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July 1994

EPA Superfund
Record of Decision:

Luke Air Force Base
(O.U. 2) Site, AZ

FINAL
RECORD OF DECISION
OPERABLE UNIT 2

U.S. AIR FORCE
LUKE AFB, ARIZONA

Prepared By:
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Under Contract To The:
U.S. ARMY CORPS OF ENGINEERS
OMAHA DISTRICT
OMAHA, NEBRASKA 68102

JANUARY 1994

GERAGHTY & MILLER PROJECT No. AZ0370.004
AIR FORCE PROJECT No. NUEX91-7003 CONTRACT No. DACW45-90-D-007

LIST OF ACRONYMS

ADEQ	Arizona Department of Environmental Quality
AGE	Aerospace Ground Equipment
APC	air pollution control
BNAs	base/neutral and acid extractable compounds
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COCs	constituents of concern
CSF	cancer slop factor
ECAO	Environmental Criteria and Assessment Office
ELCR	Excess Lifetime Cancer Risk
FFA	Federal Facilities Agreement
ft bgs	feet below ground surface
GAC	granular activated carbon
HI	hazard index
HQ	hazard quotient
kg	kilograms
Luke AFB	Luke Air Force Base
m^3	cubic meters
mg	milligrams
mg/L	milligrams per liter
msl	mean sea level
NCP	National Contingency Plan
NPL	National Priorities List
OU	Operable Unit
PAHs	polycyclic aromatic hydrocarbons
POL	petroleum, oil, and lubricant
PRGs	health-based preliminary remediation goals
PSC	Potential Sources of Contamination
RCRA	Resource Conservation and Recovery Act
RfCs	reference concentrations
RfD	reference dose
RfDis	reference doses for inhalation exposure

RfDox	reference doses
RI/FS	Remedial Investigation/Feasibility Study
RMEs	reasonable maximum exposures
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SFTA	South Fire Training Area
TCE	trichloroethene
TEFs	Toxicity Equivalence Factors
TRC	Technical Review Committee
TRPHs	total recoverable petroleum hydrocarbons
TSD	Treatment, Storage, and Disposal
UCLs	upper confidence limits
USEPA	U.S. Environmental Protection Agency
USTs	underground storage tanks
VES	vapor extraction system
VOCs	volatile organic compounds
WSRV	West Salt River Valley

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TABLES

- Inspection and maintenance of a concrete cap at PSC ST-18; and
- Excavation, ex-situ biological treatment, confirmation sampling, and on-site disposal of impacted soils from the canal portion of PSC DP-23.

1.4 DECLARATION

The selected remedies are protective of human health and the environment, comply with federal and state requirements that are legally applicable or relevant and appropriate to the remedial action, and are cost-effective. The remedies utilize permanent solutions and alternative treatment technologies to the maximum extent practicable for this site. The remedies satisfy the statutory preference for remedies that employ treatment to reduce the toxicity, mobility, or volume as a principal element.

The fact that PSCs have calculated health-based risks which are within USEPA guidelines eliminates the need for a remedy in which contaminants would be treated or disposed. Because the no action remedy will result in constituents of concern in soils remaining on-site above health-based levels in limited areas, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

1.0 DECLARATION

1.1 SITE NAME AND LOCATION

Operable Unit No. 2
Luke Air Force Base, Arizona

1.2 STATEMENT OF BASIS AND PURPOSE

This decision document, the Record of Decision (ROD) presents the selected remedial action for Operable Unit No. 2 (OU-2), Luke Air Force Base, Arizona (Luke AFB), developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Contingency Plan (NCP). This decision document is based on the administrative record for this operable unit.

The U.S. Air Force, the U.S. Environmental Protection Agency (USEPA) and the State of Arizona concur on the selected remedy.

1.3 DESCRIPTION OF THE REMEDY

Luke AFB consists of two operable units. OU-2 contains eight separate potential sources of contamination (PSCs), as follows: OT-04, DP-05, FT-06, ST-18, DP-22, DP-23, SD-40, and the western portion of PSC FT-07. The function of this operable unit is to address soil contamination only at these PSCs. The other operable unit (OU-1) involves continued study and possible remediation of soils (at 24 other PSCs), groundwater, and air.

The major components of the selected remedy include:

- No action at PSCs OT-04, DP-05, FT-06, DP-22, SD-40, the western portion of PSC FT-07, and the northern portion of PSC DP-23;

This Record of Decision (ROD) presents the selected remedial action for Operable Unit No. 2 (OU-2), Luke Air Force Base, Arizona (Luke AFB), developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

This ROD may be executed and delivered in any number of counterparts, each of which when executed and delivered shall be deemed to be an original, but such counterparts shall together constitute one and the same document.

Alan P. Babbitt — 10 Dec 93

ALAN P. BABBITT
Deputy for Hazardous Materials and Waste
Deputy Assistant Secretary of the Air Force
(Environment, Safety and Occupational Health)

Date

This Record of Decision (ROD) presents the selected remedial action for Operable Unit No. 2 (OU-2), Luke Air Force Base, Arizona (Luke AFB), developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

This ROD may be executed and delivered in any number of counterparts, each of which when executed and delivered shall be deemed to be an original, but such counterparts shall together constitute one and the same document.

for John Wise, Deputy Regional Administrator
U.S. Environmental Protection Agency

1/14/94
Date

This Record of Decision (ROD) presents the selected remedial action for Operable Unit No. 2 (OU-2), Luke Air Force Base, Arizona (Luke AFB), developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

This ROD may be executed and delivered in any number of counterparts, each of which when executed and delivered shall be deemed to be an original, but such counterparts shall together constitute one and the same document.

Edward Z. Fox, Director
Arizona Department of Environmental Quality

11/10/94
Date

This Record of Decision (ROD) presents the selected remedial action for Operable Unit No. 2 (OU-2), Luke Air Force Base, Arizona (Luke AFB), developed in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA).

This ROD may be executed and delivered in any number of counterparts, each of which when executed and delivered shall be deemed to be an original, but such counterparts shall together constitute one and the same document.

Rita P. Pearson, Director
Arizona Department of Water Resources

1/28/94
Date

2.0 THE DECISION SUMMARY

The U.S. Air Force has prepared this ROD to address OU-2 at Luke AFB. The ROD is based on the results of the OU-2 Remedial Investigation/Feasibility Study (RI/FS) (Geraghty & Miller, Inc. 1992, 1993). The ROD is designed to be consistent with the NCP, 40 CFR Part 300, CERCLA, SARA, and the Interim Final Guidance on Preparing Superfund Decision Documents: the Proposed Plan, the Record of Decision, Explanation of Significant Differences, the Record of Decision Amendment (U.S. Environmental Protection Agency 1989a).

The ROD, which documents the remedial action plan for OU-2, has three main purposes:

1) The ROD serves a legal function in that it certifies that the remedy selection process was carried out in accordance with the procedural and substantive requirements of CERCLA and, to the extent practicable, the NCP;
2) The ROD is a technical document that outlines the engineering components and remediation goals of the selected remedy; and
3) The ROD is informational, providing the public with a consolidated source of information about the history, characteristics, and risks posed by the conditions at the site, as well as a summary of the cleanup alternatives considered, their evaluation, and the rationale behind the selected remedy.

The ROD is organized into three distinct sections:

- The Declaration functions as an abstract for the key information contained in the ROD;
- The Decision Summary provides an overview of the site characteristics, the alternatives evaluated, and the analysis of those options. The Decision Summary also identifies the selected remedy and explains how the remedy fulfills statutory requirements; and

- The Responsiveness Summary addresses public comments received on the Proposed Plan and throughout the remedy selection process.

2.1 SITE DESCRIPTION

Luke AFB is located on 4,198 acres of land in Maricopa County, Arizona, approximately 20 miles west of downtown Phoenix (Figure 1). The function of Luke AFB is to provide combat training to aircrews. The aircrews are trained to fly the advanced tactical fighter F-15 Eagle and F-16 Falcon aircraft. Approximately 75 percent of Luke AFB is dedicated to runways, taxiways, and aircraft storage tarmacs. The remaining 25 percent is used for aircraft maintenance, administrative, and other special services.

Luke AFB is located within the Sonoran Desert section of the Basin and Range physiographic province. The Basin and Range province consists of rough, rocky mountains separated by broad alluvium-filled basins or valleys. The Base is located near the center of the West Salt River Valley (WSRV). Elevations at Luke AFB range from 1,110 feet above mean sea level (msl) at the northwest corner to 1,075 feet above msl at the southeast corner of the Base. The ground surface generally slopes uniformly from northwest to southeast at 25 feet per mile. The White Tank Mountains lie approximately 8 miles west of Luke AFB, while the Sierra Estrella lie approximately 12 miles to the south, and the Hieroglyphic Mountains lie approximately 15 miles to the north.

Water-bearing geologic formations in the WSRV include the upper, middle, and lower alluvial units of the basin. The upper unit has been completely dewatered in the area of the Base due to agricultural pumping. Groundwater at the Base is first encountered in the upper part of the middle alluvial unit at a depth of approximately 350 feet below ground surface. Groundwater movement in the upper middle unit at Luke AFB is generally directed toward the southwest. The Base's production wells are screened in the lower middle unit and the lower unit at a depth of approximately 500 to 1,000 feet below ground surface.

The main surface water body in the area is the Agua Fria River, which lies approximately 2 miles east of the Base. The Agua Fria River is normally a dry river bed that flows (to the south) only during and immediately following storms or as a result of upstream discharge for flood control or other purposes. The canal that drains the north end of Luke AFB (the Dysart Drain) discharges into the Agua Fria River. The Base's Wastewater Treatment Plant, located approximately 2 miles east of the Base, also discharges its effluent into the Agua Fria River. A series of unlined canals, located to the south of the Base, receive stormwater runoff from the Base and flow to the south during and immediately following heavy rains.

Surrounding land use can be described as rural. Scattered residential housing is in the vicinity of Luke AFB, and Litchfield Park, a residential development, is approximately 2 miles to the southeast. The surrounding communities are experiencing rapid growth and development; however, residential development around the perimeter of Luke AFB is unlikely due to significant noise exposure that would occur as a result of aircraft operations.

2.2 SITE HISTORY AND ENFORCEMENT ACTIONS

Since 1941, the mission at Luke AFB has been to provide advanced training to fighter pilots. At Luke AFB fighter crews were trained for World War II from 1941 to 1946. After World War II the Base was temporarily shut down. The Base was reopened again in 1951 during the beginning of the Korean conflict and has been used ever since to train fighter crews for the USAF.

Luke AFB was placed on the USEPA's National Priorities List (NPL) in August 1990. This placement identified Luke AFB as a priority site for investigation and cleanup under CERCLA. Listing on the NPL means that investigations and remediations are subject to the USEPA's oversight and approval.

A Federal Facilities Agreement (FFA) was signed by the USEPA, the Arizona Department of Environmental Quality (ADEQ), the Arizona Department of Water Resources (ADWR), and the USAF on September 27, 1990. The FFA established the responsibilities and authority of each agency, as well as the procedural framework for investigation and remediation of PSCs at Luke AFB as necessary to protect public health, welfare, and the environment. The tasks and decision-making process are described in the Base-wide Remedial Investigation/Feasibility Study Work Plan, Luke Air Force Base, Arizona (Geraghty & Miller, Inc. 1991).

PSCs investigated during the OU-2 RI/FS consist of PSCs OT-04, DP-05, FT-06, FT-07, ST-18, DP-22, DP-23, and SD-40. The locations of these PSCs within Luke AFB are shown on Figure 2. The potential wastes associated with each PSC are listed in Table 1. A brief description and history of the eight OU-2 PSCs are discussed below.

2.2.1 OT-04, Perimeter Road POL Waste Site

This PSC is located in the southwest portion of Luke AFB around the southern end of the runways and occupies approximately 26.5 acres. The unpaved perimeter road lies in the center of the PSC throughout the length of the PSC. This PSC was used from 1951 until approximately 1970 for the disposal of most of the petroleum, oil, and lubricant (POL) wastes from the main part of Luke AFB. The POL wastes were sprayed on the road to control excessive dust.

2.2.2 DP-05, POL Waste Disposal Trench

This PSC is a triangular-shaped area located on the southeast side of Taxiway I; it occupies approximately 18 acres. PSC DP-05 is bare ground covered with sparse vegetation. Forty to fifty percent of this PSC is presently covered with inert construction debris including asphalt and concrete with rebar from the demolition of an aircraft taxiway in 1979. This PSC was used from approximately 1970 until 1972 for the disposal of POL waste which was dumped in shallow (1.5 feet deep) trenches. The waste was allowed to weather for 4 to 6 weeks and then covered with soil.

2.2.3 FT-06, South Fire Training Area (SFTA)

This PSC was the original fire department training area and is located in the southern portion of Luke AFB, east of the Facility 1009 power check pad. The PSC is a rectangular area approximately 8 acres in size. Eighty percent of the PSC is paved; this includes portions that are under building foundations, parking lot asphalt, and a concrete lined storm drain canal. Twenty percent of the PSC is unpaved including landscaped areas around buildings, parking lots that are covered with gravel, and a bare area north of the perimeter road. This PSC was used from 1941 until deactivation of Luke AFB in 1946, and again from the time of reactivation in 1951 until approximately 1963. POL waste was poured into circular unlined bermed areas and then set on fire for fire fighting training. These fires were extinguished with water.

2.2.4 FT-07, North Fire Training Area (NFTA)

This PSC occupies approximately 24 acres and is located in the northern portion of the Base. It includes the Facility 1356 Fire Training Area. Approximately 90 percent of this PSC is covered by grass and the remaining 10 percent asphalt and concrete pads. The western portion of this PSC was used from approximately 1963 until 1973, when the current fire training area was built. POL waste was poured into circular unlined bermed areas and then set on fire for fire fighting training. These fires were extinguished with water. An interim removal action was completed in the eastern portion of the fire training area that was built in 1973. This portion of the North Fire Training Area (approximately 10 acres in size) will be addressed during the OU-1 RI/FS.

2.2.5 ST-18, Facility 993

Facility 993 was constructed in 1968 for the storage of all POL waste produced at Luke AFB. Other reported wastes stored at the facility included solvents, phenolic paint strippers and thinner, paint residue, and sludge. In 1979, Facility 993 was granted interim status as a Treatment, Storage, and Disposal (TSD) facility under the Resource Conservation and Recovery Act (RCRA). The PSC is a rectangular area which occupies approximately 0.2 acres, now completely covered by concrete. The facility consisted of one 5,000-gallon and two 10,000-gallon capacity underground storage tanks (USTs) used for the storage of JP-4 fuel, oils, and solvents. Releases occurred in the form of UST leaks. The estimated volume released consists of 5200 gallons, of which 325 gallons are of trichloroethylene, 100 gallons of other halogenated solvents, 1000 gallons of aromatic hydrocarbons, and 3775 gallons of straight chain hydrocarbons. Closure of this facility began in 1982. In 1983, soils were excavated from PSC ST-18 and stockpiled. Contaminated soils were manifested to a hazardous waste landfill. Other soils were aired for several weeks and returned to the excavation. The site was capped in 1987 in accordance with RCRA post-closure requirements.

2.2.6 DP-22, POL Trench Northeast Runway

This PSC is an irregular-shaped area located at the north end of the east runway and occupies approximately 4.6 acres. Approximately 30 percent of the PSC is covered with the end of the inboard runway, 20 percent is covered with bituminous cover, and 50 percent of the site is covered by gravel with sparse vegetation.

This was a possible site used for disarmament and defueling of aircraft during the 1940s and 1950s. Reportedly, waste POL was dumped into shallow trenches at this PSC.

2.2.7 DP-23, Old Surface Impoundment Area West of Building 999

The northern portion of the Old Surface Impoundment is a rectangular-shaped area which occupies approximately 3.3 acres. It is located west of Building 999 and adjacent to the SFTA. The impoundment was constructed along an old natural drainage system or wash flowing south from Luke AFB. Eighty percent of the northern portion is paved, 20 percent is covered with asphalt, 40 percent is under the tarmac hangar, and

20 percent is under concrete, which includes the canal liner and the AGE equipment yard. The surface impoundment wash was located to the south and it had an area of approximately 19.4 acres. The surface impoundment may have been used as a disposal site for POL waste in the 1940s until construction covered the PSC in 1969. The dam used to create the surface impoundment was buried, but not removed, during the 1969 construction. The area of PSC DP-23, which is north of Super Sabre Street, collects surface water runoff which drains into the surface impoundment wash.

2.2.8 SD-40, Taxiway Fuel Discharge

This PSC unit consists of the areas located on both sides of the southeastern end of Taxiway F (Foxtrot Extension) and on both sides of the south-central section of Taxiway E (Echo); they were and are currently used for limited servicing of aircraft. The southern area of the PSC (along Taxiway F) covers approximately 3 acres and the northern area (along Taxiway E) covers approximately 7.6 acres. The areas adjacent to the taxiways are covered with a bituminous dust cover of 2-inch thick asphalt. The taxiways have been used to perform limited service and/or store aircraft since the present runway layout was complete in the 1950s. Defueling of jet aircraft onto the bituminous cover was for fuel tank maintenance. This defueling practice occurred on Taxiway F from the early 1970s until 1990.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

CERCLA, as amended by SARA, Sections 113(k)(2)(B)(i-v) and 117, requires that federal and state regulatory agencies keep the community informed, and allow the community to participate in the decision-making process. The legislation requires the development of a community relations plan that at a minimum will provide: (1) notice to potentially affected persons and the public of the availability of the proposed plan; (2) reasonable opportunity to comment of not less than 30 days on the proposed plan and supporting analysis and information, including the RI/FS; (3) an opportunity for public hearing on the proposed plan and supporting information; (4) written summary of and response to each significant comment submitted on the proposed plan; and (5) statement of the basis and purpose of the selected action.

The community relations plan describes the specific community participation activities that occurred in the process of selecting a remedy for OU-2. These activities indicate a commitment by the U.S. Air Force and Luke AFB to meet both the letter of the law and the spirit of community participation at this site. It should be noted that all community relations activities concerning the proposed plan were done with the support, acceptance, and approval of state and federal regulatory agencies. This ROD contains a response to each comment submitted by the public and provides a statement of the basis and purpose of the remedy.

The community relations plan is Base-wide, and it was developed from interviews with a cross-section of the community surrounding Luke AFB. A mailing list of persons interested in the site was developed and is included in the community relations plan. A media list is also included in the plan. This list includes Arizona elected officials, City and County officials from the surrounding areas, community organizations, base housing residents, area environmental groups, and other interested individuals. The list is updated prior to each mailing. A community relations plan was also prepared for a removal action at the North Fire Training Area (the eastern portion of PSC FT-07) in November 1991.

An administrative record was established in September 1990. A comprehensive index of site documents available in the administrative record has been compiled and is updated regularly. Information repositories were established in 1991 at two area public libraries and the Luke AFB library. These locations were suggested during the community relations plan interviews. Two other area libraries were later added for public input. The RI/FS, proposed plan, and supporting information are therefore available to the public at five local libraries. These include Glendale Public Library, Litchfield Park Public Library, Luke AFB Library, Peoria Public Library, and Sun City Public Library.

