DEPARTMENT OF THE AIR FORCE
HEADQUARTERS 27th FIGHTER WING (ACC)
CANNON AIR FORCE BASE, NEW MEXICO

6 APR 1994

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XIII

ENTERED

Dear Mr. Honker

Attached is the RCRA Facility Investigation (RFI) Final Report for Landfill No. 3 Solid Waste Management Unit (SWMU) No. 105 - Phase I at Cannon AFB. This final report incorporates responses to the two NODs from your agency dated March 10, 1993, and June 30, 1993. This report consists of the following two volumes:

1. FINAL REPORT
2. FINAL REPORT APPENDICES

Point of contact for this issue at Cannon AFB is Mr. John Ekhoff (505) 784-2739.

Sincerely

Mike Guth

WILLIAM M. GUTH
Brigadier General, USAF
Commander

Attachment:
SWMU No. 105, Landfill No. 3, Phase I Final Report

cc:
Dave Morgan, NMED
Steve Pullen, NMED

27th FIGHTER WING

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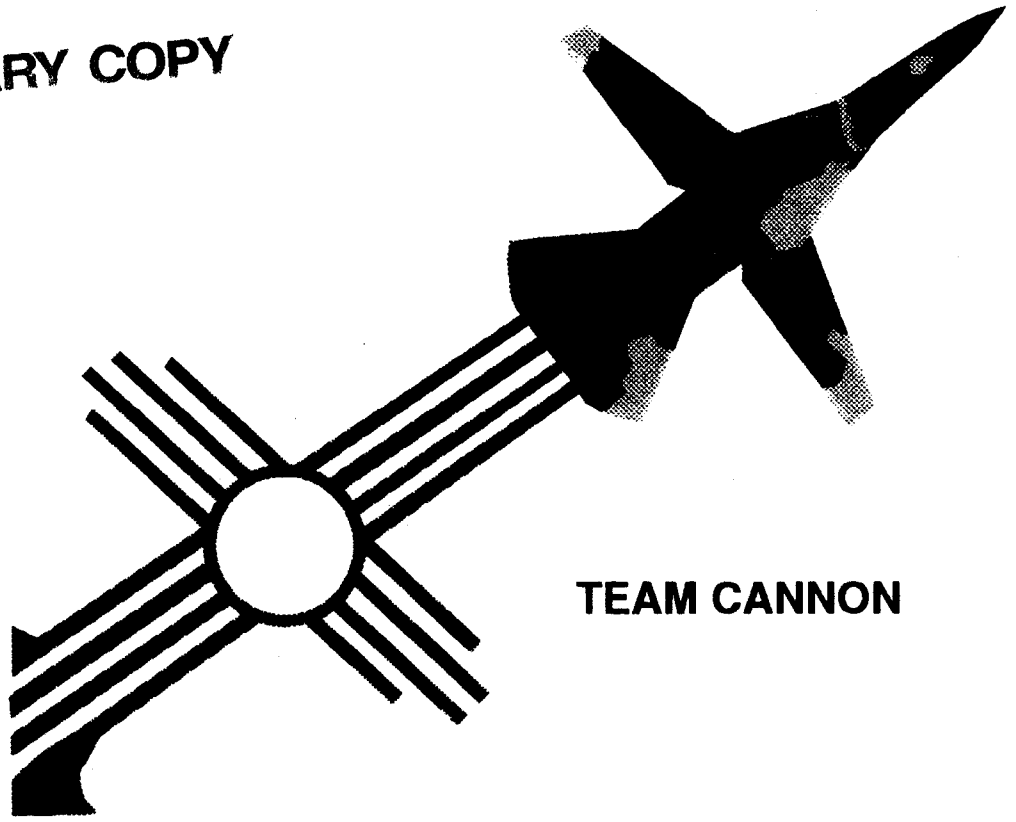

RCRA FACILITY INVESTIGATION (RFI)
SWMU NO. 104
LANDFILL NO. 4
IRP SITE LF-4

FINAL REPORT

AIR FORCE PROJECT NO. CZQZ 91 7006

CANNON AFB, NEW MEXICO

RCRA FACILITY INVESTIGATION (RFI)
FINAL REPORT
SWMU NO. 104
LANDFILL NO. 4
IRP SITE LF-4
AIR FORCE PROJECT NO. CZQZ 91 7006
CANNON AIR FORCE BASE, NEW MEXICO

Prepared for:

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March 1994

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LIST OF ACRONYMS

A-E SQCSR	Architect-Engineer Sampling and Quality Control Summary Report
AFB	Air Force Base
AQCR	New Mexico Air Quality Control Regulation
ARARs	Applicable, Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BA	Biological Assessment
BDAT	Best Demonstrated Available Treatment
BGL	Below Ground Level
BHC	Benzene Hexachloride
BP	Before The Present
BTEX	Benzene, Toluene, Ethyl Benzene, Xylene
CAA	Clean Air Act
CAFB	Cannon Air Force Base
CDAP	Chemical Data Acquisition Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act (also known as Superfund)
CEC	Cation Exchange Capacities
CFR	Code of Federal Regulations
CLP	Contract Laboratory Program (USEPA)

LIST OF ACRONYMS (Continued)

CMS	Corrective Measures Study
CNS	Central Nervous System
CWA	Clean Water Act
DL	Detection Limit
DOD	Department of Defense
DOE	Department of Energy
DOT	Department of Transportation
DQOs	Data Quality Objectives
DRMO	Defense Reutilization and Marketing Office
EM	Electromagnetic
EOD	Explosive Ordnance Detachment
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ES&E	Environmental Science and Engineering
FAMSL	Feet Above Mean Sea Level
FS	Feasibility Study
FWS	U.S. Fish and Wildlife Service
HA	Hand Auger
HARM	Hazard Assessment Rating Methodology
HEAST	Health Effects Assessment Summary Table

LIST OF ACRONYMS (Continued)

HHS	Human Health Standards
HSWA	Hazardous and Solid Waste Amendments
HQ	Hazard Quotient (=Exposure/RfD)
ID	Identification
IRFNA	Inhibited Red Fuming Nitric Acid
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
IWFNA	Inhibited White Fuming Nitric Acid
LCSs	Laboratory Control Samples
LEL	Lowest Effect Level
LOAEL	Lowest Observed Adverse Effect Level
LOX	Liquid Oxygen
MCLs	Maximum Contaminant Levels
MCLG	Maximum Contaminant Level Goals
MRD	Missouri River Division (USACE)
MS/MSD	Matrix Spike/Matrix Spike Duplicate
MTV	Mobility, Toxicity, or Volume
MW	Monitor Wells
NCP	National Oil and Hazardous Substances Pollution Contingency Plan

