KIRTLAND AIR FORCE BASE
ALBUQUERQUE, NEW MEXICO

ENGINEERING EVALUATION/COST ANALYSIS REPORT

Military Munitions Response Program
Sites TS775 and TS776

March 2012

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Kirtland AFB, New Mexico 87117-5270

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Military Munitions Response Program
Sites TS775 and TS776

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March 2012

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COLONEL JOHN C. KUBINEC
377th Air Base Wing and Installation Commander

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ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
ARAR	applicable relevant and appropriate requirements
ARI	Abbreviated Remedial Investigation
bgs	below ground surface
BMP	Best Management Practice
BRA	baseline risk assessment
BTAG	Biological Technical Assistance Group
CERCLA	Comprehensive Environment Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
COC	chemical of concern
CSE	Comprehensive Site Evaluation
EC	engineering control
ECC	Environmental Chemical Corporation
EE/CA	Engineering Evaluation/Cost Analysis
EO	Executive Order
EPC	exposure point concentration
FOD	foreign object debris
IC	institutional control
IEUBK	Integrated Exposure Uptake Biokinetic
ITRC	Interstate Technology Regulatory Council
HGL	HydroGeoLogic, Incorporated
LUC	land use control
mg/kg	milligrams per kilogram
MMRP	Military Munitions Response Program
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NDAI	No Department of Defense Action Indicated
NFA	No Further Action
NMAC	New Mexico Administrative Code
NMED	New Mexico Environment Department
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
PAH	polycyclic aromatic hydrocarbon
PRG	preliminary remediation goal
RAO	removal action objective
SSL	soil screening level
TBC	to be considered
TCLP	toxicity characteristic leaching procedure
USAF	United States Air Force
USC	United States Code
USEPA	United States Environmental Protection Agency

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EXECUTIVE SUMMARY

Environmental Chemical Corporation (ECC) has prepared this Engineering Evaluation/Cost Analysis (EE/CA) Report to support a non-time-critical removal action at the Military Munitions Response Program (MMRP) Sites TS775 and TS776 at Kirtland Air Force Base (AFB) in Albuquerque, New Mexico. This EE/CA was conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the United States Environmental Protection Agency (USEPA) *Guidance for Conducting Non-Time Critical Removal Actions Under CERCLA* (USEPA, 1993). This EE/CA Report describes site characteristics, removal action objectives (RAOs), screening of technologies, development and evaluation of removal action alternatives, and identification of the recommended removal action alternative for Sites TS775 and TS776.

Sites TS775 and TS776 are former skeet ranges located in the northwestern portion of Kirtland AFB. Skeet range operations at Site TS775 are believed to have ended after World War II. The former skeet range at Site TS776 is documented to have continued operation as a recreational skeet range through 1998. Historical skeet range operations have resulted in the presence of lead shot and clay target fragments at both sites (USA Environmental, 2007).

Site TS775 encompasses 25.2 acres of land area, immediately adjacent to the Albuquerque International Sunport south airport taxiway. Site TS776 encompasses 29.3 acres of land area, approximately 1 mile east-southeast of the taxiway. The current land use at both sites is designated for light industrial, administrative, and research purposes (Kirtland AFB, 2002).

The Baseline Risk Assessment (BRA), completed as part of the Abbreviated Remedial Investigation (ARI), determined that polycyclic aromatic hydrocarbon (PAH) concentrations in soil within the primary clay target fragment fall zone at both sites pose an unacceptable risk to potential future residents (ECC, 2011). The clay target fragments, which are made from coal tar and limestone, were identified as the primary source of the PAHs in soil. The removal of surface soil with PAH concentrations exceeding the New Mexico Environment Department (NMED) residential soil screening levels (SSLs) would reduce the risk within the USEPA target lifetime excess cancer risk range of 1 in 1,000,000 (10^{-6}) to 1 in 10,000 (10^{-4}) (ECC, 2011). Previous soil sampling results indicate that PAH contamination is limited to the upper 12 inches of soils within the primary clay target fragment fall zone.

The BRA concluded that current lead concentrations in soil do not pose an unacceptable risk to current and future receptors, even though lead shot have been present at both sites for over 70 years. The removal of lead-impacted soil from these sites is not warranted.

Based on the results of the BRA, the RAOs for Sites TS775 and TS776 include:

- Removal of soil with PAH concentrations exceeding the NMED residential SSLs, and
- Removal of visible clay target fragments.

The EE/CA evaluated several technologies and developed the following five alternatives for achieving the RAOs:

- Alternative 1: No Department of Defense Action Indicated
- Alternative 2: Land Use Controls
- Alternative 3: Excavation and Off-Site Disposal of Surface Soil Impacted by Visible Clay Target Fragments
- Alternative 4: Excavation of Surface Soil Impacted by Visible Clay Target Fragments; Removal of Visible Clay Target Fragments by Dry Screening; and Off-Site Disposal of Soil with PAH Concentrations above Residential SSLs and Visible Clay Target Fragments
- Alternative 5: Excavation of Surface Soil Impacted by Visible Clay Target Fragments at Sites TS775 and TS776; Removal of Clay Target Fragments by Dry Screening at Sites TS775 and TS776; Off-Site Disposal of Soil with PAH Concentrations above Residential SSLs and Clay Target Fragments at Site TS776; and Excavation, Screening, and Removal of Clay Target Fragments with Land Use Controls at Site TS775

These alternatives provide a range of options to address the risks at the sites. Alternative 1 is required under CERCLA as a baseline for comparing other alternatives. Alternatives 2 and 5 do not meet the RAOs because these alternatives place portions of the sites under land use controls, which are protective of human health but do not allow for unrestricted land use. Alternatives 3 and 4 meet the RAOs and allow unrestricted land use at the sites.

The EE/CA includes an individual assessment of each proposed removal alternative based on the criteria of effectiveness, implementability, and cost. The proposed alternatives then were compared to each other on the same criteria and ranked from most desirable to least desirable.

Based on the comparative analysis, the recommended alternative is Alternative 4: Excavation of Surface Soil Impacted by Visible Clay Target Fragments; Removal of Visible Clay Target Fragments by Dry Screening; and Off-Site Disposal of Soil with PAH Concentrations above Residential SSLs and Visible Clay Target Fragments. The recommended alternative involves the following removal action elements:

- Excavate and screen soil in the low density target fragment area of Stratum 1 at both sites to separate clay target fragments from soil that does not have PAH concentrations above the NMED residential SSLs;
- Excavate soil in the high density target fragment area of Stratum 1 at both sites to removal clay target fragments and soil with PAH concentrations above the NMED residential SSLs;
- Transport clay target fragments and soil with PAH concentrations above the NMED residential SSLs to an off site Subtitle D landfill for disposal;
- Reuse soil that does not have PAH concentrations above the NMED residential SSLs to backfill excavations; and
- Restore the sites by grading and seeding.

The recommended alternative has an estimated capital cost of $1,039,281. This alternative meets the RAOs, meets the NCP criteria for protectiveness of human health and the environment, and meets all ARARs.

1 INTRODUCTION

The Air Force Center for Engineering and the Environment (AFCEE) has tasked Environmental Chemical Corporation (ECC) to conduct an Engineering Evaluation/Cost Analysis (EE/CA) to support a non-time-critical removal action at the Military Munitions Response Program (MMRP) Sites TS775 and TS776 at Kirtland Air Force Base (AFB) in Albuquerque, New Mexico.

ECC conducted the EE/CA in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), and the United States Environmental Protection Agency (USEPA) *Guidance for Conducting Non-Time Critical Removal Actions Under CERCLA* (USEPA, 1993).

This EE/CA Report describes site characteristics, removal action objectives (RAOs), screening of technologies, development and evaluation of removal action alternatives, and identification of the recommended removal action alternative for Sites TS775 and TS776.

1.1 REPORT ORGANIZATION

This EE/CA Report is composed of the following sections:

- **Section 1** presents an introduction to the EE/CA, including site history and characterization.
- **Section 2** summarizes the removal action scope, goals, and objectives.
- **Section 3** identifies removal action alternatives capable of meeting the RAOs and provides a brief discussion of the processes associated with each alternative.
- **Section 4** provides a comparative analysis of the alternatives with respect to effectiveness, implementability, and cost.
- **Section 5** provides a determination of the recommended alternative and a basis for the selection.

1.2 SITE LOCATION

Sites TS775 and TS776 are located on an elevated mesa in the northwest portion of Kirtland AFB, in Albuquerque, New Mexico. **Figure 1** depicts the locations of Sites TS775 and TS776 within Kirtland AFB.

Site TS775 encompasses 25.2 acres of land area, immediately adjacent to the Albuquerque International Sunport south airport taxiway. Site TS776 encompasses 29.3 acres of land area, approximately 1 mile east-southeast of the taxiway.

1.3 SITE HISTORY

Sites TS775 and TS776 are former skeet ranges initially operated during World War II. Range operations at Site TS775 are believed to have ended after World War II. The former skeet range at Site TS776 is documented to have continued operation as a recreational skeet range from the 1960s through 1998 (USA Environmental, 2007).

The historical records review reported that approximately 84,000 pounds of lead shot were removed from Site TS776 approximately every 3 years during active use and sent to Illinois for recycling as part of range maintenance. The historical records did not indicate if lead shot was removed from Site TS775 on a routine basis (USA Environmental, 2007). The historical records review did not provide any indication of whether clay target fragments at either of the sites were removed or collected.

Previous investigations of Sites TS775 and TS776 under the United States Air Force (USAF) MMRP include a two-phase Comprehensive Site Evaluation (CSE) and an Abbreviated Remedial Investigation (ARI).

The CSE Phase I complies with the Preliminary Assessment under CERCLA, and the CSE Phase II complies with the Site Inspection under CERCLA. USA Environmental completed the CSE Phase I in 2007. The CSE Phase I Report recommended further investigation of Sites TS775 and TS776 under the MMRP (USA Environmental, 2007). HydroGeoLogic (HGL) completed the CSE Phase II in 2010. The CSE Phase II Report identified concentrations of polycyclic aromatic hydrocarbons (PAHs) in soil above New Mexico Environment Department (NMED) residential soil screening levels (SSLs) at Site TS775 and concentrations of lead and PAHs in soil above NMED residential SSLs at Site TS776, indicating a potential risk to human health and the environment (HGL, 2010).

ECC completed the ARI in 2011 to determine the nature and extent of the contamination and document the potential risks to human health and the environment (ECC, 2011). The Baseline Risk Assessment (BRA) was completed as part of the ARI Report to assess potential exposures to current lead and PAHs in surface soil, identify potential at risk populations, and provide a baseline for future risk management decisions at the sites. The BRA identified unacceptable risk to potential future residents at both sites from PAHs in soil. Although lead was detected at concentrations above NMED residential SSLs in the CSE Phase II samples, the BRA found that current lead in soil concentrations at the sites did not pose an unacceptable level of risk to current or potential future receptors. The current lead concentrations in soil are associated with lead shot that have been present at the sites for the past 70 years (ECC, 2011). The results of the BRA form the basis for the removal alternatives presented in **Section 3** of this document.

1.4 SITE CHARACTERIZATION

Kirtland AFB lies along the eastern margin of the Albuquerque basin and on part of the central Rio Grande rift. Kirtland AFB has an average elevation of 5,300 feet above sea level and includes elevated mesas, flat scrubland and desert, and steep grades along the eastern portion adjacent to the Manzanita Mountains.

Sites TS775 and TS776 are located on an elevated mesa in the northwestern portion of the installation. Site TS775 is located immediately adjacent to the Albuquerque International Sunport south airport taxiway. Site TS776 is located approximately 1 mile east-southeast of the taxiway. **Figure 2** shows the proximity of Sites TS775 and TS776 to the airport taxiway and supporting facilities.

The surface water system within the Kirtland AFB area consists primarily of ephemeral streams, or arroyos, which flow temporarily or seasonally after sufficient rain and contribute to groundwater recharge. The nearest surface water feature to Sites TS775 and TS776 is the Tijeras Arroyo, located approximately 1.25 miles south of the sites. Storm water runoff from Site TS775 is conveyed to the

Tijeras Arroyo by a drainage channel located on the western boundary of the site. This drainage discharges water into a storm water detention basin prior to the confluence with the Tijeras Arroyo. Storm water runoff from Site TS776 occurs as sheet flow with a general flow direction to the west (ECC, 2011). **Figure 2** shows the surface water drainage features near Sites TS775 and TS776.

According to the Kirtland AFB Comprehensive General Plan (Kirtland AFB, 2002), the current land use scenario for Site TS775 is light industrial, administrative, and research.

Site TS775 has been cleared and graded, with paved taxiways and tarmac across the site. Much of the surface of Site TS775 is covered with imported material, including sands and gravel. Site TS775 is located within 400 feet of the taxiway. Site TS775 qualifies for ecological exclusion in accordance with the New Mexico ecological risk assessment guidance because no sensitive habitats exist within the site (ECC, 2011).

Site TS776 is vacant, sparsely covered grassland. The site is topographically flat with no evidence of scouring or erosion from runoff associated with precipitation events. Although no sensitive habitats have been identified within the site, the former range is habitat for western burrowing owls (ECC, 2011). Due to their status as a species of concern at Kirtland AFB, these owls were included as potential receptors in the ecological risk assessment for Site TS776.

1.4.1 Source, Nature, and Extent of Contaminants

This section summarizes the source, nature, and extent of contaminants at Sites TS775 and TS776. The ARI Report provides a full analysis of potential receptors and exposure pathways supporting the source, nature, and extent of contaminants (ECC, 2011).

The BRA identified PAHs in soil at concentrations that pose an unacceptable level of risk to potential future residents at both sites (ECC, 2011). Clay target fragments, which are made from coal tar and limestone, were identified as the primary source of the PAHs in soil near the firing points. The BRA also evaluated the potential risk to human health from the exposure to lead in soil. The BRA concluded that current concentrations of lead in soil at the sites do not pose an unacceptable risk to potential human receptors and that the current concentrations of lead in soil at the sites are associated with lead shot pellets that have been present in site soil over the past 70 years (ECC, 2011).

The source of the PAH contamination is the mechanical breakdown of the clay target fragments (HGL, 2010). During the ARI field activities, the field team observed very little deterioration of the visible clay target fragments, indicating that these materials release PAHs slowly and may provide a long-term source of PAHs unless removed (ECC, 2011).

Based on the site inspections and visible clay target fragment fall patterns, Site TS775 was divided into five sampling strata and Site TS776 was divided into seven sampling strata. **Figures 3** and **4** show the sampling strata at Sites TS775 and TS776, respectively. Stratum 1 for each site encompasses the area with visible clay target fragments. The remaining portions of Sites TS775 and TS776 were divided into the other strata based on distance and angle from the shooting locations in accordance with the Interstate Technology Regulatory Council (ITRC) *Technical/Regulatory Guidelines for Characterization and Remediation of Soils at Closed Small Arms Firing Ranges* (ITRC, 2003). This approach allowed for sample results to be grouped by strata and for potential risk, likely transport, and specific nature of contamination to be determined for individual stratum.

The sample results from the ARI and the CSE Phase II were combined into a single data set for use in risk assessments (ECC, 2011). The sample locations with PAH concentrations in soil above the NMED residential SSLs are shown in **Figures 3** and **4**. Stratum 1 at each site represents the primary clay target fragment fall zone. Reported concentrations of PAH concentrations in the high density target fragment area are greater than or equal to 125 mg/kg. Based on the sampling results, PAH concentrations decrease rapidly in soil samples by three to four orders of magnitude as distance from the principal fragment fall zone increases (ECC, 2011). Therefore, it is assumed that the coal tar/limestone matrix of the clay targets is not transported readily from the source material (clay target fragments). The absence of observable weathering indicates that the clay target fragments do not break down quickly. Based on the assumption that the primary route for impacts is continual weathering of the clay target fragments, it is likely that PAHs will not be released readily to the surrounding environment. However, PAHs in soil of the primary clay target fragment fall zone are associated strongly with the presence of visible clay target fragments (ECC, 2011). Based on these results, the continual slow breakdown of the clay target fragments likely would continue to release PAHs into the immediate surroundings.

For Site TS775, ARI sample locations KAFB-N7-01 and KAFB-O7-04 had elevated concentrations of PAHs in samples collected down to 9 inches below ground surface (bgs). These sample locations are located within the primary clay target fragment fall zone with high densities of visible clay target fragments (ECC, 2011). CSE Phase II samples TS775-001, TS775-002, TS775-003, TS775-004, TS775-005, and TS775-008 were also collected from areas with a high density of target fragments. These samples had PAH concentrations above their respective NMED residential SSLs to a depth of approximately 6 inches bgs (HGL, 2010). Therefore, it is assumed that areas of the site with a high density of target fragments have PAH impacts above NMED residential SSLs to depths up to 6 inches bgs. Conservatively, it is estimated that PAH impacts may reach depths up to 12 inches bgs.