Newsletters containing background information on the site, environmental concerns, the CERCLA process, and the status and results of environmental investigations and studies were distributed to persons on the mailing list in February 1992, May 1992, and June 1993. The June 1993 newsletter contained a description of the proposed plan, an announcement for the public meeting and comment period, and instructions on how to comment on the plan. All newsletters contain project contact names, addresses, and phone numbers as well as information repository locations and directions for media inquiries.

A technical review committee (TRC) was established for the site in 1992. The committee consists of 10 community leaders from the surrounding community. Quarterly meetings are held. The proposed plan was presented to the TRC at the May 1993 quarterly meeting. Suggestions on public input and participation on the proposed plan were sought during this meeting in an effort to prepare an effective public meeting and outreach program.

A 30-day public comment period on the proposed plan was held from June 8, 1993 to July 7, 1993. In addition to the announcement placed in the newsletter, the comment period was announced on three separate occasions in five area newspapers. These include the Arizona Republic/Phoenix Gazette, Daily News-Sun, Glendale Star, Peoria Times, and Tally Ho. The Tally Ho is the Base paper. Where available, the announcement appeared in the newspaper community sections covering the area surrounding Luke AFB. This announcement is one of many published by the Base to ensure the opportunity for public comment on all CERCLA documents. A press release about the proposed plan, the public comment period, and upcoming public meeting was also issued during the first week of June.

A public meeting on the proposed plan was held on June 15, 1993 at the Litchfield Park Elementary School. The purpose of the meeting was to give the community an opportunity to gain more information on OU-2, the proposed plan, and public participation activities. A presentation on OU-2 and the proposed plan was provided to the public. An exhibit on OU-2 and the plan was also displayed at the meeting location and copies of the proposed plan were available. A question and answer session ensured that the community could fully understand the plan and have the greatest opportunity to comment. A formal comment period followed the question and answer session. A transcript of the public meeting is available in the Administrative Record. The meeting and proposed plan were also the subject of an article in the June 17, 1993 edition of the Glendale Star.

2.4 SCOPE AND ROLE OF THE RESPONSE ACTION

The site has been broken into two parts, defined as "operable units." OU-2, as mentioned earlier, addresses soil contamination only at eight PSCs. The only potential threat posed is that from the canal portion of PSC DP-23 where there is a potential for the migration of constituents in soils to groundwater. OU-1 addresses potential soil contamination at 24 PSCs, and potential groundwater and air contamination Base-wide. OU-1 also includes the ecological assessment for Luke AFB. A RI/FS is currently being conducted for OU-1.

2.5 SUMMARY OF SITE CHARACTERISTICS

All soil samples collected from the eight OU-2 PSCs were analyzed for total recoverable petroleum hydrocarbons (TRPHs), volatile organic compounds (VOCs), base/neutral and acid extractable compounds (BNAs), and Priority Pollutant Metals plus barium (metals). The 0 to 2 feet below ground surface (ft bgs) sample from each boring was also analyzed for PCBs. Composite surficial soil samples from the fire training areas were analyzed for dioxins and furans.

The most common constituents detected during the OU-2 RI were TRPHs. VOCs and BNAs were detected; however, they were generally detected only when elevated levels of TRPHs were also detected. PCBs were never detected in OU-2 samples. The only dioxins or furans detected in soils were total HpCDD, OCDD, total HpCDF, and OCDF, at extremely low levels. Dioxin/furan concentrations in nanograms per gram (ng/g) detected are as follows: 1) total HpCDD, 1.2, 2) OCDD, 4.6, 3) total HpCDF, 1.1, and 4) OCDF, 2.0.

Metals were detected in soils at concentrations within the same order of magnitude as or similar to the background concentrations. The exception is lead, which was elevated relative to background in two samples from depths of up to 4 ft bgs at PSC FT-06.

The horizontal extent of TRPHs in soils is limited to several isolated areas within each of the PSCs and appears to be limited to areas where reported historical releases or disposal activities occurred. The depth of TRPHs in soils is assumed to be 2 to 10 ft bgs at PSC OT-04, 4 to 22 ft bgs at PSC DP-05, 24 to 68 ft bgs at PSC FT-06, 14 ft bgs at PSC FT-07, 36 to 60 ft bgs at PSC ST-18, 4 ft bgs at PSC DP-22, 16 to 24 ft bgs at PSC DP-23, and 10 to 12 ft bgs at PSC SD-40. Depths were estimated by assuming that the TRPH detects extended to the depths of samples with non-detects. In cases where considerable distances existed between contract laboratory sampling intervals, mobile laboratory and field screening (PID readings) data were consulted to calculate realistic depths.

Base-wide and PSC-specific concentration ranges for constituents of concern (COCs) identified by the risk assessment for OU-2 are shown in Table 2. The health-based preliminary remediation goals (PRGs) identified during the risk assessment are also shown in Table 2. The identification of COCs and the calculation of PRGs are discussed in detail in Section 2.6 of this ROD, Summary of Site Risks.

The PRGs identified during the risk assessment were used to evaluate areas and volumes that may require additional attention. The intent of the PRGs is to establish guidance (i.e., cleanup levels) in the event remediation activities are implemented. The PRGs are not intended to dictate if remediation is necessary; the decision to remediate is based on the results of the complete risk assessment and the potential for constituent migration. It should be noted that the volume computations are based on conservative assumptions regarding the extent of impacted soils; actual volumes of soil to be remediated will be more precisely calculated when additional sampling is conducted during remedial design.

PSCs which had samples with concentrations of COCs above PRGs were evaluated for more than just the No Action alternative during the detailed evaluation portion of the FS; the remaining PSCs were evaluated only for the No Action alternative based on the results of the risk assessment. It is important to note that the PRGs are not site-specific in the sense that they are back-calculations which use default values rather than site-specific exposure factors from the RI. The USEPA equation for commercial/industrial land use was used to develop the soil PRGs. Worker exposure was assumed to involve ingestion of soil and inhalation of particulates and vapors released from the soil. The default assumptions provided in the USEPA industrial site worker equation were used to develop the PRGs. The assumptions include: 1) an exposure duration of 25 years (the 90th percentile value for time spent in one industry), 2) an exposure frequency of 250 days per year "spent on the job," 3) a soil ingestion rate of 50 mg/day, 4) an inhalation rate of 20 m^3/day, and 5) a body weight of 70 kg.

Three VOCs (benzene, 1,1-dichloroethene, and trichloroethene [TCE]), and six BNAs (benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno(1,2,3-cd)pyrene, and dibenzo-anthracene) were detected at concentrations above the PRGs at one or more sampling locations (Table 3). The BNAs detected above their PRGs are polycyclic aromatic hydrocarbons (PAHs). Locations with concentrations of COCs above the PRGs are limited to three of the eight OU-2 PSCs (PSCs FT-06, ST-18, and DP-23), as described below.

At PSC FT-06, COCs were detected above PRGs at depths of up to 2 to 10 ft bgs. Only one VOC (TCE) was detected above the PRG and this occurred in only one sample, from a depth of 2 to 4 ft bgs. The other COC detected above its PRG at PSC FT-06 was benzo(a)pyrene. Figure 3 indicates the lateral extent of each of these areas.

At PSC ST-18, three VOCs (benzene, 1,1,2,2-trichloroethene, and 1,1-dichloroethene) were detected at concentrations above PRGs at one location, at depths of 12 to 22 ft bgs. Figure 4 identifies the lateral extent of this area.

At PSC DP-23, COCs were detected at concentrations above PRGs at two locations. COCs were detected above PRGs at PSC DP-23 at depths of up to 4 ft bgs. The COC detected above its PRG at PSC DP-23 was benzo(a)pyrene. Benzo(a)pyrene was not detected in any deeper samples from PSC DP-23. Figure 5 presents the lateral extent of each area. Approximately 9,250 cubic yards of soil may exceed PRGs at PSC DP-23.

In summary, five of the eight PSCs had extremely low levels of COCs in soil. The remaining three PSCs had individual samples with concentrations of COCs slightly above the PRGs. However, as explained in more detail in Section 2.6 of this ROD, Summary of Site Risks, the overall site risks for soil at all eight of the OU-2 PSCs are within USEPA guidelines.

2.6 SUMMARY OF SITE RISKS

The risk assessment provides an evaluation of the potential threat to human health at each PSC in the absence of any remedial actions. The risk assessment employed conservative exposure assumptions to approximate the human health risks that could be incurred by an individual under reasonable "worst case" exposure conditions.

2.6.1 Human Health Risks

2.6.1.1 Contaminant Identification

The medium of concern at OU-2 is soil. All detected constituents expected to be related to past activities at the PSCs were included as COCs with the following exceptions:

- o Inorganic constituents detected at arithmetic average concentrations below site-specific background average concentrations were eliminated as COCs
- o Constituents that are common laboratory contaminants (e.g., acetone, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, etc.) and are not expected to be related to past site activities were eliminated as COCs unless their concentrations exceeded 10 times the maximum blank concentration

COCs in soils at the OU-2 PSCs include TRPHs, 12 VOCs, 25 semivolatile organic constituents (BNAs), and two inorganic constituents (copper and lead). Table 2 presents a summary of all COCs identified.

The concentrations of the COCs on which the risk assessment was based are as follows: 1) the medium-specific arithmetic average concentrations for the COCs were used as exposure point concentrations to estimate average exposure conditions and 2) the 95 percent upper confidence limits (UCLs) on the arithmetic average concentrations were used as exposure point concentrations to estimate the reasonable maximum exposures (RMEs).

2.6.1.2 Exposure Assessment

Civilian employees (base workers) are the most probable receptors for current exposure to surficial soils at PSCs OT-04, DP-05, FT-07, DP-22, and DP-23. Base workers and military personnel are the most probable receptors for current exposure to surficial soils at PSC FT-06. PSCs ST-18 and SD-40 are completely paved. Thus, there is no current exposure to surficial soils at these two PSCs. Exposure pathways evaluated for current base worker and military personnel exposure to surficial soils include incidental ingestion, dermal contact, and dust or vapor inhalation.

Potential future risks posed by the OU-2 PSCs were evaluated based upon the exposure scenarios described above and hypothetical future excavation worker exposure to subsurface soils. The excavation worker scenario was only evaluated for depths of up to 16 ft bgs. Hypothetical future exposure of a base worker to surficial soils at PSCs ST-18 and SD-40 was evaluated, based on the possibility that the pavement at these PSCs might be removed sometime in the future. Hypothetical future exposure of military personnel servicing aircraft at PSC SD-40 was evaluated based on the possibility that the pavement is removed from the PSC.

The medium-specific arithmetic average concentrations for the COCs were used as exposure point concentrations to estimate average exposure conditions. The 95 UCLs on the arithmetic average concentrations were used as exposure point concentrations to estimate the RMEs. The exposure point concentrations for the surficial soils (0 to 2 ft bgs) are shown in Table 4. The exposure point concentrations for the subsurface soils (2 to 16 ft bgs) are shown in Table 5. Exposure to soils deeper than 16 ft bgs is not expected to occur and was not evaluated.

Exposure assumptions for average and RME exposure scenarios are shown in Table 6. A conservative assumption underlying all the dosage calculations is that constituent concentrations remain constant over the entire period of exposure. The effects of attenuation processes in the soils were not considered. For cancer effects, doses were averaged over a lifetime; doses for non-cancer effects were averaged over the exposure period.

2.6.1.3 Toxicity Assessment

The risks associated with exposure to constituents detected at OU-2 are a function of the inherent toxicity (hazard) of the constituents and the exposure dose. A distinction is made between carcinogenic and non-carcinogenic effects.

Identification of constituents as known, probable, or possible human carcinogens is based on a USEPA weight-of-evidence classification scheme in which chemicals are systematically evaluated for their ability to cause cancer in mammalian species and conclusions are reached about the potential to cause cancer in humans. The USEPA classification scheme (USEPA, 1989b) contains six classes based on the weight of available evidence, as follows:

- A known human carcinogen;
- B1 probable human carcinogen -- limited evidence in humans;
- B2 probable human carcinogen -- sufficient evidence in animals and inadequate data in humans;
- C possible human carcinogen -- limited evidence in animals;
- D inadequate evidence to classify; and
- E evidence of non-carcinogenicity.

Constituents in Classes A, B1, B2, and C are included in this assessment as potential human carcinogens.

Currently, the USEPA uses a linearized multistage model for extrapolating from high to low doses. The model provides a 95 percent upperbound estimate of cancer incidence at a given dose. The slope of the extrapolated curve, called the cancer slope factor (CSF), is used to calculate the probability of cancer associated with the exposure dose.

Recent research on the mechanisms of carcinogenesis suggests that use of this model may overestimate the cancer risks associated with exposure to low doses of chemicals. At high doses, many chemicals cause large-scale cell death which stimulates replacement by division. Dividing cells are more subject to mutations than quiescent (non-dividing) cells; thus, there is an increased potential for tumor formation. It is possible that administration of these same chemicals at lower doses would not increase cell division and thus would not increase mutations. This would suggest that the current methodology may overestimate cancer risk.

For many non-carcinogenic effects, protective mechanisms must be overcome before the effect is manifested. Therefore, a finite dose (threshold), below which adverse effects will not occur, is believed to exist for non-carcinogens. Non-carcinogenic health effects include birth defects, organ damage, behavioral effects, and many other health impacts. A single compound might elicit several adverse effects depending on the dose, the exposure route, and the duration of exposure. For a given chemical, as a matter of scientific policy, the study on a sensitive test species (the species showing a toxic effect at the lowest administered dose) is selected as the critical study for the basis of establishing a toxicity value for non-carcinogenic effects. USEPA-verified toxicity values for non-carcinogenic effects are called verified reference doses (RfDox) for oral exposure or reference concentrations (RfCs) for inhalation exposure. In this risk assessment, RfCs have been converted to reference doses for inhalation exposure (RfDis). A summary of the potential health effects of the COCs for OU-2 is provided in Table 7.

2.6.1.4 Risk Characterization

The Excess Lifetime Cancer Risk (ELCR) is an estimate of the increased risk of cancer which results from exposure to constituents detected in the media at the site. Current regulatory methodology assumes that ELCRs can be summed across routes of exposure and constituents to derive a "Total Site Risk" (U.S. Environmental Protection Agency 1989b). The USEPA has indicated that, where cumulative carcinogenic site risk to an individual based on RME is less than 1 in 10,000 (10^{-4}), action is generally not warranted. The USEPA uses the 10^{-4} to 1 in 1,000,000 (10^{-6}) ELCR range as a "target range" within which the USEPA strives to manage risks as part of cleanups (U.S. Environmental Protection Agency 1991b).

The hazard quotient (HQ) is the ratio of the estimated exposure dose to the reference dose (RfD). This ratio is used to evaluate non-carcinogenic health effects associated with exposure to a constituent. An HQ of 1.0 or less indicates that the estimated exposure dose is below acceptable levels for protection against non-carcinogenic effects. The sum of the HQs is termed the hazard index (HI). Current regulatory methodology assumes that HQs can be summed across exposure routes for all media at the site to derive a Total Site Risk. The USEPA has indicated that, when the HI calculated for a site based on RME is less than 1, action is generally not warranted (U.S. Environmental Protection Agency 1991b).

ELCRs and the HIs for current exposure to soils at the OU-2 PSCs were below the USEPA's risk-based remediation benchmarks (ELCR less than 10^{-4}, HI below 1.0). Hypothetical future ELCRs and HIs for exposure to soils at the OU-2 PSCs were also below the USEPA benchmarks. Table 8 presents current and hypothetical future risks. Detailed calculations and assumptions are included in the risk assessment (Geraghty & Miller, Inc. 1992).

Lead was identified as a COC in soils at PSCs DP-05 and FT-06. Because no RfD or CSF is currently available for lead, it is not possible to evaluate the risks associated with lead exposure using conventional risk assessment methods. The blood lead levels of a current base worker at PSC DP-05, and a current base worker, current military employee, and a future excavation worker at PSC FT-06 were evaluated using a model for adults that is similar to the USEPA's "Lead 5" model, which was designed to evaluate blood lead levels in children. The calculated blood lead levels for the current base worker at PSC DP-05 and all current and hypothetical future receptors at PSC FT-06 were well below the level of concern (10 μg/Dl). Table 9 summarizes the blood lead levels calculated for both PSC DP-05 and FT-06.

In summary, based on the site specific ELCRs and HIs for OU-2, the OU-2 PSCs do not pose significant present or future hazards to human health.

2.6.1.5 Preliminary Remediation Goals

USEPA guidance (U.S. Environmental Protection Agency 1991c) was used to calculate PRGs for OU-2 soils. PRGs were calculated using the USEPA equation for commercial/industrial land use. Exposure was assumed to involve ingestion of soil and inhalation of particulates and vapors released from the soil. The default assumptions provided in the USEPA industrial site worker equation were used to develop the PRGs. The assumptions include: 1) an exposure duration of 25 years (the 90th percentile value for time spent in one industry); 2) an exposure frequency of 250 days per year "spent on the job;" 3) a soil ingestion rate of 50 milligrams (mg) per day; 4) an inhalation rate of 20 cubic meters (m^3) per day; and 5) a body weight of 70 kilograms (kg). Base workers, military personnel, and excavation workers were the only receptor populations identified for current or future exposure to soils at the OU-2 PSCs. The PRGs were calculated using the exposure assumptions outlined above and the USEPA toxicity values (RfDs for non-carcinogenic effects and CSFs carcinogenic effects). For non-carcinogenic effects, the target HI was set at the default value of 1.0. For carcinogenic effects, the target ELCR was set at the default value of 1×10^{-6}. Use of these target levels ensures exposure is below acceptable levels. The proposed PRG is the lesser of the PRG for carcinogenic effects and the PRG for non-carcinogenic effects.

2.6.2 Environmental Risks

The only environmental risk evaluated during OU-2 was the potential for COCs to migrate and cause an impact to groundwater.

A vadose zone transport model was used to evaluate the current potential for COCs in soils at OU-2 to leach from the soil and cause an impact to groundwater. The model was not developed to be used to explain the presence of constituents in groundwater which may be the result of historical activities at the Base.

PSC-specific models were not constructed; rather, an extremely conservative, OU-2-specific model was developed. The model evaluated leaching of several COCs detected in soils from OU-2 PSCs using the actual concentrations detected and depths from which soil samples were collected and analyzed during the OU-2 RI.

Six OU-2-specific COCs, listed in Table 10, were chosen from Tables 11 and 12 to predict future concentrations at the bottom of the vadose zone (i.e., the water table). The criteria for selecting these six compounds were: 1) observed soil concentrations compared to PRGs and 2) the depth at which the constituents were found in the soil. The maximum observed concentrations for these six COCs, the PSCs where they were detected, and the depth at which these COCs were no longer detected (i.e., assumed maximum depth of detection) at the PSC are listed in Table 10. Table 10 also presents maximum computed soil water concentrations in the vadose zone and a summary of the transport parameters needed to model each of the compounds.

The source concentration for each of the COCs was assumed to equal the maximum possible concentration, regardless of the solubility of each compound in water. In addition, the source was assumed to have a constant concentration over time (i.e., no source decay). This, again, is a conservative assumption because the source is not constant (i.e., source is decaying).

