830 is mitigated.

Alternative 2 uses exposure control methods and administrative controls to provide initial protection to human health and to ecological receptors. This alternative also provides additional protection to human health by restoring and protecting the beneficial uses of ground water in the shallow alluvium (Qal) and underlying bedrock ($Tnbs_2$, $Tnsc_1$, and $Tnbs_1$) through active remediation of contaminants in ground water and the vadose zone.

Alternative 2 meets the RAO of preventing potential inhalation of VOCs above health-based concentrations in the vicinity of Building 830 by reducing VOC concentrations in subsurface soil through soil vapor extraction. As part of the risk and hazard management component, access control measures would be implemented, if necessary, to prevent VOC inhalation exposure at Spring 3 until concentrations are reduced to health-protective levels through ground water extraction and treatment

In Alternative 2, no further action is proposed for HMX in surface soil and nitrate in subsurface soil/bedrock at Building 830 and HMX and nitrate in subsurface soil/bedrock at Building 832. However, there is no risk or hazard to human health or ecological receptors posed by HMX or nitrate in surface soil, subsurface soil, or bedrock. In addition, there is no significant impact to ground water indicated by modeling of HMX. Nitrate contamination in ground water is addressed through extraction and treatment technologies.

In the baseline risk assessment, it was determined that there were no impacts from VOCs or other COCs to ecological receptors at Buildings 830 and 832.

The goal of Alternative 2 is to use active ground water and soil vapor remediation to meet all ARARs. The requirements of the Basin Plan and SWRCB Resolutions 68-16 and 92-49 would be met by actively reducing VOC, perchlorate, and nitrate concentrations in ground water to MCLs, or any more stringent WQOs. Ground water and soil vapor extraction and treatment would be implemented at both the Building 830 and Building 832 source areas to reduce source mass. One to two additional ground water extraction and treatment systems would be installed downgradient of Building 832 to prevent the migration of the VOC plume. A ground water extraction and treatment system would also be installed in the downgradient portion of the Building 830 plume to control plume migration and prevent contamination of ground water offsite. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

The toxicity and volume of extracted VOCs, and perchlorate are eliminated by thermal regeneration of the aqueous-phase GAC. The toxicity and volume of extracted nitrate would be eliminated through biochemical processes in the bioreactor. Migration of dissolved COCs above the cleanup goals would be controlled by ground water extraction.

Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

Alternative 2 is implementable. Equipment, materials, and services necessary for implementing Alternative 2 are available. The operation of the treatment systems for Alternative 2 would require WDRs from the RWQCB for the discharge of treated effluent and obtaining air permits from the local air board.

The estimated present worth of the life-cycle costs for Alternative 2 is $26,766,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.16. Comparative Evaluation of Remedial Alternatives for the Building 832 Canyon OU

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives presented for remediation of the Building 832 Canyon OU with respect to the first seven EPA criteria. As a presumptive remedy has been identified for this OU, only one alternative (Alternative 2), has been compared against the no action alternative required by EPA guidance.

7.2.16.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may not be protective of human health and the environment because no active measures are taken to reduce contaminant concentrations in the vadose zone or ground water to health- and environmentally-protective levels. In addition, potential changes in plume concentration and size that could result in impacts to downgradient receptors would not be monitored or detected.

Alternative 2 mitigates risk to human health from potential ingestion of contaminated ground water from Buildings 830 and 832 and inhalation of VOC vapors at Building 830 through extraction and treatment of contaminated soil vapor and ground water at the Buildings 830 and 832 source areas and ground water extraction and treatment in the downgradient portion of the plume. This alternative also includes measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced such as administrative controls to prevent access to contaminated ground water and access restrictions for Spring 3.

Alternative 2 includes measures to reduce contaminant concentrations and mass in ground water and therefore would provide long-term and effective protection of human health and the environment.

7.2.16.2. Compliance with ARARs

In Alternative 1 (no action), concentrations of VOCs, nitrate, and perchlorate may remain above MCLs in the foreseeable future, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

Alternative 2 includes active measures to reduce contaminant concentrations and mass in ground water and subsurface soil to meet all ARARs. The remedial actions described in Alternative 2 can be designed and implemented in compliance with ARARs.

7.2.16.3. Long-Term Effectiveness and Permanence

Alternative 1 (no action) does not provide long-term effectiveness in meeting ARARs or permanently reduce COC concentrations.

Alternative 2 provides long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs through active remediation. This alternative also provides monitoring to determine the long-term effectiveness and permanence of the remedies.

7.2.16.4. Reduction of Toxicity, Mobility, and Volume

Alternative 1 does not remove COCs from the subsurface. Therefore, implementation of this alternative would not reduce the toxicity, mobility, or volume of the COCs.

In Alternative 2, remedial actions involve removing contaminants from soil and ground water and adsorbing them to carbon. The toxicity of the contaminants would be reduced through the thermal destruction of these contaminants sorbed to GAC and the biochemical processes in the bioreactor. Contaminant volume and mobility in ground water would be reduced irreversibly by source mass removal, contaminant concentration reduction, and plume control.

7.2.16.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors.

In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment system component of Alternative 2 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

The ground water and soil vapor extraction of Alternative 2 will reduce concentrations to MCLs, any more stringent WQOs, or below. Based on current concentrations and the known effectiveness of ground water and soil vapor extraction, concentrations of TCE may fall below the MCL in about 30 years. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

7.2.16.6. Implementability

No actions would be necessary to implement Alternative 1.

The treatment technologies incorporated into Alternative 2 are well proven and have been identified as presumptive technologies for VOCs. The implementation of this alternative would require the construction and operation of soil vapor and ground water extraction and treatment systems at the Buildings 830 and 832 source areas. Ground water extraction and treatment systems would also be installed downgradient of Buildings 830 and 832 to control plume migration. For Alternative 2, permitting of the treatment facility discharges would be required.

7.2.16.7. Cost

The estimated present worth of the life-cycle costs for the Building 832 Canyon OU alternatives range from no cost for Alternative 1 to $26,766,000 for Alternative 2. Costs are summarized in Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs exceed the costs of Alternative 1 by $26.8 million, which includes the costs for monitoring, risk and hazard management, and the capital and operation and maintenance (O&M) costs for the extraction and treatment facilities.

7.2.17. Analysis of Remedial Alternatives for Building 801 and the Pit 8 Landfill, OU 8

This section presents the evaluation of how each of the three alternatives proposed for Building 801 and the Pit 8 Landfill address the first seven EPA criteria.

7.2.17.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 801 and Pit 8 Landfill areas, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment for without monitoring of the VOC ground water plume emanating from the Building 801 dry well area, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with VOCs originating from the Building 801 dry well area. Fencing and full-time security patrols are in place that effectively prevent public access to the onsite portion of the plume and the landfill.

This alternative meets all ARARs if natural attenuation continue to act to reduce contaminant concentrations in ground water to background within a reasonable timeframe. Ground water data for 1998 indicate that VOC concentrations are near or below State and Federal MCLs and State WQOs. Nitrate concentrations are slightly above MCLs. However, there are no provisions in this alternative to monitor the progress of natural attenuation toward meeting ARARs or determining when ARARs have been achieved.

The long-term effectiveness and permanence of this alternative relies on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs and other contaminants in ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.17.2. Evaluation of Alternative 2—No Further Action for VOC Contaminants in Subsurface Soil and Monitoring

The only COCs identified for the Building 801 dry well area were TCE in subsurface soil/rock in the vicinity of the Building 801 dry well and VOCs and nitrate in ground water emanating from the dry well area. The dry well source was removed and closed in 1981. In the baseline risk assessment, no risk or hazard to human health or ecological receptors posed by VOCs or nitrate in subsurface soil/rock was identified. The water-bearing zone affected by the contamination is not currently a drinking water source. Concentrations of TCE and other COCs in ground water are near or below State and Federal MCLs and State WQOs and are declining. The monitoring of VOC and nitrate concentrations in ground water would indicate any changes in plume size or concentration and enable the assessment of changes in risk or hazard that would affect human health and the environment.

