Executive Summary

Introduction

The purpose of this Corrective Measures Study (CMS) is to evaluate final remedial alternatives for both on base soil and shallow groundwater contamination and off base shallow groundwater contamination in Zone 5 at Kelly Air Force Base (AFB) in San Antonio, Texas. This CMS integrates the findings of previous reports addressing interim remedial actions for shallow groundwater and soil in Zone 5 with an evaluation of remedial alternatives for other Zone 5 areas of concern that have not been previously evaluated. Thus, this document concludes the remedy selection portion of the phased approach to remediation of Zone 5. It is anticipated that an alternative, or combination of alternatives, will be selected from this CMS report by Kelly AFB and the regulatory agencies and presented in a separate proposed plan to the public for review and comment.

Background

Kelly AFB consists of two non-contiguous areas, the main portion of Kelly AFB and East Kelly. As a result of past waste management practices, the soil at Kelly AFB and shallow groundwater underlying and adjacent to the installation have become contaminated. To organize cleanup at the installation, Kelly AFB is divided into five zones. Zone 5 consists of all on base areas outside of Zones 1 through 4. This CMS report is focused on evaluation of remedial alternatives at and immediately adjacent to Zone 5.

Kelly AFB is authorized for closure and post-closure care of certain hazardous waste units under Permit No. HW-50310 issued by the Texas Natural Resource Conservation Commission (TNRCC). The permit and associated compliance plan specify cleanup requirements for solid waste management units, including many in Zone 5. The cleanup of Kelly AFB is also being addressed pursuant to the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) and the Department of Defense Environmental Restoration Program (DERP). The USAF program is called the Installation Restoration Program (IRP) and it is conducted in a manner that is consistent with both CERCLA and the National Contingency Plan, even for those USAF installations that are not on the U.S. Environmental Protection Agency's National Priorities List. Kelly AFB is one of the installations being addressed under the IRP; it is not, however, on the National Priorities List.

Soil and Groundwater Characterization

The 1999 Final Zone 5 Remedial Investigation (RI) Report constitutes the primary source of environmental data used for this CMS. The RI data have been supplemented by several more recent supplementary characterization efforts.

Soil Contamination

Site S003 (S-1) is the only site in Zone 5 where significant soil contamination has been documented to date. The primary contaminants of concern (COCs) found in Site SS003 (S-1) are chlorobenzene (CB), 1,2-dichlorobenzene (1,2-DCB), and 1,4-dichlorobenzene (1,4-DCB). This contamination shows up at unsaturated zone depths in the sump area ranging from 12 to 14 feet below ground surface (bgs) to the water table (24 to 26 feet bgs), which correlates well with the estimated surface elevation of the former sump area. The CB, 1,2-DCB, and 1,4-DCB detected in the deeper zone outside of the sump area, referred to as the "smear zone," suggests that this contamination reached this area through light nonaqueous phase liquid (LNAPL) transport. Cholorbenzene and 1,2-DCB are liquids denser than water and 1,4-DCB is a solid at room temperature. However, if the CB and DCBs had been mixed with oils (which is quite possible since the site was used to store wastes), they could have formed LNAPL.

Groundwater Contamination

A total of 35 contaminants of potential concern were identified in Zone 5 groundwater, resulting in the delineation of eleven distinct groundwater contaminant plumes designated A through K. The plumes were grouped by location of contamination, and, for some constituents, the similarity between chemistry. The key contaminants of potential concern in groundwater include trichloroethene (TCE), dichloroethene (DCE), 1,2-DCE, tetrachloroethene (PCE), benzene, CB, and arsenic. As shown in Figure ES.1, the groundwater contaminant plumes and the key contaminants of potential concern present in each are as follows:

- Plume A (TCE)
- Plume B (PCE)
- Plume C (chlorobenzene and arsenic)
- Plume D (TCE, PCE, and 1,2-DCE)
- Plume E (benzene and arsenic)
- Plume F (PCE/TCE)
- Plume G (benzene and arsenic)
- Plume H (TCE and total 1,2-DCE)
- Plume I (PCE, TCE, and DCE)
- Plume J (PCE and TCE)
- Plume K (chlorobenzene).