The absence of clay target fragments and distribution of PAHs in surface soil of Stratum 2 at Site TS775 indicate that the detected PAH impacts are not a result of historical skeet range operations. Based on the presence of the asphalt roadway and the evident blacked surface compared to other asphalt surfaces in the area, these PAH impacts most likely are related to the coal tar sealant used in typical asphalt roadways (ECC, 2011). Coal tar sealant–related PAH impacts are a well-known issue associated with asphalt roadways and are beyond the scope of the MMRP. The PAH impacts related directly to the coal tar sealant will be addressed during a future project focusing on the environmental impacts associated with asphalt roadways.

At Site TS776, ARI sample location KAFB-AJ9-01 had elevated concentrations of PAHs in samples collected at 12 inches bgs (ECC, 2011). This sample location is within the primary clay target fragment fall zone with high densities of visible clay target fragments. CSE Phase II sample locations TS776-001, TS776-003, TS776-004, TS776-008, TS776-009, TS776-010, and TS776-011 were also collected from areas with a high density of target fragments. These samples had PAH concentrations above their respective NMED residential SSLs to a depth of approximately 6 inches bgs (HGL, 2010).

The final extent of contamination and soil removal will be determined by visual observance of clay target fragments during excavation and confirmation sampling during the removal action, as discussed in

Section 3. Additional delineation soil samples may be incorporated into the removal action to further refine the horizontal or vertical extents contamination.

1.4.2 Fate and Transport

Based on the low solubility of PAHs, low rainfall conditions (9.47 inches per year), and slow weathering of the exposed clay target fragments, there are few fate and transport mechanisms for PAH-impacted soils to be transported off site via storm water runoff. Due to the arid conditions and significant depth to water (average of 450 to 550 feet bgs), migration of PAHs to groundwater is not a pathway of concern at either Site TS775 or Site TS776 (ECC, 2011).

Sites TS775 and TS776 are located over 1 mile from the nearest surface water body (Tijeras Arroyo). The sites are extremely flat, resulting in sheet flow from storm water runoff. There are no visible signs of erosion in surface soil at either Site TS775 or Site TS776. Based on the characteristics of these sites, entrainment of contaminants in storm water runoff and transport to Tijeras Arroyo is unlikely to occur. As a result, migration of PAHs to surface water in storm water runoff is not a complete pathway at either site (ECC, 2011).

1.4.3 Exposure Pathways

Pathways of concern include direct contact by human and ecological receptors to PAHs in surface soil. Direct contact routes of exposure include incidental ingestion of PAHs in soil, dermal absorption of PAHs from soil, inhalation of PAHs in airborne dust, and uptake of PAHs by plants and animals.

1.4.4 Summary of Risk Evaluation

The BRA evaluated potential risks to human health and ecological receptors from exposure to PAHs and current lead concentrations in soils at Sites TS775 and TS776. Based on the site survey and existing knowledge of typical trap and skeet range sites (ITRC, 2003), the skeet ranges were divided into strata based on likely impacts and surface soil properties. For each site, Stratum 1 was based on the primary clay target fragment fall zone and represents areas with the most potential risk from exposure to PAHs. The BRA concluded the following (ECC, 2011):

At Site TS775:

- Risk to human health from exposure to current lead concentrations in surface soil at Strata 1 through 5 is within acceptable limits established by the USEPA and the State of New Mexico for site workers, construction workers, and potential future residents.
- Risk to human health from exposure to PAH concentrations in surface soil at Strata 3, 4, and 5 is within acceptable limits (10^{-6} to 10^{-4}) established by the USEPA for site workers, construction workers, and potential future residents.
- Risk to human health from exposure to PAH concentrations in surface soil at Strata 1 and 2 is at the upper limit of acceptable risk range (10^{-6} to 10^{-4}) established by the USEPA for site workers and construction workers.
- Risk to human health from exposure to PAH concentrations in surface soil at Strata 1 and 2 is above the acceptable limit (10^{-6} to 10^{-4}) established by the USEPA for potential, future, residential receptors.

- Results of the ecological risk assessment showed that the site met the requirements for an ecological exclusion. As no ecological receptors were identified at the site, ecological risk calculations were not performed.
- The asphalt coal tar sealant from the paved areas in Stratum 2 is the source of PAHs in Stratum 2. These PAH impacts are not associated with clay target fragments, are not related to historical operations of the former skeet range, and are not within the scope of the MMRP.
- Removal alternatives should be developed to control potential exposure of potential future residents to carcinogenic PAHs in soil at Stratum 1.
- Chemicals of concern (COCs) at Stratum 1 include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

At Site TS776:

- Risk to human health from exposure to current lead concentrations in surface soil at Strata 1 through 7 is within acceptable exposure levels based on IEUBK model results in accordance with USEPA requirements for site workers, construction workers, and potential future residents.
- Risk to human health from exposure to PAH concentrations in surface soil at Strata 2 through 7 is within acceptable limits (10^{-6} to 10^{-4}) established by the USEPA for site workers, construction workers, and potential future residents.
- Results of the ecological risk assessment demonstrate that PAH and current lead concentrations in surface soil do not pose an unacceptable risk to ecological receptors. The ecological risk assessment also demonstrated that residual lead shot pellets in surface soil did not pose a risk to avian receptors by incidental ingestion.
- Risk to human health from exposure to PAH concentrations in surface soil at Stratum 1 is above the acceptable limit (10^{-6} to 10^{-4}) established by the USEPA for potential, future, residential receptors.
- Removal alternatives should be developed to control potential exposure to site workers and potential future residents from carcinogenic PAHs in soil at Stratum 1.
- COCs at Stratum 1 include benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

The BRA concluded that current lead concentrations in soils at Sites TS775 and TS776 do not present unacceptable risk to human health or the environment. A summary of the risk calculations and acceptable risk levels is provided in **Appendix A**. The BRA concluded that PAHs in soil from the clay target fragments do pose an unacceptable level of risk to potential future residential receptors in Stratum 1 at each site. The risk posed by existing PAH impacts at Site TS775 is consistent with its current and likely future use profile. PAHs in soil at Site TS776 pose an unacceptable risk to existing and future site workers. Current lead concentrations in soil were not found to be a source of unacceptable risk for current commercial/industrial land use or future residential land use scenarios.

Based on the BRA findings, this EE/CA has been developed to address the following specific site conditions:

- PAHs that pose an unacceptable risk to future potential residents in Stratum 1 at Site TS775;

- PAHs that pose an unacceptable risk to future potential residents and current site workers in Stratum at of Site TS776; and
- Clay target fragments that provide a future source of PAHs to soil in Stratum 1 at Sites TS775 and TS776.

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2 REMOVAL ACTION SCOPE, GOALS, AND OBJECTIVES

The removal action scope involves addressing the impacted soil and clay target fragments at Sites TS775 and TS776 and bringing the sites to a “No Further Action” (NFA) condition based on the NMED residential SSLs. The scope of the removal action also includes confirmation sampling to verify that the removal goals and objectives have been achieved.

This section provides a discussion of regulatory guidance and directives, RAOs, applicable relevant and appropriate requirements (ARARs), and other relevant information.

2.1 REGULATORY FRAMEWORK

This response action is being conducted under the Defense Environmental Restoration Program to address releases of hazardous substances in accordance with the provisions of CERCLA and the NCP and USEPA guidance under the delegated authority granted by the Office of the President via Executive Order (EO) 12580 (Executive Order, 1987). The EO authorizes the USAF to conduct and finance removal actions when unacceptable risk to human health or the environment is present. This EE/CA is being developed for an NTCRA because a greater than 6-month planning window is available for the development of the removal action. This EE/CA follows the requirements of CERCLA in 40 CFR, Part 300 and EO 12580.

2.2 REMOVAL ACTION OBJECTIVES

The main objective for this removal action is to remove visible clay target fragments and reduce the levels of PAH contamination in the soil to below NMED residential SSLs, which would allow unrestricted use of the sites. The RAOs for the skeet range sites at Kirtland AFB have been developed to address the PAHs in surface soil identified in the BRA as posing an unacceptable risk to human health. The current concentrations of lead, which have been identified in surface soil at concentrations above NMED residential SSLs in Stratum 1 of Site TS776, were found not to pose an unacceptable risk to human health in the BRA. The current lead concentrations in soil at these sites are associated with lead shot pellets that have been present in site soil for 70 years. Based on these observations, the RAOs for Sites TS775 and TS776 are:

- Removal of soils impacted by PAHs at concentrations above the NMED residential SSLs from Sites TS775 and TS776 and
- Removal of visible clay target fragments.

These RAOs have been developed to address potential risks identified in the BRA. The removal alternatives selected for consideration in this EE/CA have been limited to those that can achieve the goal of unrestricted land use. Technologies considered but not selected include capping, stabilization, wet screening, and surface removal via vacuuming. The rationale for excluding these technologies in the considered alternatives is discussed in **Section 3**.

2.3 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are required by CERCLA and the NCP and are identified to aid in development and execution of removal actions and in establishment of required cleanup levels. Applicable requirements refer to federal or state requirements that are legally enforceable. Relevant and appropriate requirements are federal or state standards, criteria, or guidelines that are not legally enforceable but, where application, are appropriate to the site. All ARARs carry the same weight and consideration. Additionally, other federal or state recommended standards or criteria that are not generally enforceable but are advisory may be applicable to a specific site. These standards or criteria are categorized as "to be considered" (TBC).

ARARs and TBC criteria are further categorized as chemical-specific, location-specific, or action-specific, as described below:

- **Chemical-Specific**. Chemical-specific requirements define acceptable exposure levels for specific hazardous substances and, therefore, may be used as a basis for establishing preliminary remediation goals (PRGs) and cleanup levels for COCs in the designated media. Chemical-specific ARARs and TBC criteria also are used to determine treatment and disposal requirements for removal actions. In the event a chemical has more than one requirement, the more stringent of the two requirements is used.
- **Location-Specific**. Location-specific requirements set restrictions on the types of removal actions that can be performed based site-specific characteristics or location. Alternative removal actions may be restricted or precluded based on federal and state laws for hazardous waste facilities or proximity to wetlands, floodplains, or man-made features, such as existing landfills, disposal areas, and local historic landmarks or buildings.
- **Action-Specific**. Action-specific requirements set controls or restrictions on the design, implementation, and performance of removal actions. These requirements are triggered by the particular types of treatment or removal actions that are selected to accomplish the cleanup. After removal alternatives are developed, action-specific ARARs and TBC criteria that specify removal action performance levels, specific contaminant levels for discharge of media, or residual chemical levels for media left in place are used as a basis for assessing the feasibility and effectiveness of the removal action.

2.3.1 Chemical-Specific Applicable Relevant and Appropriate Requirements and To Be Considered Criteria

As a basis for comparison of the contaminant concentrations discussed in this section, lists of chemical-specific ARARs and TBC criteria have been developed for the sites. Chemical-specific ARARs and TBC criteria have been identified from the following regulations and standards:

ARARs

- **New Mexico Environment Department Soil Screening Levels (2009).** The NMED SSLs provide maximum contaminant concentrations for specific site uses.

TBC Criteria

- **USEPA Regional Screening Levels (2012).** The USEPA regional screening levels are used for soil analytical screening for constituents that are not addressed within the NMED SSLs.
- **USEPA Regional Biological Technical Assistance Group (BTAG) Screening Levels (2004).** The USEPA BTAG screening levels are provided to assist the performance of ecological risk assessment at CERCLA sites. BTAG screening levels are focused on potential risks posed to ecological receptors.

2.3.2 Location-Specific Applicable Relevant and Appropriate Requirements and To Be Considered Criteria

Potential location-specific ARARs and TBC criteria include the following:

- **Federal Endangered Species Act, promulgated in Title 16, Sections 1531-1544 of the United States Code (16 USC 1531-1544).** The Federal Endangered Species Act protects animal and plant species that are in danger of extinction or are threatened due to loss of habitat or other pressures. The western burrowing owl is listed within the Federal Endangered Species Act, but the populations are not endangered or threatened in New Mexico.
- **New Mexico Regulations Governing Water Quality Standards for Interstate and Intrastate Surface Waters, promulgated in Title 20, Chapter 6, Part 4 of the New Mexico Administrative Code (20.6.4 NMAC).** This state regulation addresses the protection of groundwater and surface waters within New Mexico. All activities conducted at the sites will conform to 20.6.4 NMAC.
- **New Mexico Regulations Governing Endangered Plant Species Wildlife Conservation Act, promulgated in 19.21.2 NMAC.** This state regulation addresses endangered plant species within New Mexico. Based on prior investigation, no known endangered plant species are present on the sites.

2.3.3 Action-Specific Applicable Relevant and Appropriate Requirements and To Be Considered Criteria

Potential action-specific ARARs and TBC criteria may include the following based on the required removal action:

- **Federal Transportation Hazardous Materials Regulations, promulgated in Title 49, Parts 171- 177 of the Code of Federal Regulations (49 CFR 171-177)**. This federal regulation addresses the transportation of hazardous materials within the United States. All activities involving transport of hazardous materials will conform to 49 CFR 171-177.
- **Federal National Pollutant Discharge Elimination System (NPDES) Regulations, promulgated in 40 CFR 122 and 125**. The federal regulation addresses all potential point sources that may negatively impact water quality. All discharges from the site will conform to 40 CFR 122 and 125.
- **Federal Clean Water Act, promulgated in 33 USC 1251-1387**. This federal regulation addresses the discharge of pollutants into waters of the United States. Any discharge associated with the removal response at the sites will conform to 33 USC 1251-1387.
- **New Mexico Regulations Governing Hazardous Waste, promulgated in 20.4 NMAC**. This state regulation addresses the generation, management, and transportation of hazardous waste at facilities in New Mexico. All activities pertaining to generation, management, and transportation of hazardous waste at the sites will conform to 20.4 NMAC.
- **New Mexico Regulations Governing Air Quality, promulgated in 20.2 NMAC**. This state regulation addresses air quality and emissions within New Mexico. All activities resulting in the generation of emissions or dust generation at the sites will conform to the regulations of this 20.2 NMAC.
- **New Mexico Regulations Governing Air Quality in Albuquerque and Bernalillo County, promulgated in 20.11 NMAC**. This state regulation addresses air quality and emissions

specifically within Albuquerque and Bernalillo County. All activities resulting in the generation Sources of emissions or dust generation at the sites will conform to the regulations of this 20.11 NMAC.

2.4 PRELIMINARY REMEDIATION GOALS

The PRGs for Sites TS775 and TS776 are based on NMED residential SSLs (2009). The NMED residential SSLs are based on an excess lifetime cancer risk of 1 in 100,000 ($1x10^{-5}$) for individual COCs based on residential exposures. Based on the chemical-specific ARARs identified above, PRGs are presented in **Table 2-1**.

Table 2-1: Preliminary Removal Goals for PAHs in Soil

Parameter	NMED Residential SSLs (mg/kg)
Benzo[a]anthracene	6.21
Benzo[a]pyrene	0.621
Benzo[b]fluoranthene	6.21
Benzo[k]fluoranthene	62.1
Chrysene	621
Dibenzo[a,h]anthracene	0.621
Indeno[1,2,3-cd]pyrene	6.21

2.5 PUBLIC INVOLVEMENT

The NCP requires a public comment period of 30 days following release of the EE/CA Report to ensure the public appropriate opportunities for involvement in site-related decisions. The USAF will provide public notification of the 30-day public comment period upon issuance of the EE/CA Report. The USAF will respond to significant comments received during the public comment period, and an Action Memorandum will be prepared following the response to comments.