There were no COCs identified in any environmental media associated with the Pit 8 Landfill. The depth to ground water below Pit 8 (120 ft) indicates there is no risk of inundation of the pit that could result in releases. Data indicate there is no evidence of significant releases as a result of the infiltration of precipitation or surface runoff into the Pit 8 Landfill waste in the past that have impacted environmental media. The monitoring of ground water in the vicinity of the Pit 8 Landfill would indicate if contamination is released from the landfill that would impact human health or the environment. For these reasons, the monitoring of VOCs and nitrate concentrations in ground water should be protective of human health and the environment.

Alternative 2 relies on natural attenuation to reduce concentrations of VOCs and nitrate in ground water to meet ARARs within a reasonable timeframe. As indicated in the information presented above, natural attenuation should lead to full compliance with ARARs in a reasonable timeframe. Monitoring of these contaminants in ground water provides a tool for: (1) demonstrating the continued decrease in VOC and nitrate concentrations to meet ARARs, (2) assuring that no releases from the Pit 8 Landfill occur, and (3) verifying attainment of ARARs.

The degradation of TCE and nitrate is irreversible and hence effective in the long term and permanent. Monitoring would be continued after ARARs have been achieved to ensure long-term effectiveness and permanence.

The toxicity and volume of VOCs and nitrate are reduced by natural degradation, and there would be no impacts on the community or onsite workers from allowing these processes to occur. Monitoring would be conducted to identify any potentially toxic transformation products resulting from the biodegradation of TCE and to ensure the plumes do not migrate and impact downgradient receptors.

Because there are no remediation-related construction activities included in this alternative, there would be no impact to human or ecological receptors from the implementation of this alternative, and therefore it would be effective in the short-term.

This alternative is readily implementable. It may be necessary to install additional ground water monitor wells in order to provide complete detection monitoring for the Pit 8 Landfill.

The estimated present worth of the life-cycle costs for Alternative 2 is $535,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.17.3. Evaluation of Alternative 3—No Further Action for VOCs in Subsurface Soil, Monitoring, and Waste Characterization with Contingent Monitoring, Capping, or Excavation of Pit 8 Landfill

Alternative 3 includes the no further action for VOCs in subsurface soil and monitoring components of Alternative 2, and adds waste characterization with contingent monitoring, capping, or excavation of the Pit 8 Landfill.

Alternative 3 would meet RAOs and ARARs by monitoring the continued decrease of VOC and nitrate in ground water as discussed in Section 7.2.17.2 above.

If characterization of the waste in the Pit 8 Landfill indicates that the contaminants in the pit pose an unacceptable risk or hazard to human health and the environment and/or a significant threat to ground water, it may be necessary to cap or excavate the landfill to protect human health and/or beneficial uses of ground water. Both capping and excavation provide long-term protection of human health and the environment, and ensure compliance with ARARs. As the depth to ground water below Pit 8 is 120 ft bgs, there is no risk of inundation of the pit that could result in contaminant releases. Therefore, the excavation of the waste may not provide a significant increase in protection to human health or the environment over that provided by capping.

Monitoring may be adequate if characterization determines that the pit waste does not pose an unacceptable risk or hazard or threat to ground water. Either monitoring, capping, or excavation/disposal may be effective in the long-term protection of human health and the environment.

Neither capping or removal of contaminants from the landfill would reduce the toxicity and volume. These remedial measures are only capable of reducing the mobility of contaminants in the waste. Monitoring does not reduce the toxicity, mobility, or volume of contaminants in the waste but provides a mechanism for detecting the migration of the contaminants into ground water.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. There would be minimal impact to onsite workers during characterization and monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks that may be posed in the course of characterization and monitoring activities. A higher level of exposure controls would be necessary to prevent short-term exposure of onsite workers and ecological receptors during capping. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during cap installation or waste excavation.

Excavation activities pose the highest short-term risk of exposure and potential impact to human and ecological receptors. Previously buried waste and associated contamination is brought to the surface, handled, transported, and redeposited at a new location. Excavation and disposal could increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Off-site disposal would require transport of potentially hazardous materials over public roads, whereas disposal of waste in an on-site containment unit would only involve movement of this material within site boundaries. Construction of an on-site containment unit may impact ecological habitat and its inhabitants.

A health and safety plan would be developed prior to installation of the pit cap or waste excavation to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during these activities. Biological resource surveys are conducted prior to any construction or ground disturbing activities at Site 300 to ensure there are no impacts to ecological receptors.

Each of the Alternative 3 remedial options for the Pit 8 Landfill can be implemented. However, implementation becomes more complicated with each remedial option. Characterization can be fairly easily implemented depending on the extent of characterization required. Monitoring can be implemented easily although the installation of additional monitor wells may be necessary. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected. The estimated present worth of the life-cycle costs for the remedial measures presented in Alternative 3 are:

Monitoring: $535,000.

Characterization and capping: $1,376,000.

Characterization with total excavation and off-site disposal: $21,612,000.

The costs for partial excavation of the landfill are presented in Appendix D. If large volumes of waste are excavated, placement of the waste in an on-site engineered containment unit may be more cost-effective than for off-site disposal. Siting, design, and approval issues, discussed in Section C-2.7 of Appendix C, could significantly impact the time, resources, and costs necessary to implement an on-site disposal option.

Costs for this alternative are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.18. Comparative Evaluation of Remedial Alternatives for the Building 801 Dry Well and Pit 8 Landfill, OU 8

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Building 801 dry well and Pit 8 Landfill with respect to the first seven EPA criteria.

7.2.18.1. Overall Protection of Human Health and the Environment

Alternative 1 (No further action) may not be protective of human health and the environment. In the baseline risk assessment, no risk or hazard to human health or ecological receptors posed by VOCs or nitrate in subsurface soil/rock was identified. The Building 801 dry well source was closed in 1981. VOC and nitrate concentrations in ground water in the Building 801 dry well area are near or below State and Federal MCLs and/or State WQOs and are declining. The water-bearing zone affected by the contamination is not currently a drinking water source. Although the concentrations of these contaminants may be reduced to health- and environmentally-protective levels through natural attenuation, potential changes in plume concentration and size that could result in impacts to downgradient receptors would not be monitored or detected in Alternative 1.

There are no COCs identified in surface soil, subsurface soil/rock, ground water, or surface water in the Pit 8 Landfill area. The baseline risk assessment did not identify any risk or hazard to human health or the environment. However, Alternative 1 does not provide ground water monitoring to detect potential future leaks from the landfill.

Alternatives 2 and 3 both address risk to human health from potential ingestion of contaminated ground water. Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water and monitor for changes that could impact human health and the environment. Thus, both alternatives would provide long-term and effective protection of human health and the environment. If the characterization data for the Pit 8 Landfill waste indicate that contaminants associated with the waste could impact human health and/or the environment, the capping and/or excavation components of Alternative 3 would provide additional long-term protection for human health and the environment. If the waste characterization results indicate that human health and the environment would not be impacted by contaminants in the landfill waste, Alternative 3 would provide no significant quantifiable additional health risk benefit as compared to Alternative 2.

7.2.18.2. Compliance with ARARs

Alternative 1 (no action) may meet all ARARs if natural attenuation continues to act to reduce contaminant concentration to MCLs, any more stringent WQOs, or lower within a reasonable timeframe. However, there are no provisions in this alternative to monitor the progress of natural attenuation toward meeting ARARs or determining when these goals are met.

Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water to meet all ARARs. Data indicate that COCs are naturally attenuating and will achieve ARARs in a reasonable timeframe as proposed in Alternative 2.

7.2.18.3. Long-Term Effectiveness and Permanence

Alternative 1 may provide long-term effectiveness in meeting ARARs by permanently reducing COC concentrations, however there are no mechanisms included in this alternative for establishing the achievement of these goals.

Alternatives 2 and 3 both provide long-term effectiveness by permanently reducing contaminant concentrations to health-protective levels and to meet ARARs. Alternative 2 would effectively and permanently reduce contamination in ground water through irreversible chemical degradation. Alternatives 2 and 3 provide monitoring to determine the long-term effectiveness and permanence of the remedies.