The predicted concentrations at the bottom of the vadose zone reported in Table 10 demonstrate that it is highly unlikely that groundwater impacts will ever occur as a result of existing, unsaturated conditions at OU-2. Predicted concentrations for the six COCs analyzed range from less than $1x10^{-100}$ to $1.269x10^{-21}$ milligrams per liter (mg/L), as shown in the far right-hand column of Table 10. Climatic conditions (low recharge), the thickness of the vadose zone unaffected by COCs (greater than 280 feet), low observed soil concentrations, long advective travel time through the vadose zone (550 yrs), and relatively short half-lives for each compound all contribute to prevent groundwater impacts (Table 12).

This model is applicable to all OU-2 PSCs with the possible exception of the surface impoundment wash (or canal portion) of PSC DP-23. The surface impoundment wash, located south of Super Sabre Street, receives surface-water runoff from the Base during and after storm events. Runoff has a tendency to collect and sit in this canal for extended periods and may act as a potential driving force for the migration of constituents in soil. Recharge rates have not been evaluated for this drainage canal; however, the recharge rates may be higher than the remainder of OU-2. Because of the potential for migration of constituents to groundwater, the Base is taking the initiative to excavate and treat soils with concentrations above PRGs in the canal portion of PSC DP-23. An ecological assessment for Luke AFB will be performed as part of the OU-1 RI/FS.

2.7 DESCRIPTION OF ALTERNATIVES

A total of 12 remedial alternatives were evaluated using the preliminary criteria of effectiveness, implementability, and cost. These 12 alternatives are summarized in Table 13. Five of these 12 alternatives were retained for a more detailed analysis. These five alternatives are described in detail below.

2.7.1 Remedial Measure S-1: No Action

- No Action

Remedial Alternative S-1 involves no remedial action. The no action alternative can serve as a reference base for comparison of the other possible remedial alternatives.

Effectiveness. This alternative is not effective in preventing occupational exposure to impacted soils. However, based on the risk assessment, conditions at all OU-2 PSCs do not represent a significant hazard to human health. ELCRs and HIs for current and future exposure to soils at the OU-2 PSCs were below the USEPA's risk-based remediation benchmarks (ELCR less than 10^{-4}, HI below 1.0). Based on the vadose zone transport model, it was concluded that under the typical, unsaturated conditions at the OU-2 PSCs, COCs will not migrate to groundwater. The one exception to this conclusion may be PSC DP-23. The southern portion of PSC DP-23 consists of a drainage canal (the surface impoundment wash) where saturated conditions may exist during and for a limited time following storm events.

Implementability. The no action alternative is completely implementable at all PSCs.

Cost. No costs are associated with the no action alternative.

<u>2.7.2 Remedial Measure S-3: Capping, Surface Controls, and Monitoring</u>

- o Construct a cap over the impacted sites to prevent human exposure and migration of organic constituents in the soil.
- o Grade areas surrounding the impacted areas to promote surface water runoff away from the cap.
- o Monitor soil and groundwater (groundwater monitoring will be addressed under OU-1) to confirm effectiveness and potential migration of the COCs.

Remedial Measure S-3 provides for caps to be constructed over the impacted PSCs. The caps will prevent physical contact with the impacted soil. Caps also prevent surface-water infiltration into the unsaturated soil beneath them and thus prevent migration of COCs. However, the vadose zone transport model demonstrates that COCs at any of the OU-2 PSCs will not migrate to groundwater under existing, unsaturated conditions.

Large portions of many of the PSCs are currently covered by asphalt or concrete comprising roads, sidewalks, buildings, storage areas, or tarmac dust cover. These surface covers can provide sufficient caps to accomplish the remedial action objectives. Additional coverage may be required at some PSCs to complete full caps of the impacted areas. Luke AFB will maintain and repair the cap as needed in accordance with the Air Force design guidance for airfield pavement maintenance. This guidance is contained in the Air Force technical manual CEEDO-TR-77-44, Volume II, Section V, Guidelines for Determining Maintenance and Repair Requirements. The cap will be inspected weekly by the base Airfield Pavement Shop per AFR 55-48 Part 7(i). Additionally, the cap will be inspected annually by a civil engineer who will provide a written report to the Environmental Programs Flight Chief of any observed distresses along with recommendations for repair. When and if the Base is closed, more durable, multi-media caps may be required. However, since a multi-media cap is not expected to be required in the foreseeable future, the cost for this type of cap is not included in this analysis.

Surface controls such as grading will be employed to control runon and runoff at capped areas. These controls will reduce required maintenance of the caps and enhance the long-term effectiveness of the cap by limiting erosion.

Monitoring of soils and groundwater (groundwater monitoring will be addressed under OU-1) around the PSCs will provide information about potential migration to other environmental media not presently impacted. Natural attenuation of COCs present in the soil could also be documented by a monitoring program.

Access controls are not required as long as the site is under the operation of the U.S. Air Force. The Base is currently fenced and restricts access to the site by unauthorized personnel. Site use following capping can be controlled without the use of additional fencing. Deed restrictions are applicable and will be imposed at the time the ROD is signed. The deed restrictions will prevent removal of the concrete cap and excavation of the soil. These deed restrictions will prevent disturbance of the cap and exposure to impacted soils.

Effectiveness. This alternative is effective in both the short term and the long term in protecting human health and the environment. The cap should be effective in reducing surface-water infiltration through the soil and, therefore, reduce potential migration of COCs. Constituent concentrations will not be actively reduced and may require an extended period of time to attenuate naturally. Inspection and maintenance to ensure the cap remains effective will be required. Luke AFB will maintain and repair the cap as needed in accordance with the Air Force design guidance for airfield pavement maintenance. This guidance is contained in the Air Force technical manual CEEDO-TR-77-44, Volume II, Section V, Guidelines for Determining Maintenance and Repair Requirements. The cap will be inspected weekly by the base Airfield Pavement Shop per AFR 55-48 Part 7(i). Additionally, the cap will be inspected annually by a civil engineer who will provide a written report to the Environmental Programs Flight Chief of any observed distresses along with recommendations for repair.

Implementability. This alternative is readily implementable at all PSCs. The cap can be easily constructed and maintained indefinitely. Implementation at PSCs near the runways will require at-grade caps. Construction may require removal of surface soils to prevent the cap from interfering with air traffic. Implementation will require coordination of construction activities so as not to interfere with Base operations.

Cost. The unit cost of this alternative is approximately $3.02 per cubic foot. Should surface soils require excavation and disposal, this unit cost increases by $5.55 per cubic foot of material disposed.

2.7.3 Remedial Measure S-8: Excavation, Ex-Situ Biological Treatment, and On-Site Disposal

- o Excavate soils with COCs in excess of PRGs.
- o Biologically treat excavated soils to reduce COCs.
- o Monitor the treated soils to confirm effectiveness.
- o Return the effectively treated soils to the excavation for final disposal.

This alternative consists of excavating soils with COCs above their PRGs to a depth of no greater than 16 ft bgs. Excavation to up to 16 ft bgs will prevent occupational exposure to soil, even though the risk assessment demonstrated that the OU-2 PSCs do not represent a significant hazard human health. The vadose zone transport model demonstrates that COCs at the OU-2 PSCs will not migrate to groundwater under existing, unsaturated conditions.

The excavated soils will then be subjected to an aerobic, biological treatment to reduce the non-halogenated VOCs, TRPHs, and PAHs. Soils containing halogenated VOCs may subsequently be subjected to an anaerobic, biological treatment. The method of biological treatment may be composting. Independent of the method, favorable conditions for biological degradation of the organic compounds will be developed by providing for nutrient (i.e., phosphorus or nitrogen), oxygen, moisture, and/or cultured bacterial strain additions. Air emissions, residues, or leachate from the treatment process may require treatment. The treatment selected is dependent upon the quantity of emissions, residue, and leachate generated by the process, which may be better estimated by design investigation studies. Based upon the climate and nature of contamination, the treatment of these byproducts will likely be recycling of the streams back into the treatment unit. The treated soil will be sampled to confirm treatment effectiveness and then returned to the excavation for final disposal.

Effectiveness. This alternative is proven for reducing the VOCs, TRPHs, and PAHs found in the soils at the OU-2 PSCs. This remedial measure would be effective in both the short-term and the long-term in protecting human health at OU-2 PSCs by reducing those COCs that are present in the surface soils above PRGs.

Implementability. This alternative is technically and administratively implementable at most PSCs. Excavation of soil from beneath and directly adjacent to structures constructed at some of the PSCs is not possible without demolition of the structures (PSCs FT-06 and ST-18). Implementation at PSCs DP-22 and SD-40 would disrupt air traffic and thus interfere with the mission of the Base. This system could be implemented at any of the remaining OU-2 PSCs with appropriate scheduling of construction, excavation, and operation activities so as not to interfere with Base operations.

Cost. The unit cost of this alternative is approximately $5.25 per cubic foot.

2.7.4 Remedial Measure S-10: In-Situ Extraction and Monitoring

- Install soil vapor extraction system (VES) to reduce VOCs, TRPHs, and potentially PAHs if thermal extraction is used.
- Monitor soil and groundwater (groundwater monitoring will be addressed under OU-1) to confirm effectiveness and potential migration of the COCs.

This alternative consists of installing a network of extraction wells in the impacted soils and applying a vacuum to the network. The applied subsurface vacuum induces a negative pressure gradient that propagates laterally resulting in in-situ volatilization of adsorbed organics. The gases migrate through the soil to the area of lowest pressure (the extraction well), where they are extracted and pulled through separation tanks and an air pollution control (APC) apparatus before being discharged to the atmosphere. A likely APC system would be a granular activated carbon (GAC) for removing the volatilized organics from the extracted air. The GAC would require periodic reactivation. This would probably occur off-site by the company the GAC was originally purchased from.

Effectiveness. This process has been applied to a range of volatile compounds such as chlorinated organic solvents and aromatic hydrocarbons and is capable of removing volatile compounds (such as benzene, TCE, PCE, toluene, and xylene) from vadose zone soils. This remedial measure would be effective in the long-term in protecting human health and the environment at OU-2 PSCs with VOCs above their PRGs by removing those COCs. This measure may be capable of remediating soils impacted by PAHs as well if enhanced biological activity occurs during implementation of the measure or if the innovative technology of in-situ thermal extraction can be feasibly used. This measure would not prevent contact with soils in the short-term if surface soils are exposed.

Implementability. This alternative is technically and administratively implementable, pending approval of an air permit for the VES. This system could be installed at any of the OU-2 PSCs without interfering with Base operations, however, the shallow depth of COCs present at levels exceeding PRGs limits the feasibility of this measure at PSC DP-23. For PSCs near the runways, the well network could be installed below ground and the vacuum and off-gas treatment system located remotely.

Cost. The unit cost of this alternative is approximately $5.93 per cubic foot.

2.7.5 Remedial Measure S-12: In-Situ Biological Treatment and Monitoring

- In-situ bioremediation to reduce organic COCs.
- Installation of access controls such as temporary fencing for those PSCs which are in the vicinity of the flight-line or runways.

- o Monitoring of soil and groundwater (groundwater monitoring will be addressed under OU-1) to confirm effectiveness and potential migration of the COCs.

This alternative uses indigenous or introduced aerobic or anaerobic bacteria to biodegrade organic compounds in soils. The natural biodegradation process may be enhanced by injecting nutrients (e.g., phosphorous or nitrogen), oxygen, moisture, and/or cultured bacterial strains directly into the impacted soils. Gaseous or vapor phase injection of such compounds may be the preferred method of nutrient application at the OU-2 PSCs due to the shallow nature (up to 16 ft bgs) of the soils identified for possible remediation. Such injection would require a network of injection wells in the impacted areas. Landfarming techniques rather that injection techniques may be the preferred method of in-situ bioremediation at locations where impacted soil depths do not extend beyond 2 ft bgs.

Effectiveness. In-situ bioremediation would likely be effective in treating non-halogenated VOCs and TRPHs. PAHs and chlorinated VOCs typically have a greater resistance to being biologically degraded; therefore, extended remediation times may be required for sites with these types of compounds present. This remedial measure would be effective in the long-term in protecting human health and the environment at OU-2 PSCs by removing COCs. Temporary fencing at those PSCs which are not in the vicinity of the flight-line or runways would prevent contact with soils in the short-term if surface soils are exposed.

Implementability. This alternative is technically and administratively implementable. This system could be installed at any of the OU-2 PSCs without interfering with Base operations. For PSCs near the runways, the well network would be installed below ground and the injection system located remotely.

Cost. The unit cost of this alternative is approximately $5.20 per cubic foot.

2.8 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

Section 300.430(e)(9) of the NCP requires that the agencies evaluate the remedial cleanup alternatives based on the nine criteria discussed below. Since remedial action is proposed only at PSC DP-23, only alternatives considered for PSC DP-23 are compared here. The alternatives considered for PSC DP-23 were S-1, S-3, S-8, and S-12. The first two criteria, overall protection of human health and the environment and compliance with applicable or relevant and appropriate requirements, are threshold criteria and must be met by the selected remedy. The next five criteria are considered primary balancing criteria; the agencies must balance between these criteria in order to select the best remedy. It is understood that the selected remedy may not rank highest on every one of the balancing criteria. The remaining two, community acceptance and regulatory agency acceptance, are to be used by the lead agency as modifying factors in the decision-making process. The selected remedy must represent the best overall balance of the selection criteria. A summary of the detailed analysis of alternatives for PSC DP-23 is provided below and in Table 13.

2.8.1 Overall Protection of Human Health and the Environment

All of the remedial measures identified for detailed analysis provide adequate protection of human health and the environment at the OU-2 PSCs. Conditions at OU-2 do not represent a significant hazard to human health and the vadose zone transport model (using conservative assumptions) demonstrates that COCs should not migrate to groundwater. No remedial action is required at any of the PSCs except PSC DP-23 in order to protect human health and the environment. The southern portion of PSC DP-23 consists of a drainage canal (the surface impoundment wash) where saturated conditions may exist during and for a limited time following storm events.

2.8.2 Compliance With ARARs

All four alternatives considered for PSC DP-23 would comply with action and location specific ARARs. Although concentrations of COCs in OU-2 soils are, in some cases, above PRGs, there are no promulgated state or federal chemical-specific ARARs for soils that require remediation. Action-specific ARARs must be met by the S-8 alternative if the excavation of impacted soil includes RCRA disposal; however, the impacted soil (both before and following treatment) is not expected to be a hazardous waste. Air emission regulations apply when excavating/incinerating/treating in the S-8 alternatives. PSC DP-23 is located adjacent to an archaeological site. In the event archaeological artifacts are encountered, remedial activities will cease and the State Historic Preservation Office will be contacted for direction. PRGs and ARARs are summarized in Tables 14a, 14b, and 14c.

2.8.3 Long Term Effectiveness and Permanence

Remedial measure S-8 provides a high degree of long term effectiveness by excavating impacted soils and then subsequently treating those soils with ex-situ biological treatment. Remedial measure S-12 uses in-situ biological treatment to remove COCs from soil. This technology will be more difficult to control and monitor than an ex-situ treatment process. Therefore, S-12 provides a lesser degree of long term effectiveness and permanence than the above alternatives. Although alternative S-3 eliminates the risk of exposure at the site to the same degree as the above alternatives, it relies solely upon a cap for controlling the impacted soil that will remain at the site.

2.8.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

Alternatives S-8 and S-12 use the treatment technologies of ex-situ biological treatment, in-situ extraction, and in-situ biological treatment, respectively, to remove the COCs and thus their toxicity, mobility, and volume from the site. Although no treatment technology is used by Alternative S-3, the mobility of COCs in soil is reduced by the use of a cap to reduce infiltration of storm water.

2.8.5 Short-Term Effectiveness

All remedial measures considered for PSC DP-23 have a slightly lesser degree of short-term effectiveness because each involves some worker exposure to impacted soils during implementation of the remedial measure. However, based on the risk assessment and the limited exposure that will occur, the concern may not be warranted. The exposure of construction workers to COCs present in soil can be reduced through the use of personal protective equipment and implementation of a site-specific health and safety plan.

2.8.6 Implementability

All of the remedial measures are technically implementable without interfering with Base operations.

2.8.7 Cost

No costs are associated with the implementation of the no action alternative. The alternatives involving biological treatment processes, S-8 and S-12, are usually the most costly to implement. The excavation and ex-situ biological treatment alternative, S-8, was second to no action in terms of cost of implementation. Capital, operation and maintenance, and net present value costs for the PSC DP-23 alternatives are summarized in Table 16.

2.8.8 Regulatory Agency Acceptance

The USEPA, the ADEQ, and the ADWR have reviewed and commented on the draft RI/FS documents and the draft Proposed Plan. Comments were incorporated into the final documents. The regulatory agencies support the final Proposed Plan for OU-2 as it was presented to the public, as well as the remedy selection set forth in this ROD.

2.8.9 Community Acceptance

The community supports the Proposed Plan for OU-2. There were no comments made during the public comment period. The only comments received on the Proposed Plan were received during the Technical Review Committee (TRC) meeting on May 20, 1993. These issues are addressed in the Responsiveness Summary.

2.9 SELECTED REMEDY

2.9.1 Remedial Measure Recommendation for PSCs OT-04, DP-05, FT-06, FT-07, DP-22, DP-23, and SD-40

The remedial action selected for implementation at PSCs OT-04, DP-05, FT-06, FT-07, DP-22, SD-40, and the northern portion of PSC DP-23 is S-1 (No Action). Remedial measure S-1 is recommended because the conclusions of the site-specific risk assessment are that conditions at these PSCs do not represent a significant hazard to human health. Both current and hypothetical future ELCRs and HIs for exposure to soils at the OU-2 PSCs are below the USEPA's risk-based remediation benchmarks (ELCR less than 10^{-4}, HI below 1.0). Also, the vadose zone transport model demonstrates that under typical, unsaturated conditions at the OU-2 PSCs, COCs will not migrate to and impact groundwater. Therefore, this alternative is both technically and administratively implementable at these PSC.

2.9.2 Remedial Measure Recommendation for PSC ST-18

The remedial action selected for implementation at PSC ST-18 is S-3 (Capping, Surface Controls, and Monitoring). Other alternatives considered in the detailed analysis included remedial measure S-1 (No Action), remedial measure S-10 (In-situ Extraction and Monitoring), and remedial measure S-12 (In-situ Biological Treatment and Monitoring).

Remedial measure S-3 is selected at PSC ST-18 because the first element of this measure, capping, has already been implemented as a RCRA closure requirement. Consistent with RCRA/CERCLA integration under the FFA it is both relevant and appropriate to continue to maintain this cap in an effort to ensure the effectiveness of this response action. This response action is consistent with the CERCLA requirement to be protective of human health and the environment and satisfies the remedial action objectives for OU-2. The second element of this measure, surface controls, is satisfied as long as the Base is present. Deed restrictions will be imposed as part of this remedial measure to prevent removal of the cap and excavation of the soil in the future. There is a lack of public exposure to all OU-2 PSCs because the Base perimeter is fenced and monitored. The third element of this alternative, monitoring (with respect to groundwater) will be conducted unless the site is remediated under OU-1.

Alternative S-12 provides treatment for removal of COCs; however, following treatment, some COCs (at levels below PRGs) will remain in the soils. With no overall site risk associated with the current COC levels at the PSC and no concern about COC migration to groundwater demonstrated by the vadose zone transport model, implementation of these treatment technologies is not warranted.