The source area[1] and the body of Plume B are located offbase and the plume is migrating to the north/northeast, away from Kelly AFB. The plume is not within Zone 5 and is not

[1] "Source area" is used throughout this report to indicate an area in the contamination plume in which the groundwater exhibits high contaminant concentrations relative to the rest of the plume. "Source area" is the area within which the source of

related to operations at Kelly AFB. Therefore, remedial alternatives for Plume B are not discussed in this CMS report.

Remedial Action Objectives

Based on available data, the soil at Zone 5 does not pose unacceptable risks with respect to direct contact exposure to contaminated soil. However, unacceptable risks do occur at Site SS003 (S-1) if the groundwater below and downgradient is used as a drinking water supply because of the potential for contaminants leaching to the groundwater. Based on this, the objective for soil remedial action for Zone 5 is to prevent migration of soil contaminants to groundwater that could result in exceedances of maximum contaminant levels (MCLs) or, where there are no MCLs, Texas groundwater media-specific concentrations.

Although the risk assessment did not show unacceptable risk from direct contact to soil at Zone 5, a remedial objective addressing direct contact exposures is included to allow evaluation of soil data that might be generated in the future. This remedial objective is to prevent exposure to surface soil via ingestion, inhalation, or dermal contact that would result in an excess carcinogenic risk of 1×10^{-4} or a hazard index of 1. A risk of 1×10^{-6} will be used as a point of departure.

The shallow groundwater both on base and off base poses unacceptable risks. It is unlikely that on base groundwater will ever be withdrawn directly for use as a drinking water supply, but it still poses risks because it is migrating off base. Based on this, the following are objectives for groundwater remedial actions for Zone 5:

1. Prevent use of both on base and off base groundwater containing contaminants in concentrations exceeding MCLs, or where those are not available, Texas groundwater medium-specific concentrations.

2. Reduce or prevent further migration of contaminated groundwater (defined as groundwater with contaminant concentrations that exceed MCLs or, where those are not available, Texas groundwater medium-specific concentrations) from on base areas to off base areas. [2]

3. Restore off base groundwater to MCLs or, where those are not available, to Texas groundwater medium-specific concentrations, within a reasonable time frame.

4. Restore on base groundwater to MCLs or, where those are not available, to Texas groundwater medium-specific concentrations, within a reasonable time frame. If that time frame exceeds 20 years, establish alternate concentration limits (ACLs) that are no greater than existing contaminant concentrations and ensure that those ACLs are met during the interim time period.

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groundwater contamination probably originated in the past. Unless otherwise indicated, “source area” does not mean that there is presently an active source of contamination.

[2] For purposes of selecting an appropriate remedial action, the term “on base” refers only to those areas of Kelly AFB that will be maintained under federal control following base closure. The term “off base” refers both to those areas that are currently outside the Kelly AFB boundaries and to those areas that will be transferred to a non-federal entity following base closure.

Preliminary Remediation Goals

Preliminary remediation goals (PRGs) were developed for soil and groundwater to establish acceptable concentrations for each COC under relevant exposure settings. PRGs for soil were developed for Site SS003 (S-1). Risk-based concentrations were developed in accordance with EPA's Risk Assessment Guidance for Superfund using two industrial-use exposure scenarios. The assumed direct-contact exposure pathways for each scenario include soil ingestion, inhalation of volatile organic compounds (VOCs) and particulates, and dermal contact. A risk-based soil concentration also was developed for groundwater protection (GWP) based on the EPA's Summers Model**,** a mass balance approach to contaminant leaching, and mixing with groundwater below the source area.

PRGs for groundwater COCs were developed from the 30 TAC 335.568, Appendix II Table of medium-specific concentrations and the TNRCC Compliance Plan for Kelly AFB. For each contaminant, the more stringent value of the two sources constitutes the PRG used in this CMS for identifying the extent of groundwater to be remediated.

Development of Remedial Action Alternatives

General response actions (GRAs) were selected to satisfy the remedial action objectives and PRGs by either reducing concentrations of hazardous substances or by reducing the likelihood of contact with hazardous substances. They include actions such as treatment, containment, collection, disposal, and institutional controls. Although one response action may meet the goals, a combination of response actions may meet the goals more effectively.