If the characterization data for the Pit 8 Landfill waste gives evidence that contaminants associated with the waste could impact human health and/or the environment, the capping and excavation components of Alternative 3 would add additional long-term and permanent protection for human health and the environment.

7.2.18.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, natural attenuation of contaminants may result in the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. However there are no mechanisms included in this alternative for establishing the achievement of these goals.

Alternative 2 relies on natural attenuation to achieve the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. Both Alternatives 2 and 3 provide a monitoring component to ensure that contaminants in the subsurface are addressed.

If the characterization data for the Pit 8 Landfill waste indicate that contaminants associated with the waste could impact ground water, the capping components of Alternative 3 could reduce the mobility of the contaminants in the waste. Excavation might increase the potential for airborne releases of volatile or dust-borne contaminants during disruption, but proper disposal should lower long-term mobility. These components would not reduce the toxicity or volume of the contaminants.

The monitoring component of Alternatives 2 and 3 does not reduce the toxicity, mobility, or volume of contaminants in the waste but provides a mechanism for detecting the migration of contaminants in ground water.

7.2.18.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors. In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

There would not be a significant difference in the short-term effectiveness of Alternatives 2 and 3, if only the characterization and monitoring components of Alternative 3 were implemented. The risk of exposure for onsite workers and ecological receptors in the short-term increases if the capping component of Alternative 3 is implemented. The excavation component of Alternative 3 poses the highest short-term risk of exposure and potential impact to human and ecological receptors. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location which increases the number of exposure pathways and may disrupt plant and animal habitat. A high level of exposure control measures would need to be implemented to prevent the exposure of onsite workers, transport personnel, the public, and ecological receptors to contaminants.

Because there are no identified risks, Alternative 3 does not reduce the time to achieve protection, over Alternative 2. As there are no contaminants of concern above MCLs in ground water from the Building 801/Pit 8 area, protection is already achieved.

7.2.18.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs.

The implementability of Alternative 3 would be significantly more difficult than Alternative 2 if the pit capping or waste excavation options are selected. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

7.2.18.7. Cost

The estimated present worth of the life-cycle costs for the Building 801 dry well and Pit 8 Landfill alternatives range from no cost for Alternative 1 to a maximum of $21,612,000 for Alternative 3. Costs are summarized in Table 7-1. Monitoring costs were developed for Alternative 2. For Alternative 3, costs were developed for: (1) waste characterization, (2) monitoring, (3) installation and maintenance of a pit cap, and (4) total excavation of the pit waste with off-site disposal. The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $535,000 as the objectives of this remedy are to: (1) monitor the natural attenuation of contaminants in ground water at Building 801 to document the effectiveness of the remedy in meeting RAOs and ARARs, and determine when these goals are met, and (2) monitor for potential future leaks from the Pit 8 Landfill that could impact ground water.
- The maximum Alternative 3 costs exceed the costs of Alternative 2 by $841,000 for waste characterization and capping, to over $21 million for: (1) waste characterization, (2) monitoring, (3) total excavation of the pit waste, and 4) off-site disposal. Actual costs could be significantly reduced if only partial excavation is necessary, or if excavation is total but on-site consolidation or re-consolidation in place is feasible.

7.2.19. Analysis of Remedial Alternatives for Building 833, OU 8

This section presents the evaluation of how each of the three alternatives proposed for Building 833 address the first seven EPA criteria.

7.2.19.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 833 area, including monitoring, would cease.

Alternative 1 may not be protective of human health or the environment for without monitoring of the VOC ground water plume emanating from the Building 833 release site, there would be no means of determining changes in plume size and location that could impact downgradient receptors. No water-supply wells are currently contaminated with VOCs originating from the Building 833 release site. Fencing and full-time security patrols are in place that effectively prevent public access to the onsite portion of the plume and the release site.

This alternative meets all ARARs if natural attenuation and dispersion act to reduce contaminant concentrations in ground water to background. Without natural attenuation and dispersion, concentrations of VOCs and nitrate would remain above MCLs, which would not meet the requirements of the Basin Plan or SWRCB Resolutions 68-16 and 92-49.

The long-term effectiveness and permanence of this alternative relies on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of VOCs in ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.19.2. Evaluation of Alternative 2—Monitoring and Exposure Control

The only COCs identified for the Building 833 area were TCE in subsurface soil/rock in the vicinity of the Building 833 release site and VOCs in ground water emanating from this area.

VOC concentrations in ephemeral, perched ground water underlying Building 833 have declined over time. Ground water is present in wells in this thin, shallow water-bearing zone mainly after periods of rainfall. The regional aquifer ($Tnbs_1$) has not been impacted. The water-bearing zone affected by the contamination is not currently a drinking water source. The monitoring of VOC concentrations in ground water would indicate any changes in plume size or concentration and enable the assessment of changes in risk or hazard that would affect human health and the environment. For these reasons, the monitoring of VOCs concentrations in ground water should be protective of human health and the environment in the long-term. Risk and hazard management would be applied to prevent health impacts until ARARs are met.

An inhalation risk of 1×10^{-6} for onsite workers was estimated for VOCs in subsurface soil. The risk and hazard management program would prevent exposure by implementing restrictions in Building 833, if necessary.

Alternative 2 relies on natural attenuation to reduce concentrations of VOCs in ground water to meet ARARs. As indicated in the information presented above, natural attenuation should lead to full compliance with ARARs in a reasonable timeframe. Monitoring of these contaminants in ground water provides a tool for: (1) demonstrating the continued decrease in VOC concentrations to meet ARARs, (2) assuring that no new releases from the Building 833 source area occur, and 3) verifying attainment of ARARs.

The degradation of TCE is irreversible and hence effective in the long term and permanent. Monitoring would be continued after ARARs have been achieved to ensure long-term effectiveness and permanence.

The toxicity and volume of VOCs are reduced by natural degradation, and there would be no impacts on the community or onsite workers from allowing these processes to occur. Monitoring would be conducted to identify any potentially toxic transformation products resulting from the biodegradation of TCE and to ensure the plumes do not migrate and impact downgradient receptors.

There are no remediation-related construction activities included in this alternative, there would be no impact to human or ecological receptors from the implementation of this alternative and therefore it would be effective in the short-term. This alternative is readily implementable.

The estimated present worth of the life-cycle costs for Alternative 2 is $820,000. Costs are summarized in Table 7-1. The costs for the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.19.3. Evaluation of Alternative 3—Monitoring, Exposure Control, and Ground Water and Soil Vapor Extraction and Treatment

The objective of Alternative 3 is to meet RAOs by actively remediating ground water to the point where the beneficial uses of ground water are restored and protected, and inhalation risk inside of Building 833 is mitigated.

Alternative 3 uses exposure control methods and administrative controls to provide initial protection to human health and to ecological receptors. This alternative also provides additional protection to human health by restoring and protecting the beneficial uses of ground water in the shallow Qt and Tps water-bearing units through active remediation of contaminants in ground water and the vadose zone.

Alternative 3 meets the RAO of preventing potential inhalation of VOCs above health-based concentrations inside Building 833 by reducing VOC concentrations in subsurface soil through soil vapor extraction.

No risk or hazard is posed by contaminants present in environmental media at Building 833 to ecological receptors has been identified.

The goal of Alternative 3 is to use active ground water and soil vapor remediation to meet all ARARs. The requirements of the Basin Plan and SWRCB Resolutions 68-16 and 92-49 would be met by actively reducing VOC concentrations in ground water to MCLs, any more stringent WQOs, or below through ground water and soil vapor extraction and treatment. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

The toxicity, mobility, and volume of extracted VOCs are eliminated by thermal regeneration of the aqueous-phase GAC. Migration of dissolved VOCs above the cleanup goals would be controlled by ground water extraction.

Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The public would not be adversely affected by implementation of this alternative. Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term.

Alternative 3 is implementable. Equipment, materials, and services necessary for implementing Alternative 3 are available. Operation of the treatment system would require obtaining WDRs from the RWQCB and air permits from the local air board.