LIST OF ACRONYMS (Continued)

NMWQCC	New Mexico Water Quality Control Commission
NMWQCCR	New Mexico Water Quality Control Commission Regulations
NOAEL	No Observed Adverse Effect Level
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PCBs	Polychlorinated Biphenyls
PID	Photoionization Detector
POL	Petroleum, Oils, and Lubricants
QA/QC	Quality Assurance/Quality Control
QL	Quantitation Limits
RAPs	Remedial Action Plans
RAS	Radian Analytical Services
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facilities Assessment
RfDs	Reference Doses
RfCs	Reference Concentration For Noncarcinoginic Toxicity
RFI	RCRA Facilities Investigation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision

LIST OF ACRONYMS (Continued)

SARA	Superfund Amendments and Reauthorization Act
SB	Soil Boring
SFs	Carcinogenic Slope Factors
SMCLs	Secondary Drinking Water Maximum Contaminant Levels
SSHP	Site Safety and Health Plan
SVOCs	Semi-volatile Organic Compounds
SWQC	Surface Water Quality Criteria
SWMUs	Solid Waste Management Units
TAC	Tactical Air Command
TAL	Total Analyte List
TBC	To Be Considered
TDS	Total Dissolved Solids
TEL	Tetraethyl Lead
TFW	Tactical Fighter Wing
TIC	Tentatively Identified Compound
TPH	Total Petroleum Hydrocarbons
TRPH	Total Recoverable Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
TSDFs	Treatment, Storage or Disposal Facilities

LIST OF ACRONYMS (Continued)

UDMH	Unsymmetrical Dimethyl Hydrazine
USACE	U.S. Army Corps of Engineers
USAF	U.S. Air Force
USDA	U.S. Department of Agriculture
USGS	United States Geological Survey
UST	Underground Storage Tank
UTL	Upper Tolerance Limit
VOC	Volatile Organic Compounds

EXECUTIVE SUMMARY

Radian Corporation (Radian) was contracted by the U.S. Army Corps of Engineers (USACE) Omaha District to conduct a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), of Landfill No. 4 at Cannon Air Force Base (CAFB), New Mexico. The work performed under this contract supplements work performed by Radian between 1984 and 1986 at CAFB (Phase II, Stage 1 of the Installation Restoration Program (IRP) Investigation). The field work discussed herein was based upon procedures contained in the RFI Work Plan written by Lee Wan and Associates in June 1990 and on the work plan supplements written by Radian in July 1992. This document is the RFI report for Landfill No. 4 and includes a risk assessment for the landfill.

Landfill No. 4 is an unlined 6.3-acre landfill located on the east side of CAFB immediately north of the Playa Lake (Figure 1). This landfill was operated from 1967 to 1968 during which time it received domestic and industrial wastes including waste oil and solvents, paints, paint thinners, pesticide containers, and empty cans and drums. Accumulated wastes were placed in trenches and burned. The landfill was abandoned in 1968 and presently exists as a vegetated, mostly flat area with remnant depressions of the former trenches.

The investigation of Landfill No. 4 involved excavating an exploration trench to determine the depth of the landfill. Soil borings were drilled through the landfill in 10 locations and samples were collected at intervals from just beneath the landfill to approximately 60 feet below grade. Specific procedures for field activities are found in the *Field Sampling Plan* (FSP), (Radian, July 1992) the *Quality Assurance Project Plan* (Radian, July 1992) and the *Site Specific Health Plan* (Radian, July 1992). The field investigation began on 11 August 1992 and ended on 19 August 1992. Additional field

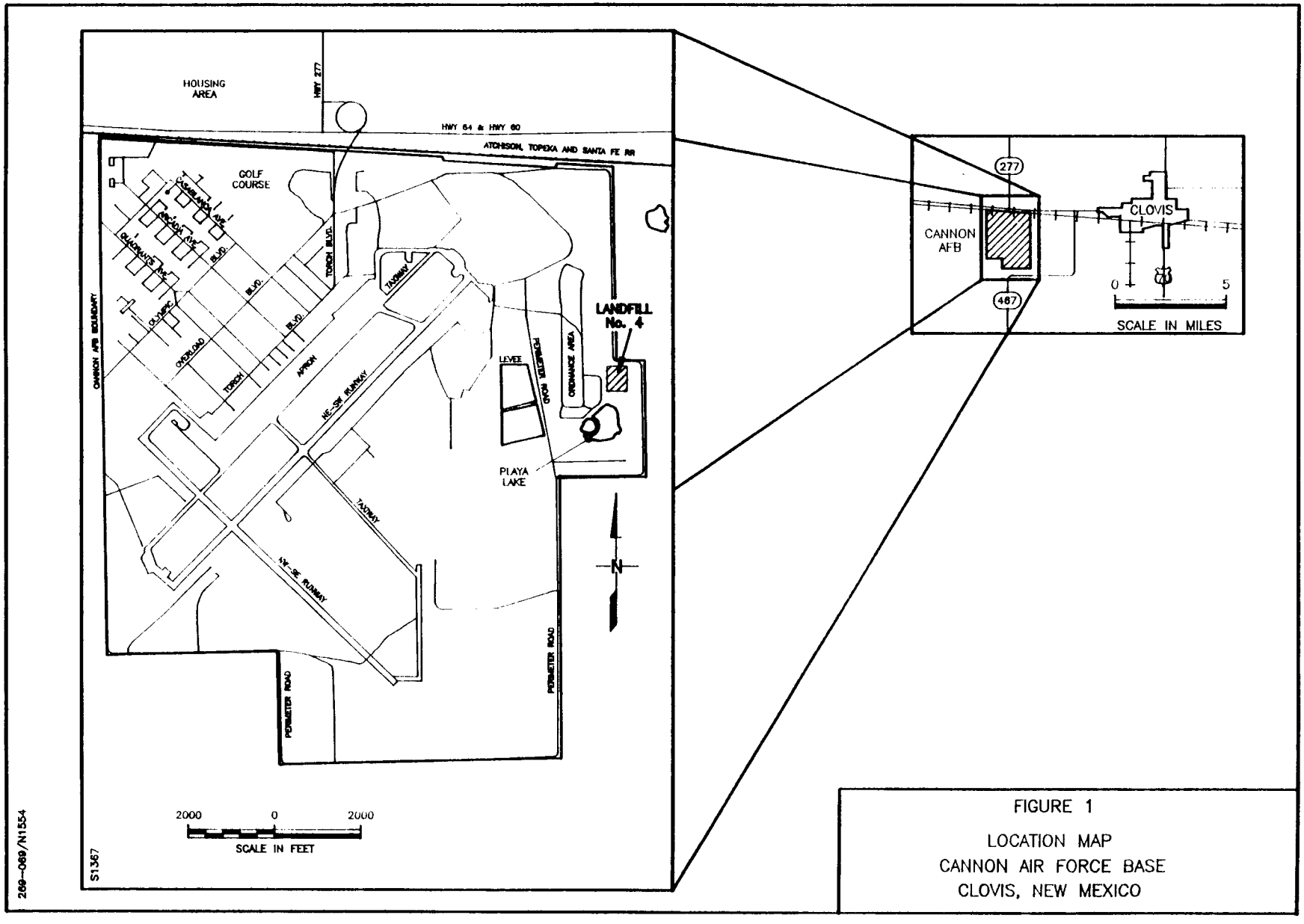


FIGURE 1

LOCATION MAP
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

269-069/N1554

work was performed 28 and 29 September 1992 to collect surface soil samples in support of the risk assessment.