The technology types and process options available for remediation of both soil and groundwater were identified and screened for suitability to eliminate those technologies that are clearly not applicable for remediation. Technology types and process options considered are based on professional experience, published sources, computer databases, and other available documentation for the identified GRAs. GRA's that remained following screening were developed into remedial action alternatives.

Remedial Alternatives for Soil

Six alternatives were developed for soil at the site SS003 (S-1) sump area:

- Alternative 1 - No Further Action
- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 – Source Control
- Alternative 4 - Soil Vapor Extraction (SVE)
- Alternative 5 - Excavation and Off-Base Disposal
- Alternative 6 - Ex Situ Biological Treatment

Four alternatives were developed for the site SS003 (S-1) smear zone:

- Alternative 1 - No Further Action

- Alternative 2 – Monitored Natural Attenuation
- Alternative 3 - SVE
- Alternative 4 - Dual Phase Groundwater Recovery and SVE

Remedial Alternatives for Groundwater

Seven remedial alternatives were developed for groundwater contaminant plumes:

- Alternative 1 - No Further Action
- Alternative 2 - Monitored Natural Attenuation
- Alternative 3 - Source Control
- Alternative 4 - Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control
- Alternative 5 - Source and Perimeter Control
- Alternative 6 - Targeted Source and Perimeter Control
- Alternative 7 - Source Ex Situ and In Situ Treatment and Perimeter Control

Detailed and Comparative Analyses of Alternatives

The detailed analysis of alternatives presents the relevant information needed to compare the remedial alternatives assembled for site SS003 (S-1) soils and for groundwater contaminant plumes. Provisions of the National Contingency Plan require that each alternative be evaluated against nine criteria listed in 40 CFR 300.430(e)(9), as follows:

- Overall protection of human health and the environment
- Compliance with ARARs
- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost
- Community acceptance
- State acceptance

State and community acceptance will be assessed at the conclusion of the public comment period. In addition, because this document also serves to satisfy the Kelly AFB obligations under NEPA, the detailed analysis considers potential environmental impacts that are not otherwise addressed by CERCLA criteria. The results of the detailed analyses for each individual alternative are used to provide a basis for comparison of the relative performance

of each of the alternatives and to identify their relative advantages and disadvantages. This approach is intended to provide sufficient information to adequately compare the alternatives and to allow Kelly AFB, the regulatory agencies, and the public to eventually select the most appropriate alternative or combination of alternatives for implementation at the site as remedial actions.

Comparative Analysis for Site SS003 (S-1) Sump Area Alternatives

Overall Protection of Human Health and the Environment

Except for the No Further Action Alternative, all alternatives are protective of public health and the environment. The Excavation and Offsite Disposal and Ex Situ Biological Treatment Alternatives are most protective of public health and the environment because the physical removal of the CB, 1,2-DCB, and 1,4-DCB that exceed PRGs eliminates the risk of the contaminants from leaching to the groundwater. Other alternatives that either allow contaminants to remain in place or treat them in situ are less certain in their ability to prevent leaching in the long term.

The SVE Alternative is protective of public health and the environment because the CB, 1,2-DCB, and 1,4-DCB that exceed PRGs are reduced through both physical removal and enhanced aerobic biodegradation. The No Further Action, Monitored Natural Attenuation, and Capping Alternatives rely on the operation of the existing groundwater collection and treatment system to be protective to capture the groundwater exceeding MCLs and/or medium-specific concentrations as a result of leaching. Even under continued operation of the existing groundwater collection system, the water table may rise in the future causing remobilization of the contaminants in soils immediately above the water table. Because the soils in the smear zone directly above the current water table are the most contaminated soils at the site, monitoring and operation of the groundwater collection system are much more important under these alternatives that leave contaminated soils in place.

Compliance with ARARs

Except for the No Further Action Alternative, all alternatives would meet ARARs. The Excavation and Disposal and Ex Situ Biological Treatment Alternatives would meet ARARs because the risks associated with the leaching of CB, 1,2-DCB, and 1,4-DCB to the groundwater that would result in concentrations exceeding drinking water MCLs or Texas groundwater medium-specific concentrations would be eliminated with the removal of the soil. For the Ex Situ Biological Treatment Alternative, *Clean Air Act* ARARs would be met because treatment piles would be either located inside an existing building or be covered.

