# Executive Summary

## Introduction

The attached report presents the Feasibility Study (FS) for Operable Unit 1 (OU 1) at Hill Air Force Base (HAFB), Utah. This Executive Summary summarizes the contents of the FS report.

## Site Background

### Nature and Extent of Contamination

The area designated as OU 1 includes a number of contaminated sites which are described in detail in Section 1 of the FS. The disposal of liquid and solid wastes at the Chemical Disposal Pits (CDPs), Landfill (LF) 3, and the Waste Phenol/Oil Pit (WPOP), and the release of fuels at the fire training grounds resulted in the contamination of soil and groundwater. Since some of the wastes and the fuels were light nonaqueous phase liquids (LNAPLs), a mobile LNAPL layer formed on the water table and spread laterally. In addition, the LNAPL smeared through the soil resulting in a residual LNAPL layer in the soil that has covered as much as nine acres. For the most part, the free-phase, mobile LNAPL has thinned out and is now only measurable in a few wells. The wastes placed in LF 4 were predominantly solid wastes, although some liquid wastes were reportedly placed there.

The contaminants found in the soils, groundwater, and LNAPL of the Source Area include chlorinated solvents such as tetrachloroethene (PCE), trichloroethene (TCE), 1,2-dichloroethene (DCE), and fuel hydrocarbons such as jet fuel range hydrocarbons. In addition, soil at OU 1 also contains lesser concentrations of dioxin, furans, pesticides, and polychlorinated biphenyls (PCBs).

The area of OU 1 which contains the mobile and residual LNAPL, soil contamination, and solid wastes in the landfills is termed the Source Area. It is the area capped during the Phase I and Phase II capping response action. Dissolved groundwater contamination, most notably DCE, also exists on the base and has migrated off the base, as will be discussed below. The area of groundwater contamination outside the Source Area is termed the Non-Source Area. There is an on base component of the Non-Source Area, and a larger off base component on the hillside and in the upper Weber River Valley.

### Site Geology and Hydrogeology

The surficial geological and hydrogeologic units of most importance are summarized below and are illustrated in Figure ES-1 (found at the end of this section). The following descriptions start with the most southern and upper units and work north, downhill.

- Provo Formation: Gravel, gravel and sand, and sand materials.
- Alpine Formation: The Alpine Formation is subdivided into four units:

- Upper Clay Unit: 80 to 90 percent clay with 10 to 20 percent fine to very fine-grained sand interbeds (1/16 to 1/2 inch thick).
- Lower Clay Unit: 90 to 95 percent clay with 5 to 10 percent sand interbeds.
- Middle Sand Unit: Fine to very fine-grained sand, with few clay or silt interbeds.
- Clay/Sand Unit: Approximately 30 percent fine to very fine-grained sand and 70 percent silts and clays.

- Landslide Debris: Unstable topsoil, colluvium, and Alpine Formation clays. These materials are very broken and contain numerous vertical fractures.
- Recent Terrace Deposits: Unconsolidated sands and gravel with silt interbeds.

## Summary of Groundwater Flow and Contaminant Transport

Figure ES-1 provides a cross-section showing the main flow paths of groundwater and contamination at OU 1. Groundwater flowing horizontally through the Provo Formation becomes contaminated as it passes through the soil and LNAPL contamination in the Source Area. The contaminated groundwater in the Provo Formation appears to flow mainly west in the OU 1 area, in channels within the upper Alpine Formation. A portion of the flow also flows east along another channel. Some of this flow appears as springs and seeps at the hillside while some may migrate down the hill in the fractures of the landslide debris formation.

A portion of the contaminated groundwater also appears to migrate vertically from the Provo Formation into the sand layers of the upper Alpine Formation below the Source Area. Since the sand layers are not continuous, the extent of vertical migration appears to be limited. Any contaminated groundwater in the upper Alpine Formation may migrate horizontally in a northerly direction toward the hill side. When this groundwater encounters the landslide debris formation along the hill side, some of it may emanate as seeps and springs, while the rest migrates downhill in the fractures of the landslide debris.

It appears that the majority of the groundwater flow passing through OU 1 leaves the source area to the west. Of the flow that does move east, it appears that most emanates in seeps and springs and little migrates downhill through the landslide debris formation. This may have limited contaminant migration in an easterly direction off base.