3 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

The removal action alternatives identified in this section were developed to meet the RAOs identified in **Section 2**. The alternatives are based on the nature, extent, and analysis of existing PAH concentrations in surface soil; the primary sources of potential impact (mechanical breakdown of clay target fragments releasing PAHs to soil); intended future land uses; and risk reduction goals. The alternatives demonstrate approaches that are consistent with best industry practices and have been proven to be accepted by stakeholders at other small arms ranges throughout the United States and fulfill the unrestricted, future residential land use goals for the sites. **Table 3-1** provides a summary of these alternatives. The alternatives include the following:

- Alternative 1: No Department of Defense Action Indicated (NDAI)
- Alternative 2: Land Use Controls (LUCs)
- Alternative 3: Excavation and Off-site Disposal of Surface Soils Impacted by Visible Clay Target Fragments
- Alternative 4: Excavation of Surface Soil Impacted by Visible Clay Target Fragments, Removal of Visible Clay Target Fragments by Dry Screening, and Off-site Disposal of Soil with PAH Concentrations above NMED Residential SSLs and Clay Target Fragments
- Alternative 5: Excavation of Surface Soil Impacted by Visible Clay Target Fragments at Sites TS775 and TS776; Removal of Clay Target Fragments by Dry Screening at Sites TS775 and TS776; Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Clay Target Fragments at Site TS776; and Excavation, Screening, and Removal of Clay Target Fragments with Land Use Controls at Site TS775

The inclusion of no action (Alternative 1) is intended to serve as a baseline against which other alternatives are evaluated and does not provide any additional remediation, containment, or security measures to reduce potential risk to human health or the environment. Alternative 2, LUCs, is a minimal-effort solution that is protective of human health but does not achieve the unrestricted, future residential land use goals or address the presence of target debris. The three remaining removal action alternatives are designed to remove soil with PAH concentrations above the NMED residential SSLs, remove visible clay target fragments, or control potential exposures to these contaminants. Alternative 5 meets the unrestricted, future residential land use goal at Site TS776 and maintains the current site use profile for Site TS775 while removing potential PAH source material, which are the visible clay target fragments. This scenario was included based on its compatibility with the foreseeable future land use at Site TS775 (restricted due to taxiway activities) and the unlikelihood that current land use conditions would change due to the presence of the Albuquerque Airport.

As part of the development of the alternatives, excavation and dry screening were selected as the preferred and recommended technology to address the impacted soils and visible clay target fragments present at the sites. Other technologies were considered but were eliminated from consideration based on their inability to attain the RAOs, difficulty of implementation, or inability to address the required key elements of the removal action. Considered technologies included the following:

- Wet screening: This technology would include significant handling of PAH-impacted wash water and the production of saturated soils for disposal with no significant benefits over dry screening.

- Stabilization: This technology would not address removal of target debris in any portion of the site and would require LUCs on both sites to address the presence of contaminated soils above the PRGs.
- Capping: This technology would not address removal of target debris in any portion of the Site and would require LUCs on both sites to address the presence of contaminated soils above the PRGs.
- Vacuum collection of visible clay target fragments: This technology would be limited in depth; does not provide benefits over similar mass excavation of soils and target debris; and can generate significant dust.

3.1 PRINCIPAL REMOVAL ASSUMPTIONS

The CSE Phase II and ARI sampling events were designed to determine the nature and extent of the impacts and provide a basis for determining appropriate removal action. These investigations determined that the PAH impacts in excess of the PRGs are associated directly with the clay target fragments present in Stratum 1 of each site. The final lateral and vertical extent of removal will be determined in the field during the removal action. The observable clay target fragments have been utilized to determine an approximate area, which will be refined during the field removal activities. The Work Plan document will provide detail on how field removal depths will be determined and how confirmation sampling will be utilized to establish final excavation boundaries.

In order to compare the removal alternatives and estimate costs, the following general assumptions were made based on sampling results conducted for the CSE Phase II, ARI, and BRA:

- PAH exceedances are limited to localized areas within the primary clay target fragment fall zone (Stratum 1) at both ranges.
- Vertical extent of PAH exceedances is assumed to be limited to the near surface, less than or equal to 1.0 foot. This assumption is based on the sampling results from the ARI and CSE Phase II and limited mobility of PAHs at the sites.
- The presence of clay target fragments is confined to the uppermost 6 inches of soil or less. This assumption is based upon observations during the ARI and CSE Phase II investigation by field personnel.
- The highest density of visible clay target fragments is present within Stratum 1 of each site, which was defined during the ARI. Other strata were defined based on the typical shot fall pattern described by the ITRC guidance on small arms range remediation (ITRC, 2003). Therefore, visible clay target fragment removal activities will be limited to Stratum 1 at each site.
- At Site TS775, a 0.3-acre area lies outside of the taxiway safety area, as delineated by the fence line. This area is included in all alternatives and is part of Stratum 1 at Site TS775.
- Excavation areas and volumes are considered conceptual, and field verification during the removal action will be required. The Work Plan document will provide details on determining the final depths for the selected removal action. The assumptions above are based on the current knowledge of the sites.
- The proposed soil removal depths are assumptions based on a limited spatial data set and provide consistency across the examined alternatives discussed below. The Work Plan will provide details on how the final removal and screening depths will be determined.

3.2 EVALUATION CRITERIA

Following their presentation, each alternative is assessed individually based on effectiveness, implementability, and cost. A comparison among the proposed alternatives is provided in **Section 4**.

3.2.1 Effectiveness

Effectiveness is a measure of the ability of an alternative to reduce risk to the public and the environment from exposure to contaminant hazards from long-term and short-term perspectives. The following criteria are used in the evaluation:

- **Protection of Public Safety and the Environment**. This criterion is a measure of the effectiveness of the alternative to reduce the risk from the public's exposure to constituents and protection of the environment. The following considerations were evaluated:
  - Elimination and reduction of constituents present;
  - Estimated residual quantity of constituents;
  - Estimated depth of residual constituents;
  - Potential exposure pathways between humans and constituents; and
  - Potential of human interaction with constituents during exposure.
- **Compliance with ARARs**. This criterion is a measure of whether each alternative meets all the potential federal and state ARARs, as defined in 40 CFR 300.5 and identified in the EE/CA process in **Section 2.3**. Selection of an ARAR is dependent upon the hazardous substances present, characteristics and location of the site, and actions selected.
- **Long-Term Effectiveness**. This criterion is a measure of the effectiveness of the alternative to protect the public after the risk-reduction objectives have been implemented. The remaining potential for exposure to constituents and the adequacy and reliability of the controls and maintenance measures to manage the residual risk following implementation of the alternative are considered.
- **Short-Term Effectiveness**. This criterion is a measure of the effectiveness of the alternative to protect the public during implementation of the risk-reduction objectives. The potential risk to humans, including those in the community, site visitors, and workers implementing the alternatives; potential adverse impact on the environment; and time required to implement the alternative are considered for each alternative.

3.2.2 Implementability

Implementability is a measure of the physical, technical, and administrative feasibility of implementing an alternative and a measure of the availability of materials and services. Stakeholder acceptance of a given alternative also is considered. The following criteria were used in this evaluation:

- **Technical Feasibility**. This criterion is a measure of the ability to implement the alternative, reliability of the action, ability to implement future actions, and ability to monitor the effectiveness of the action relative to its practicality of completing the alternative.
- **Administrative Feasibility**. This criterion is a measure of the ease with which an alternative can be coordinated with multiple offices, agencies, and private property owners and implemented in terms of permits and right-of-way or alignment agreements.

- **Availability of Services and Materials**. This criterion is a measure of the availability of goods and services to implement the alternative.
- **Local Agency Acceptance**. This criterion is a measure of the acceptance of the alternative by city, county, and state agencies.
- **Community Acceptance**. This criterion is a measure of the acceptance of the alternative by the community, including homeowners adjacent to the project site.
- **Regulatory and Governmental Acceptances**. This criterion is a measure of the acceptance of the alternative by the USEPA, NMED, and local government agencies.

3.2.3 Cost

The costs associated with implementation of each alternative were estimated using RS Means Construction Cost Estimating resources, local and industry resources, and engineering judgment. Cost estimates were developed in general accordance with the USEPA cost estimating guidance for Feasibility Studies (USEPA, 2000), with consideration for the reduced costing required for EE/CAs.

3.3 ALTERNATIVE 1: NO DEPARTMENT OF DEFENSE ACTION INDICATED

The declaration of the NDAI alternative on a property or project is a programmatic decision that indicates it has been determined that NFA is required to address unsafe conditions or hazardous substance, pollutants, or contaminants that may affect future land uses. Under this alternative, “no action” would be taken to remediate the impacted soil. The soil would be left in place with no disturbance to the surrounding environment. No administrative controls would be put into place to limit potential exposure to current or future site users. This alternative would leave a project or property open for further and future review as additional information is received. As no action is associated with this alternative, implementation would be immediate upon its acceptance. Implementation of Alternative 1 would not meet the RAOs and does not remove or reduce the risks present at the sites.

Selection of this alternative would leave contaminated soil above the NMED residential SSLs for PAHs on site. A review of site conditions would be required every 5 years in order to assess site conditions.

3.3.1 Evaluation of Alternative 1

3.3.1.1 Effectiveness

This alternative would not be an effective method of addressing the contamination at Sites TS775 and TS776. This alternative would not meet the regulatory preference for treatment, the PRGs, or the unrestricted use and unlimited exposure goals.

- **Protection of Public Safety and the Environment**. This alternative would not eliminate or reduce the volume of contaminated media on either site, nor would it limit the potential exposure pathways for current or potential future receptors to the contaminants.
- **Compliance with ARARs**. This alternative would not be compliant with the ARARs.
- **Long-Term Effectiveness**. This alternative would not provide long-term effectiveness because all contaminant mass would remain on the sites.

- **Short-Term Effectiveness**. This alternative would have good short-term effectiveness because no additional site disturbance or additional receptor exposure to the existing contamination would occur.

3.3.1.2 Implementability

This alternative would be implementable because it requires no action on the part of the installation.

- **Technical Feasibility**. This alternative would have no technical requirements.
- **Administrative Feasibility**. This alternative would be administratively feasible because no action would be required. Both sites would require recurring 5-year reviews due to the contaminated soils remaining on site.
- **Availability of Services and Materials**. This alternative would require no services or materials.
- **Local Agency Acceptance**. This alternative would not be acceptable to the local regulatory agencies because site risks would not be reduced or controlled.
- **Community Acceptance**. This alternative would not be acceptable to the local community because site risks would not be reduced or controlled. The local community is advocating for active restoration of contaminated sites.
- **Regulatory and Governmental Acceptances**. This alternative would not be acceptable to USEPA, NMED, or local government agencies because site risks would not be reduced or controlled. These agencies prefer active remediation and removal actions.

3.3.1.3 Cost

No capital costs would be associated with this alternative. Both sites would require 5-year reviews because contaminants above the PRGs would be left on site. The estimated net present worth for each 5-year review is $45,065.

3.4 ALTERNATIVE 2: LAND USE CONTROLS

LUCs include engineering controls (ECs) and institutional controls (ICs). LUCs include any type of physical, legal, or administrative mechanism that restricts the use of, or limits the access to, real property to prevent or reduce the risks to human health, safety, and the environment. LUCs are considered a response action under CERCLA. The objective of LUCs is to ensure that future land use remains compatible with the land use that was the basis for the evaluation, selection, and implementation of the response action.

ECs encompass a variety of engineered remedies to contain, control, or reduce contamination and risk associated with a hazard. For Alternative 2, ECs would include a physical barrier (fence), signage, and a soil cap to limit potential receptors from possible contact with the soil. The costs developed for this alternative include minimal fencing around the 0.3-acre at Site TS775 because most of the site is already fenced. The specific list of ECs would be selected by the installation and may change over time due to regulatory requirements or usage of adjacent sites. Some of these ECs already are in effect at Site TS775 due to the presence of the taxiway safety area. Portions of the site that have PAH contamination would require additional ECs to conform to the conditions of this alternative.

ICs include legal and administrative mechanisms, such as permitting programs, restrictive covenants, and zoning restrictions. For Alternative 2, ICs would include site usage restrictions that would stay in place if the land was sold or transferred. In addition, media would be produced for distribution to the public through formal educational seminars, press releases, or in response to public queries. For Sites TS775 and TS776, a number of ICs that were developed for the taxiway safety area required by the Federal Aviation Administration already limit the usage and development of the sites.

Implementation of this alternative would be relatively rapid. ECs, including fencing and signage, could be implemented within a few months or less, and ICs would be implemented during the annual update of the installation’s Master Plan.

This alternative does not meet the RAOs discussed in **Section 2.2** because neither site would be available for unrestricted use and unlimited exposure. Selection of this alternative would leave contaminated soil above the NMED SSLs for PAHs on site. A review of site conditions would be required every 5 years in order to assess site conditions.

3.4.1 Evaluation of Alternative 2

3.4.1.1 Effectiveness

This alternative would be an effective method for reducing access and restricting potential pathways for potential future receptors to be exposed to the contamination. This alternative would not provide a reduction of contaminant mass or toxicity, meet the regulatory preference for treatment, achieve the PRGs, or meet the unrestricted use and unlimited exposure goals.

- **Protection of Public Safety and the Environment**. This alternative would not eliminate or reduce the volume of contaminated media on either site. By restricting access to the site, it would reduce or eliminate the potential exposure pathways for the contaminants to current or potential future receptors.
- **Compliance with ARARs**. This alternative would not be compliant with the ARARs.
- **Long-Term Effectiveness**. This alternative would provide long-term effectiveness through deed and land use restrictions on both sites. However, a risk that potential future receptors would be exposed to the contaminants would remain because all contaminant mass would be left on the sites.
- **Short-Term Effectiveness**. This alternative would provide good short-term effectiveness because minimal soil disturbance would occur during the implementation of the ECs.

3.4.1.2 Implementability

This alternative would be implementable because ICs and ECs are relatively simple to employ.

- **Technical Feasibility**. This alternative would be technically feasible because ICs and ECs are simple to implement.
- **Administrative Feasibility**. This alternative would be administratively feasible, requiring the creation of deed restrictions and permanent land use restrictions for the sites and incorporating the restrictions into the installation’s Master Plan. A recurring 5-year review would be required, as contaminated soils would remain on site.

- **Availability of Services and Materials**. The services and materials to complete this alternative would be acquired easily.
- **Local Agency Acceptance**. This alternative likely would not be acceptable to the local regulatory agencies because site risks would not be reduced or controlled.
- **Community Acceptance**. This alternative likely would not be acceptable to the local community because site risks would not be reduced or controlled. The local community is advocating for active restoration of contaminated sites.
- **Regulatory and Governmental Acceptances**. This alternative would not be favored by USEPA, NMED, and local government agencies. These agencies prefer active remediation and removal actions.

3.4.1.3 Cost

This alternative would have an estimated capital cost of $184,272 and net present worth operation and maintenance (O&M) cost of $154,202 (total for the first 5 years), for a total net present worth of $338,474 for the implementation and first 5 years of LUCs at both sites. The estimated net present worth for each 5-year review thereafter is $45,065.

3.5 ALTERNATIVE 3: EXCAVATION AND OFF-SITE DISPOSAL OF SURFACE SOILS IMPACTED BY VISIBLE CLAY TARGET FRAGMENTS

This alternative involves excavation and off-site disposal of surface soil and clay targets fragments from the entire extent of clay target fragment fall zones (Stratum 1) as surveyed using Global Positioning System technology during the ARI (ECC, 2011). Although not all soils within Stratum 1 are impacted by PAHs in excess of the PRGs, the clay target fragments within this zone constitutes a source for ongoing potential risk. These soils eventually may be impacted by PAHs in excess of the PRGs (ECC, 2011). This alternative would eliminate all human and ecological exposure pathways for contaminated soil and potential PAH source material at the site. This alternative would not require ICs or additional monitoring following completion of the remedy.

Figure 3 provides the conceptual extent of excavation at Site TS775 for Alternative 3. For Stratum 1 at Site TS775, soils would be excavated to an assumed maximum depth of 0.5 feet. Based on the vertical characterization conducted during the ARI (ECC, 2011), areas where a high density of visible clay target fragments are present would be excavated to a maximum depth of 1 foot. These depths are approximate, and field verification would provide data to determine the final excavation depth. **Section 3.1** provides the rationale for the proposed removal depths.

Figure 4 provides the conceptual extent of excavation at Site TS776. Similar to Site TS775, the 0.5-foot excavation zone is assumed to cover the entire portion of Stratum 1 with visible clay target fragments. An average 1.0-foot excavation depth is assumed to be required where there is a high density of clay target fragments. **Section 3.1** provides the rationale for the proposed removal depths.

Excavation of soil would be achieved using conventional equipment, such as excavators and dozers. As shown in **Figure 3**, Site TS775 would have an area of disturbance of approximately 4.0 acres. The low density clay target area, comprising 2.68 acres, would be excavated to a maximum depth of 0.5 feet, resulting in approximately 2,162 cubic yards of excavated materials. The high density clay target area comprises an additional 1.32 acres and would be excavated to a maximum of 1.0 foot, resulting in approximately 2,130 cubic yards of excavated material. Approximately 4,292 total cubic yards of material would be excavated from Site TS775 under Alternative 3.