The No Further Action, Monitored Natural Attenuation, and Capping Alternatives would meet ARARs provided that the existing treatment system remains in operation. State ARARS would be met under the first two alternatives when Texas Risk Reduction Standard (RRS) 3 groundwater protection medium-specific concentrations for CB, 1,2-DCB, and 1,4-DCB are met; however, this may take decades. The Capping Alternative meets the RRS 3 for engineering controls once it is constructed. ARARs would be met using the SVE Alternative because, within less than 5 years the contaminants would be reduced to concentrations below those, that would result in exceedance of groundwater standards. Air treatment for the emissions would be implemented if required to meet *Clean Air Act* ARARs.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of the Excavation and Off-Site Disposal and the Ex Situ Biological Treatment Alternatives are better than the other alternatives because the soil posing the potential risk would be removed. The Monitored Natural Attenuation, Capping, and SVE Alternatives require reliance on continued operation of the groundwater treatment system. If turned off, because groundwater medium specific concentrations are met, heavy reliance on continued monitoring will be important because of the potential for an elevated water table remobilizing contaminants in soil. The long-term effectiveness of monitoring is diminished because site SS003 (S-1) is slated to be transferred to a private entity and access for monitoring may be more difficult. Also, assurance of the institutional controls being followed is less certain once the Air Force is no longer the property owner. There is no significant change in the magnitude of residual risk for the No Further Action, Monitored Natural Attenuation, and Capping Alternatives because no action with respect to the reduction of the contaminants to below PRGs is taken by these alternatives.

Reduction of Toxicity, Mobility, or Volume through Treatment

The SVE, Excavation and Offsite Disposal, and Ex Situ Biological Treatment Alternatives offer the best reductions in toxicity, mobility, or volume for the soil. For the other three alternatives, active treatment is not used. Reduction in toxicity, mobility, or volume through natural biodegradation would occur for the No Further Action and Monitored Natural Attenuation Alternatives, but the degradation rate is slow and could take decades. Natural degradation would be considerably slower under the Capping Alternative because oxygen and moisture needed for biological growth would be diminished .

Short-Term Effectiveness

All alternatives have minimal impacts with respect to the protection of workers during remedial construction, protection of community during remedial action, and environmental impacts of remedial action. The No Further Action and Monitored Natural Attenuation Alternatives have no impacts because both alternatives involve no remedial construction. The Capping and SVE Alternatives have little impacts because the contamination exceeding PRGs is located 14 ft or greater below ground surface and would not be disturbed during construction. For the Excavation and Offsite Disposal and Ex Situ Biological Treatment Alternatives, the risk assessment showed risk to construction workers to be less than acceptable levels.

The short-term effectiveness with respect to the time until the remedial action objectives are achieved is shortest for the Capping, Excavation and Off-Site Disposal and Ex Situ Biological Treatment Alternatives because these alternatives would be completed within 1 to 2 years. The next shortest time of about 5 years is the SVE Alternative. The slowest is the No Further Action and Monitored Natural Attenuation Alternatives, which would take decades until remedial action objectives are achieved.

Implementability

Technical or administrative implementability problems are not expected for any of the alternatives.

Cost

A summary of the estimated costs for each of the sump area alternatives is presented in Table ES.1**.** The No Further Action Alternative has no cost, while the Ex Situ Biological Treatment Alternative has the highest cost. Of the active remediation alternatives, all the costs are within order-of-magnitude comparison. Final project costs will vary from the cost estimates. The specific details of remedial actions and cost estimates would be refined during final design. Project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help ensure proper project evaluation and adequate funding.

Comparative Analysis for Site SS003 (S-1) Smear Zone Alternatives

Overall Protection of Human Health and the Environment

Except for the No Further Action Alternative, all alternatives are protective of public health and the environment. Both the SVE and Dual-Phase Groundwater Recovery and SVE Alternatives are protective of public health and the environment because the CB, 1,2-DCB, and 1,4-DCB that exceed PRGs are reduced through physical removal and enhanced aerobic biodegradation. The No Further Action and Monitored Natural Attenuation Alternatives rely heavily on continued operation of the existing treatment system to capture the groundwater exceeding MCLs and/or medium-specific concentrations as a result of leaching.