Groundwater continues to flow downhill through fractures in the landslide debris formation. Where groundwater is close to land surface, portions are lost by evapotranspiration and through discharge as seeps and springs. Below the Davis-Weber Canal, the quantity of groundwater increases because of leakage from the canal.

When the groundwater in the fractures of the landslides contact the sand unit of the Alpine Formation, the water flows vertically to the contact with the underlying sand/clay unit. When this relatively impervious unit is reached, groundwater flows horizontally to the northeast and into the recent terrace deposits. The groundwater continues to flow northeasterly through the recent terrace deposits, and appears to outlet almost totally in a series of springs north of South Weber Drive.

The transport of contaminants at OU 1 followed the path of the groundwater described above, but a few key factors have limited the migration of contaminants into the Weber River Valley. First, natural biodegradation has resulted in the conversion of chlorinated hydrocarbons to less chlorinated hydrocarbons (e.g., TCE to DCE). The fuel hydrocarbons also appear to have undergone significant natural biodegradation since they have not migrated out of the Source Area. The second factor is the physical loss that probably occurred along the hill side. It is likely that a significant amount of the contaminated groundwater emanated as seeps and springs along the hillside and never made it to the Weber River Valley. It is also possible that contaminants volatilized out of the groundwater even when it was not on the ground surface. The interim actions taken at OU 1 have also reduced the extent of migration of contaminants, although the extent of this reduction cannot be quantified. The interim actions are likely responsible for the recent declines in offsite groundwater concentrations of DCE, the primary offsite groundwater contaminant. The extent of the contaminant plumes in the various formations is shown in Figure 1-6 of the FS.

## Summary of Remedial Action Objectives

The remedial action objectives for OU 1 are as follows:

- Prevent human exposure through contact, ingestion, or inhalation to contaminated soil, landfill contents, and LNAPL that presents an unacceptable risk (e.g., hazard index greater than 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$).
- Remediate contaminated soil as necessary to prevent migration of contaminants in excess of maximum contaminant levels (MCLs) or hazard index greater than 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$ to groundwater.
- Minimize the potential for human exposure to contaminated shallow groundwater both within and outside the Source Areas. Remediate contamination in shallow groundwater outside the areas of waste left in place to concentrations below MCLs or hazard index of 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$ within a reasonable time frame.
- Prevent exposure to seep and spring water in excess of MCLs.
- Remediate LNAPL and landfill contents as necessary to also enable long-term attainment of groundwater, surface water, and soil remedial action objectives.
- Prevent above ground landfill gas concentrations, and subsurface landfill gas concentrations from reaching dangerous (i.e., explosive) levels.
- Prevent migration of contaminants in excess of MCLs or hazard index greater than 1 or excess cancer risk greater than $1x10^{-4}$ to $1x10^{-6}$ to groundwater beyond the point of compliance for waste management areas.
- Remove as much free-phase LNAPL as practicable.

## Summary of Remedial Alternatives

To develop and evaluate alternatives, OU 1 has been separated into two areas of concern; the Source Area, and the Non-Source Area. The alternatives developed for each area are summarized in Tables ES-1 and ES-2 (found at the end of this section).

## Comparison of Alternatives

### Source Area Alternatives Comparison

All alternatives, with the exception of Alternative 1, are protective of public health and the environment, and should be able to meet applicable or relevant and appropriate requirements (ARARs). The primary measure of this is their ability to prevent offsite migration of contaminated groundwater. Each alternative provides an added degree of reliability that migration will be stopped, as discussed below for each alternative. A detailed evaluation and comparative analysis of alternatives is completed, based on the following five balancing criteria:

- Long-term Effectiveness and Permanence
- Reduction of Toxicity, Mobility, and Volume (TMV) through Treatment
- Short-term Effectiveness
- Implementability
- Cost

The alternatives vary in the degree to which they best balance the five balancing criteria. This is discussed below for each alternative:

- Alternative 1-No Further Action: The interim actions currently in place have reduced the extent of offsite migration. The magnitude of the current offsite migration is, however, not known. It is likely that some migration of contaminants offsite currently exists so that this alternative is not protective and does not meet ARARs. It also does not provide an ideal balance of the five balancing criteria since its long-term effectiveness is poor, and it does not provide any reduction in TMV. Its cost is, however, the lowest.
- Alternative 2-Existing System Upgrade: Would increase the reliability of preventing migration by installing trenches across the troughs of the Provo Formation. However, it would not prevent migration through the upper Alpine Formation. The additional present worth cost of providing these added controls on offsite migration is estimated to be $1.9 million. This alternative is less certain in its effectiveness at preventing offsite migration, but with routine groundwater monitoring, it is expected to be protective of public health and the environment. Although meeting ARARs is an object of Alternative 2, there is uncertainty on whether achievement of MCLs will occur in a reasonable time frame. As a result, a technical impracticability waiver from meeting MCLs for groundwater outside areas where waste is left in place may be needed in the future.