As shown in **Figure 4**, Site TS776 would have an area of disturbance of approximately of 3.63 acres. Approximately 2.51 acres would be excavated to a maximum 0.5-foot depth, resulting in approximately 2,025 cubic yards of soil. The high density clay target area comprises 1.12 acres, which would be excavated to an average depth of 1.0 foot, resulting in approximately 1,807 cubic yards of soil. Approximately 3,832 total cubic yards of material would be excavated from Site TS776 under Alternative 3.

The actual volume of soil to be removed from each site would be based on observations in the field and the results of confirmation sampling.

The former skeet ranges are currently maintained to prevent heavy vegetative growth; therefore, it is assumed that very little site preparation would be required before excavation could begin. Staging areas would need to be established, and erosion controls would need to be installed. Dust controls might be necessary during excavation and loading activities. After an area is excavated, confirmation samples would be collected to ensure that remaining soil is below the PRGs. Based on the rapid reduction of PAH concentrations as distance from the clay target fragments increases (HGL, 2010), one confirmation sample would be collected from each 100-foot-by-100-foot cell, as presented in the ARI (ECC, 2011). For areas where confirmation sampling detects PAH concentrations above PRGs, excavations would extend horizontally and/or vertically until remaining PAH concentrations are below PRGs.

Excavated soil would be staged on site and transported to a Subtitle D permitted landfill for disposal. Based on the Toxicity Characteristic Leaching Procedure (TCLP) analysis performed on the soil from both sites during the ARI, the soils would not be designated as hazardous. However, the soil would be characterized prior to disposal in accordance with the requirements of the receiving landfill. The excavated areas would be returned to grade using imported fill.

Since all of the impacted soil exceeding PRGs would be removed, land use restrictions and long-term monitoring would not be required. Following successful removal of impacted soil, the site would be regraded and restored with appropriate vegetative cover. This alternative would meet the RAOs and fulfills ARARs. This alternative could be implemented upon selection and approval by the stakeholders. This alternative is estimated to require approximately 7 weeks of field activities following site mobilization.

In summary, Alternative 3 would include the following activities:

- Installation of storm water and erosion controls in compliance with NPDES permit requirements
- Implementation of dust controls as required to protect workers from PAH impacted soils and limit potential impact of foreign object debris (FOD) to the airport
- Excavation of contaminated soil and visible clay target fragments from both low density and high density areas within Stratum 1 at both sites
- Off-site landfill disposal following waste profile acceptance

- Confirmation sampling after soil excavation
- Restoration of the sites through backfilling, grading and seeding

3.5.1 Evaluation of Alternative 3

3.5.1.1 Effectiveness

This alternative would be an effective method for reducing the volume of contamination on site and removing the source of PAHs. This alternative would not provide a reduction of contaminant mass or toxicity or meet the regulatory preference for treatment because the contaminated media are only removed and not treated. This alternative would achieve the PRGs at both sites and would meet the unrestricted use and unlimited exposure goals for both sites.

- **Protection of Public Safety and the Environment**. This alternative would reduce the volume of contaminants below the PRGs. This alternative would provide protection to the environment.
- **Compliance with ARARs**. This alternative would be compliant with the ARARs.
- **Long-Term Effectiveness**. This alternative would provide long-term effectiveness through removal of contaminated media and the source of PAHs.
- **Short-Term Effectiveness**. This alternative would have minimal short-term risks associated with handling and transport of contaminated soils. Proper contractor training and protective measures, including dust control, would minimize the risks.

3.5.1.2 Implementability

This alternative would be implementable because it uses known and well developed technologies.

- **Technical Feasibility**. This alternative would be technically feasible because it utilizes well-known and proven technologies.
- **Administrative Feasibility**. This alternative would be administratively feasible and has no long-term administrative burden.
- **Availability of Services and Materials**. The services and materials to complete this alternative would be acquired easily.
- **Local Agency Acceptance**. This alternative generally would be acceptable to the local regulatory agencies because site risks would be reduced through removal.
- **Community Acceptance**. This alternative likely would be acceptable to the local community because site risks would be reduced or controlled.
- **Regulatory and Governmental Acceptances**. This alternative likely would be acceptable by USEPA, NMED, and local government agencies.

3.5.1.3 Cost

This alternative would have a capital cost of $1,237,395 for both sites. This alternative would not require a 5-year review or LUCs.

3.6 ALTERNATIVE 4: EXCAVATION OF SURFACE SOIL IMPACTED BY VISIBLE CLAY TARGET FRAGMENTS, REMOVAL OF VISIBLE CLAY TARGET FRAGMENTS BY DRY SCREENING, AND OFF-SITE DISPOSAL OF SOIL WITH PAH CONCENTRATIONS ABOVE RESIDENTIAL SSLS AND VISIBLE CLAY TARGET FRAGMENTS

This alternative involves excavation of the entirety of Stratum 1 for each site. Soils with PAH impacts below the PRGs (low density clay target fragment areas) would be excavated and screened to remove visible clay target fragments and returned to the site excavations. Soils and overlying visible clay target fragments from the high density clay target fall zone that exceed human health PRGs for potential residential use (**Figures 3** and **4**) would be disposed of off site and not screened. The selected screen would allow most of the sandy soils to pass through the screen but would retain the clay target fragments. Hand screening would be used on any areas outside of the excavation zone that contain visible clay target fragments or on areas marked for excavation and screening that are difficult to access based on site conditions. Based on previous investigations, the presence of visible clay target fragments outside of Stratum 1 is limited to incidental and isolated fragments. This remedy would remove contaminated soil exceeding the PRGs and would meet the unrestricted use and unlimited exposure requirement without ICs. This alternative also would selectively remove the visible clay target fragments, the source of PAH impacts, from the remainder of Stratum 1 at each site.

Excavation of contaminated soil would be achieved using conventional equipment, such as excavators and dozers. Removal of contaminated soil at the two sites under Alternative 4 would be limited to a portion of Stratum 1, as shown in **Figures 3** and **4**, where soils exceed the PRGs based on the results of the CSE Phase II and ARI. Based on the vertical sampling conducted during the CSE Phase II, excavations in the high density area are assumed to extend to a 1.0-foot bgs depth (ECC, 2011), as discussed in **Section 3.1**. At Site TS775, this area is defined by ARI sample locations KAFB-N7-01 and KAFB-O7-04 and CSE Phase II sample locations TS775-001, TS775-002, TS775-003, TS775-004, TS775-005, and TS775-006. At Site TS776, this area is defined by ARI sample location KAFB-AJ9-01 and CSE Phase II sample locations TS776-001, TS776-002, TS776-003, TS776-008, and TS776-009.

The remaining portions of Stratum 1 at each site would be excavated to approximately 0.5 feet bgs. The visible clay target fragments will be separated from the soil using a dry screening process. The separated clay target fragments would be removed from the sites for disposal in a Resource Conservation and Recovery Act Subtitle D landfill, and the soils would be returned to the excavated area following confirmation sampling that the concentration of PAHs in the soil does not exceed the PRGs.

Alternative 4 has the same soil disturbance profile as Alternative 3. Site TS775 would have a total of 4.0 acres of soil disturbance. Approximately 1.32 acres of soil exceeding the PRGs would be excavated to an average depth of 1.0 foot bgs (2,130 cubic yards), and 2.68 acres of soil with visible clay target fragments would be excavated to a depth of 0.5 feet bgs (2,162 cubic yards) and screened. Site TS776 would have a total area of 3.63 acres of soil disturbance. Approximately 1.12 acres of soils exceeding the PRGs would be excavated to 1.0 foot bgs (1,807 cubic yards) for off-site disposal, and 2.51 acres of soils with a low density of visible clay target fragments would be excavated to 0.5 feet bgs (2,025 cubic yards) and screened on site.

The former skeet ranges are currently maintained to prevent heavy vegetative growth; therefore, it is assumed that very little site preparation would be required before excavation and soil screening could begin. Staging areas would need to be established, and erosion controls would need to be installed. Dust controls might be necessary during soil excavation, loading, and the screening process. The screening process would be assessed to address the possibility that the screening activities could cause additional mechanical breakdown of the clay target fragments. The Work Plan document would address this possibility and provide a list of actions to be taken to address this potential issue. After an area is excavated, confirmation samples would be collected to ensure that remaining soil is below PRGs. It is assumed that one confirmation samples would be collected from each 100-foot-by-100-foot cell, as presented in the ARI (ECC, 2011). For areas where confirmation sampling detects PAH concentrations are above PRGs, excavations would extend horizontally and/or vertically until remaining PAH concentrations are below PRGs.

Excavated soil exceeding the PRGs would be staged on site and transported to a Subtitle D permitted landfill for disposal. Based on the TCLP data for each site, the soils would be designated as nonhazardous. However, excavated soils and bulk clay target fragments (post-screening) would be characterized prior to disposal, in accordance with the requirements of the receiving landfill. Soils that were screened to remove visible clay target fragments would be sampled for PAHs to confirm that they are below PRGs before being reused as backfill materials on the sites. The excavated areas would be returned to grade.

This alternative fulfills the RAOs for both sites. The sites would be available for unrestricted, future residential land use by removing soils above the PRGs and removing the PAH source via screening and disposal of clay target fragments. This alternative limits the off-site disposal of soils that do not exceed the PRGs by screening the clay target fragments. No LUCs would be required following the implementation of this alternative. This alternative could be implemented immediately upon selection and approval by the stakeholders. This alternative is estimated to require approximately 7 weeks of field activities following site mobilization.

In summary, Alternative 4 would include the following activities:

- Installation of storm water and erosion controls in accordance with the NPDES permit
- Implementation of dust controls, as required, to protect workers from PAH impacted soils and limit potential impact of FOD to the airport
- Excavation and off-site disposal of contaminated soil above PRGs
- Removal and off-site disposal of clay target fragments via separation from remaining surface soils in Stratum 1 at each site
- Off-site landfill disposal of soils with PAH concentrations above PRGs
- On-site backfilling of soils separated from clay target fragments and with PAH concentrations below PRGs
- Confirmation sampling during soil excavation and soil screening
- Restoration of the sites through backfilling, grading and seeding

3.6.1 Evaluation of Alternative 4

3.6.1.1 Effectiveness

This alternative would be an effective method for reducing the volume of contamination on site and removing the source of PAHs. This alternative would not provide a reduction of contaminant mass or toxicity or meet the regulatory preference for treatment because the contaminated media is only removed and not treated. This alternative would achieve the PRGs at both sites and would meet the unrestricted use and unlimited exposure goals for both sites. This alternative would also utilize green technologies by reducing the volume of soils disposed off site via a screening process.

- **Protection of Public Safety and the Environment**. This alternative would reduce the volume of contaminants on the site to below the PRGs. This alternative would provide protection to the environment.
- **Compliance with ARARs**. This alternative would be compliant with the ARARs.
- **Long-Term Effectiveness**. This alternative would provide long-term effectiveness through removal of contaminated media and the source of PAHs.
- **Short-Term Effectiveness**. This alternative would have minimal short-term risks associated with the handling and transport of contaminated soils. Proper contractor training and protective measures, including dust control, would minimize the risks.

3.6.1.2 Implementability

This alternative would be implementable because it uses known and well developed technologies.

- **Technical Feasibility**. This alternative would be technically feasible because it utilizes well-known and proven technologies.
- **Administrative Feasibility**. This alternative would be administratively feasible and has no long-term administrative burden.
- **Availability of Services and Materials**. The services and materials to complete this alternative would be acquired easily.
- **Local Agency Acceptance**. This alternative generally would be acceptable to the local regulatory agencies because site risks would be reduced through removal.
- **Community Acceptance**. This alternative likely would be acceptable to the local community because site risks would be reduced or controlled.
- **Regulatory and Governmental Acceptances**. This alternative likely would be acceptable by USEPA, NMED, and local government agencies.

3.6.1.3 Cost

This alternative would have a capital cost of $1,039,281 for both sites. This alternative would not require a 5-year review or LUCs.

3.7 ALTERNATIVE 5: EXCAVATION OF SURFACE SOIL IMPACTED BY VISIBLE CLAY TARGET FRAGMENTS AT SITES TS775 AND TS776; REMOVAL OF CLAY TARGET FRAGMENTS BY DRY SCREENING AT SITES TS775 AND TS776; OFF-SITE DISPOSAL OF SOIL WITH PAH CONCENTRATIONS ABOVE RESIDENTIAL SSLS AND CLAY TARGET FRAGMENTS AT SITE TS776; AND

EXCAVATION, SCREENING, AND REMOVAL OF CLAY TARGET FRAGMENTS WITH LAND USE CONTROLS AT SITE TS775

For Site TS776, this alternative is identical to Alternative 4. However, at Site TS775, this alternative would control exposure to PAHs through the application of LUCs rather than removal and off-site disposal of soil exceeding the PRGs. Visible clay target fragments would be removed from the surface soils within Stratum 1 at Site TS775 to control the future release of additional PAHs into the soils. Though this alternative would not meet the revised RAOs (**Section 2.2**) that allow unrestricted use and unlimited exposure, it would offer a reasonable end point for the site. This alternative would provide protection for all at risk receptors as determined in the BRA. The BRA demonstrated that the existing commercial/industrial land use at Site TS775 is associated with a 1 in 10,000 ($1x10^{-4}$) excess lifetime cancer risk, a value at the upper limit of the USEPA's acceptable range. Site TS775 is part of an active airport taxiway safety area (which precludes many activities, such as residential use) and, therefore, cannot be placed into an unrestricted use and unlimited exposure scenario. The establishment of LUCs for Site TS775 is consistent with current land use and all foreseeable land use as the Albuquerque International Airport is unlikely to reduce its footprint. Due to the presence of the taxiway safety area, this land is already within an area of LUCs associated with aviation safety requirements.

All assumptions for excavations, soil removal, and clay target fragment separation and removal via screening presented for Site TS776 (**Figure 4**) under Alternative 4 are applicable to Alternative 5. Site TS776 would qualify for unrestricted, future residential land use at the completion of this alternative.

The screening planned for Site TS775 under Alternative 5 would include Stratum 1, as shown in **Figure 3**. The areas with visible clay target fragments would be excavated to a depth of 0.5 feet bgs, as discussed in **Section 3.1**. The soils would be dry screened to remove visible clay target fragments, and the screened soil would be returned to the excavation at Site TS775. The approximate volume of material to be excavated and screened from Site TS775 is 3,230 cubic yards.

Following successful removal of clay target fragments and the return of all excavated and screened soil to the Site TS775 excavations, the disturbed portion of the site would be graded and restored with appropriate vegetative cover. All excavation, removal, and restoration activities described for Site TS776 under Alternative 4 would apply to Alternative 5.

Following completion of the excavation, LUCs would be instituted at Site TS775. These would include all ECs and ICs discussed in Alternative 2, including installation of signs and addition of land use restrictions to the Kirtland AFB Master Plan. The costs developed for this alternative do not include fencing around Site TS775 because this site is already fenced. The 0.3-acre area at TS775 would not be fenced, because it would have been cleared of all soils and debris, and screened soils with PAH impacts would not be returned to this area.

As stated above, selection of this alternative would remove the contaminated soils, address concerns of ongoing PAH impacts from clay target fragments, and meet RAOs at Site TS776. This alternative is consistent with and would maintain the current use and foreseeable use of Site TS775 but would not meet the RAOs (specifically, returning the site to a condition allowing unrestricted use and unlimited exposure). This alternative would manage the residual risk at Site TS775 by dry screening of soils to remove visible clay target fragments and adding LUCs to control exposure to contaminated soil. This alternative could be implemented upon selection and approval by the stakeholders. This alternative is estimated to require approximately 7 weeks of field activities following site mobilization.

Selection of this alternative would leave contaminated soil above the NMED SSLs for PAHs at Site TS775. Therefore, a review of site conditions would be required every 5 years in order to assess conditions at Site TS775 only.

In summary, Alternative 5 would include the following activities:

- Installation of storm water and erosion controls in accordance with the NPDES permit
- Implementation of dust controls, as required, to protect workers from PAH impacted soils and limit potential impact of FOD to the airport
- Removal and off-site disposal of surface soils with PAHs above the PRGs and associated clay target fragments from Stratum 1 at Site TS776
- Screening and off-site disposal of visible clay target fragments from surface soil that does not exceed the PRGs in Stratum 1 of Site TS776 and the return of the associated uncontaminated soil to the excavation
- Screening and off-site disposal of visible clay target fragments in surface soils at Site TS775 and return of the screened soils, both soils exceeding PRGs and uncontaminated soils, to the excavations within the taxiway safety area
- Off-site disposal of soil with PAHs above the PRGs within Site TS776 and all separated clay target fragments
- Restoration of the sites through backfilling, grading, and seeding
- Establishment of LUCs for Site TS775 to restrict future land use to commercial/industrial activities
- Implementation of 5-year recurring reviews of the site conditions

3.7.1 Evaluation of Alternative 5

3.7.1.1 Effectiveness

This alternative would be an effective method for reducing the volume of contamination on site and removing the source of PAHs at Site TS776. This alternative would not provide a reduction of contaminant mass or toxicity or meet the regulatory preference for treatment because the contaminated media are only removed and not treated. This alternative would achieve the PRGs and meet the unrestricted use and unlimited exposure goals at Site TS776. No reduction of contaminant mass would be achieved at Site TS775. This alternative would not achieve the PRGs and would not meet the unrestricted use and unlimited exposure goals at Site TS775.