The estimated present worth of the life-cycle costs for Alternative 3 is $4,256,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.20. Comparative Evaluation of Remedial Alternatives for Building 833, OU8

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives presented for remediation of the Building 833 area with respect to the first seven EPA criteria.

7.2.20.1. Overall Protection of Human Health and the Environment

Alternative 1 (No further action) may not be protective of human health and the environment. Although contaminant concentrations may be reduced to health- and environmentally-protective levels through natural attenuation, potential changes in plume concentration and size that could result in impacts to downgradient receptors would not be monitored or detected.

Alternatives 2 and 3 both address risk to human health from potential ingestion of contaminated ground water. Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

Alternative 3 provides for more rapid contaminant mass removal and concentration reduction through the extraction and treatment of contaminated ground water than by the natural attenuation of contaminants in Alternative 2. However, the additional mass removal provided in

Alternative 3 would provide no significant quantifiable health risk benefit as compared to Alternative 2 because ground water in this area is not used for drinking water.

Both alternatives include the same measures to prevent exposure to contamination by human and ecological receptors while contaminant concentration are being reduced such as administrative controls to prevent access to contaminated ground water and building use restrictions.

7.2.20.2. Compliance with ARARs

Alternative 1 (no action) may meet all ARARs if natural attenuation acts to reduce contaminant concentration to MCLs, any more stringent WQOs, or lower. However, there are no provisions in this alternative to monitor the progress of natural attenuation toward meeting ARARs or determining when these goals are met.

Alternatives 2 and 3 both include measures to reduce contaminant concentrations and mass in ground water to meet all ARARs. Data indicate that VOCs are naturally attenuating and will achieve ARARs in a reasonable timeframe as proposed in Alternative 2. However, ARARs may be achieved in a shorter timeframe through the active remediation presented in Alternative 3.

The remedial action described in Alternative 3 can be designed and implemented in compliance with ARARs.

7.2.20.3. Long-Term Effectiveness and Permanence

Alternative 1 may provide long-term effectiveness in meeting ARARs and permanently reducing COC concentrations, however there are no mechanisms included in this alternative for establishing the achievement of these goals.

Alternatives 2 and 3 both provide long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs. Alternative 2 would effectively and permanently reduce contamination in ground water through irreversible chemical degradation. In Alternative 3, contaminants are actively removed from ground water through extraction and treatment. Alternatives 2 and 3 provide monitoring to determine the long-term effectiveness and permanence of the remedies.

7.2.20.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, natural attenuation of contaminants may result in the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. However there are no mechanisms included in this alternative for monitoring the progress toward or establishing the achievement of these goals.

Alternative 2 relies on natural attenuation to achieve the long-term reduction of the toxicity, mobility, and volume of contamination in the subsurface. Alternative 3 actively removes contaminants from the subsurface and would reduce the volume and mobility of contaminants more rapidly. Both alternatives provide a monitoring component to ensure that contaminants in the subsurface are addressed.

7.2.20.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors. In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment system in Alternative 3 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

Whereas Alternative 3 may reduce the time for TCE concentrations to decrease below MCLs, the total mass of contaminants is small and limited in area. Natural processes may decrease TCE concentrations to below the MCL in between 5 and 10 years. Detailed modeling with refined cleanup time estimates will be presented in the Remedial Design report.

7.2.20.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs and continuing administrative controls to prevent exposure.

Alternative 3 can be readily implemented although additional time, labor and expense would be necessary both in the short- and long-term to construct, operate and monitor the treatment system. Operation of the treatment system in Alternative 3 would require obtaining WDRs from the RWQCB and air permits from the local air board.

7.2.20.7. Cost

The estimated present worth of the life-cycle costs for the Building 833 alternatives range from no cost for Alternative 1 to $4,256,000 for Alternative 3. Costs are summarized in Table 7-1. Monitoring and risk and hazard management costs were developed for Alternative 2. Capital, operation and maintenance (O&M) costs for the extraction and treatment facility, as wells as monitoring, and risk and hazard management costs, were developed for Alternative 3.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $820,000, as the main objective of this remedy is to monitor the natural attenuation of contaminants in ground water to document the effectiveness of the remedy in meeting RAOs and ARARs and determine when these goals are met.
- Alternative 3 costs exceed the costs of Alternative 2 by $3.4 million, which includes the capital and O&M costs for the ground water extraction and treatment system.

7.2.21. Analysis of Remedial Alternatives for the Building 845 Firing Table and Pit 9 Landfill, OU 8

This section presents the evaluation of how each of the three alternatives proposed for the Building 845 firing table and Pit 9 Landfill address the first seven EPA criteria.

7.2.21.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities in the Building 845 firing table and Pit 9 Landfill areas, including monitoring, would cease.

Ground water has not been impacted by HMX and uranium-238 present in subsurface soil/rock in the vicinity of the Building 845 firing table. No COCs have been identified in any environmental media in the vicinity of the Pit 9 Landfill. In the baseline risk assessment, no risk or hazard to human health or ecological receptors was identified for either the Building 845 firing table or the Pit 9 Landfill. Therefore, Alternative 1 may be protective of human health or the environment. This alternative meets all ARARs if natural attenuation acts to reduce contaminant concentrations in subsurface soil/rock at the Building 845 firing table area to background. However, Alternative 1 does not provide monitoring to detect if contaminants in subsurface soil/rock at the Building 845 firing table impact ground water or detect leaks from the Pit 9 Landfill.

The long-term effectiveness and permanence of this alternative relies on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of HMX and uranium-238 in subsurface soil/rock.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.21.2. Evaluation of Alternative 2—No Further Action for HMX and Uranium-238 in Subsurface Soil and Monitoring

The only COCs identified for the Building 845 firing table area were HMX and uranium-238 in subsurface soil/rock. In 1988, 1,942 yd^3 of gravel from the firing table and 390 yd^3 of soil from the firing table berm were removed and disposed of in Pit 1. In the baseline risk assessment, no risk or hazard to human health or ecological receptors posed by HMX or uranium-238 in subsurface soil/rock was identified. No contamination has been detected in ground water under the Building 845 firing table. The monitoring for HMX or uranium-238 in ground water would indicate if contamination in subsurface soil/rock has impacted ground water, and enable the assessment of changes in risk or hazard that could affect human health and the environment.

No COCs have been identified in any environmental media in the vicinity of the Pit 9 Landfill. The depth to ground water below Pit 9 (140 ft) indicates there is no risk of inundation of the pit could result in releases. Data indicate there is no evidence of significant releases as a result of the infiltration of precipitation or surface runoff into the Pit 9 Landfill waste in the past that have impacted environmental media. No risk or hazard to human or ecological receptors has been identified. The monitoring of ground water in the vicinity of the Pit 9 Landfill would indicate if contamination is released from the landfill that would impact human health or the environment.

As there is no risk or hazard or ground water contamination associated with the Building 845 firing table or the Pit 9 Landfill, Alternative 2 should be protective of human health and the environment.

As indicated in the information presented above, the Building 845 firing table and Pit 9 Landfill are currently in compliance with ARARs. Monitoring for contaminants in ground water provides a tool for: (1) demonstrating the continued compliance with ARARs, and (2) assuring that no releases from the Building 845 firing table or Pit 9 Landfill occur that could pose a risk or hazard to human health or ecological receptors or impact ground water.

Literature reviewed indicated that degradation of HMX occurs through photolysis and microbial degradation. Studies underway at LLNL indicate that indigenous microbes degrade HMX. This work may identify the breakdown pathways and allow modeling and monitoring of appropriate breakdown products. The degradation/decay of HMX and uranium-238 in subsurface soil/rock is irreversible and hence effective in the long term and permanent. Monitoring would be continued to ensure long-term effectiveness and permanence.

The toxicity and volume of HMX and uranium-238 in subsurface soil/rock are reduced by natural degradation and decay and there would be no impacts on the community or onsite workers from allowing these processes to occur. Monitoring would be conducted to identify any potentially toxic transformation products resulting from the degradation and decay of these contaminants.