Soil samples collected from Landfill No. 4 were analyzed for volatile and semi-volatile organics, pesticides, PCBs, herbicides, metals, and total petroleum hydrocarbons. When laboratory analyses were completed, a quality assurance/quality control (QA/QC) review of the analytical results was performed. In addition to the QA/QC review, CLP data validation of 10% of the analytical results was performed. The review indicated that the chemical data are acceptable and defensible (*Quality Control Summary Report*, Radian, December 1992). Data show that quality control mechanisms were effective in ensuring measurement data reliability within expected limits of sampling and analytical error. The chemical data were then used to perform a risk assessment for Landfill No. 4. Figures 2 through 4 give the maximum concentrations for chemicals of concern used in the risk assessment.

The risk assessment presents an assessment of the risks to human health and the environment attributable to current and potential future activities at Landfill No. 4. The objectives of the risk assessment were to determine the average and reasonable maximum carcinogenic and noncarcinogenic risks associated with Landfill No. 4. The risk assessment was performed according to the *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)*, (USEPA, 1989a).

To ensure adequate characterization of risk that may be incurred at Landfill No. 4 presently or in the future, the baseline risk assessment considers several populations in six exposure scenarios including four chronic and two subchronic scenarios. The four chronic scenarios include present and future off-site residents in areas downwind and hydraulically downgradient from Landfill No. 4 and present and future on-site workers. The two subchronic scenarios include present and future on-site workers.

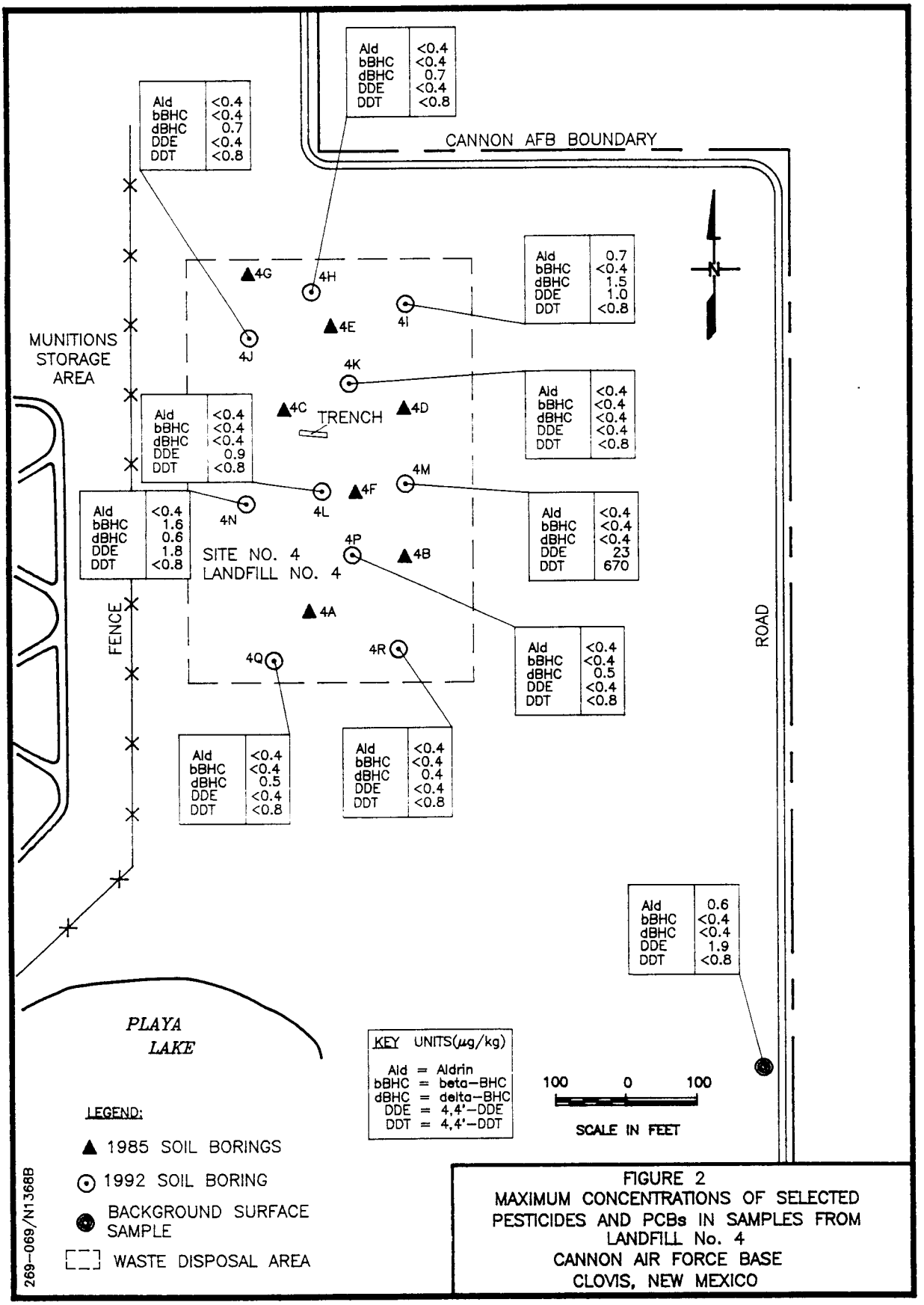


FIGURE 2
MAXIMUM CONCENTRATIONS OF SELECTED PESTICIDES AND PCBs IN SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