- **Protection of Public Safety and the Environment**. This alternative would reduce the volume of contaminants at Site TS776 to below the PRGs. However, the risk would be managed though LUCs at Site TS775.
- **Compliance with ARARs**. This alternative would be compliant with the ARARs for Site TS776 but not at Site TS775.

- **Long-Term Effectiveness**. At Site TS776, this alternative would provide long-term effectiveness through removal of contaminated media and the source of PAHs. This alternative would rely on LUCs to provide long-term protection at Site TS775.
- **Short-Term Effectiveness**. This alternative would have minimal short-term risks associated with handling and transport of contaminated soils. Proper contractor training and protective measures, including dust control, would minimize the risks.

3.7.1.2 Implementability

This alternative would be implementable because it uses known and well developed technologies.

- **Technical Feasibility**. This alternative would be technically feasible because it utilizes well-known and proven technologies.
- **Administrative Feasibility**. This alternative would be administratively feasible. There would be a long-term administrative commitment at Site TS775 for the LUCs at that site. In addition, a recurring 5-year review of the Site TS775 would be required due to contaminated media above the PRGs left onsite.
- **Availability of Services and Materials**. The services and materials to complete this alternative would be acquired easily.
- **Local Agency Acceptance**. This alternative may be acceptable to the local regulatory agencies because site risks are reduced through removal at Site TS776 and the LUCs to be implemented at Site TS775 are similar to those already implemented in the taxiway safety area.
- **Community Acceptance**. This alternative may be acceptable to the local community.
- **Regulatory and Governmental Acceptances**. This alternative likely would be acceptable by USEPA, NMED, and local government agencies.

3.7.1.3 Cost

This alternative would have an estimated capital cost of $818,272 and a net present worth O&M cost of $86,864 (total for the first 5 years), for a total current net worth of $905,135 for the implementation and first 5 years of LUCs at both sites. The estimated net present worth for each 5-year review thereafter is $45,065.

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4 COMPARATIVE ANALYSIS OF ALTERNATIVES

This section presents the comparative analyses of the alternatives based on effectiveness, implementability, and cost.

4.1 ALTERNATIVES ANALYSIS

Each of the five alternatives outlined in **Section 3** were analyzed and compared against each other.

Alternative 1: No Department of Defense Action Indicated

Alternative 2: Land Use Controls

Alternative 3: Excavation and Off-site Disposal of Surface Soils Impacted by Visible Clay Target Fragments

Alternative 4: Excavation of Surface Soil Impacted by Visible Clay Target Fragments, Removal of Visible Clay Target Fragments by Dry Screening, and Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Visible Clay Target Fragments

Alternative 5: Excavation of Surface Soil Impacted by Visible Clay Target Fragments at both Sites TS775 and TS776; Removal of Clay Target Fragments by Dry Screening at both Sites TS775 and TS776; Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Clay Target Fragments at Site TS776; and Excavation, Screening, and Removal of Clay Target Fragments with Land Use Controls at Site TS775

4.1.1 Effectiveness Analysis and Evaluation

Four evaluation criteria (protection of public safety and the environment, compliance with ARARs, long-term effectiveness, and short-term effectiveness) were considered in the scoring of the effectiveness category. Each criterion was assigned a score of 1 (most desirable), 2 (more desirable than undesirable), 3 (more undesirable than desirable), or 4 (undesirable); the lowest total score for the sum of the four evaluation criteria reflects the most desirable alternative. The results are reflected in **Table 4-1**.

Table 4-1: Scoring of Alternatives for Effectiveness

Effectiveness	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Protection of public safety and the environment	NC	4	1	1	3
Compliance with ARARs	NC	3	1	1	2
Long-term effectiveness	NC	3	1	1	2
Short-term effectiveness	NC	1	2	3	3
Total	NC	11	5	6	10
Rank	NC	4	1	2	3

Note:
Scoring: 1=most desirable, 2=more desirable than undesirable, 3=more undesirable than desirable, 4=undesirable; NC=not considered

4.1.1.1 Protection of Public Safety and the Environment

Alternative 1 was "not considered" because it would not remove any of the contaminant risks to human health and the environment and would not provide a physical barrier. Therefore, this alternative was not considered an acceptable response action. This alternative would not meet the RAOs for either site.

Alternative 2 was scored the least desirable among the alternatives because it would not remove any of the contaminant risks to human health and the environment. This alternative would address the risk at both sites by providing a physical barrier from the hazards with ECs and control future exposures by implementing ICs to prevent changes in site use. This alternative would not meet the RAOs for either site.

Alternative 5 was scored less desirable than Alternatives 3 and 4 because the source of the risk (soil with PAH concentrations above the PRGs) would remain at Site TS775. The residual excess cancer risk for soil at Site TS776 would be the same as described for Alternative 4, $6x10^{-5}$. However, Site TS775 would have the same excess lifetime cancer risk of $2x10^{-3}$ for residential land use presented in the BRA since soil removal and disposal would be limited to those sections outside of the taxiway fence line. This alternative would achieve the RAOs for Site TS776 but not for Site TS775.

Alternatives 3 and 4 would provide the greatest level of protection for the public since they meet the RAOs for both sites. Alternatives 3 and 4 would remove the contaminated soils above the PRGs and associated clay target fragments. Alternative 3 would remove the remaining clay target fragments and soils contaminated with PAHs below the PRGs. Alternative 4 would remove the potential source material of PAHs (clay target fragments) but leave the soils with PAH impacts below the PRGs on site. The excess lifetime cancer risks for unrestricted land use at Sites TS775 and TS776 after implementation of Alternative 4 would be $6x10^{-5}$, which is within the acceptable range established by the USEPA. These alternatives would achieve the RAOs for the sites.

4.1.1.2 Compliance with Applicable Relevant and Appropriate Requirements

With the exception of Alternative 1, all of the alternatives would provide some level of compliance with ARARs. Alternatives 3 and 4 would comply with all ARARs. Alternative 5 would comply with most ARARs but would not achieve the PRG at Site TS775. However, Alternative 5 would address the risk through LUCs. Alternative 2 would address the risk and achieve compliance with the ARARs through site access control only. Alternative 1 was "not considered" because it would not remove contaminant risks to human health and the environment and would not provide a physical barrier. Therefore, Alternative 1 would not adequately address any of the ARARs that are drivers for this removal action.

4.1.1.3 Long-Term Effectiveness

Alternatives 3 and 4 provide the greatest long-term effectiveness because the PAH contamination in soil above PRGs and clay target fragments would be removed and disposed of off site.

Alternative 5 was scored less desirable because it would not remove all soil with PAH concentrations above PRGs at Site TS775 and would use LUCs to address long-term risk.

Alternative 2 was scored least desirable because it would use LUCs to address long-term risk, and there would be no actual reduction of risk at either site.

Alternative 1 was "not considered" because it would not remove any of the contaminant risks to human health and the environment and would not provide a physical or administrative barrier to future exposures. Therefore, this alternative is not considered an acceptable response action.

4.1.1.4 Short-Term Effectiveness

Alternative 2 was scored the most desirable because it is the quickest to implement, affords some protection from contaminant risks, and incurs virtually no risk to implement. Alternative 3 was scored less desirable because implementation would be less rapid and exposures to PAHs might occur as the result of the implementation process through potential soil handling and dust generation. Alternative 4 is scored less desirable than Alternatives 2 and 3 because soils and clay target fragments would be handled and processed on site and dust generation from the clay target fragments might pose a controllable risk to site workers during the removal action. Alternative 5 is similar to Alternative 4 in terms of short-term effectiveness.

Alternative 1 was "not considered" because it would not remove any of the contaminant risks to human health and the environment and would not provide a physical barrier. Therefore, this alternative is not considered an acceptable response action.

4.1.2 Implementability Analysis and Evaluation

Six evaluation criteria (technical feasibility, administrative feasibility, availability of services and materials, local agency acceptance, community acceptance, and regulatory and governmental acceptances) were considered in the scoring of the effectiveness category. Each criterion was assigned a score of 1 (most desirable), 2 (more desirable than undesirable), 3 (more undesirable than desirable), or 4 (undesirable); the lowest total score reflects the most desirable alternative. The results are reflected in **Table 4-2**.

Table 4-2: Scoring of Alternatives for Implementability

Implementability	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Technical feasibility	NC	1	2	3	3
Administrative feasibility	NC	3	2	1	3
Availability of services and materials	NC	1	2	3	3
Local agency acceptance	NC	4	2	1	3
Community acceptance	NC	4	2	1	3
Regulatory and governmental acceptances	NC	4	2	1	3
Total	NC	17	12	10	18
Rank	NC	3	2	1	4

Note:
Scoring: 1=most desirable, 2=more desirable than undesirable, 3=more undesirable than desirable, 4=undesirable; NC=not considered

4.1.2.1 Technical Feasibility

Alternative 2 was rated most desirable because the establishment of LUCs is the easiest technically of the alternatives to implement. Alternative 3 is scored slightly less desirable than Alternative 2 because monitoring of effectiveness would be performed during implementation and the technology (excavation) is relatively more simple and conventional. Alternatives 4 and 5 are scored less desirable than Alternatives 2 and 3 because soil screening to remove the clay target fragments might require mitigation (e.g., dust generation). In addition, the screening process might cause mechanical breakdown of the clay target fragments, which could allow fragments to pass through the screens.

Alternative 1 was "not considered" because it does not remove contaminant risks to human health and the environment and does not provide a physical barrier. Therefore, this alternative is not considered an acceptable response action.

4.1.2.2 Administrative Feasibility

Alternatives 3, 4, and 5 would require soil characteristic testing results for approval prior to disposal at a landfill. However, only Alternatives 3 and 4 meet the goals for achieving unrestricted, future residential land use. Alternative 4 was scored most desirable because it would reduce disposal volumes and meet RAOs. Alternative 3 was scored less desirable than Alternative 4 because it would involve the disposal of significantly more soils off site.

Alternatives 2 and 5 are less desirable than Alternatives 3 and 4 because they would require LUCs and fail to meet RAOs at both sites.

Alternative 1 was "not considered" because it would not remove contaminant risks to human health and the environment, would not provide a physical barrier, and would require additional administrative action to manage the risk. Therefore, this alternative is not considered an acceptable response action.

4.1.2.3 Availability of Services and Materials

Alternative 2 was scored the most desirable because the establishment of LUCs would be relatively simple and easy to enact and services and materials would be limited to signage and/or fencing to control access to the site. Alternative 3 is scored less desirable than Alternative 2 due to the requirement for heavy machinery for soil moving and skilled on-site services. Alternatives 4 and 5 are scored lower than Alternatives 2 and 3 because they would require additional equipment for soil screening. All considered alternatives would use known and mature technologies. All alternatives could be implemented upon approval from stakeholders.

Alternative 1 was "not considered" because it would not remove contaminant risks to human health and the environment and would not provide a physical barrier. Therefore, this alternative is not considered an acceptable response action.

4.1.2.4 Local Agency and Community Acceptance

Alternative 4 was scored most desirable because it would achieve the RAOs at both sites and would minimize off-site waste disposal. Alternative 3 was scored slightly less desirable due to the greater volume of off-site waste disposal.

Alternative 5 is scored less desirable than Alternatives 3 and 4 because it would not meet the RAOs for Site TS775. Alternative 2 was scored the least desirable because it would not remove contaminant risks to human health and the environment and would not gain approval from local agencies or the community.

Alternative 1 was "not considered" because it would not remove contaminant risks to human health and the environment, would not provide a physical barrier, and would not gain local agency or community acceptance.

4.1.2.5 Regulatory and Government Acceptance

Alternative 4 was scored most desirable of the alternatives because it would meet the unrestricted, future residential land use goal and would reduce the volume of soils for off-site disposal by separating the visible clay target fragments from the soils. Alternative 4 would satisfy the CERCLA preference for treatment as a principal element that permanently and significantly reduces the toxicity, mobility, or volume of the contaminants.

Alternative 3 was scored slightly less desirable because it would remove more uncontaminated soil for off-site transportation and disposal than Alternative 4. Alternative 5 is scored less desirable than either of the previous alternatives because it would only meet RAOs at Site TS776. Alternative 2 was scored least desirable because it would not meet the RAOs and would require LUCs to address risks at both Site TS775 and Site TS776. Therefore, it would provide the least desired regulatory and government acceptance of the alternatives.

Alternative 1 was "not considered" because it would not remove contaminant hazards to human health and the environment, would not provide a physical barrier, and would not gain acceptance from the regulatory agencies. Therefore, this alternative is not considered as an acceptable response action.

4.1.3 Total Cost

Table 4-3 summarizes the comparative scoring of the alternatives for total cost. A detailed summary of these costs and cost assumptions is included in **Appendix B**. The costs were developed from vendor quotes, standard environmental project cost tables, and previous contractor experience.

Table 4-3: Scoring of Alternatives for Cost

Cost	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Rank	NC	1	4	3	2

Note:
Scoring: Alternatives are ranked 1 (lowest cost) through 4 (highest cost).
NC=not considered

Alternative 2 is scored most desirable due to the comparably low cost of implementing LUCs. Alternative 5 is scored slightly less desirable than Alternative 2 due to the cost savings compared to Alternatives 3 and 4. The cost savings are due to the use of LUCs at Site TS775 rather than off-site disposal of the contaminated soils for Alternative 5. This assessment assumes that long-term costs of administrating the LUCs within the already stringent airport taxiway area are negligible compared with the current costs associated with remediation.

Alternative 4 is scored less desirable than the alternatives using LUCs to manage risk due to the costs associated with excavation of soils and screening of clay target fragments at Site TS775 and Site TS776.

Alternative 3 is scored least desirable due to the costs associated with the disposal of the soils commingled with the clay target fragments from both sites.

Alternative 1 was “not considered” in this analysis because it would not remove contaminant hazards to human health and the environment, nor would it provide a physical barrier. By design, there is no cost associated with Alternative 1. This alternative is not considered as an acceptable response action.

4.2 SUMMARY

This study conducted a comparative analysis of alternatives using the evaluation criteria of effectiveness, implementability, and cost based upon the objectives presented earlier in the EE/CA. Scores for individual criteria are summarized in **Table 4-4**. The alternative with the lowest total score is the most desirable.

Table 4-4: Summary of Comparative Scoring

Evaluation Criteria	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Effectiveness	NC	4	1	2	3
Implementability	NC	3	2	1	4
Cost	NC	1	4	3	2
Total	NC	8	7	6	9
Rank	NC	3	2	1	4

Note:
Scoring: 1=most desirable, 2=more desirable than undesirable, 3=more undesirable than desirable, 4=undesirable; NC=not considered

Based on the comparison above, Alternative 4 is the most desirable alternative based on the achievement of RAOs and implementability. Alternative 3, Alternative 2, Alternative 5, and Alternative 1 are ranked in order of most desirable to least desirable.

5 RECOMMENDED REMOVAL ACTION ALTERNATIVE

This section provides the recommendations for reducing human health and ecological risks at Sites TS775 and TS776. These removal action recommendations are based on RAOs (unrestricted, future residential land use), costs, existing site conditions, archival information regarding previous uses of the site, and the desired future land use of the site. The selected alternative provides the most effective and efficient use of resources and appropriately balances trade-offs that affect the remedy selection. In addition, the selected alternative allows for the unrestricted use of Site TS776 and Site TS775. This EE/CA report represents a “desk top” study, and conclusions are based on quantitative information from previous studies and professional judgment.

The goal of the recommended alternative is to provide the most effective protection to the public from potential contaminant hazards while meeting RAOs and managing costs. Final recommendations for Sites TS775 and TS776 will be documented in an Action Memorandum. A Removal Action Work Plan (or similar document specifying how the selected alternative will be implemented) will be prepared and submitted for review after the submittal of the Action Memorandum and prior to commencement of the removal actions.