There are no remediation-related construction activities included in this alternative, there would be no impact to human or ecological receptors from the implementation of this alternative and therefore it would be effective in the short-term.

This alternative is readily implementable. It may be necessary to install additional ground water monitor wells in order to provide complete detection monitoring for the Pit 9 Landfill.

The estimated present worth of the life-cycle costs for Alternative 2 is $488,000. Costs are summarized in Table 7-1. The costs for the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.21.3. Evaluation of Alternative 3—No Further Action for HMX and Uranium-238 in Subsurface Soil/Rock, Monitoring, and Waste Characterization with Contingent Monitoring, Capping, or Excavation of Pit 9 Landfill

Alternative 3 includes the no further action for HMX and uranium-238 in subsurface soil/rock and monitoring components of Alternative 2 and adds waste characterization with contingent monitoring, capping, or excavation of Pit 9 Landfill.

Alternative 3 ensures compliance with RAOs and ARARs by monitoring for HMX and uranium-238, as well as potential contaminants that may be present in Pit 9 waste, in ground water as discussed in Section 7.2.21.2.

If characterization of the waste in the Pit 9 Landfill indicates that the contaminants in the pit pose an unacceptable risk or hazard to human health and the environment and/or a significant threat to ground water, it may be necessary to cap or excavate the landfill to protect human health and/or beneficial uses of ground water. Both capping and excavation provide long-term protection of human health and the environment and ensure compliance with ARARs. As the depth to ground water below Pit 9 is 140 ft bgs, there is no risk of inundation of the pit that could result in contaminant releases. Therefore, the excavation of the waste may not provide a significant increase in protection to human health or the environment over that provided by capping.

Monitoring may be adequate if characterization determines that the pit waste does not pose an unacceptable risk or hazard or threat to ground water. Either monitoring, capping, or excavation/disposal may be effective in the long-term protection of human health and the environment.

Neither capping nor removal of contaminants from the landfill would reduce the toxicity and volume. Capping is potentially capable of reducing the mobility of contaminants in the waste. Monitoring does not reduce the toxicity, mobility, or volume of contaminants in subsurface soil/rock at the Building 845 firing table or that may be present in the Pit 9 Landfill waste, but provides a mechanism for detecting the migration of the contaminants into ground water.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. There would be minimal impact to onsite workers during characterization and monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks that may be posed in the course of characterization and monitoring activities. A higher level of exposure controls would be necessary to prevent short-term exposure of onsite workers and ecological receptors during capping. Workers would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure during cap installation or waste excavation.

Excavation activities pose the highest short-term risk of exposure and potential impact to human and ecological receptors. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location. Excavation and disposal could increase the number of exposure pathways, as well as disrupt habitat, increasing the potential for short-term exposure and impacts to the environment. Off-site disposal would require transport of potentially hazardous materials over public roads, whereas disposal of waste in an on-site containment unit would only involve movement of this material within site boundaries. Construction of an on-site containment unit may impact ecological habitat and its inhabitants.

A health and safety plan would be developed prior the installation of the pit cap or waste excavation to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during these activities. Biological resource surveys are conducted prior to any construction or ground disturbing activities at Site 300 to ensure there are no impacts to ecological receptors.

Each of the remedial options for the Pit 9 Landfill can be implemented. However, implementation becomes more complicated with each alternative. Characterization can be fairly easily implemented depending on the extent of characterization required. Monitoring can be implemented easily, although the installation of additional monitor wells may be necessary. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected. The estimated present worth of the life-cycle costs for the remedial measures presented in Alternative 3 are:

Monitoring: $488,000.

Characterization and capping: $909,000.

Characterization with total excavation and off-site disposal: $7,065,000.

The costs for partial excavation of the landfill are contained in Appendix D. If large volumes of waste are excavated, placement of the waste in an on-site engineered containment unit may be more cost-effective than for off-site disposal. Siting, design, and approval issues, discussed in Section C-2.7 of Appendix C, could significantly impact the time, resources, and costs necessary to implement an on-site disposal option.

Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.22. Comparative Evaluation of Remedial Alternatives for the Building 845 Firing Table and Pit 9 Landfill, OU 8

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives for the Building 845 firing table and Pit 9 Landfill with respect to the first seven EPA criteria.

7.2.22.1. Overall Protection of Human Health and the Environment

Alternative 1 (No further action) may be protective of human health and the environment for the following reasons: (1) no risk or hazard to human health or ecological receptors posed by HMX or uranium-238 in subsurface soil/rock in the vicinity of the Building 845 firing table was identified, (2) ground water has not been impacted by contamination in either the Building 845 firing table or Pit 9 Landfill areas, and (3) no COCs were identified in any media for the Pit 9 Landfill. Although there is no risk or hazard associated with the contaminants in subsurface soil at Building 845 or associated with the Pit 9 Landfill, potential impacts to ground water would not be monitored or detected.

Alternatives 2 and 3 both include the same measures to monitor for potential future impacts to ground water and any associated changes in risk or hazard that could affect human health and the environment. Thus, both alternatives would provide long-term and effective protection of human health and the environment.

If the characterization data for the Pit 9 Landfill waste gives evidence that contaminants associated with the waste could impact human health and/or the environment, the capping and/or excavation components of Alternative 3 would provide additional long-term protection for human health and the environment. If the waste characterization results indicate that human health and the environment would not be impacted by contaminants in the landfill waste, Alternative 3 would provide no significant quantifiable health risk benefit as compared to Alternative 2.

7.2.22.2. Compliance with ARARs

Alternative 1 (no action) may meet all ARARs if natural attenuation continues to act to reduce contaminant concentration in subsurface soil and bedrock within a reasonable timeframe, and these contaminants do not impact ground water in the future. However, there are no provisions in this alternative to monitor for continued compliance with ARARs.

Alternatives 2 and 3 both include measures to monitor for continued compliance with ARARs.

7.2.22.3. Long-Term Effectiveness and Permanence

Alternative 1 may provide long-term effectiveness in meeting ARARs and permanently reduce COC concentrations in subsurface soil/rock, however there are no mechanisms included in this alternative for monitoring continued compliance with ARARs in the long-term.

Alternatives 2 and 3 provide monitoring to determine the long-term effectiveness and permanence of the remedies.

If the characterization data for the Pit 9 Landfill waste provide evidence that contaminants associated with the waste could impact human health and/or the environment, the capping and/or excavation components of Alternative 3 would add additional long-term and permanent protection for human health and the environment.

7.2.22.4. Reduction of Toxicity, Mobility, and Volume

While Alternative 1 does not remove COCs from the subsurface, natural attenuation of contaminants may result in the long-term reduction of the toxicity, mobility, and volume of contamination in subsurface soil/bedrock. However there are no mechanisms included in this alternative for determining if contaminants in subsurface soil/rock impact ground water in the future.

Alternatives 2 and 3 rely on natural attenuation to achieve the long-term reduction of the toxicity, mobility, and volume of contamination in subsurface soil/bedrock. Both Alternatives 2 and 3 provide a monitoring component to determine if contaminants in subsurface soil/rock impact ground water in the future.

If the characterization data for the Pit 9 Landfill waste indicate that contaminants associated with the waste could impact ground water, the capping components of Alternative 3 could reduce the mobility of the contaminants in the waste. Excavation might increase the potential for airborne releases of volatile or dust-borne contaminants during disruption, but proper disposal should lower long-term mobility. These components would not reduce the toxicity or volume of the contaminants.

The monitoring components of Alternatives 2 and 3 do not reduce the toxicity, mobility, or volume of contaminants in subsurface soil/rock at Building 845, or that may be present in Pit 9 Landfill waste, but both provide a mechanism for detecting the migration of contaminants into ground water.