The remediation goal for PSC ST-18 is to ensure the effectiveness of the cap in preventing the potential migration of constituents. PSC ST-18 was capped in 1987 as part of the closure requirements for former Facility 993. The Base will continue to inspect and maintain the cap to ensure integrity of the concrete and sealed joints. Luke AFB will maintain and repair the cap as needed in accordance with the Air Force design guidance for airfield pavement maintenance. This guidance is contained in the Air Force technical manual CEEDO-TR-77-44, Volume II, Section V, Guidelines for Determining

Maintenance and Repair Requirements. The cap will be inspected weekly by the base Airfield Pavement Shop per AFR 55-48 Part 7(i). Additionally, the cap will be inspected annually by a civil engineer who will provide a written report to the Environmental Programs Flight Chief of any observed distresses along with recommendations for repair. The cap is also inspected on a routine basis by the ADEQ. Therefore, the only additional requirement for implementation of this remedial measure is monitoring of groundwater (groundwater monitoring will be addressed under OU-1) for potential migration of COCs.

There are no capital costs associated with this alternative since PSC ST-18 is already capped. Costs associated with maintenance of the cap will be incorporated into the Base infrastructure maintenance program.

2.9.3 Remedial Measure Recommendation for PSC DP-23

The remedial action selected for implementation at the canal portion of PSC DP-23 is S-8 (Excavation, Ex-situ Biological Treatment, On-site Disposal, and Monitoring). Other alternatives considered in the detailed analysis included remedial measure S-3 (Capping, Surface Controls, and Monitoring) and remedial measure S-12 (In-situ Biological Treatment and Monitoring).

Remedial measure S-8 is recommended for implementation at the surface impoundment wash portion of PSC DP-23 (the area south of Super Sabre Street) to ensure that migration of the COCs to groundwater does not occur. In this area of the PSC, saturated conditions may exist during and for a limited time following storm events. Therefore, remediation is recommended for areas where COCs in soils were found to exist at levels exceeding the PRGs. Table 15 summarizes concentrations of constituents exceeding PRGs at PSC DP-23, as well as the PRGs for these COCs.

Alternative S-8 provides immediate removal of COCs from the wash by removing impacted soils, where alternative S-12 requires significant treatment time before a reduction in COCs to levels below PRGs is achieved. Alternative S-3 allows the COCs to remain in place. Both S-3 and S-12 will be more difficult to implement in the wash than will S-8. Remedial measure S-8 is also more cost effective to implement than S-3 or S-12.

In the area of Soil Boring SB-5 (in the northern portion of the drainage canal, Figure 5) an estimated 3,472 cubic yards of soil must be remediated. This volume is based on a site width of 125 ft, a length of impacted soil of 125 ft, and a depth of impacted soil of 6 ft. The volume of soil will be more precisely calculated during remedial design. The remedy is schematically shown on Figure 5.

The biological treatment system will be monitored by collecting soil samples and analyzing the samples for the constituents that exceeded the PRGs. Excavated soils from the area of Soil Boring SB-5 (in the northern portion of the drainage canal) will be analyzed for benzo(a)pyrene since the benzo(a)pyrene concentration exceeded its PRG. It is estimated that one to two composite samples from the excavated soil pile will be collected approximately every 2 months to verify the effectiveness of the treatment system.

The remediation goals for soils from PSC DP-23 are the PRGs. For the PAH mentioned above, the PRG is 0.78 mg/kg. PRGs are discussed in Section 2.6.1.5 of this ROD. The ELCR associated with this remedy is 10^{-6}, while both the USEPA and the State recognize a range of 10^{-4} to 10^{-6}.

It should be noted that some changes may be made to the remedy as a result of the remedial design and construction processes. Such changes, in general, reflect modifications resulting from the engineering design process.

Capital costs associated with this alternative are estimated to be $420,000. Costs for operation, maintenance, and confirmatory sampling are estimated to be $16,000 per year. The present value of these costs over 2 years is estimated to be $450,000.

2.10 STATUTORY DETERMINATIONS

Under CERCLA Section 121, the selected remedy must be protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), be cost-effective, and utilize permanent solutions to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principle element. The following sections present how the selected remedy meets these statutory requirements for PSCs ST-18 and the canal portion of PSC DP-23. No action is the selected remedy for the remaining PSCs; the no action remedy satisfies the statutory requirements at these PSCs.

2.10.1 Protection of Human Health and the Environment

The remedy selected for the canal portion of PSC DP-23 is protective of human health and the environment. The potential risk posed by impacted soils at the PSC (i.e., migration of contaminants to groundwater) will be eliminated. Impacted soils will be treated biologically to PRG levels. Short-term risks and the potential for cross-media impacts will be controlled through use of good construction practices and institutional controls.

The remedy selected for PSC ST-18 is protective of human health and the environment. The potential risk posed by impacted soils at the site is not significant and is below the USEPA's risk-based remediation benchmarks. However, consistent with RCRA/CERCLA integration under the FFA it is both relevant and appropriate to continue to maintain the concrete cap which was constructed over this PSC as part of a RCRA closure requirement. The model used to predict potential impact to groundwater indicates that underlying groundwater should not be impacted by contaminants remaining in the soil.

2.10.2 Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with all applicable or relevant and appropriate requirements. No waiver of ARARs is necessary.

2.10.3 Cost Effectiveness

The selected remedies are cost-effective in mitigating the principal threats posed by the site. Cost-effectiveness is determined by evaluating the following three balancing criteria to determine overall effectiveness: long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; and short-term effectiveness. Overall effectiveness is then compared to cost to ensure that the remedy is cost-effective.

The net present worth cost for the capping surface controls, and monitoring alternative, S-3, is the most cost effective remedial measure for PSC ST-18 next to no action. This is largely due to the fact that PSC ST-18 is already capped and the area restricted, so only monitoring is required.

Alternative S-3 provides long-term effectiveness and permanence by minimizing or eliminating the potential for constituents to leach into groundwater. S-3 also reduces mobility. Short-term risks are not an issue because this PSC is already capped.

At PSC DP-23, the excavation, ex-situ biological treatment, and confirmatory sampling alternative, S-8, is second only to no action in terms of cost of implementation. This alternative provides long-term effectiveness and permanence and reduces toxicity, mobility, and volume because soils will be treated on-site to the PRG levels. Short-term risks will be controlled through use of good construction practices and institutional controls.

2.10.4 Preference for Permanent Solutions and Alternative Treatment Technologies

Where possible, the selected remedies satisfy the preference for utilization of permanent solutions and alternative treatment technologies. This applies specifically to PSC DP-23, where impacted soils will be excavated and biologically treated on-site, as opposed to other alternatives such as off-site landfill disposal. The five primary balancing criteria were equally decisive factors in the selection decision for PSC DP-23. PSC ST-18 does not pose a significant threat to human health and constituents will not migrate to and impact groundwater based on the vadose zone leaching model. Since PSC ST-18 is already capped, the S-3 alternative is implementable and cost-effective and short-term effectiveness is not an issue.

2.10.5 Preference for Treatment as a Principal Element

The statutory preference for treatment as a principal element is satisfied for the canal portion of PSC DP-23. At PSC DP-23, soils will be biologically treated to PRG levels. Treatment is not necessary at PSC ST-18 because the soils do not pose a significant threat to human health or the environment. Previous action at PSC ST-18 (UST removal and removal and treatment of contaminated soils) already addressed threats posed by that PSC.

2.11 DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan for OU-2 was released for public comment in May 1993. The Proposed Plan identified Remedial Measure S-3 (Capping, Surface Controls, and Monitoring) for PSC ST-18, Remedial Measure S-8 (Excavation, Ex-situ Biological Treatment, On-site Disposal, and Monitoring) for the canal portion of PSC DP-23, and Remedial Measure S-1 (No Action) for the remainder of OU-2 as the preferred alternatives. No written or verbal comments were submitted during the public comment period. Verbal comments from the TRC were received during the May 1993 TRC meeting. Upon review of comments from the TRC, it was determined that no significant changes to the remedy, as it was originally identified in the Proposed Plan, were necessary.

Currently, the USEPA does not have a national standard for assigning cancer slope factors (CSFs) to different PAHs. In the past the policy has been to assume the cancer potency of all of the carcinogenic PAHs is equivalent to that of benzo(a)pyrene. This approach was taken in the risk assessment that was completed for OU-2. Since the OU-2 risk assessment was published, USEPA Region IX set an interim regional policy for evaluating the carcinogenicity of the PAHs based on a recommendation from the USEPA's Environmental Criteria and Assessment Office (ECAO) (U.S.Environmental Protection Agency, 1993). ECAO conducted a scientific review of PAH cancer potency issues and concluded that a set of toxicity equivalence factors (TEFs) based on a report from Clement International is the most scientifically appropriate approach to PAH cancer risk assessment. Region IX USEPA has adopted these TEFs under an interim policy (U.S. Environmental Protection Agency, 1993).

The use of the TEFs results in the increase of the PRGs for the PAHs benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, and indeno(1,2,3-cd)pyrene and eliminates the need to remediate near sediment sampling location SD-5 at PSC DP-23. This results in a reduction of the remediation volume from approximately 4,600 cubic yards (as was stated in the Proposed Plan) to approximately 3,500 cubic yards.

3.0 RESPONSIVENESS SUMMARY

No verbal or written questions or comments on the OU-2 Proposed Plan were received during the public comment period which lasted from June 8 through July 7, 1993. However, questions on the OU-2 Proposed Plan were received from the TRC during the May 20, 1993 TRC Meeting. The questions and answers are summarized below.

The TRC asked what types of POL waste were disposed at OU-2. The majority of POL was contaminated fuel. Since aircraft have high quality fuel requirements, waste fuel is common.

The TRC asked if there was an oil/water separator associated with the canal at PSC DP-23. There is no oil/water separator directly associated with PSC DP-23. There is another canal to the east of PSC DP-23 which is associated with an oil/water separator. That canal is an OU-1 PSC, PSC SD-20, the Oil/Water Separator Canal.

The TRC asked what reference numbers were used in the risk calculations. To determine total site risk, an HI of 1.0 and an ELCR within the 10^{-4} to 10^{-6} range were used as references. To determine PRGs, an ELCR of 10-6 was used as a reference.

The TRC asked if there was a shallow, secondary aquifer at Luke AFB. There is no shallow aquifer. Groundwater at the main Base is first encountered at approximately 350 feet below ground surface. Approximately 2 miles to the east of the main Base, near the Agua Fria River, groundwater is first encountered at approximately 125 feet below ground surface.

The TRC asked specific questions regarding the design of the biological treatment system remedy for PSC DP-23. The details of the biological treatment system will be determined during the remedial design phase of the project.

The TRC asked about the time frame of the remedial action at PSC DP-23. The remediation is estimated to take 12 months. The ROD is scheduled to be finalized on December 29, 1993. CERCLA requires that remedial action begin within 15 months of the Final ROD.

4.0 REFERENCES

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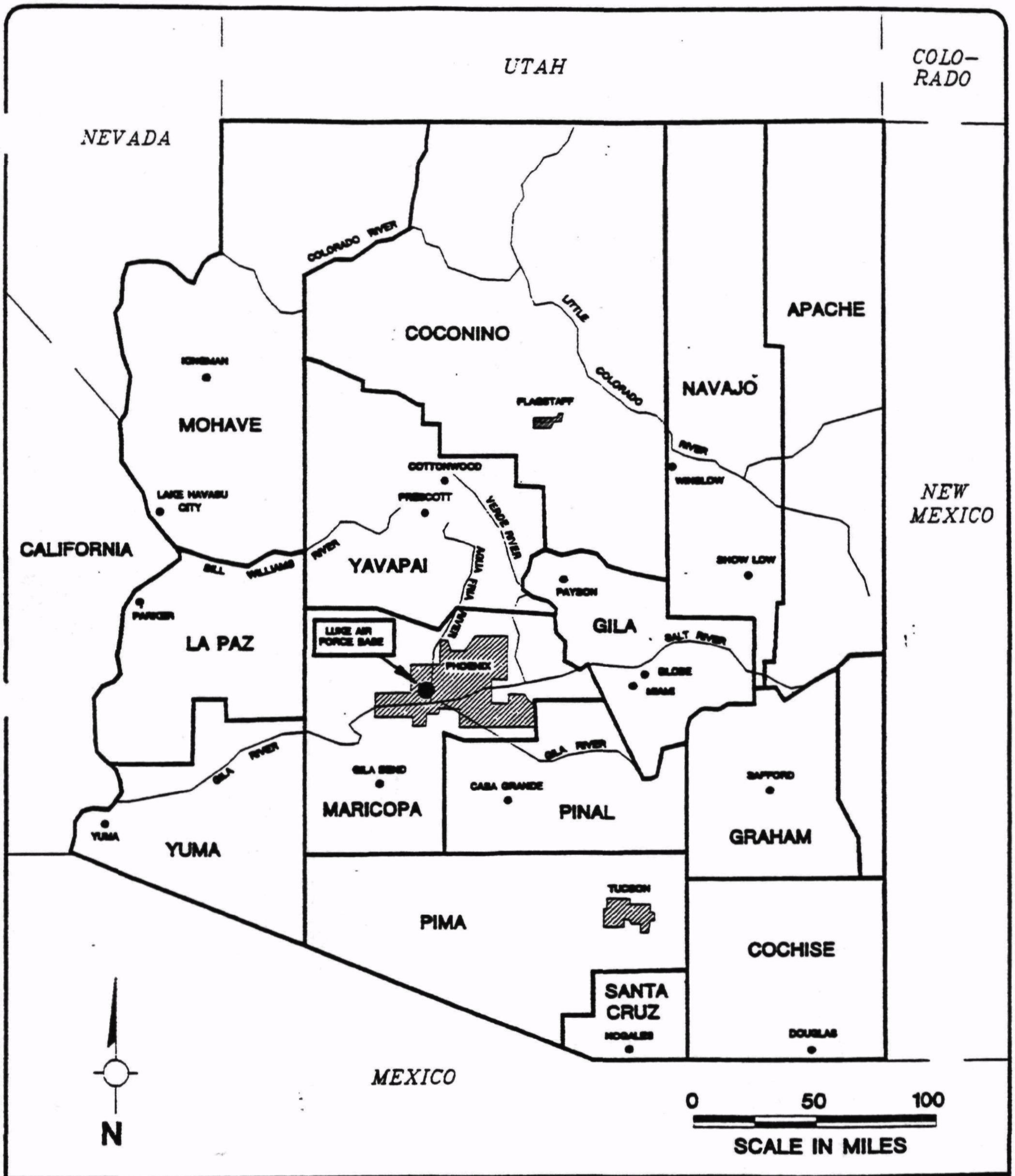
U.S. Environmental Protection Agency (USEPA), 1993. Letter from USEPA Region IX to Richard A. Becker, Ph.D., Chief, Human & Ecological Risk, California Environmental Protection Agency, May 25, 1993.

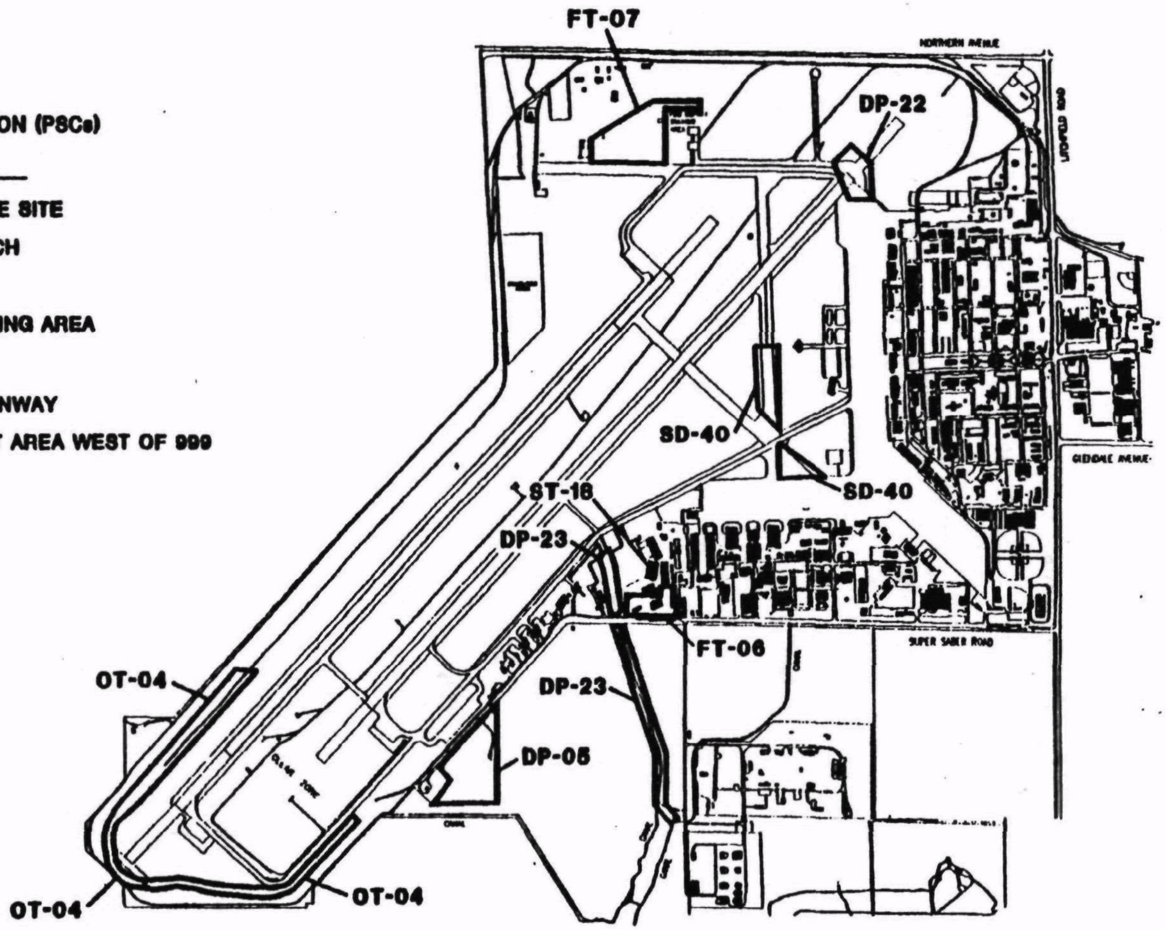


LOCATION OF LUKE AIR FORCE BASE, ARIZONA

FIGURE 1

POTENTIAL SOURCES OF CONTAMINATION (PSCs)
OPERABLE UNIT NO. 2

OT-04 PERIMETER ROAD POL WASTE SITE
DP-05 POL WASTE DISPOSAL TRENCH
FT-06 SOUTH FIRE TRAINING AREA
FT-07 WESTERN NORTH FIRE TRAINING AREA
ST-18 FACILITY NO. 933
DP-22 POL TRENCH NORTHEAST RUNWAY
DP-23 OLD SURFACE IMPOUNDMENT AREA WEST OF 999
SD-40 TAXIWAY FUEL DISCHARGE