- Alternative 3-Groundwater Dewatering: Would increase the reliability of preventing offsite migration by removing groundwater before it can migrate through the Provo Formation. However, since it cannot capture all the water in the upper Alpine Formation, there may still be a small amount of migration through the upper Alpine. The additional present worth cost of providing this reliability over Alternative 2 is $1.5 million. This alternative provides a good balance of the five balancing criteria since its long- and short-term effectiveness are good, it is implementable, and it does provide for some TMV reduction through groundwater and mobile LNAPL extraction. Its cost is also relatively low. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 4-Source Containment: Would increase the reliability of preventing offsite migration by providing a physical barrier to groundwater movement. Since the dewatering system should remove all of the groundwater in the Provo, the physical containment would do little to stop migration through the Provo, except during times of long-term shutdown of the dewatering system. The physical containment will also reduce the contaminant migration that may occur through the upper Alpine Formation. Since the magnitude of migration through the upper Alpine is uncertain and could be insignificant, it may be prudent to make the installation of the physical containment contingent on the performance of the dewatering system. The additional present worth cost of providing the added reliability is $1.6 million. This alternative provides a similar balance of the five balancing criteria to Alternative 3 since its greater cost is balanced by its slightly better long-term effectiveness. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 5-Source Containment and Cap Upgrade: Would increase the reliability of preventing offsite migration by reducing the infiltration through the contaminated soil into the groundwater. However, the amount of water that currently infiltrates through the cap is relatively small and should be captured by the dewatering system. Consequently, the slight increase in long-term effectiveness of the cap upgrade is poorly balanced by the additional $16.3 million in present worth cost. This alternative may not provide a good balance of the five balancing criteria, since its cost is much higher than Alternatives 3 or 4 even though its long-term effectiveness and reduction in TMV are similar. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 6-Source Treatment and Cap Upgrade: Would increase the reliability of preventing offsite migration by removing the majority of the mobile contaminant mass through soil vapor extraction (SVE). The additional reliability of preventing contaminant migration by conducting source treatment is likely to be small since the groundwater extraction system and physical containment should effectively prevent migration. The additional reliability provided by source treatment is estimated to add $1.3 million to the present worth cost. This alternative may not provide a good balance of the five balancing criteria, since its cost is much higher than Alternatives 3 or 4. However, its long-term effectiveness and reduction in TMV are better since it provides for mass removal. If the cap upgrade were not included with this alternative, it would provide a better balance of the five balancing criteria since it provides for mass removal but its cost is not substantially greater than Alternatives 3 or 4. If the cap upgrade is not included, the estimated total present worth cost of this alternative would be

$8.3 million. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.

- Alternative 7-Excavation, Treatment, and Offsite Disposal: Would increase the reliability of preventing offsite migration by removing the majority of the contaminated soils and wastes. The additional present worth cost of providing this certainty is $277.5 million. This alternative does not provide a good balance of the five balancing criteria since the cost is so much higher than the other alternatives, and short-term effectiveness and implementability of this alternative are poor. The short-term risks to the community and workers of the excavation and hauling of the soils and wastes is very high with this alternative. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.

## Non-Source Area Alternatives Comparison

All alternatives, with the exception of Alternative 1, are protective of public health and the environment, and should be able to meet ARARs in a reasonable time period. The primary measures of this are the ability to prevent exposure, and the time institutional controls are necessary to prevent potable use of seeps/springs and groundwater (i.e., the time required before MCLs are reached). The differences between alternatives in their overall protectiveness are not considered great because they all rely on the same institutional controls to prevent exposure and the time period for which the controls are necessary are not significantly different. Each alternative provides some added degree of protection and reliability in achieving ARARs, as discussed below for each alternative. The alternatives, however, do not vary significantly in the degree to which they best balance the five balancing criteria.