Compliance with ARARs

All alternatives would meet ARARs. The No Further Action and Monitored natural attenuation alternatives may not meet the Texas RRS 3 soil medium-specific concentrations for protection of groundwater for decades. The actual duration can be estimated more precisely once an ongoing natural attenuation study is completed. ARARs for both the SVE and Dual-Phase Groundwater Recovery and SVE Alternatives would be met because the contaminants would be reduced in about 5 years to the Texas RRS 3 soil medium-specific concentrations for protection of groundwater. Air treatment for the emissions may be required to meet *Clean Air Act* ARARs.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of the SVE and Dual-Phase Groundwater Recovery and SVE Alternatives are better than the other two alternatives because contaminant leaching is reduced through the reduction of contaminant concentrations in the subsurface. The No Further Action and Monitored Natural Attenuation Alternatives require reliance on continued operation of groundwater collection and treatment system. There is no significant change in the magnitude of residual risk for the No Further Action or Monitored Natural Attenuation Alternatives because no action with respect to the reduction of the contaminants to below PRGs was taken.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The SVE and Dual-Phase Groundwater Recovery and SVE Alternatives offer the best reductions in toxicity, mobility, or volume for the soil. About 80 percent of the estimated amount of CB, 1,2-DCB, and 1,4-DCB are reduced during the SVE and Dual-Phase

Groundwater Recovery and SVE Alternatives. For the other alternatives, reduction in toxicity, mobility, or volume is not applicable because active treatment is not performed. Treatment via natural degradation could take decades for the No Further Action and the Monitored Natural Attenuation Alternatives.

Short-Term Effectiveness

All alternatives have minimal impacts with respect to the protection of workers during remedial construction, protection of community during remedial action, and environmental impacts of remedial action. The No Further Action and Monitored Natural Attenuation Alternatives have no impacts because both alternatives involve no remedial construction. The other alternatives have little impacts because the contamination exceeding PRGs is located 20 ft or greater below ground surface. They will also have limited short-term installation and some operational impacts due to noise. The short-term effectiveness with respect to the time until the remedial action objectives are achieved is shortest for both SVE and Dual-Phase Groundwater Recovery and SVE Alternatives because both alternatives involve the physical removal and enhanced aerobic degradation of the contaminants exceeding PRGs. The slowest is for the other two alternatives, which would take decades until remedial action objectives are achieved.

Implementability

No technical or administrative implementability problems are expected for all of the alternatives.

Cost

A summary of the estimated costs for each of the smear zone alternatives is presented in TableES.2. The table breaks down the estimated capital, O&M, and present net worth cost. The No Further Action Alternative has no cost, while the Dual-Phase Groundwater and SVE Alternative has the highest cost. Of the active remediation alternatives, the costs are within order-of-magnitude comparison. Final project costs will vary from the cost estimates. The specific details of remedial actions and cost estimates would be refined during final design. Project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help ensure proper project evaluation and adequate funding.

Comparative Evaluation for Groundwater Remediation Alternatives

Overall Protection of Human Health and Environment

Except for the No Further Action Alternative, all of the alternatives are protective of human health and the environment and prevent the use of contaminated groundwater by using administrative controls to restrict the use of the on base shallow groundwater.

Except for the No Further Action Alternative, all of the alternatives substantially reduce or eliminate further migration of contaminants through the groundwater by intercepting or eliminating contaminants in the groundwater at various locations both on and off base.

In off base areas, the time frame to restore groundwater contamination concentrations to PRG levels is difficult to estimate because the fate and transport model does not extend more than 1,500 ft off base. The Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 4 through 7) would restore the groundwater contaminant levels in this region in about 25 years. Capping would achieve this result in 25 to 30 years, and the No Further Action and Monitored Natural Attenuation Alternatives would require more than 40 years to achieve this result.

In areas subject to base closure (essentially the area east of the runway), the Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 3 through 7) would restore groundwater contaminant concentrations to PRGs in the least amount of time (25 to 30 years) while the No Further Action and Monitored Natural Attenuation Alternatives would achieve this objective over the longest time frame (40 years or more).