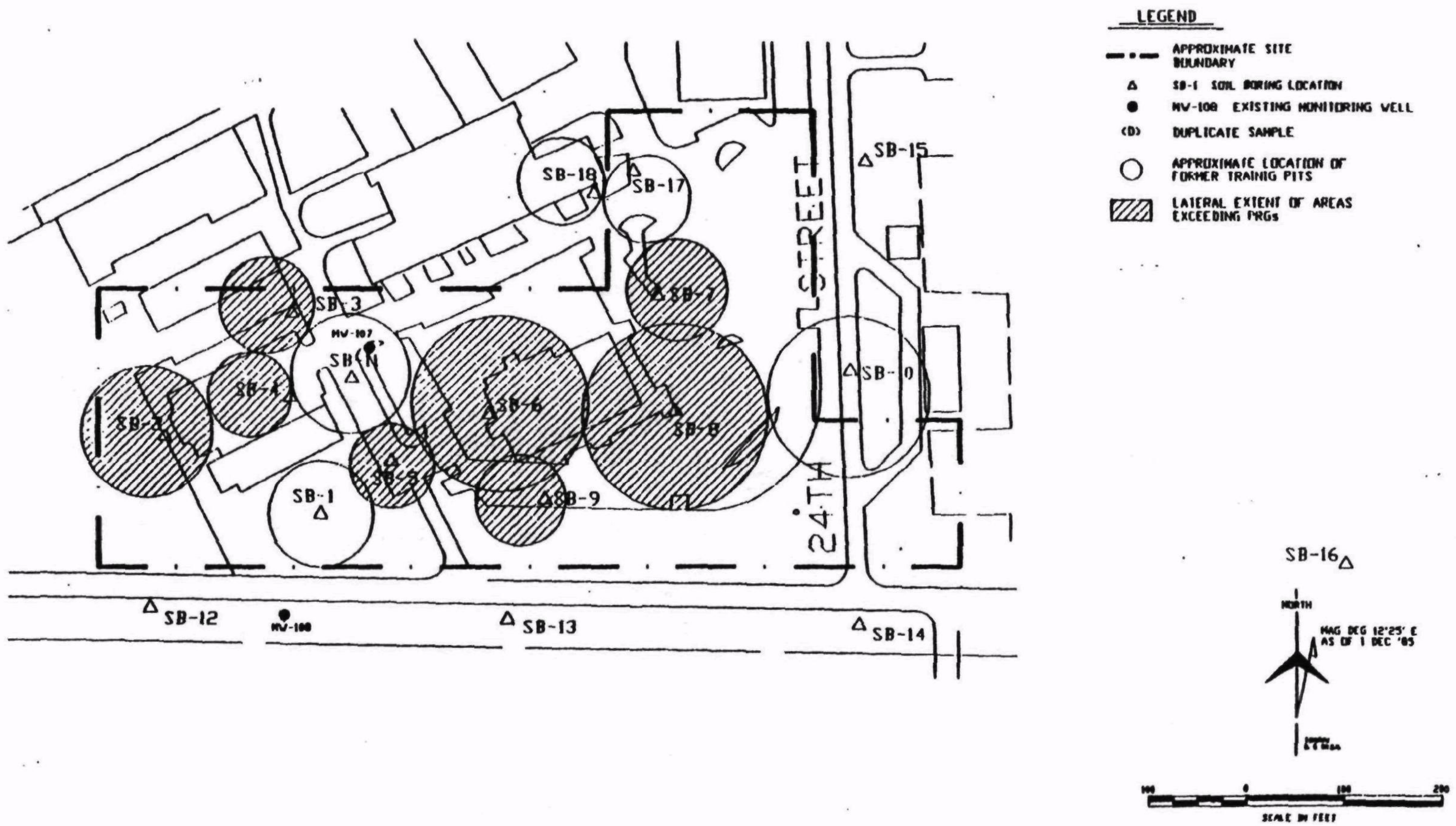


0 1200 2400
APPROXIMATE SCALE IN FEET

PREPARED FROM USAF LUKE AFB BASE MAP (AUTOCAD R12, 1993)

LOCATION OF PSCs
OPERABLE UNIT NO. 2
LUKE AFB, ARIZONA

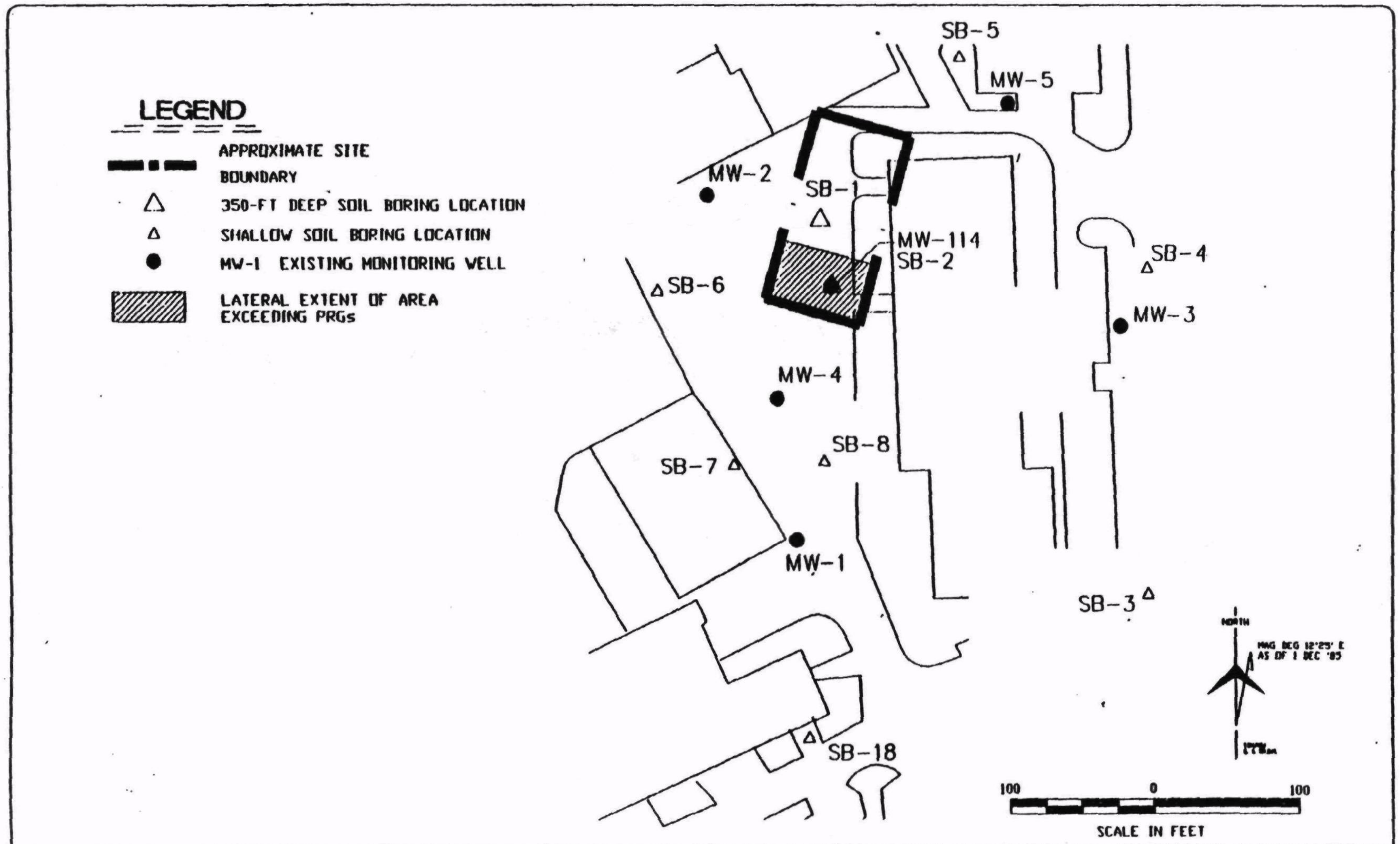
FIGURE 2



DRAWING NO:	AZ36105-A1
DRAWN BY: DAM/GRH	DATE: SEP. 1992
CHECKED BY:	DATE:
APPROVED BY:	DATE:

LATERAL EXTENT OF AREAS EXCEEDING PRGs
PSC FT-06, OPERABLE UNIT NO. 2
REMEDIAL INVESTIGATION
Luke AFB, Arizona

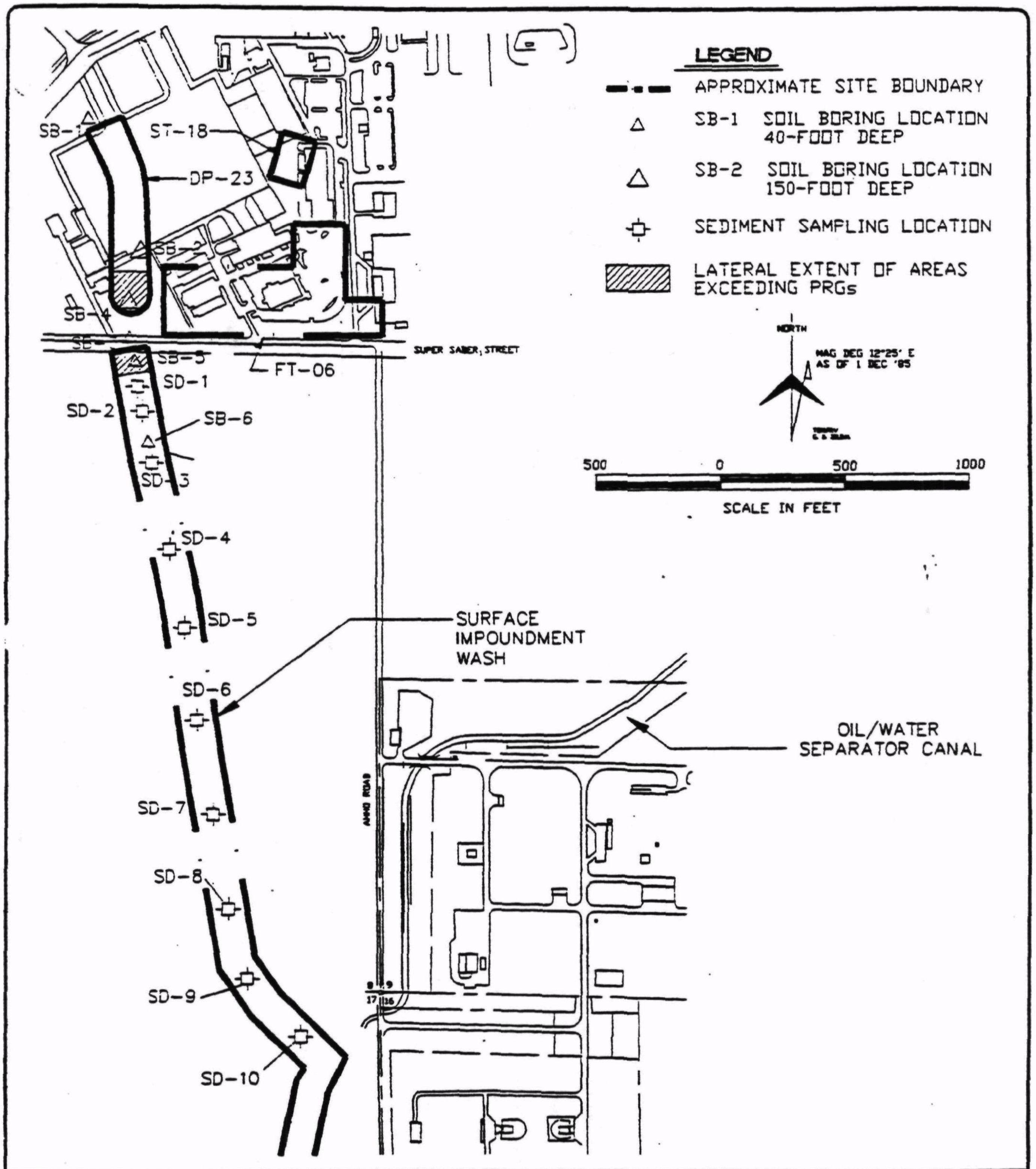
FIGURE 3



DRAWING NO: AZ361.05-A2			
DRAWN BY: DAH/GRN	DATE: SEP. 1992		
CHECKED BY:	DATE:		
APPROVED BY:	DATE:		

LATERAL EXTENT OF AREA EXCEEDING PRGs
PSC ST-18, OPERABLE UNIT NO. 2
REMEDIAL INVESTIGATION
Luke AFB, Arizona

FIGURE 4



DRAWING NO:	AZ316.05-A3			LATERAL EXTENT OF SOIL EXCEEDING PRGs PSC DP-23, OPERABLE UNIT NO.2 REMEDIAL INVESTIGATION Luke AFB, Arizona	FIGURE 5
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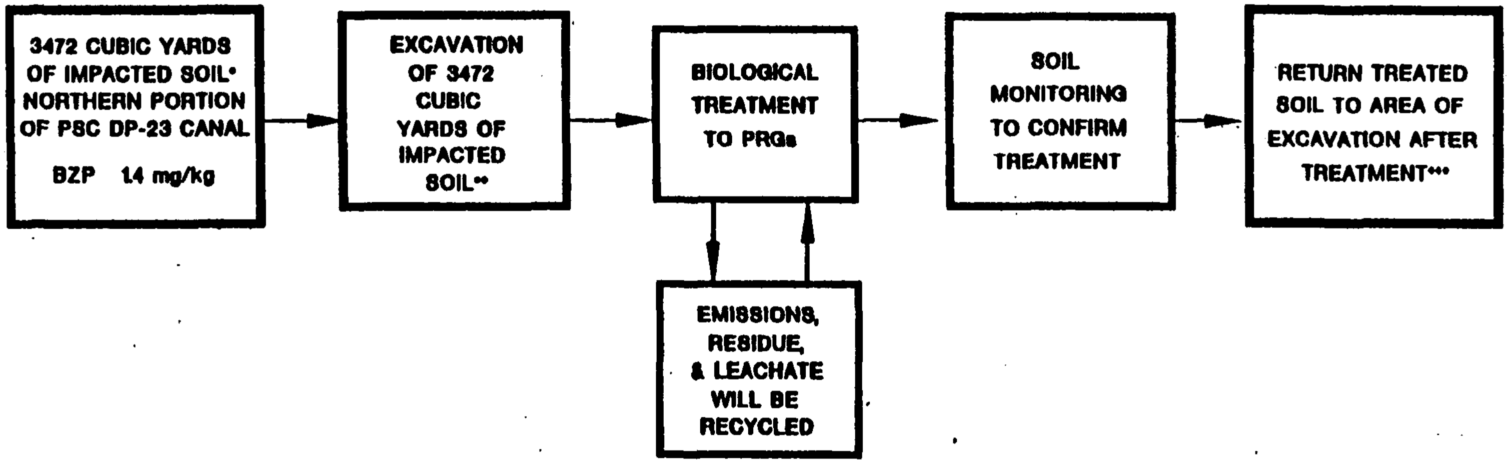
UPDATE BY:	A LEIBOLD	DATE:	NOV 2 1993		
APPROVED BY:		DATE:			



NOTES:

* The PRG for BZP is 0.78 MG/KG.

** The amount will be more precisely calculated when sampling is conducted during remedial design.

*** Clean closure; 5-year monitoring not necessary.

SELECTED REMEDY, CANAL PORTION OF PSC-DP-23
OPERABLE UNIT No.2, LUKE AFB, ARIZONA

FIGURE 6

Table 1. Summary of OU−2 PSCs, OU−2 RI, Luke Air Force Base, Arizona.

PSC	Brief Description	Potential Wastes
OT−04	The Old Perimeter Road was an unpaved dirt road that extended south along the southern end of the runways and then north along the northern edge of the runways. The road surface consisted of weathered asphalt, soil, and packed gravel and occupies approximately 26.5 acres.	petroleum, oil, and lubricant
DP−05	The Waste Disposal Trench PSC was a landfill used to dispose of liquid POL wastes. The area consists of sparsely vegetated soil with piles of construction debris and occupies approximately 18 acres of land south of the Hush Houses.	petroleum, oil, lubricant, and solvents
FT−06	The South Fire Training Area is located around Building 988 and covers approximately eight acres. Most of the area is covered by roads, buildings, and parking lots.	petroleum, oil, and lubricant
FT−07	The North Fire Training Area is located east of the abandoned Firing−In−Butt and includes Building 1356. Most of the PSC is covered with grasses and desert vegetation. Concrete, asphalt, and building 1356 are located in the OU−1 (eastern) portion. The OU−2 (western) portion covers approximately 14 acres.	petroleum, oil, and lubricant
ST−18	The Facility 993 PSC is an area west of the existing Building 993 and north of Building 999. Two 10,000 gallon and one 5,000 gallon storage tanks were excavated from this PSC when the former Facility 993 was demolished. The PSC covers approximately 0.2 acres and is completely covered by concrete.	petroleum, oil, lubricant, and solvents
DP−22	The POL Trench Northeast Runway is located at the northeastern end of the Base's northeast runway and occupies approximately 4.6 acres. Approximately 50 percent of the PSC is covered by the inboard runway extension and a bituminous cover material and 50 percent is gravel and soil with sparse vegetation.	petroleum, oil, and lubricant

ble 1. Summary of OU-2 PSCs, OU-2 RI, Luke Air Force Base, Arizona.

PSC	Brief Description	Potential Wastes
DP-23	The Old Surface Impoundment PSC occupies approximately 3.3 acres west of Building 999. Approximately 20 percent of this PSC is covered by concrete and asphalt with approximately 80 percent consisting of a drainage canal covered with sparsely vegetated soil.	petroleum, oil, and lubricant
SD-40	The Taxiway Fuel Discharge PSC consists of the areas on both sides of the southeastern end of Taxiway F (approximately 2.75 acres) and on both sides of the southcentral section of Taxiway E (approximately 7.58 acres). The areas are overlain with a cover of 2-inch thick asphalt. Taxiway's E and F are covered with concrete and are currently used for the limited servicing and maintenance aircraft.	petroleum, oil, and lubricant

Table 2. PSC-Specific Concentration Ranges for COCs, OU-2 RI, Luke Air Force Base, Arizona.