- Alternative 1-No Further Action: For the purpose of establishing a true "no further action" alternative, the no further action alternative for the source area is combined with the no further action alternative of the non source area. This evaluation of Non-Source Area Alternative 1 assumes that the Source Area is not remediated. Consequently, contaminants will continue to migrate offsite **for many decades** and ARARs cannot be achieved. In addition, this alternative is not completely protective since there is some potential for exposure to the moderately contaminated seeps and springs that are currently not controlled. This alternative does not provide a good balance of the five balancing criteria since it has poor long-term effectiveness, and it does not provide for any reduction in TMV. Its cost, however, is the lowest.
- Alternative 2-Natural Attenuation: This alternative is combined with Source Area Alternatives which effectively prevent contaminants from migrating into the Non-Source Area, and is expected to reduce discharge of the contaminated seeps and springs. With the source area contaminants cut off, the restoration time frame is substantially reduced. This alternative provides better reliability of meeting ARARs than Alternative 1. It is estimated that the time required to achieve ARARs is between 5 and 50 years, with a best estimate of 12 years. This alternative also provides additional monitoring to better understand the mechanisms occurring naturally, and it will provide better warnings if natural attenuation processes are not being effective. This alternative provides a better balance of the five balancing criteria since its cost is relatively low and the better monitoring it provides will add to the long-term

protectiveness. The additional present worth cost of providing the additional monitoring is $0.2 million. Although meeting ARARs is an objective of alternative 2, there is uncertainty on whether achievement of MCLs will occur in a reasonable time frame. As a result, a technical impracticability waiver, from meeting MCLs for groundwater outside areas where waste is left in place, may be needed in the future.

- Alternative 3-Natural Attenuation and Existing Seep Collection Upgrade: This alternative provides an additional protection to human health and the environment by collecting additional seeps/springs that are contaminated above remedial goals, and by removing sediments contaminated by arsenic. The added reliability of this protectiveness is probably small because chances for use as a drinking water supply are low. The time required to achieve ARARs is the same as Alternative 2, a best estimate of 12 years. The present worth cost of providing this added protection is estimated to be $0.7 million. This alternative provides a similar balance of the five balancing criteria as Alternative 2, even though it is somewhat more costly. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 4-Plume Cut-Off at bottom of bluff: This alternative provides a slightly increased degree of protectiveness and slightly better ability to achieve ARARs since water reaching the bottom of the bluff would be treated. This is especially true if the Source Area alternative implemented is not effective in stopping offsite migration. Any contamination reaching the bottom of the bluff should be removed with this system. The time required to achieve ARARs is essentially the same as Alternatives 2 and 3, a best estimate of 11 years. The additional $1.5 million in present worth cost suggest that this alternative has a slightly poorer balance of the five balancing criteria than Alternative 3. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 5-Hydraulic Containment at Leading Plume Edges: This alternative provides a slightly increased degree of protectiveness by preventing the migration of contamination into areas previously not contaminated. However, minimal migration is expected even without this alternative and, in the Weber River Valley, concentrations beyond the seeps and springs are less than remedial goals. The time required to achieve ARARs is the same as Alternatives 2 and 3, a best estimate of 12 years. This alternative has a better balance of the five balancing criteria than Alternative 4 since its cost is lower, although it is not significantly better than Alternative 3. The additional present worth cost to prevent further migration compared to Alternative 3 is $0.6 million. A TI waiver may be needed in the event this alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.
- Alternative 6-Groundwater Collection Throughout the Plume: This alternative is the only alternative that substantially decreases the time to achieve ARARs compared to Alternative 2. The time to achieve ARARs may decrease to between four and 23 years, with a best estimate of five years. However, given the low potential for exposure currently caused by the offsite contamination and the use of institutional controls to prevent changes in land use or use of the groundwater, the overall increase in protectiveness is small. Because of only a small increase in protectiveness and a $1.0 million increase in present worth costs compared to Alternative 3, it has a poor balance of the balancing criteria. A TI waiver may be needed in the event this

alternative does not return groundwater in the Alpine formation to MCLs in a reasonable time frame.

From the above discussion of the Non-Source alternatives, it is clear that their evaluation depends significantly on the ability of the Source Area alternatives to effectively prevent offsite contaminant migration. Consequently, it may be prudent to stage the selection of the Non-Source Area alternatives until information is available on the performance of the Source Area alternatives. Likewise, further investigations of natural attenuation are currently underway at OU 1 that may provide more information on the effectiveness of Alternative 2.