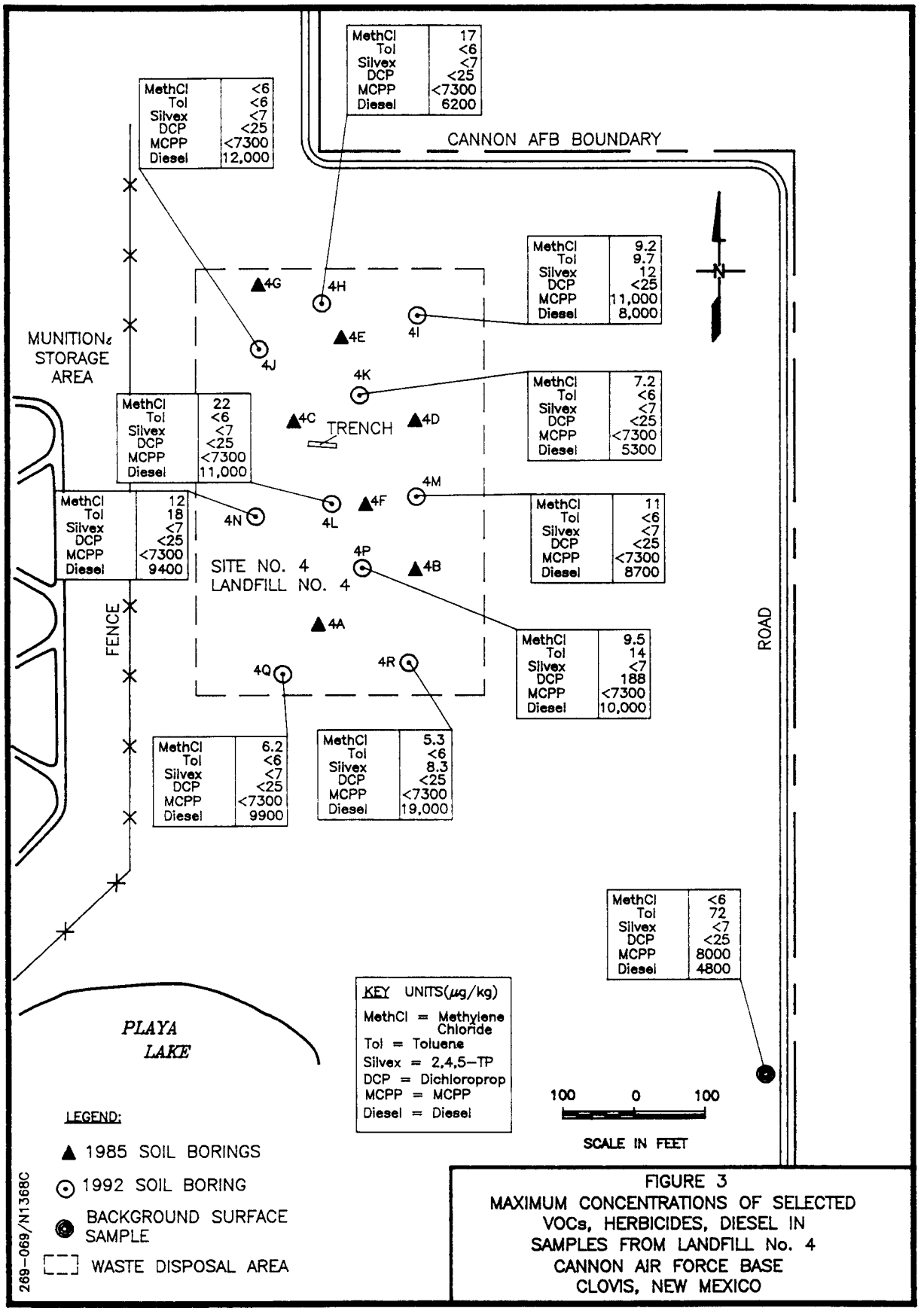


FIGURE 3
MAXIMUM CONCENTRATIONS OF SELECTED VOCs, HERBICIDES, DIESEL IN SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