Constituents of Concern	OT-04 (mg/kg) 12 borings	DP-05 (mg/kg) 28 borings	FT-06 (mg/kg) 18 borings	FT-07 (mg/kg) 20 borings	ST-18 (mg/kg) 8 borings	DP-22 (mg/kg) 5 borings	DP-23 (mg/kg) 6 borings 10 sediment locations	SD-40 mg/kg 11 borings	Basewide Concentration Ranges (mg/kg)	PRG (mg/kg)	No. of Boring Locations with values greater than the PRG
VOCs											
Acetone	NP	NP	NP	NP	NP	1.0–1.0	NP	1.8–1.8	1.0–1.8	200,000	0
Benzene	NP	NP	NP	NP	<0.05–6.4	NP	NP	<0.05–0.13	<0.05–6.4	1.2	1
2-Butanone (MEK)	NP	NP	0.7–0.9	NP	NP	NP	NP	NP	0.7–0.9	1,900	0
1,1-Dichloroethene	NP	NP	NP	NP	<0.05–1.0	NP	NP	NP	<0.05–1.0	0.02	1
Ethylbenzene	NP	<0.05–0.9	<0.05–6.0	NP	<0.05–84	NP	<0.05–Tr	<0.05–1.0	<0.05–84	4,800	0
2-Hexanone (MBK)	NP	NP	0.8–0.8	NP	NP	NP	NP	NP	0.8–0.8	NA	NP
4-Methyl-2-pentanone	NP	NP	NP	NP	NP	NP	NP	NP	NA	1,900	0
1,1,2,2-Tetrachlorethane	NP	NP	<0.05–0.4	NP	<0.05–3.0	NP	NP	NP	<0.05–3.0	0.69	1
Tetrachloroethene	NP	NP	<0.05–Tr	NP	<0.05–3.0	NP	NP	NP	<0.05–3.0	39	0
Toluene	NP	NP	<0.05–3.0	NP	<0.05–200	NP	<0.05–Tr	<0.05–0.2	<0.05–200	2,200	0
Trichloroethene	NP	NP	<0.05–9.0	NP	<0.05–3.0	NP	NP	NP	<0.05–9.0	5.5	1
Xylenes	NP	<0.05–86	<0.05–43	NP	<0.05–380	NP	NP	<0.05–2.4	<0.05–380	NR	NP
BNAs											
Acenaphthene	NP	NP	<0.17–1.8	NP	NP	NP	NP	NP	<0.17–1.8	120,000	0
Anthracene	NP	NP	<0.17–2.6	NP	NP	NP	<0.17–1.3	NP	<0.17–2.6	610,000	0
Benzo(a)anthracene	NP	NP	<0.17–27	NP	<0.17–0.43	NP	<0.17–6.6	NP	<0.17–27	7.8	2
Benzo(b)fluoranthene	NP	NP	<0.17–46	<0.17–0.26	<0.17–0.77	NP	<0.17–13	NP	<0.17–46	7.8	5
Benzo(k)fluoranthene	NP	NP	<0.17–73	NP	NP	NP	<0.17–5.8	NP	<0.17–73	7.8	1
Benzo(g,h,i)perylene	NP	NP	<0.17–10	<0.17–0.22	<0.17–0.56	NP	<0.17–4.0	NP	<0.17–10	61,000	0
Benzo(a)pyrene	NP	NP	<0.17–30	NP	<0.17–0.43	NP	<0.17–3.3	NP	<0.17–30	0.78	9
Benzyl alcohol	NP	NP	NP	NP	0.42–0.42	NP	NP	NP	0.42–0.42	610,000	0
Bis(2-ethylhexyl)phthalate	<0.17–1.3	<0.17–3.7	<0.17–3.2	<0.17–0.21	<0.17–6.3	NP	<0.17–2.2	NP	<0.17–6.3	410	0
Butylbenzylphthalate	<0.17–0.22	NP	<0.17–0.68	NP	NP	NP	ND	NP	<0.17–0.68	410,000	0
Chrysene	NP	NP	<0.17–52	<0.17–0.29	<0.17–0.92	NP	<0.17–7.5	NP	<0.17–52	780	14
Dibenzo(a,h)anthracene	NP	NP	<0.17–10	NP	NP	NP	<0.17–0.21	NP	<0.17–10	0.78*	5
Dibenzofuran	NP	NP	<0.17–0.67	NP	NP	NP	NP	NP	<0.17–0.67	61,000	0
Di-n-butylphthalate	NP	NP	<0.17–0.46	NP	NP	NP	NP	NP	<0.17–0.46	200,000	0
Fluoranthene	NP	NP	<0.17–42	<0.17–0.22	<0.17–0.49	NP	<0.17–9.9	NP	<0.17–42	82,000	0

Table 2. PSC-Specific Concentration Ranges for COCs, OU-2 RI, Luke Air Force Base, Arizona.

Constituents of Concern	OT-04 (mg/kg) 12 borings	DP-05 (mg/kg) 28 borings	FT-06 (mg/kg) 18 borings	FT-07 (mg/kg) 20 borings	ST-18 (mg/kg) 8 borings	DP-22 (mg/kg) 5 borings	DP-23 (mg/kg) 6 borings 10 sediment locations	SD-40 (mg/kg) 11 borings	Basewide Concentration Ranges (mg/kg)	PRG (mg/kg)	No. of Boring Locations with values greater than the PRG
Fluorene	NP	NP	<0.17-0.83	NP	NP	NP	NP	NP	<0.17-0.83	82,000	0
Indeno(1,2,3-c,d)pyrene	NP	NP	<0.17-8.1	NP	<0.17-0.34	NP	<0.17-1.7	NP	<0.17-8.1	0.78	1
2-Methylnaphthalene	NP	<0.17-4.7	<0.17-3.0	<0.17-0.91	<0.17-20	NP	NP	<0.17-2.0	<0.17-30	61,000	0
4-Methylphenol	NP	NP	<0.17-9.1	NP	NP	NP	NP	NP	<0.17-9.1	100,000	0
Naphthalene	NP	<0.17-4.6	<0.17-9.7	<0.17-0.26	<0.17-13	NP	NP	<0.17-0.98	<0.17-9.7	82,000	0
OCDD	NP	NP	NP	NP	NP	NP	NP	NP	NP	0.038	0
Pentachlorophenol	NP	NP	<0.17-3.1	NP	NP	NP	NP	NP	<0.17-3.1	48	0
Phenanthrene	NP	NP	<0.17-13	NP	<0.17-0.18	NP	<0.17-6.2	NP	<0.17-13	61,000	0
Phenol	NP	NP	<0.17-3.1	NP	NP	NP	NP	NP	<0.17-3.1	NR	NP
Pyrene	NP	NP	<0.17-36	<0.17-0.28	<0.17-0.56	NP	<0.17-13	NP	<0.17-36	61,000	0
TRPH	<10-250	<10-8300	<10-18000	<10-3800	<10-17000	<10-970	<10-2000	<10-1200	<10-18000	120,000	0
Metals											
Copper	7.3-30.5	6.1-37.8	4.5-40.3	5.8-37.3	5.5-34.7	5.0-25.8	9.7-39.9	8.8-42.8	4.5-42.8	76,000	0
Lead	<5.0-21	<5.0-115	<5.0-101	<5.0-172	5-32	<5-30	<5-34.1	<5-20	<5.0-172	NA	NP
Total No. of Boring Locations with values greater than the PRGs	0	0	11	0	2	0	3	0	16	NP	16

Tr Trace amount detected.
NA Not available; reference dose and cancer slope factor not available for lead.
NP Not applicable.
NR Not reported; calculated value was greater than one million parts per million.
PRG Preliminary remediation goal; lesser concentration of non-carcinogenic effects and carcinogenic effects.
TRPH Total recoverable petroleum hydrocarbons.

FRDTB2.WK3
11/11/93

Table 3. Soil Samples with Values Greater than PRGs, OU-2 RI, Luke Air Force Base, Arizona.

PSC FT-06	TCE	BZ	1,1DCE	BZA	BZB	BZK	BZP	IND	DBA
SB-2				0-2	0-2		0-2	0-2	0-2
SB-3					0-2/8-10		0-2/8-10		0-2/8-10
SB-5	2-4						2-4		2-4
SB-6							4-6		
SB-7					0-2		0-2		0-2
SB-8				0-2	0-2	0-2	0-2/4-6		0-2
SB-9					6-8		0-2/6-8		
PSC ST-18									
SB-2		12-14/20-22	12-14						
SB-3									
PSC DP-23									
SB-4					0-2		0-2/2-4		
SB-5							0-2		

0-2/8-10 Refers to depth of samples in feet below ground surface.
Blanks indicate PRGs not exceeded.
SB Soil boring.
SD Sediment sampling location.
TCE Trichloroethene.
BZ Benzene.
BZK Benzo(k)fluoranthene.

BZP Benzo(a)pyrene.
CRY Chrysene.
IND Indeno(1,2,3-cd)pyrene.
DBA Dibenzo-anthracene.
BZA Benzo(a)anthracene.
BZB Benzo(b)fluoranthene.
1,1DCE 1,1-Dichloroethene.

TAB77.WK1
11/11/93

Table 4. Exposure Point Concentrations, Surficial Soils, Operable Unit No. 2, Luke AFB, Arizona

	Constituent	Average Exposure	Reasonable Maximum Exposure
OT-04	BEP	0.21	0.39
	Butylbenzylphthalate	0.096	0.12
	TRPHs	57	100
DP-05	TRPHs	24	41
	Lead	22	30
	Copper	27	28
FT-06	BZA	2.9	5.6
	BAB	4.7	9.4
	BAK	4.1	11
	BZP	3.1	6.0
	BZG	1.3	2.3
	Chrysene	5.4	10
	Dibenzo(a,h)anthracene	1.3	2.5
	Indeno(1,2,3-c,d)pyrene	1.0	1.8
	Acenaphthene	0.25	0.45
	Anthracene	0.33	0.59
	Dibenzofuran	0.12	0.17
	Fluoranthene	4.2	8.3
	Fluorene	0.13	0.20
	2-Methylnaphthalene	0.099	0.12
	Naphthalene	0.13	0.21
	OCDD	0.00015	0.00015
	Phenanthrene	1.4	2.7
	Pyrene	3.6	7.1
	TRPHs	46	67
	Lead	31	41
	2-Butanone	0.28	0.32
	EB	0.046	0.082
	Tol	0.029	0.036
	Xyl	0.13	0.27
FT-07	BZB	0.098	0.11
	BZG	0.096	0.11
	Chrysene	0.10	0.12
	OCDD	0.00046	0.00064
	Fluoranthene	0.096	0.11
	Pyrene	0.099	0.12
	TRPHs	18	32
ST-18	BZA	0.17	0.28
	BAB	0.27	0.49
	BAP	0.16	0.27
	Chrysene	0.33	0.61
	Indeno(1,2,3-c,d)pyrene	0.14	0.23
	BZG	0.19	0.34
	Fluoranthene	0.21	0.34
	Phenanthrene	0.12	0.15
	Pyrene	0.22	0.37
	TRPHs	49	99
DP-22	TRPHs	240	630

Table 4. Exposure Point Concentrations, Surficial Soils, Operable Unit No. 2, Luke AFB, Arizona

	Constituent	Average Exposure	Reasonable Maximum Exposure
DP-23	BZA	0.39	0.81
	BZB	0.77	1.6
	BZK	0.30	0.66
	BZP	0.28	0.50
	BZG	0.26	0.51
	BEP	0.20	0.34
	Chrysene	0.47	0.95
	Dibenzo(a,h)anthracene	0.097	0.11
	Indeno(1,2,3-c,d)pyrene	0.18	0.28
	Fluoranthene	0.54	1.2
	Phenanthrene	0.34	0.72
	Pyrene	0.65	1.5
	TRPHs	120	210
	EB	0.025	0.025
	Tol	0.025	0.025
	Xyl	0.036	0.054
SD-40	EB	0.11	0.27
	Tol	0.041	0.070
	Xyl	0.24	0.63
	2-Methylnaphthalene	0.26	0.57
	Naphthalene	0.17	0.31
	TRPHs	130	330

Concentrations in milligrams per kilogram.
BZA - Benzo(a)anthracene
BZB - Benzo(b)fluoranthene
BZK - Benzo(k)fluoranthene
BZG - Benzo(g,h,i)perylene
BZP - Benzo(a)pyrene
BEP - Bis(2-ethylhexyl)phtralate
TCA - 1,1,2,2-Tetrachloroethane
TRPHs - Total Recoverable Petroleum Hydrocarbons

PCE - Tetrachloroethene
TCE - Trichloroethene
DCE - 1,1-Dichloroethene
Tol - Toluene
Xyl - Xylenes
EB - Ethyl benzene

Table 5. Exposure Point Concentrations, Subsurface Soils, Operable Unit No. 2, Luke AFB, Arizona

	Constituent	Average Exposure	Reasonable Maximum Exposure
OT-04	BEP	0.12	0.17
	Butylbenzylphthalate	0.085	0.085
	TRPHs	5.3	5.9
DP-05	BEP	0.60	0.88
	2-Methylnaphthalene	0.33	0.58
	Naphthalene	0.25	0.46
	TRPHs	340	720
	EB	0.071	0.12
	XYL	2.5	6.4
FT-06	BZA	0.52	0.83
	BZB	0.96	1.7
	BZK	0.12	0.17
	BZP	0.62	1.0
	BEP	0.29	0.55
	Buthlbenzylphthalate	0.14	0.20
	Chrysene	0.86	1.4
	Dibenzo(a,h)anthracene	0.41	0.71
	Indeno(1,2,3-c,d)pyrene	0.57	0.96
	4-Methylphenol	0.55	1.2
	Pentachlorophenol	0.66	0.93
	Acenaphthene	0.13	0.18
	Anthracene	0.12	0.15
	BZG	0.72	1.2
	Di-n-butylphthalate	0.12	0.16
	Fluoranthene	0.66	1.0
	2-Methylnaphthalene	1.6	3.8
	Naphthalene	0.43	0.95
	Phenanthrene	0.34	0.52
	Phenol	0.29	0.54
	Pyrene	0.62	0.97
	TRPHs	1,400	3,000
	Lead	21	30
	TCA	0.041	0.069
	PCE	0.025	0.025
	TCE	0.42	1.1
	2-Butanone	0.28	0.33
	EB	0.38	0.84
	2-Hexanone	0.27	0.31
	4-Methyl-2-pentanone	0.25	0.25
	Tol	0.23	0.47
	Xyl	2.5	5.8
FT-07	BEP	0.094	0.11
	2-Methylnaphthalene	0.12	0.18
	Naphthalene	0.093	0.11
	TRPHs	170	450

Table 5. Exposure Point Concentrations, Subsurface Soils, Operable Unit No. 2, Luke AFB, Arizona

	Constituent	Average Exposure	Reasonable Maximum Exposure
ST-18	BZA	0.11	0.15
	BZB	0.12	0.15
	BEP	0.20	0.40
	Chrysene	0.14	0.22
	Benzyl alcohol	0.15	0.24
	2-Methylnaphthalene	3.2	8.1
	Naphthalene	1.5	3.8
	Pyrene	0.11	0.15
	TRPHs	2,200	5,000
	Benzene	0.31	0.86
	DCE	0.16	0.43
	EB	8.5	25
	TCA	0.45	1.3
	PCE	0.45	1.3
	Tol	16	47
	TCE	0.16	0.43
	Xyl	40	120
DP-22	Acetone	0.41	0.58
	TRPHs	5.6	6.8
DP-23	BZB	0.74	2.0
	BZP	0.50	1.3
	Chrysene	0.40	1.0
	Pyrene	0.82	2.2
	TRPHs	310	860
SD-40	TRPHs	16	22

Concentrations in milligrams per kilogram.
BZA – Benzo(a)anthracene
BZB – Benzo(b)fluoranthene
BZK – Benzo(k)fluoranthene
BZG – Benzo(g,h,i)perylene
BZP – Benzo(a)pyrene
BEP – Bis(2-ethylhexyl)phtalate
TCA – 1,1,2,2-Tetrachloroethane
TRPHs – Total Recoverable Petroleum Hydrocarbons
PCE – Tetrachloroethene
TCE – Trichloroethene
DCE – 1,1-Dichloroethene
Tol – Toluene
Xyl – Xylenes
EB – Ethyl benzene

TABLE 6
EXPOSURE ASSUMPTIONS FOR AVERAGE AND REASONABLE MAXIMUM EXPOSURE SCENARIOS
OPERABLE UNIT 2 (OU-2)
Luke Air Force Base, Arizona.

	Base Worker		Military Personnel		Future Excavation Worker	
	Average	RME	Average	RME	Average	RME
AP (carcinogens)(days/lifetime)	25,550	25,550	25,550	25,550	25,550	25,550
AP (non-carcinogens)(days/lifetime)	2,190	9,125	1,095	1,825	42	84
BR (m^3/hr)	2.5[a]	2.5[a]	2.5[a]	2.5[a]	2.5[a]	2.5[a]
BW (kg)	70[a]	70[a]	70[a]	70[a]	70[a]	70[a]
Cs (mg/kg)	b	c	b	c	d	e
ED (years)	6[f]	25[a]	3[f]	5[f]	1[g]	1[g]
EF (days/year)	12[g]	24[g]	250[a]	250[a]	30[g]	72[g]
ET (hours/day)	2[g]	4[g]	8[a]	8[a]	8[a]	8[a]
IR (mg/day)	50[a]	50[a]	50[a]	50[a]	100[g]	480[a]
SAR (mg/cm^2-day)	0.2[h]	1[h]	0.2[h]	1[i]	0.2[i]	1[i]
SSA (cm^2)	3,160[h]	3,160[h]	990[i]	990[i]	3,160[i]	3,160[i]