In areas that will remain under Department of Defense control, the Capping, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 3, 4, 5, and 7) would reduce contamination levels to PRGs in about 25 to 30 years. The No Further Action, Monitored Natural Attenuation, and Targeted Source and Perimeter Control Alternatives (Alternatives 1, 2, and 6) would take 30 to 40 years to achieve this result.

Source control and upgrade of the existing perimeter pump and treat systems as necessary (Source Control, Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives [Alternatives 3, 5, and 7]) would be effective at reducing off base contaminant levels in a reasonable time frame (remedial action objectives 4 and 5). Of those alternatives, only the Source and Perimeter Control and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives would be effective at reducing on base contaminant levels (remedial action objective number 4).

Compliance with ARARs

Except for the No Further Action Alternative, all alternatives would comply with ARARs by meeting National Pollution Discharge Elimination System permit discharge limits. Air emissions (if any) would meet concentration and volume limits for discharge of VOCs under the state standard exemption for remediation.

Long-Term Effectiveness

All alternatives would be effective in the long term, although each alternative would vary in the time frame needed to meet the objectives. The active remediation alternatives (Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives [Alternatives 3 through 7])

achieve the PRGs in shorter time than the passive remediation alternatives (No Further Action and Monitored Natural Attenuation [Alternatives 1 and 2]).

All of the alternatives, including the passive remediation alternatives) involve remediation mechanisms that are generally irreversible. There is no residual risk once the concentrations have been reduced to acceptable levels.

Reduction of Toxicity, Mobility, or Volume Through Treatment

The No Further Action and Monitored Natural Attenuation Alternatives do not include active treatment to reduce the toxicity, mobility, or volume of contaminants. VOCs occurring in the plumes would attenuate naturally over time.

The Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 3 through 7) include active treatment that would reduce toxicity, mobility, and volume of contaminants in the groundwater. Each of the active remediation alternatives would remove or destroy about the same amount of VOCs over the life of the remediation activity. The Targeted Source and Perimeter Control Alternative would remove or destroy the least (about 440 lb) while the Source Ex Situ and In Situ Treatment, Perimeter Control and off Base Control Alternative would remove or destroy the most (about 530 lb).

Short-Term Effectiveness

There would not be any significant effects on workers, the community, or the environment during remediation for any of the seven alternatives.

The No Further Action and Monitored Natural Attenuation Alternatives would require the longest remediation time because they rely on no action and natural attenuation for remediation. For remediation of contaminated groundwater on base, the Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives may achieve remedial action objectives faster than Alternatives 3, 5, and 6 because they use in situ treatment which may eliminate contamination faster.

Implementability

All alternatives can be implemented, however, there are technical issues associated with the alternatives that involve active remediation (Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives [Alternatives 3 through 7]) related to the heterogeneous nature of the aquifer. The relatively low hydraulic conductivity and heterogeneities may make it difficult to extract groundwater in the area. The Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives, which include an in situ bioremediation component may have some difficulties in achieving uniform dispersion of substrates and/or nutrients into the aquifer. Alternative injection systems (such as dual-phase, horizontal two-pipe systems or

recirculating wells) are not considered feasible because of the difficulty of reinjecting water into the low permeability subsurface.

In general, the Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 3 through 7) all involve technologies, services, and materials that are readily available. In situ bioremediation (Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control and Source Ex Situ and In Situ Treatment and Perimeter Control) is a relatively new and innovative technology, and most applications of this technology to date have been at relatively small remediation sites, and has not been proven on larger sites.

The Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control Alternative requires the installation of wells located in off base areas and this could be difficult. The eastern section of Plume A is widely dispersed and is currently in a residential area. Because the plume is in a residential area, it will become increasingly difficult to install sampling wells. As the plume continues to disperse, this shortage of sampling wells will make it difficult to define the plume. Without a clear plume definition, properly installing off base recovery wells could become a problem.

Cost

Table ES.3 presents the capital cost present worth for the seven alternatives. These cost estimates have been developed strictly for comparing the seven proposed alternatives. Final project costs will vary from the cost estimates. The specific details of remedial actions and cost estimates would be refined during final design. Project feasibility and funding needs must be reviewed carefully before specific financial decisions are made or project budgets are established to help ensure proper project evaluation and adequate funding.