7.2.22.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors. In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

There would not be a significant difference in the short-term effectiveness of Alternatives 2 and 3, if only the characterization and monitoring components of Alternative 3 were implemented. The risk of exposure for onsite workers and ecological receptors in the short-term increases if the capping component of Alternative 3 is implemented. The excavation component of Alternative 3 poses the highest short-term risk of exposure and potential impact to human and ecological receptors during implementation of the remedy. Previously buried waste and associated contamination would be brought to the surface, handled, transported, and redeposited at a new location which increases the number of exposure pathways and may disrupt plant and animal habitat. A high level of exposure control measures would need to be implemented to prevent the exposure of onsite workers, transport personnel, the public, and ecological receptors to contaminants.

Because there are no identified risks, Alternative 3 does not reduce the time to achieve protection, over Alternative 2. As there are no contaminants of concern in ground water from the Building 845/Pit 9 area, protection is already achieved.

7.2.22.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 could be readily implemented by continuing and enhancing the existing ground water monitoring programs.

The implementability of Alternative 3 would be significantly more difficult than Alternative 2 if the pit capping or waste excavation options are selected. Capping of the landfill presents additional challenges to prevent onsite worker exposure during installation. Excavation of landfill waste would require extensive provisions to prevent exposure and protect the safety of onsite workers, transport personnel, and the public during transport of the waste.

7.2.22.7. Cost

The estimated present worth of the life-cycle costs for the Building 845 firing table and Pit 9 Landfill alternatives range from no cost for Alternative 1 to a maximum of $7,065,000 for Alternative 3. Costs are summarized in Table 7-1. Monitoring costs were developed for Alternative 2. For Alternative 3, costs were developed for: (1) waste characterization, (2) monitoring, (3) installation and maintenance of a pit cap, and (4) total excavation of the pit waste with off-site disposal. The cost to implement Alternative 3 is dependent on the characterization results and remedial measure selected.

Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs $488,000, as the objectives of this remedy are to: (1) monitor for continued compliance with RAOs and ARARs and (2) monitor for potential future leaks from the Pit 9 Landfill which impact ground water.
- The maximum Alternative 3 costs exceed the costs of Alternative 2 by up to $6.6 million, which includes the costs for: (1) waste characterization, (2) monitoring, (3) total excavation of the pit waste, and (4) off-site disposal. Actual costs could be significantly less if only a portion of the waste is excavated.

7.2.23. Analysis of Remedial Alternatives for the Building 851 Firing Table, OU 8

This section presents the evaluation of how each of the three alternatives proposed for the Building 851 firing table area address the first seven EPA criteria.

7.2.23.1. Evaluation of Alternative 1—No Action

Alternative 1 is designed to provide a baseline for purposes of comparison to other alternatives. Under a no-action response, all activities at the Building 851 firing table, including monitoring, would cease.

Ground water has not been impacted by RDX, cadmium, copper, and zinc present in surface soil in the vicinity of the Building 845 firing table. VOCs and uranium-238 have been identified as COCs in subsurface soil/rock and ground water. However, concentrations of all VOCs in ground water have declined to below analytical method detection limits indicating the lack of a continuing source in subsurface soil/rock. Uranium-238 was detected in ground water at a maximum historical activity of 1.3 pCi/L (1990), slightly above the cancer PRG of 1.1 pCi/L and below the MCL and background activities for total uranium. In the baseline risk assessment, no risk or hazard to human health or ecological receptors was identified for the Building 851 firing table. Therefore, Alternative 1 may be protective of human health or the environment. However, without ground water monitoring, there would be no means of determining changes in concentrations of uranium-238 in ground water or if contaminants in surface soil or subsurface soil/rock impact ground water.

This alternative meets all ARARs if natural attenuation acts to reduce contaminant concentrations to background within a reasonable timeframe.

The long-term effectiveness and permanence of this alternative relies on natural attenuation to reduce contaminant concentrations and to restrict the mobility and reduce the toxicity and volume of COCs in surface soil, subsurface soil/rock, and ground water.

Since there would be no remediation-related construction occurring under Alternative 1, there would be no impact to human or ecological receptors from this type of activity and therefore it would be effective in the short-term. This alternative is readily implementable.

There are no costs associated with this alternative.

7.2.23.2. Evaluation of Alternative 2—No Further Action for COCs in Surface Soil and Subsurface Soil/Rock and Monitoring

Ground water has not been impacted by RDX, cadmium, copper, and zinc present in surface soil in the vicinity of the Building 851 firing table. Modeling of these contaminants to ground water indicates that these contaminants will not significantly impact ground water (concentrations slightly above background or method detection limits but below MCLs). There is no risk or hazard for human or ecological receptors posed by these contaminants in surface soil.

The maximum concentrations of VOCs detected in subsurface soil are TCE at 0.0003 mg/kg and cis-1,2-DCE at 0.012 mg/kg. Concentrations of TCE and other VOCs in ground water have declined to below analytical method detection limits indicating that VOCs in subsurface soil/rock are not a continuing source of contamination in ground water. There has been no risk or hazard for VOCs in subsurface soil identified.

Uranium-238 has been detected in surface soil and subsurface soil/rock at maximum activities of 14 pCi/g and 11 pCi/g, respectively. Uranium-238 was detected in ground water at a maximum historical activity of 1.3 pCi/L (1990), slightly above the cancer PRG of 1.1 pCi/L but below the MCL and background activities for total uranium. The water-bearing zone affected by the contamination is not currently a drinking water source. No risk or hazard to human health or ecological receptors was identified for uranium in surface or subsurface soil/rock.

No further action for these COCs in surface soil and subsurface soil/rock should be protective of human health and the environment because: (1) there is no risk or hazard associated with these contaminants in surface soil and subsurface soil/rock, (2) there is no significant impact or threat to ground water, (3) monitoring of uranium-238 would indicate any changes in activities and enable the assessment of changes in risk or hazard that could affect human health and the environment, and (4) monitoring for VOCs, metals, and RDX in ground water would determine if these soil and rock contaminants impact human health or the environment in the future. For these reasons, the monitoring of VOCs, metals, RDX, and uranium-238 in ground water should be protective of human health and the environment.

Alternative 2 recognizes that natural attenuation will reduce activities of uranium-238 in ground water. Monitoring of contaminants in ground water provides a tool for: (1) demonstrating the continued decrease in uranium-238, (2) assuring that no future releases of contaminants in surface soil or subsurface soil/rock occur, and (3) verifying compliance with MCLs.

The decay of uranium-238 is irreversible and hence effective in the long term and permanent. Monitoring would be continued to ensure long-term effectiveness and permanence.

The toxicity and volume of uranium-238 is reduced by natural decay, and there would be no impacts on the community or onsite workers from allowing this process to occur. Monitoring would be conducted to ensure uranium does not migrate and impact downgradient receptors.

As there are no remediation-related construction activities included in this alternative, there would be no impact to human or ecological receptors from the implementation of this alternative and therefore it would be effective in the short-term. This alternative is readily implementable.

The estimated present worth of the life-cycle costs for Alternative 2 is $530,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 2 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.23.3. Evaluation of Alternative 3—No Further Action for COCs in Surface Soil and Subsurface Soil/Rock, Monitoring, and Ground Water Extraction and Treatment of Uranium

The objective of Alternative 3 is to meet RAOs by actively remediating ground water to the point where the beneficial uses of ground water are restored and protected.

As in Alternative 2, no further action is proposed for COCs in surface soil and subsurface soil/rock under Alternative 3. As described in Section 7.2.23.3 above, no further action for these COCs in surface soil and subsurface soil/rock should be protective of human health and the environment because: (1) there is no risk or hazard associated with these contaminants in surface soil and subsurface soil/rock, (2) there is no significant impact or threat to ground water, (3) monitoring of uranium-238 would indicate any changes in activities and enable the assessment of changes in risk or hazard that could affect human health and the environment, and 4) monitoring for VOCs, metals, and RDX in ground water would determine if these soil and rock contaminants impact human health or the environment in the future. For these reasons, the monitoring for VOCs, metals, RDX, and uranium-238 in ground water should be protective of human health and the environment.