a USEPA (1991a).
b Average concentration in surficial soils.
c Lesser of maximum concentration or 95 percent UCL on the arithmetic average.
d Average concentration in subsurface soils.
e Lesser of maximum concentration or 95 percent UCL on the arithmetic average.
f Information from Luke AFB (Geraghty & Miller, 1992).
g Professional judgment based on available information.
h USEPA (1992).
i USEPA (1989b).
AP Averaging period.
BR Breathing rate.
BW Body weight.
cm^2 Square centimeters.
Cs Soil concentration.
ED Expposure duration.
EF Exposure frequency.
ET Exposure time.
IR Soil ingestion rate.
kg Kilograms.
m^3/hr Cubic meters per hour.
mg Milligrams
mg/day Milligrams per day.
mg/cm^2-day Milligram per square centimeter-day.
SAR Skin adherence rate.
SSA Skin surface area.
UCL Upper confidence limit.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
<u>VOCs</u>				
Acetone	Critical Effects: Skin and eye irritation, nausea, vomiting, headache.	Critical Effects: EEG changes, kidney damage, metabolic changes. Data Summary: The oral RfD was based on a rat study in which a LOAEL of 500 mg/kg/day was reported.	Class D; inadequate evidence of carcinogenicity.	Developmental: No data available. Reproductive: No data available. Mutagenicity: No data available.
Ethylbenzene	Critical Effects: Throat irritation, chest constriction, eye irritation, dizziness, vertigo.	Critical Effects: Increases in kidney to body weight ratios were seen in rats. Data Summary: The oral RfD is based on a NOEL of 97 mg/kg/day in rats. The inhalation RfD is based on a NOEL of 100 ppm in rats.	Class D; inadequate evidence of carcinogenicity.	Developmental: Increases in the incidence of fetal anomalies were seen in rats, mice, and rabbits. Reproductive: No data available. Mutagenicity: Negative results were seen in various *S. typhirium* assays.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Tetrachloroethene	Critical Effects: Eye irritation, headache, dizziness, hypertension.	Critical Effects: Cirrhosis, hepatitis, fatty degeneration of the liver, renal dysfunction. Data Summary: The RfD is based on a NOAEL of 14 mg/kg/day in mice.	Class B2; probable human carcinogen.	Developmental: Increases in fetal resorptions were seen in rats. Reproductive: No effects reported. Mutagenicity: Negative results reported for human chromosome aberrations.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Toluene	**Critical Effects:** Narcosis, CNS dysfunction, eye and skin irritation. **Comments:** Toluene is abused for its narcotic effects. This usually occurs with sniffing toluene-based glue.	**Critical Effects:** Decreased blood leukocytes, renal tubular acidosis, ataxia, tremors, impaired speech, hearing, and vision. **Data Summary:** The oral RfD was derived from a 13-week rat gavage study. A NOAEL of 223 mg/kg/day was developed. Changes in liver and kidney weights were seen at a LOAEL of 446 mg/kg/day. The inhalation RfD is based on human data in which a LOAEL of 88 ppm caused CNS toxicity.	Class D; no evidence of carcinogenicity.	**Developmental:** CNS anomalies, growth retardation. **Reproductive:** No evidence. **Mutagenicity:** Results were negative or inconclusive for various tests.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Xylenes	Critical Effects: Dyspnea, nose, skin, and throat irritation, nausea, vomiting, CNS depression, moderately toxic.	Critical Effects: Increased hepatic weights in rats, renal toxicity, tremors, labored breathing. Data Summary: The oral RfD was based on a chronic rat gavage study in which a NOAEL of 250 mg/kg/day was reported. At higher doses, hyperactivity occurred.	Class D; inadequate evidence of carcinogenicity.	Developmental: Fetal hemorrhages and decreased fetal weights in rats. Reproductive: No evidence exists. Mutagenicity: Negative results were seen in various tests.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
BNAs				
Anthracene	**Critical Effects:** No data available.	**Critical Effects:** Humans consuming anthracene-containing laxatives developed melanosis of the colon and rectum. **Data Summary:** The oral RfD is based on a subchronic study in mice in which a NOEL of 1,000 mg/kg/day was established.	Class D; inadequate evidence of carcinogenicity.	**Developmental:** No data available. **Reproductive:** No data available. **Mutagenicity:** Negative results were seen in various prokaryote assays.
Benzo(a)pyrene	**Critical Effects:** No data available. **Comments:** Used as a surrogate for carcinogenic PAHs.	**Critical Effects:** Aplastic anemia. **Data Summary:** No data available.	Class B2; probable human carcinogen. The oral cancer slope is based on mice developing stomach tumors. Respiratory tract tumors resulted in hamsters upon inhalation.	**Developmental:** No data available. **Reproductive:** Decreased fertility in both male and female mice. **Mutagenicity:** Tested positive in both animal and bacterial assays.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Bis(2-ethylhexyl)-phthalate	Critical Effects: Eye and skin irritant, poly-neuropathies.	Critical Effects: Hepatotoxicity, hepatitis. Data Summary: The RfD is based on a LOAEL of 19 mg/kg/day in which the liver weight of guinea pigs increased.	Class B2; probable human carcinogen. In a 103 week study in mice, liver tumors developed.	Developmental: In mice, bis(2-ethylhexyl)-phthalate caused a decrease in fetal body weight. Reproductive: It causes testicular effects in both rats and mice. Mutatagenicity: Chromosomalaberrations and sister chromatid exchange were found in hamster cells exposed to bis(2-ethylhexyl)-phthalate.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Butylbenzylphthalate	Critical Effects: No data available.	Critical Effects: No data available. Data Summary: The oral RfD is based on a rat study in which a NOAEL of 159 mg/kg/day was determined.	Class C; probable human carcinogen.	Developmental: No data available. Reproductive: No data available. Mutagenicity: No data available.
Di-n-butylphthalate	Critical Effects: No data available.	Critical Effects: Increase in liver enzymes. Data Summary: The oral RfD is based on a rat study in which a NOAEL of 125 mg/kg/day was determined.	Class D; inadequate evidence of carcinogenicity.	Developmental: Increases in the number of fetal resorptions were seen in mice. Reproductive: Decreases in testicular weight and sperm activity have been reported in mice. Mutagenicity: Weakly mutagenic in in vitro studies.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Fluoranthene	Critical Effects: No data available; mildly toxic.	Critical Effects: No data available. Data Summary: The oral RfD is based on a study in mice in which a NOAEL of 125 mg/kg/day was determined. Kidney and liver toxicity resulted in a LOAEL of 250 mg/kg/day. Comments: There is limited bioaccumulation due to rapid metabolism and excretion.	Class D; inadequate evidence of carcinogenicity.	Developmental: No data available. Reproductive: No data available. Mutagenicity: Negative results were detected in bacteria tests.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
n-Hexane (TRPH)	Critical Effects: Hallucinations after inhalation, parasthesia, muscle weakness. Comments: Used as a surrogate for total recoverable petroleum hydrocarbons (TRPHs).	Critical Effects: Motor neuropathies, anorexia. Data Summary: The oral RfD is derived from a rat study in which NOAEL of 570 mg/kg/day was reported. A NOAEL of 58 ppm from human epidemiological studies was used to derive an inhalation RfD.	Cancer Effects: Class D; inadequate evidence of carcinogenicity.	Developmental No data available. Reproductive: Reproductive dysfunction in men. Mutagenicity: No data available.
Phenanthrene	Critical Effects: Increased liver enzyme activity; slightly toxic.	Critical Effects: No data available.	Class D; inadequate evidence of carcinogenicity.	Developmental: No data available. Reproductive: No data available. Mutagenicity: Positive results in bacteria tests.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Pyrene	Critical Effects: No data available; slightly toxic. Comments: Pyrene is used as the surrogate for non-carcinogenic PAHs without toxicity values.	Critical Effects: Fatty and enlarged liver. Data Summary: The RfD is based on a mouse study in which a NOAEL of 75 mg/kg/day was developed.	Class D; inadequate evidence of carcinogenicity.	Developmental: No data available. Reproductive: No data available. Mutagenicity: Negative results were seen in bacteria tests.
<u>PCBs</u>				
PCBs	Critical Effects: Chloracne, eye and skin irritation.	Critical Effects: Increase in serum liver-related enzymes. Increases in urinary porphyrin. Data Summary: No data available.	Class B2, probable human carcinogen. This is based on dietary studies in rats with aroclor 1260.	Developmental: Lower mean birth weights, lengths and gestational ages in children born to women chronically exposed to PCBs. Reproductive: Decreases in liver sizes were seen in various animal species. Mutagenicity: Negative results in *S. typhimurium* and in vivo studies.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Metals				
Antimony	**Critical Effects:** Lung inflammation, eye and skin irritation, vomiting.	**Critical Effects:** Rhinitis, bronchitis, emphysema. **Data Summary:** The oral RfD is based on a rat study in which a NOAEL of 0.35 mg/kg/day was developed.	Class D; inadequate evidence of carcinogenicity.	**Developmental:** Increases in spontaneous abortions. **Reproductive:** Disturbances in the menstrual cycle of women occupationally exposed. **Mutagenicity:** No data available.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Arsenic	**Critical Effects:** Gastro-intestinal disturbances (nausea, diarrhea, abdominal pain), cardiac arrhythmias, vomiting, and vertigo; moderately toxic. **Comments:** When arsenic is heated or comes in contact with acids, it emits highly toxic fumes. Toxicity varies depending on the form.	**Critical Effects:** Polyneuro-pathies (both motor and sensory in the extremities), anorexia, hyperpigmenta-tion, hepatitis, anemia. **Data Summary:** The oral RfD is based on a human epidemiological study in which a NOAEL of 9 µg/kg/day was determined. **Comments:** Arsenic accumulates in hair and nails. This can be a useful indicator of chronic toxicity.	Class A; human carcinogen via inhalation. This is based on human epidemiological data from smelter workers. It is also a known carcinogen by the oral route.	**Developmental:** Increases in spontaneous abortions were seen in women living near smelter plants. **Reproductive:** No evidence suggesting toxicity. **Mutagenicity:** Chromoso-mal aberrations in humans and laboratory animals.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Beryllium	**Critical Effects:** Chemical pneumonitis, contact dermatitis.	**Critical Effects:** Granulomatous lesions in the lung. **Data Summary:** The oral RfD is based on a rat study in which a NOAEL of 0.54 mg/kg/day was determined.	Class B2; probable human carcinogen. Oral studies indicate that beryllium produces all types of tumors, but exposure via inhalation results in tumors in the respiratory tract.	**Developmental:** Increases in fetal mortality were reported in rats. **Reproductive:** No evidence. **Mutagenicity:** Beryllium sulfate can induce sister chromatid exchange and chromosomal aberrations.

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TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Cadmium	Critical Effects: Gastrointestinal distress, lung irritation; moderately toxic. Comments: Toxicity depends on the chemical and physical form. Soluble forms (cadmium chloride, cadmium oxide) tend to be more toxic than insoluble forms (cadmium sulfide).	Critical Effects: Lung, kidney, liver, bone, testes, immune system, cardiovascular system. Data Summary: Cadmium has two oral RfDs. Studies involving humans resulted in proteinuria. The water RfD is a result of a NOAEL of 0.005 mg/kg/day. The food NOAEL of 0.01 mg/kg/day is a result of toxicokinetic modelling using 2.5 percent absorption from food. Comments: The lung and kidney are most likely affected from inhalation exposure. Long-term exposure to concentrations below 0.02 mg/m³ is not likely to affect the lung or kidney.	Class B1; probable carcinogen, inhalation exposure only. Limited evidence of lung cancer observed in smelter workers. Lung tumors and mammary tumors have been reported in laboratory studies.	Developmental: Not shown to cause developmental effects in humans. Some evidence from animal studies but most oral and inhalation studies have not shown developmental or fetotoxic effects. Reproductive: None reported in humans. Some decreased reproductive success reported in a few animal studies. Mutatagenicity: Conflicting results from human data. Studies in bacteria and yeast are inconclusive. Positive responses in mutation assays with hamster cells and mouse lymphoma cells.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Chromium	Critical Effects: Dermatitis, respiratory irritation, renal tubular necrosis. Comments: Toxicity depends on valence form, with Chromium VI exerting more toxicity.	Critical Effects: Ulceration of the nasal cavity, eczema. Data Summary: The RfD was based on a 1-year study in rats. This was based on a NOAEL of 2.4 mg/kg/day.	Class A; human carcinogen for inhalation exposure. The cancer slope factor is a result of human epidemio-logical data showing an increase in lung cancer.	Developmental: None observed. Reproductive: None observed. Mutagenicity: Positive results in human red blood cells, Chinese hamster cells, and bacteria tests for Chromium VI.
Copper	Critical Effects: Metal fume fever, gastritis, discoloration of skin and hair.	Critical Effects: Anemia. Data Summary: There is no RfD available.	Class D; inadequate evidence of carcino-genicity.	Developmental: Increases in fetal mortality were seen in both mice and minks. Reproductive: In a rat study, increases in rat weights were seen. Sexual impotence was seen in factory workers. Mutagenicity: No evidence was found in humans or animals.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Cyanide	Critical Effects: Parasthesis, abdominal pain, tachycardia, cyanosis; highly toxic. Comments: Toxicity depends on the form of cyanide, whether it be with hydrogen, potassium, or sodium.	Critical Effects: Optic atrophy, pernicious anemia. Data Summary: The RfD was based on a NOAEL of 10.8 mg/kg/day in rats.	Class D; inadequate evidence of carcinogenicity.	Developmental: Decreases in fetal growth and body weight were detected in rats. Reproductive: No data available. Mutagenicity: Negative results were seen in vitro.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Lead	Critical Effects: Reversible kidney damage. Comments: Toxicity is dependent on its accumulation in the blood.	Critical Effects: Brain encephalopathy, peripheral neuropathies, kidney damage, learning disabilities, anemia. Data Summary: There is no RfD for lead. A blood lead model is used to determine toxicity. Comments: Children have a greater risk of toxicity due to greater absorption and less developed blood brain barrier.	Class B2; probable carcinogen. No slope factor exists.	Developmental: A relationship in the decreased gestation period and fetal weights to maternal blood lead levels was seen. Reproductive: Increases in spontaneous abortions were detected in women living near smeltering plants. In men, decreases in sperm count were detected. Mutagenicity: Positive results in sister chromatid exchange and chromosomal aberrations.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Nickel	Critical Effects: Nausea, vomiting, diarrhea, allergic contact dermatitis, asthma, conjunctivitis.	Critical Effects: Dermatitis. Data Summary: The oral RfD is based on a chronic rat feeding study in which a NOAEL of 5 mg/kg/day was determined.	Class A; human carcinogen by inhalation. It results in respiratory tract carcinomas.	Developmental: Mice exposed to nickel in their drinking water had an increase in spontaneous abortions. Reproductive: Testicular degeneration was noted in mice upon inhalation of nickel. Mutagenicity: Positive results were seen in human lymphocytes for chromosomal aberrations and sister chromatid exchange.

Footnotes appear on page 20.

TABLE 7
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

Constituent	Acute Toxicity Summary	Chronic Toxicity Summary	Cancer Potential	Other
Silver	**Critical Effects:** Respiratory irritation, abdominal pain.	**Critical Effects:** Hypertension, argyria. **Data Summary:** The RfD is based on an epidemiological study in humans. In a 1 to 3-year therapeutic study, a LOAEL of 0.0052 mg/kg/day was established.	Class D; inadequate evidence of carcinogenicity.	**Developmental:** No data available. **Reproductive:** No data available. **Mutagenicity:** Chromosomal aberrations were seen in plants.
Zinc	**Critical Effects:** Dyspnea, cough, vomiting.	**Critical Effects:** Copper deficiency in blood. **Data Summary:** The RfD was based on human epidemiological data involving therapeutic doses causing anemia. **Comments:** Zinc is an essential element in our daily diet.	Class D; inadequate evidence of carcinogenicity.	**Developmental:** Reduced fetal weights and copper deficiency in rats. **Reproductive:** Decreased level of maternal copper and iron. **Mutagenicity:** Chromosomal aberrations in rats exposed to 650 mg/kg/day in their diet.

Footnotes appear on page 20.

TABLE E-1
TOXICITY SUMMARIES FOR CONSTITUENTS OF POTENTIAL CONCERN
OPERABLE UNIT 2 (OU-1)
Luke Air Force Base, Arizona

References: ATSDR documents; GAP, 1991; IRIS, 1993; NTP, 1989; Sax and Lewis, 1989; USEPA, 1993.

Limited information was available on the PAHs. Benzo(a)pyrene and pyrene were used as surrogates for PAHs lacking individual toxicity information. This includes benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, dibenzo(a,h) anthracene, and indeno(1,2,3-c,d)pyrene.

CNS	Central nervous system.	NOAEL	No observed adverse effect level.
EEG	Electroencephalogram.	NOEL	No observed effect level.
LOAEL	Lowest observed adverse effect level.	PAHs	Polycyclic aromatic hydrocarbons.
mg/kg	Milligrams per kilogram.	ppm	Parts per million
mg/kg/day	Milligrams per kilogram per day.	RfD	Reference dose.

TABLE 8.
CURRENT AND HYPOTHETICAL FUTURE RISK FOR EXPOSURE TO SOIL AT OPERABLE UNIT 2 (OU-2)
Luke Air Force Base, Arizona

	Base Worker				Military Personnel				Excavation Worker			
	ELCR		HI		ELCR		HI		ELCR		HI	
PSC	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME	Average	RME
OT-04												
Current	1E-11	7E-10	0.00005	0.0006	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	5E-12	8E-11	0.00002	0.0002
DP-05												
Current	NA	NA	0.00004	0.0003	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	2E-11	4E-10	0.001	0.01
FT-06												
Current	3E-07	6E-06	0.0001	0.001	3E-06	1E-05	0.002	0.006	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	5E-08	1E-06	0.005	0.05
FT-07												
Current	3E-09	4E-08	0.00002	0.0002	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	4E-12	5E-11	0.0005	0.007
ST-18 [a]												
Current	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	2E-08	2E-07	0.00005	0.0006	*	*	*	*	4E-07	3E-06	0.02	0.1
DP-22												
Current	NC	NC	0.0002	0.004	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	NC	NC	0.00002	0.0001
DP-23												
Current	4E-08	6E-07	0.0001	0.001	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	*	*	*	*	*	*	*	*	2E-08	6E-07	0.0009	0.01
SD-40 [a]												
Current	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP	NAP
Future	NC	NC	0.0001	0.002	NC	NC	0.002	0.008	NC	NC	0.00004	0.0004

Footnotes appear on page 2.

TABLE 8.
CURRENT AND HYPOTHETICAL FUTURE RISK FOR EXPOSURE TO SOIL AT OPERABLE UNIT 2 (OU-2)
Luke Air Force Base, Arizona

[a]	Soils at this PSC are paved.
COC	Constituent of concern.
ELCR	Excess lifetime cancer risk.
HI	Hazard index.
NA	Toxicity value not available.
NAP	Not an applicable receptor.
NC	No carcinogenic COCs were identified.
PSC	Potential Source of Contamination.
RME	Reasonable maximum exposure.
*	Future risk the same as current risk.

Table 9. Predicted Blood Lead Levels for Exposure to Soils at PSCs, OU-2 RI, Luke Air Force Base, Arizona

PSC	Predicted Blood Levels Average Exposure (ug/dL)	RME (ug/dL)
DP-05		
Current Base Worker	0.028	0.075
FT-06		
Current Base Worker	0.039	0.10
Military Personnel	0.039	0.10
Hypothetical Future Worker	0.16	0.98

ug/dL - Micrograms per deciliter.
PSC - Potential source of contamination.
RME - Reasonable maximum exposure.

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Table 10. Summary of Transport Parameters and Results of Vadose Zone Solute Transport Simulations, OU-2 RI/FS, Luke AFB, Arizona

Compound	Maximum Depth of Contamination (feet)	Compound Half-Life (yr)	Maximum Observed Soil Concentration (mg/kg)	Estimated Maximum Soil Water Concentration(mg/L)[1]	Solubility Limit (mg/L)[2]	Root Filename for Computer Runs in Appendix A	Maximum Simulated Concentration at Bottom of Vadose Zone (mg/L)[3]	Maximum Simulated Concentration at Bottom of Vadose Zone (mg/L)[4]	Maximum Simulated Concentration at Bottom of Vadose Zone (mg/L)[5]
Benzene	60	2.0	6.4	108.8	1780	LUKE-BZ	0.1543×10^{-25}	0.1543×10^{-25}	0.1269×10^{-20}
Ethylbenzene	60	0.0767	84	1428	150 - 200	LUKE-EB	0.4409×10^{-220}	0.6175×10^{-221}	0.2762×10^{-170}
Toluene	60	0.0767	200	3400	500 - 600	LUKE-TO	0.1716×10^{-229}	0.3027×10^{-230}	0.3998×10^{-171}
Xylene	60	1.0	380	6460	150 - 200	LUKE-XY	0.2341×10^{-31}	0.7246×10^{-33}	0.1100×10^{-33}
1,1-Dichloro-ethene	20	0.362	1	17	400	LUKE-DCE	0.3713×10^{-86}	0.3713×10^{-86}	0.7996×10^{-78}
Benzo(k)fluor-anthene	4	11.7	73	1241	0.00055	LUKE-BF	0.0	0.0	0.0

[1]Maximum soil water concentration estimated assuming no sorption of observed contaminant mass on soil.
[2]From "Groundwater Chemicals Desk Reference," J.H. Montgomery & L.M. Welkom, 1990, Lewis Publishers.
[3]Source concentration at maximum ground water concentration level, organic carbon content 0.1%.
[4]Source concentration at the lesser value of the maximum ground water concentration level and the solubility limit, organic carbon content 0.1%.
[5]Source concentration at the lesser value of the maximum ground water concentration level and the solubility limit, organic carbon content 0.01%.

Table 11. Chemical Parameters for COCs, OU-2 RI, Luke Air Force Base, Arizona.