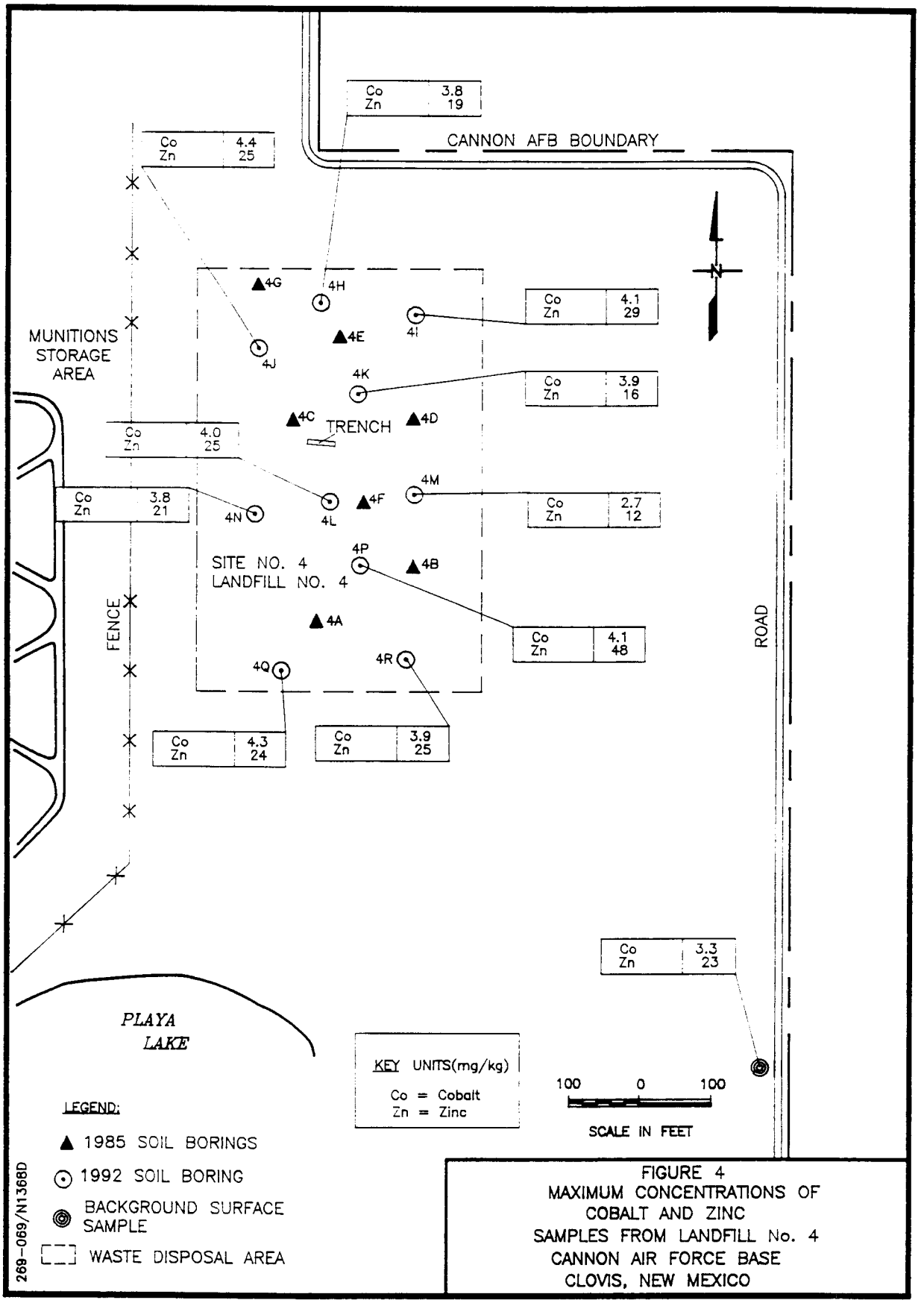


FIGURE 4
MAXIMUM CONCENTRATIONS OF
COBALT AND ZINC
SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

None of the estimated cancer risks for the various exposure scenarios exceed the Superfund site remediation risk range goal of 1E-04 (1 in 10,000) to 1E-06 (1 in 1,000,000). However, calculated risk values for the future on-site worker scenario are within the Superfund site remediation risk range goal (2E-05). Dermal contact with aldrin contaminated soil drives the future on-site worker carcinogenic risk. All of the estimated noncarcinogenic hazard indices for the various exposure scenarios are below the Superfund site remediation goal of 1.0 for noncarcinogens. However, it should be noted that the risk assessment is based on projected contaminant migration from the site and not necessarily on contaminants (or concentrations) found within the landfill itself.

Results of the environmental evaluation indicate the level of exposure of wildlife known to inhabit the landfill and surrounding areas to contaminants present at the site is likely to be low. Additionally, migration of contaminants to groundwater was shown to be insignificant. Therefore, potential adverse impacts of contamination from Landfill No. 4 on critical habitats and endangered species in the area is judged to be insignificant.

The baseline risk assessment for CAFB Landfill No. 4 based on current data indicates that there is little likelihood that adverse human health effects will occur as a result of exposure to contaminants originating at the site and that the risks to wildlife in the area are low. Additionally, migration of contaminants to the groundwater was shown to be insignificant. Therefore, the risk to human health and the environment is considered to be acceptable and no further action is recommended.

1.0 INTRODUCTION

Radian Corporation (Radian) was contracted by the U.S. Army Corps of Engineers (USACE) Omaha District to provide a Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI), of Landfill No. 4 at Cannon Air Force Base (CAFB), New Mexico. The work performed under this contract supplements work performed by Radian between 1984 and 1986 at CAFB (Phase II, Stage 1 of the Installation Restoration Program Investigation). Work was conducted according to the RFI Work Plan written by Lee Wan and Associates in June 1990 and the supplements written by Radian in July 1992. USACE personnel provided project management and technical support for the investigation. This document is the RFI report for Landfill No. 4 and includes a risk assessment for the site.

This section summarizes the history of the Installation Restoration Program (IRP), previous investigations and objectives of the CAFB Landfill No. 4 RFI and an overview of the report organization.

1.1 U.S. Air Force Installation Restoration Program

The Department of Defense (DOD) is conducting a nationwide program, the IRP, to evaluate waste disposal practices on DOD property and to mitigate environmental hazards that may result from past waste disposal practices. The United States Air Force (USAF) initiated the IRP at CAFB in 1983.

1.1.1 IRP Program Overview

Significant quantities of hazardous waste are generated by the USAF during flightline maintenance activities. Several federal and state regulatory programs exist that are designed to ensure that routinely generated wastes are properly managed.

These programs also identify and remediate past disposal sites, as necessary, to reduce hazards to human health or the environment.

The IRP began in 1975 as a pilot program conducted by the U.S. Army to investigate past hazardous waste disposal sites at DOD installations. Initial guidelines for conducting the IRP were provided to the services in a 23 July 1976 directive from the Assistant Secretary of Defense for Installations and Logistics. In the early stages of the program, DOD installations were required to identify their inactive hazardous waste disposal sites and to establish a prioritized program for conducting records searches at their installations. Subsequent legislation has modified the scope and procedures of the IRP.

The Resource Conservation and Recovery Act (RCRA), 42 *United States Code* Section 6901 *et seq.*, was enacted in 1976. This law required the EPA to regulate the generation, transportation, and treatment, storage or disposal of hazardous wastes. Subsequent amendments to the law required EPA to develop a "corrective action" program which, like the IRP, focuses on past waste management practices. These amendments, called the Hazardous and Solid Waste Amendments (HSWA) of 1984, require facilities that seek a RCRA hazardous waste operating permit to investigate and remediate the release of any hazardous wastes from active and inactive solid waste management units (SWMUs) under the corrective action program. Section 6961 of RCRA, as amended, applies RCRA to federal as well as private facilities.

In 1980, the U.S. Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 *United States Code* Section 9601 *et seq.*, as amended. This act is commonly known as the federal Superfund program. Under the Superfund program, inactive or abandoned waste disposal sites are investigated and remediated by the potentially responsible parties (PRPs), or, if no PRPs are identified, the EPA can undertake the investigation and cleanup with monies from the Superfund. The regulations that implement this program are referred to as the

National Contingency Plan (NCP), found at 40 *Code of Federal Regulations* (CFR) Part 300. The NCP describes the requirements for the heart of the Superfund process--the Remedial Investigation (RI)/Feasibility Study (FS).

The 1986 statutory amendments to CERCLA (the Superfund Amendments and Reauthorization Act (SARA) Section 9620) stressed that the provisions of the NCP apply to federal facilities in their implementation of the IRP. Additionally, SARA enacted a policy shift toward the Superfund cleanup goals and processes that affect the IRP.

Under SARA, technologies that permanently remove or destroy a contaminant are preferable to actions that only contain or isolate the contaminant. Also, the law specifies that remedial actions must achieve a degree of cleanup that satisfies applicable or relevant and appropriate requirements (ARARs) in light of the hazardous substances that are present. ARARs are quantitative standards, standards of control, and other substantive criteria or limitations promulgated by federal or state agencies; similarly, "to be considered" materials are non-promulgated federal and state guidelines, proposed rules, criteria and advisories that may be useful to apply to the particular substances or units at a Superfund site. Early identification of ARARs (including "to be considered" material) is required and potential remediation alternatives should be considered at the initiation of an RI/FS. SARA also provides for enhanced interaction with the public and state agencies and extends EPA's role in evaluating the health risks associated with the contamination.