5.1 GENERAL RECOMMENDATIONS

The recommendations herein are based on a qualitative study that relies on best industry practices, work performed at similar skeet range sites, and ECC and ARCADIS/Malcolm Pirnie professional judgment. Consequently, these recommendations are based on a conservative approach from the interpretation of the regulations and procedural approaches. Though stakeholder acceptance was considered for each alternative, not every stakeholder’s desires and concerns were addressed specifically; additional stakeholder comments and concerns will be incorporated into the Action Memorandum.

Cost estimates provided are only intended for comparing costs associated with proposed response action alternatives. They do not represent actual costs of implementation. Actual costs for implementation of any removal alternative will be determined based on observed conditions during the removal or treatment activities. Concurrence from the stakeholders should be obtained prior to adopting a specific alternative.

5.2 RECOMMENDED RESPONSE ACTION FOR SITES TS775 AND TS776

The evaluation of alternatives identified Alternative 4 “Excavation of Surface Soil Impacted by Visible Clay Target Fragments, Removal of Visible Clay Target Fragments by Dry Screening, and Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Visible Clay Target Fragments” as the most desirable using criteria established for the EE/CA process. Alternative 4 will remove existing soil with PAHs contamination above NMED residential SSLs at both sites and will separate the clay target fragments from the remaining soils located in Stratum 1 at each site. Therefore, Alternative 4 provides the best balance of trade-offs and achieves the RAOs for the sites, including removal of soils that do not meet NMED residential SSLs for PAHs and removal of visible clay target fragments.

The screening process could potentially cause mechanical breakdown of clay target fragments, thus permitting passage of the reduced-size clay target fragments through the screens. The screening process should be monitored closely to ensure that the screens retain the clay target fragments. If monitoring indicates that clay target fragments are passing through the screening process, Alternative 4 will be abandoned and Alternative 3 will be implemented.

This removal action was designed to incorporate confirmation soil sampling and additional sampling for further delineation of soils exceeding the PRGs, as appropriate. This will allow the remedy to be adapted to minimize over or under excavation of soils. The Work Plan document will provide details on field verification of the excavation extents.

6 REFERENCES

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Tables

Engineering Evaluation /Cost Assessment
TS 775 & TS 776 Skeet Ranges
Military Munitions Response Program
Kirtland Air Force Base, New Mexico

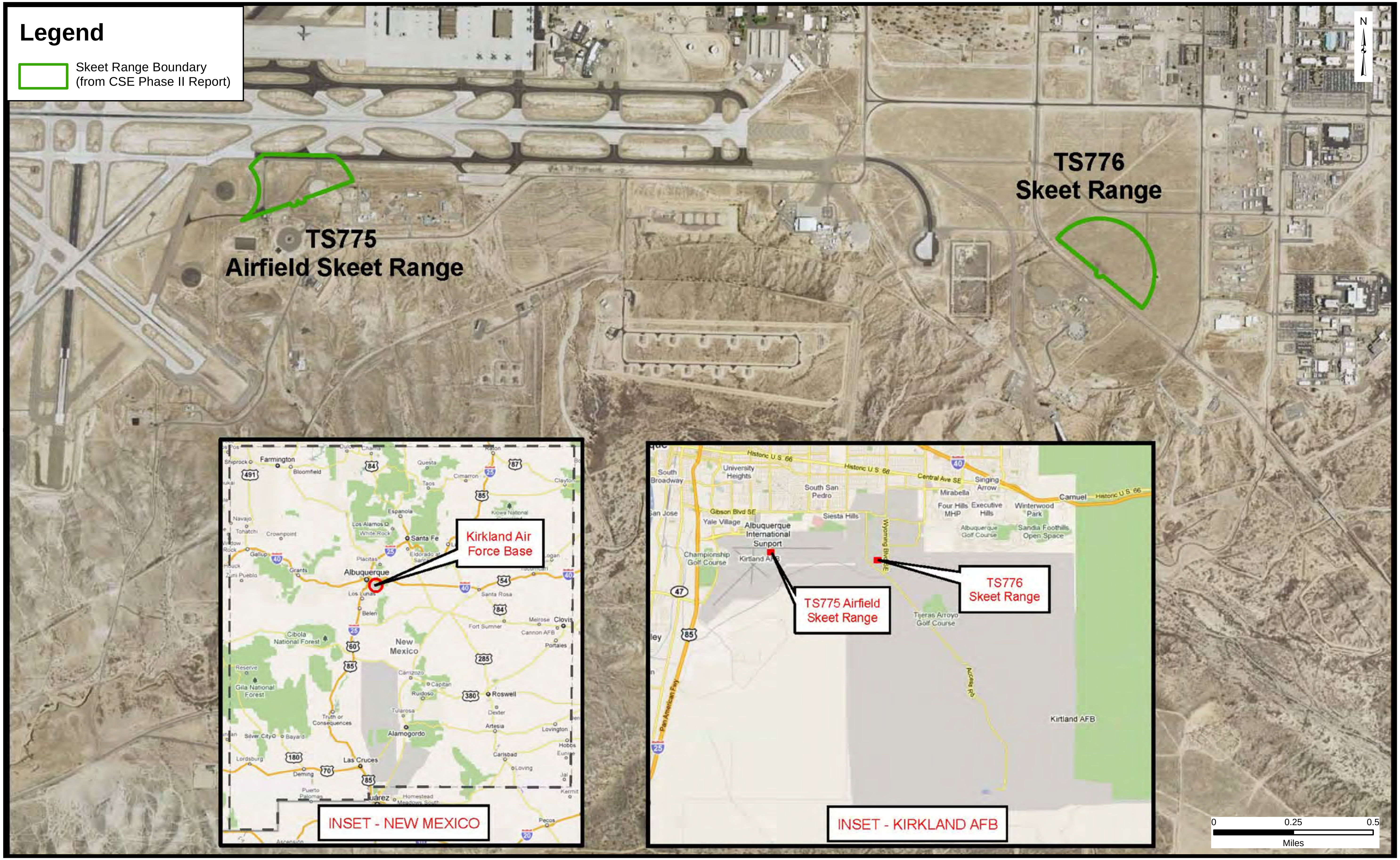
Table 3-1
Summary of Proposed Removal Alternatives
Sites TS775 and TS776
Kirtland Air Force Base, Albuquerque, New Mexico

Alternative	Description of Removal Alternative	Activity at TS775	Activity at Site TS776	Estimated Present Net Worth Cost[1]	Meets Unrestricted Use / Unrestricted Exposure Requirement
Alternative 1	No Department of Defense Action Indicated	• None	• Same as Site TS775	Not Applicable	No (Requires 5-year Review)
Alternative 2	Land Use Controls (LUCs)	• Develop and Implement LUCs for non-residential limited exposure only	• Same as Site TS775	$338,474	No (Requires 5-year Review)
Alternative 3	Excavation and Off-site Disposal of Surface Soils Impacted by Visible Clay Target Fragments and Surface Soil with PAH Concentrations above Residential SSLs	• Excavation of approximately 1-foot thickness of PAH contaminated soil and visible clay target fragments from high-density area within Stratum 1 • Excavation of approximately 0.5-foot thickness of soil containing visible clay target fragments from low-density area within Stratum 1 • Off-site landfill disposal of soils • Confirm achievement of PRGs via confirmation sampling post-soil excavation	• Same as Site TS775	$1,237,395	Yes
Alternative 4	Excavation of Surface Soil Impacted by Visible Clay Target Fragments, Removal of Visible Clay Target Fragments by Dry Screening, and Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Visible Clay Target Fragments	• Excavation of approximately 1-foot thickness of PAH contaminated soil and visible clay target fragments from high-density area within Stratum 1 • Excavation of approximately 0.5-foot thickness of soil containing visible clay target fragments from low-density area within Stratum 1, screening out of clay target fragments for off-site disposal Return soils not exceeding PRGs to site excavation • Off-site landfill disposal of soils exceeding PRGs • Confirm achievement of PRGs via confirmation sampling post-soil excavation	• Same as Site TS775	$1,039,281	Yes
Alternative 5	Excavation of Surface Soil Impacted by Visible Clay Target Fragments at both Sites TS775 and TS776, Removal of Clay Target Fragments by Dry Screening at both Sites TS775 and TS776, and Off-site Disposal of Soil with PAH Concentrations above Residential SSLs and Clay Target Fragments at Site TS776; and Excavation, Screening, and Removal of Clay Target Fragments with Land Use Controls at Site TS775	• Excavation of approximately 1-foot thickness of PAH contaminated soil and visible clay target fragments from high-density area within Stratum 1 • Excavation of approximately 0.5-foot thickness of soil containing visible clay target fragments from low-density area within Stratum 1, screening soil for removal of clay target fragments for off-site disposal • Return excavated soil • Confirm achievement of PRGs via confirmation sampling post-soil excavation • Develop and Implement LUCs	• Same as Alternative 4	$905,135	TS775: No (Requires 5-year Review) TS776: Yes

Notes: (1) Costs for Alternatives 2 and 5 are for upto the first 5-year review, they do not include costs for following 5-year reviews
PAH -polycyclic aromatic hydrocarbon
LUC - land use control
PRG - preliminary remediation goals

Figures

Engineering Evaluation /Cost Assessment
TS 775 & TS 776 Skeet Ranges
Military Munitions Response Program
Kirtland Air Force Base, New Mexico



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ECC

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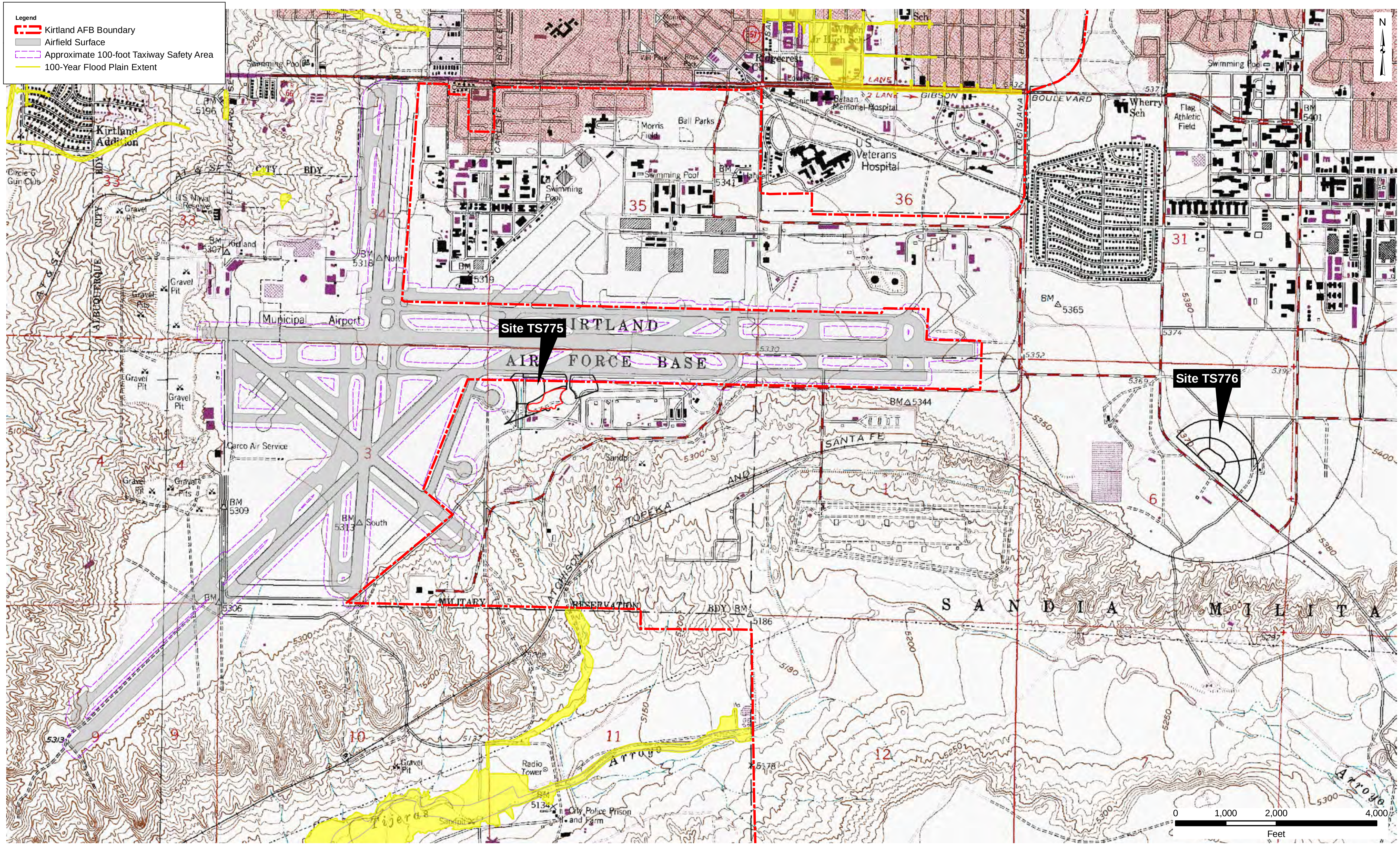
Bernalillo County, New Mexico
SKEET RANGES AT KIRTLAND AFB
PN: 04729016.0000

KIRTLAND AFB
Sites TS775 and TS776 Site Map

ARCADIS / MALCOLM PIRNIE, INC.
FEBRUARY 2012
FIGURE 1



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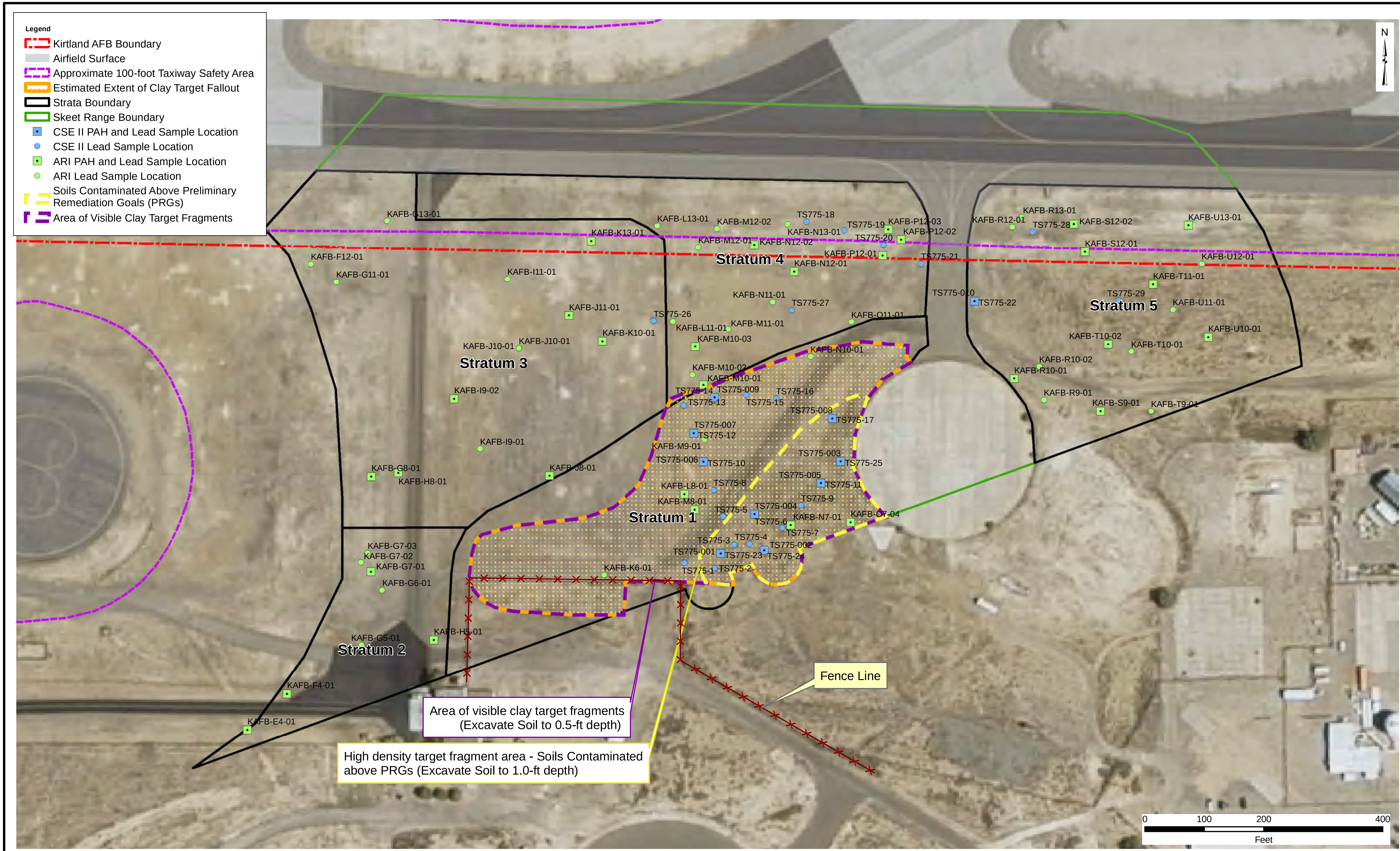
KIRTLAND AFB
Sites TS775 and TS776 Topographic Map

ARCADIS / MALCOLM PIRNIE, INC.