The goal of Alternative 3 is to use active ground water remediation to meet ARARs. The requirements of the Basin Plan and SWRCB Resolutions 68-16 and 92-49 would be met by actively reducing uranium-238 activities in ground water. Ground water extraction and treatment would be implemented at the Building 851 firing table source area to reduce source mass. Monitoring would be continued after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

In Alternative 3, remedial actions involve removing uranium from ground water through ion exchange. As the uranium collected in the ion exchange resins are not destroyed, radioactive decay would be relied upon to reduce the toxicity and volume of uranium removed from ground water. Contaminant volume and mobility in ground water would be reduced irreversibly by source mass removal, contaminant concentration reduction, and plume control. Migration of uranium-238 above the cleanup goals would be controlled by ground water extraction.

Exposure controls would prevent exposure of onsite workers and ecological receptors in the short-term. Workers performing extraction and treatment system operation and maintenance, drilling, or monitoring would use appropriate protective procedures, clothing, and equipment to prevent the possibility of exposure. The extraction and treatment of contaminants in Alternative

3 could significantly increase short-term exposure risk as uranium-contaminated ground water would be brought to the surface. Additional short-term, and possibly, long-term exposure risks are posed by the handling and storage or disposal of uranium-contaminated resins. Workers could be exposed during the installation, operation and maintenance of the treatment systems and the handling and storage of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the uranium is safely disposed.

Alternative 3 is implementable. Equipment, materials, and services necessary for implementing Alternative 3 are available. The implementability could be limited by the permitting requirements for the storage or disposal of uranium-contaminated resins.

The estimated present worth of the life-cycle costs for Alternative 3 is $4,198,000. Costs are summarized in Table 7-1. The costs of the modules used to assemble Alternative 3 are presented in Appendix D. Present worth costs for this alternative have been estimated with an accuracy of +50 and -30 percent, in accordance with EPA guidance (1987).

7.2.24. Comparative Evaluation of Remedial Alternatives for the Building 851 Firing Table, OU 8

This section presents a comparative evaluation of the characteristics of each alternative against the other alternatives presented for remediation of the Building 851 firing table area with respect to the first seven EPA criteria.

7.2.24.1. Overall Protection of Human Health and the Environment

Alternative 1 (no action) may be protective of human health and the environment, as there is no risk or hazard posed by contaminants in this area. However, potential changes in uranium activities and plume size that could result in impacts to downgradient receptors would not be monitored or detected.

Alternative 2 provides for the monitoring of uranium-238 in ground water to indicate any changes in plume size or activities and enable the assessment of changes in risk or hazard that could affect human health and the environment. Monitoring for VOCs, metals, and RDX in ground water would determine if these soil and rock contaminants impact human health or the environment in the future. For these reasons, Alternative 2 should be protective of human health and the environment.

Alternatives 3 provides additional long-term protection from exposure from ingestion of uranium-contaminated ground water through extraction and treatment of contaminated ground water at the Building 851 source area. However, as uranium activities are below the drinking water MCL and ground water is not currently used as a drinking water source, Alternative 3 may not provide a significant quantifiable health risk benefit compared to Alternative 2.

7.2.24.2. Compliance with ARARs

Alternative 1 (no action) may meet all ARARs if natural attenuation continues to act to reduce uranium activities in ground water within a reasonable timeframe. However, there are no provisions in this alternative to monitor for attainment of ARARs.

Alternatives 2 and 3 both include measures to monitor for compliance with ARARs.

Alternatives 3 include active measures to reduce uranium activities and mass in ground water and subsurface soil to meet all ARARs. The remedial actions described in Alternative 3 can be designed and implemented in compliance with ARARs. As active measures are used to reduce uranium activities in Alternative 3, ARARs may be achieved more rapidly than in Alternative 2.

7.2.24.3. Long-Term Effectiveness and Permanence

Alternative 1 (no action) may provide long-term effectiveness in meeting ARARs and permanently reduce COC concentrations. The decay of uranium-238 is irreversible and hence effective in the long term and permanent.

In Alternatives 2 and 3, monitoring would be conducted to ensure long-term effectiveness and permanence.

Alternatives 3 provides long-term effectiveness by permanently reducing contaminant concentrations to meet ARARs through active remediation. This alternative also provides monitoring to ensure the long-term effectiveness and permanence of the remedies.

7.2.24.4. Reduction of Toxicity, Mobility, and Volume

In Alternatives 1 and 2, the toxicity and volume of uranium-238 is reduced by natural decay, and there would be no impacts on the community or onsite workers from allowing this process to occur. Alternative 2 also provides monitoring which would be conducted to ensure the plumes do not migrate and impact downgradient receptors.

In Alternative 3, a reduction in contaminant toxicity, volume and mobility in ground water may be achieved more rapidly as active remediation measures are employed. Radioactive decay would reduce the toxicity and volume of extracted uranium in the ion exchange resins.

7.2.24.5. Short-Term Effectiveness

Since there would be no remediation-related construction occurring under Alternative 1, there would be no short-term impact to human or ecological receptors.

In Alternative 2, there would be minimal impact to onsite workers during monitoring activities. Workers would follow Site 300 operation procedures to mitigate potential risks during monitoring.

A health and safety plan would be developed prior to construction and operation of the extraction and treatment system component of Alternative 3 to protect the health of onsite workers. In addition, workers would follow Site 300 operation procedures, and use personal protective equipment and clothing to mitigate potential risks during construction and operation of the treatment system. Biological resource surveys are conducted prior to any construction activities at Site 300 to ensure there are no impacts to ecological receptors.

Alternative 3 also poses short-term and possibly long-term exposure risk to onsite workers as uranium would be brought to the surface through ground water extraction. Workers could be exposed during the installation, operation and maintenance of the treatment systems and the handling and storage of uranium-contaminated resin. This is due to the fact that uranium is removed and concentrated in ion exchange resins as part of the treatment process. Exposure control measures would be needed to prevent exposure until the uranium is safely disposed of.

Because there are no identified risks, Alternative 3 does not reduce the time to achieve protection, over Alternative 2. As there are no contaminants of concern detectable in ground water from the Building 851 area, protection is already achieved.

7.2.24.6. Implementability

No actions would be necessary to implement Alternative 1. Alternative 2 is readily implementable as ground water is already monitored in the vicinity of the Building 851 firing table.

The implementation of Alternative 3 would require the construction and operation of a ground water extraction and treatment system at the Building 851 source area. The implementability of Alternative 3 could be limited by permitting requirements for the long-term storage or disposal of uranium-contaminated resins.

7.2.24.7. Cost

The estimated present worth of the life-cycle costs for the Building 851 firing table alternatives range from no cost for Alternative 1 to $4,198,000 for Alternative 3. Costs are summarized in Table 7-1. Significant differences in the costs of the alternatives are due to the following differences in the alternatives listed below. Compared to the other alternatives:

- Alternative 1 has no cost as no remedial action would occur.
- Alternative 2 costs exceed the costs of Alternative 1 by $530,000, which includes the costs of ground water monitoring.
- Alternative 3 costs exceed the costs of Alternative 2 by $3.7 million, which includes the costs of ground water monitoring, and the capital, operation and maintenance (O&M) costs for the extraction and treatment facility.

7.3. References

Buchanan, R. J. J., (1996), "Intrinsic bioremediation of chlorinated organics," IBC's 2nd International Symposium on Bioremediation; Natural Attenuation.

Howard, P. H., A. E. Hueber, and R. S. Boethling (1987), "Biodegradation data evaluation for structure/biodegradability relations," *Environ. Toxicol. Chem*. **6**, 1–10.

U.S. EPA (1987), Remedial Action Costing Procedures Manual, Office of Solid Waste and Emergency Response, Washington, D.C. (EPA/600/8-87/049).

Webster-Scholten, C. P., Ed. (1994), *Final Site-Wide Remedial Investigation Report, Report Lawrence Livermore National Laboratory Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-108131).

Table 7-1. Cost for the remedial alternatives proposed for the Site 300 OUs.