In November 1986, in response to SARA and in consideration of various EPA interim guidance documents, the USAF modified the IRP to provide for a Superfund-like RI/FS program. The intent was to conduct the RI and FS in parallel instead of serial fashion. The program is now oriented to include ARAR determinations, the identification and screening of technologies, and the development of alternative remedial actions for consideration.

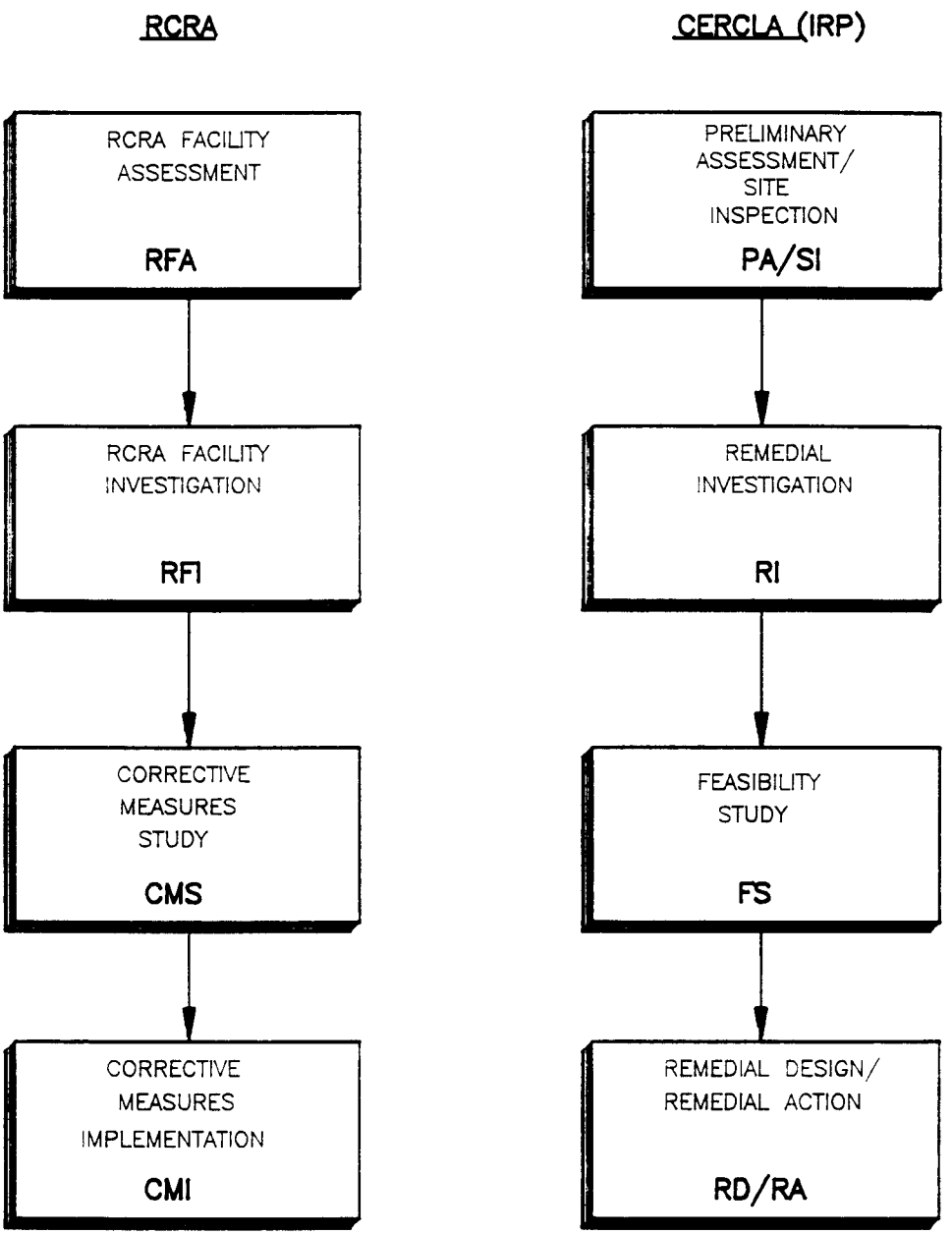
1.1.2 General Overview of IRP and RCRA Corrective Action Program Integration

Both the IRP and RCRA corrective action programs are intended to ensure remediation of contaminated sites that pose an actual or potential threat to public health, welfare or the environment. Both programs are implemented through phased approaches to identify, investigate and remediate these sites. However, there are differences in the two: for example, the IRP is a federal facility program, whereas RCRA corrective action applies to both federal and private facilities; the IRP preceded the RCRA corrective action program in time by almost 10 years; and the IRP references the requirements of other federal and state laws for identifying cleanup standards. The terminology and scope of the two programs' phases are somewhat different.

Figure 1-1 presents a side-by-side comparison of the primary phases of implementation of the IRP and RCRA corrective action processes. Generally, the scope of each of these phases is described below:

- RCRA Facility Assessment (RFA) and CERCLA Preliminary Assessment/Site Investigation (PA/SI)--the first steps in the process to screen and identify what specific sites at the installation need further investigation. The screening is usually based on a visual site inspection and records review at the installation.

- RCRA Facility Investigation (RFI) and CERCLA Remedial Investigation (RFI)--the stages during which data about site and waste characteristics, their hazards, and routes of exposure are collected and analyzed, and the need for further action developed.



269-069/N1546

FIGURE 1-1
COMPARISON OF RCRA
CORRECTIVE ACTION AND IRP PHASES
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

- RCRA Corrective Measures Study (CMS) and CERCLA Feasibility Study (FS)--the stages during which a number of potential remedial action alternatives are developed and screened, and a remediation technology is selected that meets the statutory objectives and is based on an established set of cleanup standards.

- RCRA Corrective Measures Implementation (CMI) and CERCLA Remedial Design (RD)/Remedial Action (RA)--the stages during which the chosen remedy is designed and implemented.

The EPA, in the preamble to the proposed RCRA corrective action rules, confirmed that because the IRP and RCRA corrective action programs are independent environmental requirements, federal facilities must comply with the requirements of both programs (*55 Federal Register* 30798, 30858). The agency further states that, to the extent possible, it will try to ensure the coordination of activities required under the programs so that duplicative information and work effort are minimized.