FEBRUARY 2012
FIGURE 2



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KIRTLAND AFB
Site TS775 Alternatives 3, 4, and 5

ARCADIS / MALCOLM PIRNIE, INC.
FEBRUARY 2012
FIGURE 3

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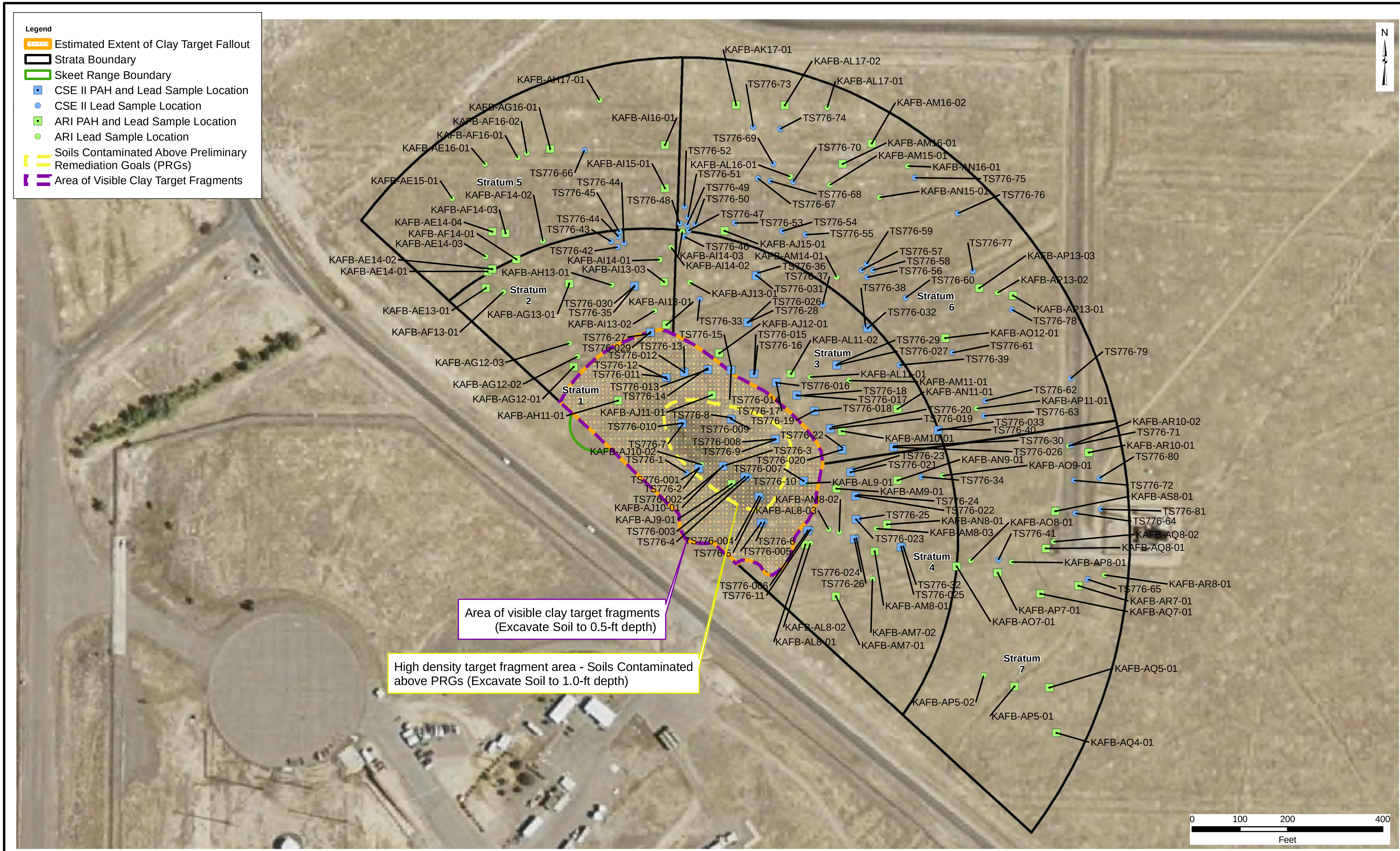

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Site TS776 Alternatives 3, 4, and 5

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FIGURE 4

Appendix A
Residual Risk Model - Human Health Risk Assessment

Engineering Evaluation /Cost Assessment

TS 775 & TS 776 Skeet Ranges

Military Munitions Response Program

Kirtland Air Force Base, New Mexico

Table A-1

Calculation of Cancer Risks at TS776 for Remedial Alternatives Based on New Mexico Environmental Department Soil Screening Levels for Polycyclic Aromatic Hydrocarbons
Skeet Range Sites TS775 and TS776, Kirtland Air Force Base, Albuquerque, New Mexico

Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		0-2 Year-old Child Cancer Risk Calculations					2-6 Year-old Child Cancer Risk Calculations					6-16 Year-old Child Cancer Risk Calculations					Adult Cancer Risk Calculations					Total Cancer Risk	Acceptable Cancer Risk Range
			Value	Units	Intake/Exposure Concentration		Cancer Slope Factor/Unit Risk[1]		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor/Unit Risk[1]		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk		
					Value	Units	Value	Units		Value	Units	Value	Units		Value	Units	Value	Units		Value	Units	Value	Units			
STRATUM 1	Ingestion	Benzo(a)anthracene	4.0E-01	mg/kg	1.5E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06	2.9E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	6E-07	7.8E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.1E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	8E-08		
		Benzo(a)pyrene	5.8E-01	mg/kg	2.1E-07	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	2E-05	4.2E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	9E-06	1.1E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	2E-06	1.6E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06		
		Benzo(b)fluoranthene	8.3E-01	mg/kg	3.0E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-06	6.1E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	1E-06	1.6E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	4E-07	2.3E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	2E-07		
		Benzo(k)fluoranthene	3.3E-01	mg/kg	1.2E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	9E-08	2.4E-07	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	5E-08	6.5E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	1E-08	9.0E-08	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	7E-09		
		Chrysene	5.9E-01	mg/kg	2.2E-07	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	2E-08	4.3E-07	mg/kg-day	2.2E-02	(mg/kg-day)$^{-1}$	9E-09	1.2E-07	mg/kg-day	2.2E-02	(mg/kg-day)$^{-1}$	3E-09	1.6E-07	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	1E-09		
		Dibenzo(a,h)anthracene	1.2E-01	mg/kg	4.4E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	3E-06	8.8E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	2E-06	2.3E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	5E-07	3.3E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-07		
		Indeno(1,2,3-cd)pyrene	3.8E-01	mg/kg	1.4E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06	2.8E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	6E-07	7.4E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.0E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	8E-08		
	Exp. Route Total								2E-05					1E-05					4E-06					2E-06	**4E-05**	
	Dermal	Benzo(a)anthracene	4.0E-01	mg/kg	5.3E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	4E-07	1.1E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	4.1E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	9E-08	5.7E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	4E-08		
		Benzo(a)pyrene	5.8E-01	mg/kg	7.7E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	6E-06	1.5E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	3E-06	5.9E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	1E-06	8.2E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	6E-07		
		Benzo(b)fluoranthene	8.3E-01	mg/kg	1.1E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	8E-07	2.2E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	5E-07	8.4E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.2E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	9E-08		
		Benzo(k)fluoranthene	3.3E-01	mg/kg	4.4E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	3E-08	8.8E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	2E-08	3.3E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	7E-09	4.7E-08	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	3E-09		
		Chrysene	5.9E-01	mg/kg	7.8E-08	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	6E-09	1.6E-07	mg/kg-day	2.2E-02	(mg/kg-day)$^{-1}$	3E-09	6.0E-08	mg/kg-day	2.2E-02	(mg/kg-day)$^{-1}$	1E-09	8.4E-08	mg/kg-day	7.3E-03	(mg/kg-day)$^{-1}$	6E-10		
		Dibenzo(a,h)anthracene	1.2E-01	mg/kg	1.6E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	1E-06	3.2E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	7E-07	1.2E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	3E-07	1.7E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-07		
		Indeno(1,2,3-cd)pyrene	3.8E-01	mg/kg	5.1E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	4E-07	1.0E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	3.9E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	8E-08	5.4E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	4E-08		
	Exp. Route Total								8E-06					5E-06					2E-06					9E-07	**2E-05**	
	Inhalation	Benzo(a)anthracene	4.0E-01	mg/kg	1.5E-08	μg/m^3	1.1E-03	(μg/m^3)$^{-1}$	2E-11	3.0E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	1E-11	7.5E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	2E-11	1.0E-07	μg/m^3	1.1E-04	(μg/m^3)$^{-1}$	1E-11		
		Benzo(a)pyrene	5.8E-01	mg/kg	2.2E-08	μg/m^3	1.1E-02	(μg/m^3)$^{-1}$	2E-10	4.3E-08	μg/m^3	3.3E-03	(μg/m^3)$^{-1}$	1E-10	1.1E-07	μg/m^3	3.3E-03	(μg/m^3)$^{-1}$	4E-10	1.5E-07	μg/m^3	1.1E-03	(μg/m^3)$^{-1}$	2E-10		
		Benzo(b)fluoranthene	8.3E-01	mg/kg	3.1E-08	μg/m^3	1.1E-03	(μg/m^3)$^{-1}$	3E-11	6.2E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	2E-11	1.6E-07	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	5E-11	2.2E-07	μg/m^3	1.1E-04	(μg/m^3)$^{-1}$	2E-11		
		Benzo(k)fluoranthene	3.3E-01	mg/kg	1.2E-08	μg/m^3	1.1E-03	(μg/m^3)$^{-1}$	1E-11	2.5E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	8E-12	6.2E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	2E-11	8.7E-08	μg/m^3	1.1E-04	(μg/m^3)$^{-1}$	1E-11		
		Chrysene	5.9E-01	mg/kg	2.2E-08	μg/m^3	1.1E-04	(μg/m^3)$^{-1}$	2E-12	4.4E-08	μg/m^3	3.3E-05	(μg/m^3)$^{-1}$	1E-12	1.1E-07	μg/m^3	3.3E-05	(μg/m^3)$^{-1}$	4E-12	1.5E-07	μg/m^3	1.1E-05	(μg/m^3)$^{-1}$	2E-12		
		Dibenzo(a,h)anthracene	1.2E-01	mg/kg	4.5E-09	μg/m^3	1.2E-02	(μg/m^3)$^{-1}$	5E-11	9.0E-09	μg/m^3	3.6E-03	(μg/m^3)$^{-1}$	3E-11	2.2E-08	μg/m^3	3.6E-03	(μg/m^3)$^{-1}$	8E-11	3.1E-08	μg/m^3	1.2E-03	(μg/m^3)$^{-1}$	4E-11		
		Indeno(1,2,3-cd)pyrene	3.8E-01	mg/kg	1.4E-08	μg/m^3	1.1E-03	(μg/m^3)$^{-1}$	2E-11	2.8E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	9E-12	7.1E-08	μg/m^3	3.3E-04	(μg/m^3)$^{-1}$	2E-11	1.0E-07	μg/m^3	1.1E-04	(μg/m^3)$^{-1}$	1E-11		
	Exp. Route Total								4E-10					2E-10					6E-10					3E-10	**1E-09**	
Exposure Point Total									3E-05					2E-05					6E-06					3E-06	**6E-05**	**1E-06 to 1E-04**

Table A-2

Calculation of Cancer Risks at TS775 for Remedial Alternatives Based on New Mexico Environmental Department Soil Screening Levels for Polycyclic Aromatic Hydrocarbons
Skeet Range Sites TS775 and TS776, Kirtland Air Force Base, Albuquerque, New Mexico

Exposure Point	Exposure Route	Chemical of Potential Concern	EPC		0-2 Year-old Child Cancer Risk Calculations					2-6 Year-old Child Cancer Risk Calculations					6-16 Year-old Child Cancer Risk Calculations					Adult Cancer Risk Calculations					Total Cancer Risk	Acceptable Cancer Risk Range
			Value	Units	Intake/Exposure Concentration		Cancer Slope Factor/Unit Risk[1]		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor/Unit Risk[1]		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk	Intake/Exposure Concentration		Cancer Slope Factor		Cancer Risk		
					Value	Units	Value	Units		Value	Units	Value	Units		Value	Units	Value	Units		Value	Units	Value	Units			
STRATUM 1	Ingestion	Benzo(a)anthracene	4.7E-01	mg/kg	1.7E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06	3.4E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	8E-07	9.2E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.3E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	9E-08		
		Benzo(a)pyrene	5.8E-01	mg/kg	2.1E-07	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	2E-05	4.2E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	9E-06	1.1E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	2E-06	1.6E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	1E-06		
		Benzo(b)fluoranthene	7.4E-01	mg/kg	2.7E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-06	5.4E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	1E-06	1.4E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	3E-07	2.0E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-07		
		Benzo(k)fluoranthene	3.7E-01	mg/kg	1.4E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	1E-07	2.7E-07	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	6E-08	7.2E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	2E-08	1.0E-07	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	7E-09		
		Dibenzo(a,h)anthracene	1.5E-01	mg/kg	5.5E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	4E-06	1.1E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	2E-06	2.9E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	6E-07	4.1E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	3E-07		
		Indeno(1,2,3-cd)pyrene	8.0E-01	mg/kg	2.9E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-06	5.8E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	1E-06	1.6E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	3E-07	2.2E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	2E-07		
	Exp. Route Total								2E-05					1E-05					4E-06					2E-06	**5E-05**	
	Dermal	Benzo(a)anthracene	4.7E-01	mg/kg	6.2E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	5E-07	1.2E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	3E-07	4.8E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	1E-07	6.7E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	5E-08		
		Benzo(a)pyrene	5.8E-01	mg/kg	7.7E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	6E-06	1.5E-07	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	3E-06	5.9E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	1E-06	8.2E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	6E-07		
		Benzo(b)fluoranthene	7.4E-01	mg/kg	9.8E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	7E-07	2.0E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	4E-07	7.5E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.1E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	8E-08		
		Benzo(k)fluoranthene	3.7E-01	mg/kg	4.9E-08	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	4E-08	9.8E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	2E-08	3.8E-08	mg/kg-day	2.2E-01	(mg/kg-day)$^{-1}$	8E-09	5.3E-08	mg/kg-day	7.3E-02	(mg/kg-day)$^{-1}$	4E-09		
		Dibenzo(a,h)anthracene	1.5E-01	mg/kg	2.0E-08	mg/kg-day	7.3E+01	(mg/kg-day)$^{-1}$	1E-06	4.0E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	9E-07	1.5E-08	mg/kg-day	2.2E+01	(mg/kg-day)$^{-1}$	3E-07	2.1E-08	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	2E-07		
		Indeno(1,2,3-cd)pyrene	8.0E-01	mg/kg	1.1E-07	mg/kg-day	7.3E+00	(mg/kg-day)$^{-1}$	8E-07	2.1E-07	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	5E-07	8.1E-08	mg/kg-day	2.2E+00	(mg/kg-day)$^{-1}$	2E-07	1.1E-07	mg/kg-day	7.3E-01	(mg/kg-day)$^{-1}$	8E-08		
	Exp. Route Total								9E-06					5E-06					2E-06					1E-06	**2E-05**	
	Inhalation	Benzo(a)anthracene	4.7E-01	mg/kg	1.8E-08	µg/m^3	1.1E-03	(µg/m^3)$^{-1}$	2E-11	3.5E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	1E-11	8.8E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	3E-11	1.2E-07	µg/m^3	1.1E-04	(µg/m^3)$^{-1}$	1E-11		
		Benzo(a)pyrene	5.8E-01	mg/kg	2.2E-08	µg/m^3	1.1E-02	(µg/m^3)$^{-1}$	2E-10	4.3E-08	µg/m^3	3.3E-03	(µg/m^3)$^{-1}$	1E-10	1.1E-07	µg/m^3	3.3E-03	(µg/m^3)$^{-1}$	4E-10	1.5E-07	µg/m^3	1.1E-03	(µg/m^3)$^{-1}$	2E-10		
		Benzo(b)fluoranthene	7.4E-01	mg/kg	2.8E-08	µg/m^3	1.1E-03	(µg/m^3)$^{-1}$	3E-11	5.5E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	2E-11	1.4E-07	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	5E-11	1.9E-07	µg/m^3	1.1E-04	(µg/m^3)$^{-1}$	2E-11		
		Benzo(k)fluoranthene	3.7E-01	mg/kg	1.4E-08	µg/m^3	1.1E-03	(µg/m^3)$^{-1}$	2E-11	2.8E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	9E-12	6.9E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	2E-11	9.7E-08	µg/m^3	1.1E-04	(µg/m^3)$^{-1}$	1E-11		
		Dibenzo(a,h)anthracene	1.5E-01	mg/kg	5.6E-09	µg/m^3	1.2E-02	(µg/m^3)$^{-1}$	7E-11	1.1E-08	µg/m^3	3.6E-03	(µg/m^3)$^{-1}$	4E-11	2.8E-08	µg/m^3	3.6E-03	(µg/m^3)$^{-1}$	1E-10	3.9E-08	µg/m^3	1.2E-03	(µg/m^3)$^{-1}$	5E-11		
		Indeno(1,2,3-cd)pyrene	8.0E-01	mg/kg	3.0E-08	µg/m^3	1.1E-03	(µg/m^3)$^{-1}$	3E-11	6.0E-08	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	2E-11	1.5E-07	µg/m^3	3.3E-04	(µg/m^3)$^{-1}$	5E-11	2.1E-07	µg/m^3	1.1E-04	(µg/m^3)$^{-1}$	2E-11		
	Exp. Route Total								4E-10					2E-10					6E-10					3E-10	**2E-09**	
Exposure Point Total									3E-05					2E-05					6E-06					3E-06	**6E-05**	**1E-06 to 1E-04**