The No Further Action Alternative has no cost. The cost for the Monitored Natural Attenuation Alternative is $1,760,000. The cost estimates for active remediation, the Source Control, Source Ex Situ and In Situ Treatment, Perimeter Control and Off Base Control, Source and Perimeter Control, Targeted Source and Perimeter Control, and Source Ex Situ and In Situ Treatment and Perimeter Control Alternatives (Alternatives 3 through 7), range between $6.86 and $12.0 million (Total project present worth).

NEPA Values

NEPA normally considers the environmental impacts of an action, such as impacts to environmental media, cultural resources, the ecosystem, and threatened and endangered species, as well as the cumulative impacts and any potential issues related to environmental justice. As indicated below, none of the alternatives would be expected to have significant environmental impacts:

- Kelly AFB is located in an attainment area for all pollutants with established national and state air quality standards (per the Air Quality Control Region 13 of the Air Quality Division of the TNRCC); none of the alternatives are anticipated to generate air emissions sufficient to jeopardize the federal attainment status of the region.

- There are no known or suspected archaeological sites on Kelly AFB, and none of the alternatives would impact any structures, buildings, or objects eligible for listing on the National Register of Historic Places, and subject to the National Historic Preservation Act (36 CFR part 800).
- Due to the urban development in the project area, there is very little natural habitat to support wildlife. Therefore, none of the alternatives would have a significant impact on sensitive, protected, threatened or endangered species. Zone 5 is also located outside of the 100-year flood plain; and there are no wetlands in or around the proposed project site.
- Because the construction activity related to these alternatives is extremely small and in an already industrialized area, and because no effects to cultural or ecological resources are anticipated, no significant cumulative impacts are anticipated from any of the remedial action alternatives.
- None of the alternatives would increase Kelly AFB's draw from the Edwards Aquifer, and, therefore, would not impact the threatened and endangered species associated with this sole source aquifer. NEPA requirements for public involvement are similar to those for remedial actions, and thus are covered under the standard IRP public comment process.

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TABLE ES.1
Summary of Costs for Site SS003 (S-1) Sump Area Remedial Alternatives
Kelly AFB, San Antonio, Texas

Alternative	Description	Capital Costs	First Year O&M Costs	Alternative Life (years)	Total Project Present Worth
Alternative 1	No Further Action	$0	$0	30	$0
Alternative 2	Monitored Natural Attenuation	$74,000	$21,300	30	$188,000
Alternative 3	Capping	$182,000	$12,700	30	$281,000
Alternative 4	SVE	$271,000	$65,800	5	$508,000
Alternative 5	Excavation and Offsite Disposal	$601,000	$0	1	$601,000
Alternative 6	Ex situ Biological Treatment	$641,000	$46,400	2	$728,000

TABLE ES.2
Summary of Costs for Soil Site SS003 (S-1) Smear Zone Remedial Alternatives
Kelly AFB, San Antonio, Texas

Alternative	Description	Capital Costs	First Year O&M Costs	Alternative Life (years)	Total Project Present Worth
Alternative 1	No Further Action	$0	$0	30	$0
Alternative 2	Monitored Natural Attenuation	$74,000	$21,300	30	$183,000
Alternative 3	SVE	$356,000	$73,800	5	$618,000
Alternative 4	Dual-Phase Groundwater Recovery and SVE	$446,000	$79,200	5	$733,000

TABLE ES.3
Summary of Costs for Zone 5 Groundwater Alternatives
Kelly AFB, San Antonio, Texas

Alternative	Description	Capital Costs ($ 000)	O&M Present Worth ($ 000)	Total Project Present Worth ($ 000)
Alternative 1	No Further Action	0	0	0
Alternative 2	Monitored Natural Attenuation	0	1,590	1,590
Alternative 3	Source Control	2,870	5,220	8,090
Alternative 4	Source Ex Situ and In Situ Treatment, Perimeter Control, and Off Base Control	5,540	7,160	12,700
Alternative 5	Source and Perimeter Control	3,160	5,530	8,690
Alternative 6	Targeted Source and Perimeter Control	2,580	5,090,	7,670
Alternative 7	Source Ex Situ and In Situ Treatment and Perimeter Control	3,800	6,500	10,300