1.1.3 Regulatory History

In 1985, CAFB submitted a RCRA hazardous waste management permit application to EPA Region VI. Prior to issuing the permit, EPA performed a RCRA Facility Assessment (RFA) to identify the SWMUs at CAFB. A total of 128 SWMUs and 51 Areas of Concern (AOC) were identified and described in the RFA (A.T. Kearney, Inc., 1987).

EPA issued the HSWA component of CAFB's RCRA permit on 16 October 1989. The permit requires CAFB to perform RFIs on 76 SWMUs and 3 AOCs identified in the RFA. Landfill No. 4 was among those SWMUs chosen for investigation.

This report is CAFB's RI Report for Landfill No. 4. It is also intended to address all of the elements required under the CAFB RCRA permit for implementing an RFI for Landfill No. 4, which was designated as SWMU 104 in the RFA. Section 1.3.2

provides a detailed reference table to help the reader of this report locate RCRA RFI information requirements in this IRP document.

1.2 Project Setting, Previous Investigations, and Objectives

1.2.1 Project Setting

CAFB is one of 36 Air Combat Command (ACC) bases. The base is located about 7 miles west of Clovis (Curry County), New Mexico in the Southern High Plains section of the Great Plains physiographic province (Figure 1-2). The CAFB is home of the 27th Tactical Fighter Wing (TFW). CAFB dates to 1929, when Portair Field was established on the site. Portair Field was a civilian passenger terminal for early commercial transcontinental flights. In 1942 the Army Air Corps took control of the civilian airfield and it became known as the Clovis Army Air Base. In 1945, the base was renamed Clovis Army Air Field and was used to teach flying, bombing, and gunnery classes until the end of World War II. After World War II, flying activities at the base decreased until the base was deactivated in May 1947.

The base was reassigned to the Tactical Air Command (TAC) in July 1951 and formally reactivated in November 1951 as Clovis Air Force Base. In 1957, the base was renamed Cannon Air Force Base in honor of the late General John K. Cannon, a former commander of the TAC. The base became part of ACC when that agency was formed to combine TAC and SAC (1 June 1992). Since 1965, the primary mission of CAFB has been to develop and maintain an F-111 tactical fighter wing capable of day, night, and all-weather combat operations and to provide replacement training of combat aircrews for tactical organizations worldwide. Off-base facilities include the Melrose Bombing Range and the Conchas Lake Recreation Annex.

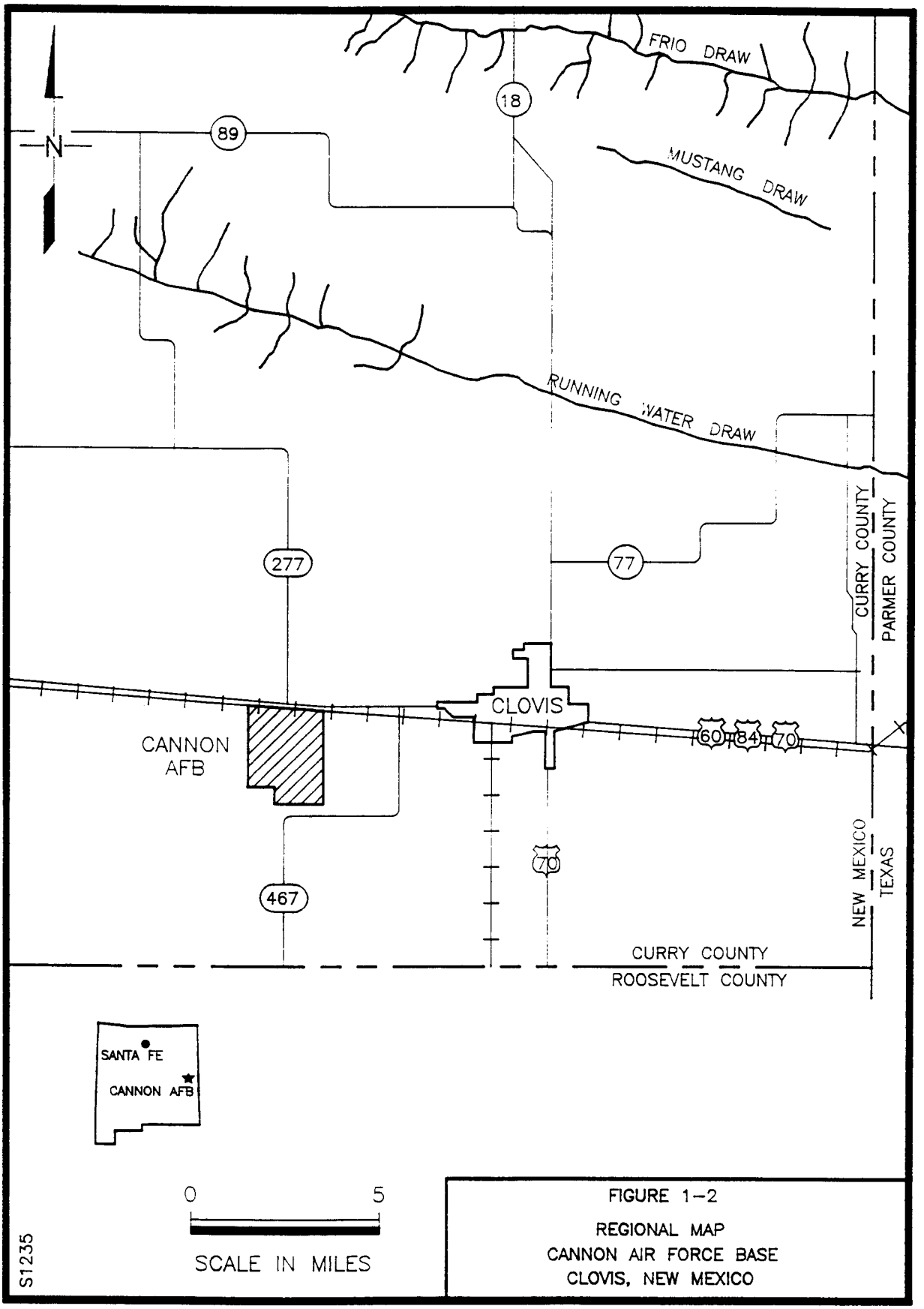


FIGURE 1–2

REGIONAL MAP
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

1.2.2 Previous Investigations

The operational history of Landfill No. 4 is described in the USAF IRP Phase I report titled *Installation Restoration Program Records Search for CAFB, New Mexico* (CH_2M Hill, 1983). Landfill No. 4 (Figure 1-3) is an unlined 6.3-acre landfill that was operated from 1967 to 1968. Landfill No. 4 is located on the east side of CAFB immediately north of the Playa Lake. While active, the cut-and-fill landfill received domestic and industrial wastes including waste oil and solvents, paints, paint thinners, pesticide containers, and empty cans and drums. Accumulated waste was burned in trenches and buried on the following day. The site was abandoned in 1968 and presently exists as a relatively flat area with remnant depressions of the former trenches.