Appendix B
Removal Alternatives Cost Analysis

Engineering Evaluation /Cost Assessment
TS 775 & TS 776 Skeet Ranges
Military Munitions Response Program
Kirtland Air Force Base, New Mexico

TABLE B-1

MMRP Sites TS775 and TS776
Soil Excavation Calculations for Alternatives

Engineering Evaluation / Cost Analysis

Kirtland Air Force Base

Disturbed Area				
Site	TS775		TS776	
Excavation Depth	0.5-foot	1.0-foot	0.5-foot	1.0-foot
Alternative	Disturbed Area (Acres)	Disturbed Area (Acres)	Disturbed Area (Acres)	Disturbed Area (Acres)
Alternative 1	0	0	0	0
Alternative 2	0	0	0	0
Alternative 3	2.68	1.32	2.51	1.12
Alternative 4 (1)	2.68	1.32	2.51	1.12
Alternative 5 (2)	4.0	0	2.51	1.12

Impact Assumptions (3)

Assumed depth of PAH impacted soil (inches) : 12

Assumed depth of clay target removal (inches) : 3

Excavated Soils						
Site	TS775			TS776		
Excavation Depth	0.5-foot	1 foot	Total	0.5-foot	1 foot	Total
Alternative	Excavated Soils (Cubic Yards)	Excavated Soils (Cubic Yards)	Excavated Soils (Cubic Yards)	Excavated Soils (Cubic Yards)	Excavated Soils (Cubic Yards)	Excavated Soils (Cubic Yards)
Alternative 1	0	0	0	0	0	0
Alternative 2	0	0	0	0	0	0
Alternative 3	2161.9	2129.6	4291.5	2024.7	1806.9	3831.7
Alternative 4 (1)	2161.9	2129.6	4291.5	2024.7	1806.9	3831.7
Alternative 5 (2)	3226.7	0.0	3226.7	2024.7	1806.9	3831.7

Notes

1. Soils from 0.5-foot excavation area will be screened and retuned to excavation area.
2. Soils from 0.5-foot at TS775 excavation area will be screened and retuned to excavation area.
3. Assumptions based on visual inspection, CSE II sampling, and ARI Sampling results.
4. The volume of target fragments estimated for disposal at the landfill facility for the Alternatives, is based on 25 percent of the total volume of excavated soil screened for the removal of target fragments. (based on engineer's judgment).

TABLE B-2
MMRP Sites TS775 and TS776
Alternative 2 Costs
Engineering Evaluation / Cost Analysis
Kirtland Air Force Base

Description	Unit	Quantity	Unit Cost	Subtotal	Notes
Land Use Controls					
Access Restrictions (Signs) (1)	each	16	$50	$800	Site TS776 and 0.3 acres of TS775. 6 ft high with 3 strand barb wire (RS Means 32 31 13.20 0200)
Fencing (1)	ft	4768	$23.50	$112,048	
Development and Implementation of LUCs (2)	ls	1	$10,000	$10,000	
Operation and Maintenance of LUCs					
O&M Administration (5%) (2)	% of LUCs	0.05	$122,848	$6,142	Review of analytical data, site use, site conditions, and LUCs
O&M Upkeep (5%) (2)	% of LUCs	0.05	$122,848	$6,142	Maintenance of fencing and signage
Total Annual O&M (2)				$12,285	
O&M LUCs Present Worth (for 5 years)				$57,736	
Site Review - TS775					
Present Net worth of 5-Year Review (2)	each	1	$50,000	$45,065	Review of analytical data, regulatory reporting, meetings, and documentation.
			Capital Cost Subtotal	$122,848	
			Contingency (30%)	$36,854	
			Engineering and Administration (3) (20%)	$24,570	
			Capital Cost Total	$184,272	
			LUC O&M and 5-Year Review Cost Subtotal	$102,801	
			Contingency (30%)	$30,840	
			Engineering and Administration (2) (20%)	$20,560	
			Capital Cost Total	$154,202	
			TOTAL	**$338,474**	

Discount Rate	0.021
Years of Maintenance	5

Notes:

(1) All cost data estimated from RSMeans Building and Construction Cost Data, 2011.

(2) Cost data from previous ECC and ARCADIS experience.

Abbreviations:

- lf: linear foot
- ls: lump sum
- LUCs: Land Use Controls
- O&M: Operations and Maintenance

TABLE B-3
MMRP Sites TS775 and TS776
Alternative 3 Costs
Engineering Evaluation / Cost Analysis
Kirtland Air Force Base

Description	Unit	Quantity	Unit Cost	Subtotal	Notes
Stormwater and Erosion Controls					
Silt Fencing [1]	lf	10,000	$2	$20,000	Erosion controls consist of a minimum of 2 rows of silt fence surrounding the disturbed areas.
Soil Excavation and Removal					
Construct Equipment/Material Staging Areas [1]	ls	1	$10,000	$10,000	
Clearing and Grubbing [1]	acre	8	$1,050	$8,400	Selective clearing with dozer, ball and chain, light clearing (RS Means 31 13 13.10 0300)
Excavate - Dozer [1]	cy	8,123	$2.74	$22,257	Excavating Bulk 460 HP Dozer, 150' Haul, Common Earth (RS Means 31 23 16.46 5540)
Load Impacted Soil [1]	cy	9,342	$1.34	$12,518	15% bulking factor, wheeled front-end loader, 3 CY capacity (RS Means 31 23 16.42 3900)
Hauling [2]	cy	9,342	$9.05	$84,542	18 CY Truck, 15 min. wait/ld/uld, 35 MPH, 30 miles (RS Means 31 23 23.20 9070)
Disposal at RCRA Facility (Subtitle D) [2]	cy	9,342	$52.86	$493,797	1.25 Tons per cubic yard, Waste Management Valencia Landfill, Los Lunas, NW
Dust Supression [2]	day	35	$250	$8,750	5,000 gallon water truck, water form installation (vendor quote)
Field Verification Sampling					
Sampling (PAHs) [3]	each	33.2	$200	$6,647	Assumes one confirmation sample would be collected from each 100-foot by 100-foot grid
Site Restoration					
Backfill Material [3]	cy	8,123	$12	$97,478	Assumes Soil will be obtained from adjacent or on-base sources
Backfill and Compaction [1]	cy	8,123	$1.59	$12,916	Dozer backfill, bulk, no compaction (RS Means 31 23 23.13 1300)
Rough Grading [1]	sy	38,720	$0.78	$30,202	Large area (RS Means 31 22 16.10 0100)
Vegetative Restoration / Stabilization [1]	sy	38,720	$0.45	$17,424	Hydroseeding including seed and fertilizer (RS Means 32 91 19.13 1000)
			Subtotal	$824,930	
			Contingency (30%)	$247,479	
			Engineering and Administration [3] (20%)	$164,986	
			TOTAL	**$1,237,395**	

Notes:
[1] All cost data estimated from RSMeans Building and Construction Cost Data, 2011.
[2] Cost data from vendor quotes.
[3] Cost data from previous ECC and ARCADIS experience.

Abbreviations:
cy: cubic yard
lf: linear foot
ls: lump sum
PAHs: Polyaromatic Hydrocarbons
sy: square yard

TABLE B-4
MMRP Sites TS775 and TS776
Alternative 4 Costs
Engineering Evaluation / Cost Analysis
Kirtland Air Force Base

Description	Unit	Quantity	Unit Cost	Subtotal	Notes
Stormwater and Erosion Controls					
Silt Fencing [1]	lf	10,000	$2	$20,000	Erosion controls consist of a minimum of 2 rows of silt fence surrounding the disturbed areas.
Soil Excavation					
Construct Equipment/Material Staging Areas [1]	ls	1	$10,000	$10,000	
Clearing and Grubbing [1]	acre	8	$1,050	$8,400	Selective clearing with dozer, ball and chain, light clearing (RS Means 31 13 13.10 0300)
Excavate - Dozer [1]	cy	8,123	$2.74	$22,257	Excavating Bulk 460 HP Dozer, 150' Haul, Common Earth (RS Means 31 23 16.46 5540)
Load Impacted Soil [1]	cy	9,342	$1	$12,518	15% bulking factor, Wheeled front-end loader, 3 CY capacity (RS Means 31 23 16.42 3900)
Field Verification Sampling					
Sampling (PAHs) [3]	each	33.2	$200	$6,647	Assumes one confirmation sample would be collected from each 100-foot by 100-foot grid
Dry Screening for Clay Target Fragment Removal					
Clay Target Removal [2]	cy	4,815	$28	$134,809	Assumes typical industry particle size separators (dry)
Soil and Target Fragment Hauling and Disposal					
Hauling Fragments to Landfill [2][4]	cy	1,204	$9.05	$10,893	18 CY Truck, 15 min. wait/ld/uld, 35 MPH, 30 miles (RS Means 31 23 23.20 9070)
Hauling [2]	cy	4,527	$9.05	$40,969	18 CY Truck, 15 min. wait/ld/uld, 35 MPH, 30 miles (RS Means 31 23 23.20 9070)
Disposal at RCRA Facility (Subtitle D) [2]	cy	5,731	$52.86	$302,923	1.25 Tons per cubic yard, Waste Management Valencia Landfill, Los Lunas, NW
Dust Supression [2]	day	35	$250	$8,750	5,000 gallon water truck, water form installation (vendor quote)
Site Restoration					
Backfill Material [3]	cy	4,512	$12	$54,146	Assumes Soil will be obtained from adjacent or on-base sources
Backfill and Compaction [1]	cy	8,123	$1.59	$12,916	Dozer backfill, bulk, no compaction (RS Means 31 23 23.13 1300)
Rough Grading [1]	sy	38,720	$0.78	$30,202	Large area (RS Means 31 22 16.10 0100)
Vegetative Restoration / Stabilization [1]	sy	38,720	$0.45	$17,424	Hydroseeding including seed and fertilizer (RS Means 32 91 19.13 1000)
			Subtotal	$692,854	
			Contingency (30%)	$207,856	
			Engineering and Administration [3] (20%)	$138,571	
			TOTAL	**$1,039,281**	

Notes:

[1] All cost data estimated from RSMeans Building and Construction Cost Data, 2011.

[2] Cost data from vendor quotes.

[3] Cost data from previous ECC and ARCADIS experience.

[4] The volume of target fragments estimated for disposal at the landfill facility is based on 25% of the total volme of excavated soil screened for the removal of target fragments based on engineer's judgement.

Abbreviations:

cy: cubic yard
lf: linear foot
ls: lump sum
PAHs: Polyaromatic Hydrocarbons
sy: square yard

TABLE B-5
MMRP Sites TS775 and TS776
Alternative 4 Costs
Engineering Evaluation / Cost Analysis
Kirtland Air Force Base

Description	Unit	Quantity	Unit Cost	Subtotal	Notes
Land Use Controls at TS775					
Access Restrictions (Signs) (1)	each	8	$50	$400	No additonal fencing as TS775 is currently fenced.
Development and Implementation of LUCs (2)	ls	1	$10,000	$10,000	
Stormwater and Erosion Controls					
Silt Fencing (1)	lf	10,000	$2	$20,000	Erosion controls consist of a minimum of 2 rows of silt fence surrounding the disturbed areas.
Soil Excavation					
Construct Equipment/Material Staging Areas (1)	ls	1	$10,000	$10,000	
Clearing and Grubbing (1)	acre	5.3	$1,050	$5,565	Selective clearing with dozer, ball and chain, light clearing (RS Means 31 13 13.10 0300)
Excavate - Dozer (1)	cy	7,058	$2.74	$19,340	Excavating Bulk 460 HP Dozer, 150' Haul, Common Earth (RS Means 31 23 16.46 5540)
Load Impacted Soil (1)	cy	8,117	$1.34	$10,877	15% bulking factor, wheeled front-end loader, 3 CY capacity (RS Means 31 23 16.42 3900)
Field Verification Sampling					
Sampling (PAHs) (3)	each	33.2	$200	$6,647	Assumes one confirmation sample would be collected from each 100-foot by 100-foot grid
Dry Screening for Clay Target Fragment Removal					
Clay Target Removal (2)	cy	6,039	$28	$169,095	Assumes typical industry particle size separators (dry)
Soil and Target Fragment Hauling and Disposal					
Hauling Fragments to Landfill (2)(4)	cy	1,510	$9.05	$13,663	18 CY Truck, 15 min. wait/ld/uld, 35 MPH, 30 miles (RS Means 31 23 23.20 9070)
Hauling soil to landfill (2)	cy	2,078	$9.05	$18,806	18 CY Truck, 15 min. wait/ld/uld, 35 MPH, 30 miles (RS Means 31 23 23.20 9070)
Disposal at RCRA Facility (Subtitle D) (2)	cy	3,588	$52.86	$189,649	1.25 Tons per cubic yard, Waste Management Valencia Landfill, Los Lunas, NW
Dust Supression (2)	day	35	$250	$8,750	5,000 gallon water truck, water form installation (vendor quote)
Site Restoration					
Backfill Material (3)	cy	2,529	$12	$30,348	Assumes soil will be obtained from adjacent or on-base sources
Backfill and Compaction (1)	cy	7,058	$1.59	$11,223	Dozer backfill, bulk, no compaction (RS Means 31 23 23.13 1300)
Rough Grading (1)	sy	25,652	$0.78	$20,009	Large area (RS Means 31 22 16.10 0100)
Vegetative Restoration / Stabilization (1)	sy	25,652	$0.45	$11,543	Hydroseeding including seed and fertilizer (RS Means 32 91 19.13 1000)
Operation and Maintenance of LUCs					
O&M Administration (5%) (3)	% of LUCs	0.05	$10,400	$520	Review of analytical data, site use, site conditions, and LUCs
Total Annual O&M (3)				$520	
O&M LUCs Present Worth (for 5 years)				$2,444	
Site Review - TS775					
Present Net worth of 5-Year Review (3)	each	1	$50,000	$45,065	Review of analytical data, site use, site conditions, and LUCs
			Capital Cost Subtotal	$545,514	
			Contingency (30%)	$163,654	
			Engineering and Administration (3) (20%)	$109,103	
			Capital Cost Total	$818,272	
			LUC O&M ans 5-Year Review Cost Subtotal	$57,909	
			Contingency (30%)	$17,373	
			Engineering and Administration (3) (20%)	$11,582	
			Capital Cost Total	$86,864	
			TOTAL	**$905,135**	

Discount Rate	0.021
Years of Maintenance	5

Notes:

(1) All cost data estimated from RSMeans Building and Construction Cost Data, 2011.

(2) Cost data from vendor quotes.

(3) Cost data from previous ECC and ARCADIS experience.

(4) The volume of target fragments estimated for disposal at the landfill facility is based on 25% of the total volme of excavated soil screened for the removal of target fragments based on engineer's judgement.

Abbreviations:

cy: cubic yard
lf: linear foot
ls: lump sum
LUCs: Land Use Controls
PAHs: Polyaromatic Hydrocarbons
O&M: Operations and Maintenance
sy: square yard