Compound	CAS Registry Number	log K_{ow}	log K_{oc}	Retardation Factor[1]	Retardation Factor[2]
Volatile Organic Compounds (VOC)					
Acetone	67-64-1	-0.24	-0.43	1.002	1.0002
Benzene	71-43-2	1.95 - 2.15	1.69 - 2.00	1.20 - 1.42	1.02 - 1.042
2-Butanone	78-93-3	0.26 - 0.29	0.09	1.005	1.0005
1,1-Dichloroethene	75-35-4	1.48 - 2.13	1.81	1.27	1.027
Ethyl-Benzene	100-41-4	3.05 - 3.15	1.98 - 2.41	1.40 - 2.07	1.040 - 1.11
2-Hexanone	591-78-6	1.38	2.13	1.56	1.056
4-Methyl-2-pentanone	108-10-1	1.09	0.79	1.03	1.003
1,1,2,2-Tetrachloroethane	79-34-5	2.39 - 2.56	1.66 - 2.07	1.19 - 1.49	1.019 - 1.049
Toluene	108-88-3	2.11 - 2.80	2.06 - 2.18	1.48 - 1.63	1.048 - 1.063
Trichloroethene	79-01-6	2.29 - 3.30	1.81 - 2.10	1.27 - 1.53	1.027 - 1.053
Xylenes	1330-20-7	2.77 - 3.20	2.11 - 3.20	1.53 - 7.62	1.053 - 1.662
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	83-32-9	3.92 - 4.33	1.25	1.07	1.007
Anthracene	120-12-7	4.34 - 4.54	4.21 - 4.41	68.7 - 108.4	7.77 - 11.74
Benzo(a)anthracene	56-55-3	5.9	6.14	5,766	578
Benzo(b)fluoranthene	205-99-2	6.57	5.74	2,296	231
Benzo(k)fluoranthene	207-08-9	6.85	6.64	18,233	1,824
Benzo(g,h,i)perylene	191-24-2	NA	NA	NA	NA
Benzo(a)pyrene	50-32-8	5.81 - 6.50	5.60 - 6.29	1,664 - 8,145	167 - 815
Benzyl alcohol	100-51-6	1.10	1.98	1.40	1.04
Bis(2-ethylhexyl)phthalate	117-81-7	4.20 - 5.11	5.0	419	42.8
Butyl benzyl phthalate	85-68-7	4.05 - 4.92	1.83 - 2.54	1.28 - 2.45	1.028 - 1.15
Chrysene	218-01-9	5.60 - 5.91	5.39	1,026	103
Dibenz(a,h)anthracene	53-70-3	5.97 - 6.50	6.22	6,932	694
Dibenzofuran	132-64-9	4.12 - 4.31	3.91 - 4.10	34.9 - 53.6	4.39 - 6.26
Di-n-butyl phthalate	84-74-2	4.31 - 4.79	3.14	6.77	1.58
Fluoranthene	206-44-0	5.22	4.62	175	18.4

Table 11. Chemical Parameters for COCs, OU-2 RI, Luke Air Force Base, Arizona (con't).

Compound	CAS Registry Number	log K_{ow}	log K_{oc}	Retardation Factor[1]	Retardation Factor[2]
Fluorene	86-73-7	4.12 - 4.38	3.70	21.9	3.09
Indeno(1,2,3-c,d) pyrene	193-39-5	5.97 - 7.70	7.49	129,071	12,908
2-Methylnaphthalene	91-57-6	3.86 - 4.11	3.87 - 3.93	32.0 - 36.5	4.10 - 4.55
4-Methylphenol	106-44-5	1.93 - 1.99	1.34	1.09	1.009
Naphthalene	91-20-3	3.01 - 4.70	2.74 - 3.50	3.30 - 14.2	1.23 - 2.32
Pentachlorophenol	87-86-5	3.69 - 5.86	2.95 - 2.96	4.72 - 4.81	1.37 - 1.38
Phenanthrene	85-01-8	4.16 - 4.57	3.72 - 4.59	22.9 - 163.5	3.19 - 17.25
Phenol	108-95-2	1.46 - 1.48	1.24 - 1.43	1.07 - 1.11	1.007 - 1.011
Pyrene	129-00-0	4.88 - 5.32	4.66 - 5.13	192 - 564	20.1 - 57.3

[1] Fraction Organic Carbon (foc) = 0.1%
[2] Fraction Organic Carbon (foc) = 0.01%
NA - Data are Not Available

Table 12. Enviromental Degradation Rates for COCs, OU-2 RI, Luke Air Force Base, Arizona.

Compound	CAS Registry Number	Aerobic Half-Life in Soil (days)		Half-Life in Ground Water (days)	
		Low	High	Aerobic	Anaerobic
Volatile Organic Compounds (VOC)					
Acetone	67-64-1	1	7	2	14
Benzene	71-43-2	5	16	10	730
2-Butanone	78-93-3	1	7	2	14
1,1-Dichloroethene	75-35-4	28	180	56	132
Ethyl-Benzene	100-41-4	3	10	7	28
2-Hexanone	591-78-6	1	7	2	14
4-Methyl-2-pentanone	108-10-1	NA	NA	NA	NA
1,1,2,2-Tetrachloroethane	79-34-5	0.45	45	10.7	45
Toluene	108-88-3	4	22	7	28
Trichloroethene	79-01-6	180	365	326	1643
Xylenes	1330-20-7	7	28	14	365
Polycyclic Aromatic Hydrocarbons (PAH)					
Acenaphthene	83-32-9	12.3	102	24.6	204
Anthracene	120-12-7	50	460	100	920
Benzo(a)anthracene	56-55-3	102	679	204	1361
Benzo(b)fluoranthene	205-99-2	360	610	719	1219
Benzo(k)fluoranthene	207-08-9	909	2139	1821	4271
Benzo(g,h,i)perylene	191-24-2	590	650	1168	1314
Benzo(a)pyrene	50-32-8	57	1.45	114	1059
Benzyl alcohol	100-51-6	NA	NA	NA	NA
Bis(2-ethylhexyl) phthalate	117-81-7	5	23	10	389
Butyl benzyl phthalate	85-68-7	1	7	2	180
Chrysene	218-01-9	372	993	745	2000
Dibenz(a,h)anthracene	53-70-3	361	942	723	1880
Dibenzofuran	132-64-9	7	28	8.5	35

Table 12. Enviromental Degradation Rates for COCs, OU-2 RI, Luke Air Force Base, Arizona (con't).

Compound	CAS Registry Number	Aerobic Half-Life in Soil (days)		Half-Life in Ground Water (days)	
		Low	High	Aerobic	Anaerobic
Di-n-butyl phthalate	84-74-2	2	23	2	23
Fluoranthene	206-44-0	140	440	280	880
Fluorene	86-73-7	32	60	64	120
Indeno(1,2,3-c,d) pyrene	193-39-5	599	730	1201	1460
2-Methylnaphthalene	91-57-6	NA	NA	NA	NA
4-Methylphenol	106-44-5	NA	NA	NA	NA
Naphthalene	91-20-3	16.6	48	1	258
Pentachlorophenol	87-86-5	23	178	46	1533
Phenanthrene	85-01-8	16	200	32	402
Phenol	108-95-2	1	10	0.5	7
Pyrene	129-00-0	210	1898	420	3796

NA - Data are Not Available

Table 13. Development of Remedial Measures for Soil, Operable Unit No.2, Luke Air Force Base, Arizona.

Screened Technology	Remedial Measure[1]											
	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
None	X	-	-	-	-	-	-	-	-	-	-	-
Access Restrictions	-	X	-	-	-	-	-	-	-	-	-	-
Monitoring	-	X	X	X	X	X	X	X	X	X	X	X
Capping	-	-	X	X	-	-	-	-	-	-	-	-
Surface Controls	-	-	X	X	-	-	-	-	-	-	-	-
Excavation	-	-	-	-	X	X	X	X	X	-	X	-
On-site Disposal	-	-	-	-	-	X	-	X	X	-	-	-
Off-site Disposal	-	-	-	-	X	-	X	-	-	-	X	-
Stabilization	-	-	-	-	-	X	X	-	-	-	-	-
Biological Treatment	-	-	-	-	-	-	-	X	-	-	-	-
Thermal Treatment	-	-	-	-	-	-	-	-	X	-	-	-
In-situ Stabilization	-	-	-	X	-	-	-	-	-	-	-	-
In-situ Extraction	-	-	-	-	-	-	-	-	-	X	X	-
In-situ Biological Treatment	-	-	-	-	-	-	-	-	-	-	-	X

1. X = Technology used as part of remedial measure.
   - = Technology not used as part of remedial measure.

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Table 14A. **List of Constituents of Concern in Soil and Their PRGs.**

Constituents of Concern	PRGs (mg/kg)
Acetone	200,000
Acenaphthene	120,000
Anthracene	610,000
Antimony	NA
Arsenic	NA
Barium	NA
Benzo(a)anthracene	7.8
Benzene	1.2
Benzo(a)pyrene	0.78
Benzo(b)fluoranthene	7.8
Benzo(k)fluoranthene	7.8
Benzo(g,h,i)perylene	61,000
Benzyl Alcohol	610,000
Beryllium	NA
Bis(2-ethylhexyl)phthalate	410
Butyl Benzyl Phthalate	410,000
Cadmium	NA
Chromium (total)	NA
Chrysene	780
Copper	76,000
Dibenzo(a,h)anthracene	0.78*
Dibenzofuran	61,000
1,1-Dichloroethene	0.02
Di-N-Butylphthalate	200,000

Table 14A. List of Constituents of Concern in Soil and Their PRGs.

Constituents of Concern	PRGs (mg/kg)
Dioxins (OCDD)	0.038
Ethylbenzene	4,800
Fluoranethene	82,000
Fluorene	82,000
Furans	NA
Indeno(1,2,3-cd)pyrene	7.8
Lead	NA
4-Methylphenol	NA
4-Methyl-2-pentanone	1900
Mercury	NA
Methyl Butyl Ketone (2-Hexanone)	NA
Methyl Ethyl Ketone (2-Butanone)	1900
Methyl Isobutyl ketone	NA
Methylene Chloride	NA
Naphthalene	82,000
2-Methylnaphthalene	61,000
Nickel	NA
Pentachlorophenol	48
Phenanthrene	61,000
Phenol	NA
Pyrene	61,000
Selenium	NA
Silver	NA
1,1,2,2-Tetrachloroethane	0.69
Tetrachloroethene (PCE)	39

Table 14A. List of Constituents of Concern in Soil and Their PRGs.

Constituents of Concern	PRGs (mg/kg)
Thallium	NA
Toluene	2,200
TRPH	120,000
Trichloroethene (TCE)	5.5
Xylene (total)	NR
Zinc	NA

NA = Not applicable.
NR = Not reported.
PRGs = Preliminary remediation goals identified by the risk assessment.
COCs = Constituents of concern identified by the risk assessment.
TRPH = Total recoverable petroleum hydrocarbons.

Table 14b. Location-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A[a]	RAR[b]	TBC[c]
Within area where action may cause irreparable harm, loss, or destruction of significant artifacts	Action to recover and preserve artifacts.	Alteration of terrain that threatens significant scientific, prehistoric, historic, or archaelogical data.	National Archaelogical and Historial Preservation Act (16 USC Section 469); 36 CFR Part 65	Artifacts have been found in areas near PSC-DP-23 but not in PSC-DP-23	S-3, S-8, S-12		
Hazardous waste site	Actions to limit worker exposure to hazardous wastes or hazardous substances, including training and monitoring.	Construction, operations and maintenance, or other activities with potential worker exposure.	29 CFR 1910.120		S-3, S-8, S-12		
Critical habitat upon which endangered species or threatened species depend	Action to conserve endangeredspecies or threatened species, including consultation with the Department of the Interior	Determination of endangered species or threatened species.	Endangered Species Act of 1973 (16 USC 1531 et seq.); 50 CFR Part 200, 50 CFR Part 402 (Federal)	No endangered species are known to exist on the site. However, two candidate species that may be considered for future listings as endangered species, the Yavapai Pocket Mouse and Mexican Garter Snake, may exist in the vicinity of the Base.	S-3, S-8, S-12		

[a] Applicable Requirements for Alternatives S-3, S-8, or S-12 as noted.
[b] Relevant and Appropriate Requirements for Alternatives S-3, S-8, or S-12 as noted.
[c] Criteria To Be Considered for Alternatives S-3, S-8, or S-12.

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A[a]	RAR[a]	TCB[a]
Soil Venting and Aeration	Hydrogen Sulfide Discharge Standards	Point Source Discharge	40 CFR Part 61 (Federal)		S-8, S-12		
	Odor Regulations Leading to Nuisance	None	CAA Section 101 (Federal)		S-8, S-12		
	Air Pollution Emission Standards	Point Source Discharge Point Source Discharge	CAA Section 109 (Federal)		S-8, S-12		
	Air Pollution Emission for Particulate Matter	Nonpoint Source	40 CFR Part 50.6 (Federal)		S-8, S-12		
	Air Pollution Emission Standards	Point Source	A.A.C. R18-2-401 (State)		S-8, S-12		
	Air Pollution Emission Standards for Volatile Organics and Gaseous Contaminants; air permit if hydrocarbon emissions exceed 3 lbs./day; aeration of soil if less than 100 cubic yards		Maricopa County Air Pollution Control Reg. III, Rules: 200, 210, 220, 300, 310, 320, and 330				S-8, S-12
	Registration of Temporary Treatment Facility	Temporary Soil Treatment Facility	Arizona Department of Environmental Quality of Waste Management Guidelines (1990)		S-8, S-12		

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A*	RAR*	TCB*
Container Storage (On-Site)	Containers of hazardous waste must be: • Maintained to good condition • Compatible wish hazardous waste to be stored • Closed during storage (except to add or remove waste)	RCRA hazardous waste (listed or characteristic) held for a temporary period before treatment, disposal, or storage elsewhere (40 CFR 264.10) in a container (i.e., any portable device in which a material is stored, transported, disposed of, or handled).	40 CFR 264.171 40 CFR 264.172 40 CFR 264.173	These requirements are applicable or relevant and appropriate for any contaminated soil or treatment system waste that might be containerized and stored on site prior to treatment or final disposal. Soil containing a listed waste must be managed as if it were a hazardous waste so long as it contains the listed waste.		S-8	
	Inspect container storage areas weekly for deterioration.		40 CFR 264.174			S-8	

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A*	RAR*	TCB*
	Place containers on sloped, crack-free base, and protect from contact with accumulated liquid. Provide containment system with a capacity of 20 percent of the volume of containers of free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.		40 CFR 264.175			S-8	
	Keep containers of ignitable or reactive waste at least 50 feet from the facility's property line.		40 CFR 264.176			S-8	
	Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier.		40 CFR 264.177			S-8	
	At closure, remove all hazardous waste and residues from the containment system, and decontainment system, and decontaminate or remove all containers, liners.		40 CFR 268.50			S-8	

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A[a]	RAR[b]	TCB[c]
	Storage of banned wastes must be in accordance with 40 CFR 268. When such storage occurs beyond one year, the owner/operator bears the burden of proving that such storage is solely for the purpose of accumulating sufficient quantities to allow for proper recovery, treatment, and disposal.					S-8	
Surface Water Control	Prevent run-on and control and collect run-off from a 24-hour 25-year storm (and treatment facility).	RCRA hazardous waste treated, stored, or disposed after the effective date of the requirements.	40 CFR 264.273 (c) (d)			S-8	
Storm Water Permitting	Operations as defined in the regulations that discharge storm water from its facility must perform sampling, submit a permit application, and comply with all permit requirements, water quality standards, and effluent limitations set by Best Achievable Technology (BAT).	Discharge of storm water from industrial facilities and large construction sites (greater than five acres in area).	40 CFR 122			S-8	
On-Site Construction and Remediation	Controlling emissions from nonpoint sources	Emissions from nonpoint sources	AAC R18-2-401, 402, 404, 405, 406, 407, and 410		S-3, S-8, S-12		

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A[a]	RAR[b]	TCB[c]
	Controlling emissions from mobile sources	Emissions from mobile sources	AAC R18-2-501 through 605		S-3, S-8, S-12		
Closure with Waste in Place	30-year post-closure care and groundwater monitoring	Applicable to land disposal of hazardous waste. Applicable RCRA hazardous waste (listed *or characteristic) place at site* after the effective date of the requirements, or placed into another unit. Not applicable to material treated, stored, or disposed only before the effective date of the requirements, or if treated in-situ or consolidated within area of contamination.	40 CFR 264.310		S-3		
Capping	Hazardous Waste Treatment, Storage and Disposal Requirements	Hazardous Waste	40 CFR 261-268	PSC ST-18 is subject to post-closure monitoring	S-3		

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A*	RAR*	TCB*
Treatment	Design and operating standards for all hazardous waste treatment units including miscellaneous units (long term retrievable storage, thermal treatment other than incineration, open burning, open detonation, chemical, physical and biological treatment units using other than tanks, surface impoundments or land treatment units) require new miscellaneous units to satisfy environmental performance standards by protection of groundwater, surface water, and air quality, and by limiting surface and subsurface migration.	Treatment of hazardous wastes in units and regulated elsewhere under RCRA (e.g., air strippers).	40 CFR 264 (Subpart. X), 40 CFR 264.273, 40 CFR 264.343-345, 40 CFR 265 (Subpart. P)	The substantive portions of these requirements will be relevant and appropriate to the construction, operation, maintenance, and closure of any miscellaneous treatment unit (a treatment unit that is not elsewhere regulated) constructed on the OU-2 site for treatment for/or disposal of hazardous site wastes.		S-8, S-12	

Table 14C. Action-Specific Applicable or Relevant and Appropriate Requirements and Other Criteria to be Considered, OU-2 Luke Air Force Base, Arizona

Location	Requirement(s)	Prerequisite(s)	Citation	Comments	A[a]	RAR[b]	TCB[c]
	Regulations for land-based corrective actions of RCRA facilities.	Land-based remedial action.	40 CFR Subpart. S (Revised)	The substantive portions of these requirements are relevant and appropriate to the treatment prior to disposal of any OU-2 site wastes in concentrations that make the site wastes sufficiently similar to the regulated wastes. The requirement specify levels of treatment that must be attained prior to land disposal.		S-8, S-12	
	Treatment of wastes subject to ban on land disposal must attain levels achievable by best demonstrated available treatment technologies (BDAT) for each hazardous constituent in each listed waste.	Treatment of LDR waste	40 CFR 263 (Subpart. D), 40 CFR 266.10, 263.11, 268.12	The substantive portions of these requirements are to be considered in the disposal of any OU-2 site wastes that can be desired as restricted hazardous wastes.		S-8, S-12	

a Applicable Requirements for Alternatives S-3, S-8, or S-12 as noted.
b Relevant and Appropriate Requirements for Alternatives S-3, S-8, or S-12 as noted.
c Criteria To Be Considered for Alternatives S-3, S-8, S-12.

Table 15. Soil Samples with Values Greater than PRGs, PSC DP-23, OU-2 Luke AFB, Arizona

		BZP Concentration (mg/kg)
SB-4	0-2'	2.8
	0-2' (duplicate)	3.3
	2-4'	3.0
SB-5	0-2'	1.4

PRGs Preliminary Remediation Goals
BZP Benzo(a)pyrene
mg/kg Milligrams per kilogram

Note: The PRG for BZP is 0.78 mg/kg

Table 16. Summary of Implementation Costs for Detailed Analysis of Remedial Measures for PSC DP–23, Operable Unit No. 2, Luke Air Force Base, Arizona.

Remedial Measure	Capital Costs	Yearly Operations and Maintenance Cost	Net Present Cost
S–1	$0	$0	$0
S–3	$87,000	$7,300	$200,000
S–8	$420,000	$16,000	$450,000
S–12	$77,000	$74,000	$460,000

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