Building 834 (OU2)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
2	$2,257,000	B	Monitoring of ground water.
	$231,000	C	Exposure control through risk and hazard management.
	$9,607,000	D	Ground water and soil vapor extraction and treatment of VOCs, TBOS/TKEBs and nitrate.
Total Cost	**$12,095,000**		
3	$2,257,000	B	Monitoring of ground water.
	$231,000	C	Exposure control through risk and hazard management.
	$9,607,000	D	Ground water and soil vapor extraction and treatment of VOCs, TBOS/TKEBs and nitrate.
	$2,409,000	E	Enhanced *in situ* bioremediation of VOCs.
Total Cost	**$14,504,000**		

Landfill Pit 6 (OU3)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
2	$1,692,000	B	Monitoring of ground and surface water.
	$209,000	C	Exposure control through risk and hazard management.
	$476,000	D	Monitored natural attenuation of VOCs and tritium in ground water.
Total Cost	**$2,377,000**		
3	$1,692,000	B	Monitoring of ground and surface water.
	$209,000	C	Exposure control through risk and hazard management.
	$4,038,000	E	Ground water extraction and treatment of VOCs and perchlorate.
Total Cost	**$5,939,000**		

Table 7-1. Cost for the remedial alternatives proposed for the Site 300 OUs. (Cont. Page 2 of 5)

HE Process Area (OU4)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
2	$0	A	No Further Action (Some contaminants, some media)
	$3,297,000	B	Monitoring
	$181,000	C	Exposure control through risk and hazard management.
	$5,812,000	D	Contaminant migration control by ground water extraction and treatment of VOCs and nitrate at the leading edge of the Building 815 TCE plume.
	$14,397,000	E	Ground water extraction and treatment of VOCs, HE compounds, nitrate, and perchlorate released from Building 815 and the high explosives rinsewater lagoons.
	$3,934,000	F	Ground water extraction and treatment of VOCs, perchlorate and nitrate released from the HE Burn Pit.
Total Cost	**$27,621,000**		

Pit 7 Complex (OU 5)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
2	$0	A	No further action for tritium and uranium in surface soil at Pits 3 & 5.
	$2,173,000	B	Monitoring of ground water.
	$230,000	C	Exposure control through risk and hazard management.
	$283,000	D	Monitored natural attenuation of tritium and uranium-238 in ground water.
	$4,341,000	G	Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers.
	$47,596,000	H	Waste Characterization with total excavation of Pits 3 & 5.
Total Cost	**$54,623,000**		(Total cost may be less depending on the amount of waste excavated.)
3	$0	A	No further action for tritium and uranium in surface soil at Pits 3 & 5.
	$2,173,000	B	Monitoring of ground water.
	$230,000	C	Exposure control through risk and hazard management.
	$283,000	D	Monitored natural attenuation of tritium in ground water.
	$3,749,000	E	Ground water extraction and treatment of VOCs south of Landfill Pit 5.
	$5,376,000	F	Ground water extraction and treatment of uranium-238 and nitrate.
	$4,341,000	G	Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers.
	$47,596,000	H	Waste Characterization with total excavation of Pits 3 & 5.
Total Cost	**$63,748,000**		(Total cost may be less depending on the amount of waste excavated.)

Table 7-1. Cost for the remedial alternatives proposed for the Site 300 OUs. (Cont. Page 3 of 5)

Building 850 (OU 5)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$2,294,000	B	Monitoring of ground and surface water (modified to include increased detection monitoring at the B850 firing table).
2	$224,000	C	Exposure control through risk and hazard management.
	$283,000	D	Monitored natural attenuation of tritium in ground and surface water.
	$1,228,000	G	Removal of contaminated sandpile at B850 and contaminated soil adjacent to B850 firing table.
Total Cost	**$4,029,000**		
	$2,294,000	B	Monitoring of ground and surface water.
	$224,000	C	Exposure control through risk and hazard management.
3	$283,000	D	Monitored natural attenuation of tritium in ground and surface water.
	$5,445,000	G	Excavation of contaminated soil and bedrock under B850 firing table, removal of contaminated sandpile, and removal of contaminated soil adjacent to the firing table.
Total Cost	**$8,246,000**		
	$2,294,000	B	Monitoring of ground and surface water.
	$224,000	C	Exposure control through risk and hazard management.
	$283,000	D	Monitored natural attenuation of tritium in ground and surface water.
4	$4,475,000	E	Ground water extraction and treatment of uranium-238 and nitrate.
	$3,376,000	F	Control migration of uranium-238 in ground water using *in situ* reactive permeable barriers.
	$5,445,000	G	Excavation of contaminated soil and bedrock under B850 firing table, removal of contaminated sandpile, and removal of contaminated soil adjacent to the firing table.
Total Cost	**$16,097,000**		

Landfill Pit 2 (OU 5)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
2	$515,000	B	Monitoring of ground and surface water.
Total Cost	**$515,000**		
3	$515,000	B	Monitoring of ground and surface water.
	$21,735,000	C	Waste characterization with total excavation of Landfill Pit 2.
Total Cost	**$22,250,000**		(Total cost may be less depending on the amount of waste excavated.)

Table 7-1. Cost for the remedial alternatives proposed for the Site 300 OUs. (Cont. Page 4 of 5)

Building 854 (OU6)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$0	A	No Further Action for metals, HMX, PCBs, and tritium in surface soil
	$945,000	B	Monitoring of ground water.
2	$239,000	C	Exposure control through risk and hazard management.
	$7,966,000	D	Ground water and soil vapor extraction and treatment of TCE, perchlorate, and nitrate.
Total Cost	**$9,150,000**		

Building 832 Canyon (OU7)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$0	A	No Further Action (Some contaminants, some media)
	$2,462,000	B	Monitoring of ground and surface water.
	$203,000	C	Exposure control through risk and hazard management.
2	$10,293,000	D	Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at B 832.
	$10,638,000	E	Ground water and soil vapor extraction and treatment of VOCs, perchlorate, and nitrate at B 830.
	$3,170,000	F	Downgradient ground water extraction using a siphon with *ex situ* treatment of VOCs by iron filings.
Total Cost	**$26,766,000**		

Building 801 and Landfill Pit 8 (OU8)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$0	A	No Further Action for VOCs in subsurface soil for the B801dry well.
2	$535,000	B	Monitoring of ground water.
Total Cost	**$535,000**		
	$0	A	No Further Action for VOCs in subsurface soil for the B801dry well.
3	$535,000	B	Monitoring of ground water.
	$21,077,000	C	Waste characterization with total excavation of Landfill Pit 8.
Total Cost	**$21,612,000**		(Total cost may be less depending on the amount of waste excavated.)

Table 7-1. Cost for the remedial alternatives proposed for the Site 300 OUs. (Cont. Page 5 of 5)

Building 833 (OU8)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$661,000	B	Monitoring of ground water.
2	$159,000	C	Exposure control through risk and hazard management.
Total Cost	**$820,000**		
	$661,000	B	Monitoring of ground water.
3	$159,000	C	Exposure control through risk and hazard management.
	$3,436,000	D	Ground water and soil vapor extraction and treatment of VOCs.
Total Cost	**$4,256,000**		

Building 845 Firing Table and Landfill Pit 9 (OU8)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
		A	No further action for some contaminants and media of concern.
2	$488,000	B	Monitoring of ground and surface water.
Total Cost	**$488,000**		
	$0	A	No further action for some contaminants and media of concern.
3	$488,000	B	Monitoring of ground and surface water.
	$6,577,000	C	Waste characterization with total excavation of Landfill Pit 9.
Total Cost	**$7,065,000**		(Total cost may be less depending on the amount of waste excavated.)

Building 851 Firing Table (OU8)

Alternative #	Present Value Cost	Module	Description
1	$0	A	No Further Action (all contaminants and all media of concern)
Total Cost	**$0**		
	$0	A	No further action for some contaminants and media of concern.
2	$530,000	B	Monitoring of ground and surface water.
Total Cost	**$530,000**		
	$0	A	No further action for some contaminants and media of concern.
3	$530,000	B	Monitoring of ground and surface water.
	$3,668,000	C	Ground water extraction and treatment of uranium.
Total Cost	**$4,198,000**		