The CAFB IRP Phase II investigation, *Installation Restoration Program Phase II - Confirmation/Quantification Stage I* (Radian, 1986), described the analytical results of 21 soil samples collected from 7 soil borings drilled adjacent to the landfill's trenches. Generally, three samples were collected from each boring at depths of 1 to 3 feet, 8 to 10 feet, and 52 to 54 feet. No purgeable halocarbons or aromatics were detected in the soil samples. Total concentrations of heavy metals were within background levels. Low levels of oil and grease were detected but were believed to be from natural sources.

Landfill No. 4 was designated as SWMU No. 104 in the *Preliminary Review/VSI Report, RCRA Facility Assessment* (A.T. Kearney, 1987) for CAFB. The landfill was so designated due to the potential for past, present, or future releases of hazardous contaminants from the landfill to the environment. This document was prepared for EPA Region VI prior to the issuance of CAFB's RCRA hazardous waste management permit.

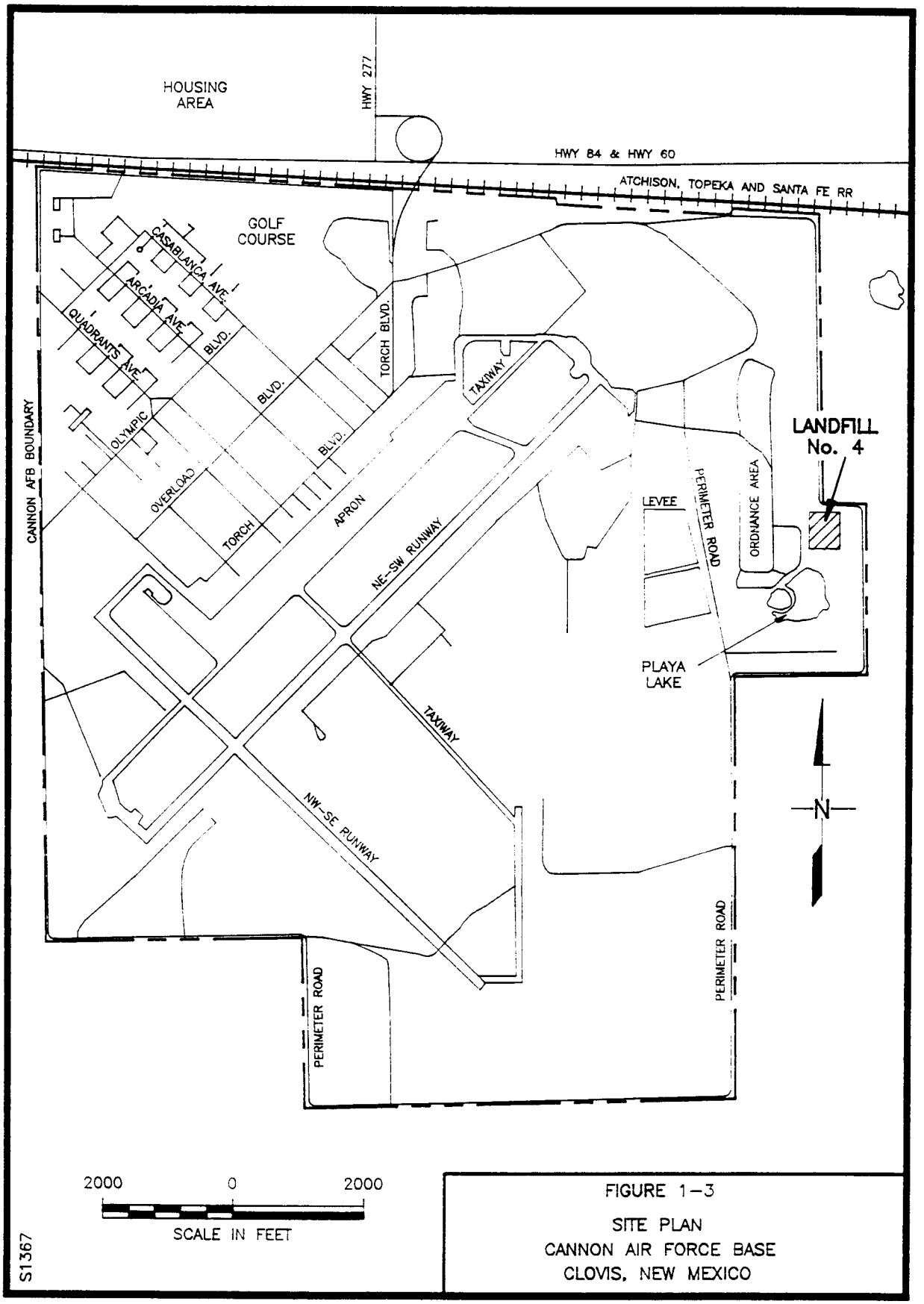


FIGURE 1-3

SITE PLAN
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

No further investigation and no remedial action were recommended for Landfill No. 4 in the report *U.S. Air Force Installation Restoration Program for Site LF-4, Landfill No. 4 (Formerly Site No. 04), Cannon Air Force Base, New Mexico, Decision Document (Final)* (EA Engineering, Science, and Technology, Inc., 1990). This document was intended to remove the landfill from CAFB's IRP. However, a request was made to perform further sampling and analyses in the interval between the bottom of the landfill and a depth of 60 feet.

The Landfill No. 4 RFI data collection and quality assurance procedures were described in the report *RCRA Facility Investigation Work Plan, Cannon Air Force Base, New Mexico* (Lee Wan and Associates, 1990). Work Plan supplements specific to Landfill No. 4 were provided in July 1992. The field work was performed in August 1992 by Radian under contract to the USACE Omaha District. The sample locations of both the February 1985 and August 1992 investigations are shown in Figure 1-4.

1.2.3 Objectives

The RFI of CAFB Landfill No. 4 was performed to characterize the risks posed by the uncontrolled hazardous waste site and to evaluate potential remedial options. Specifically, the RFI was designated to determine whether downward migration of contaminants is occurring at the site. Remedial options will be proposed to mitigate any contaminant migration, if such is found.

1.3 Integration of CAFB IRP and RCRA Corrective Action Program

1.3.1 Incorporation of RFI Requirements in this Report

The IRP designation for Landfill No. 4 is LF-4 and the RCRA corrective action program designation for Landfill No. 4 is SWMU 104. CAFB will satisfy the

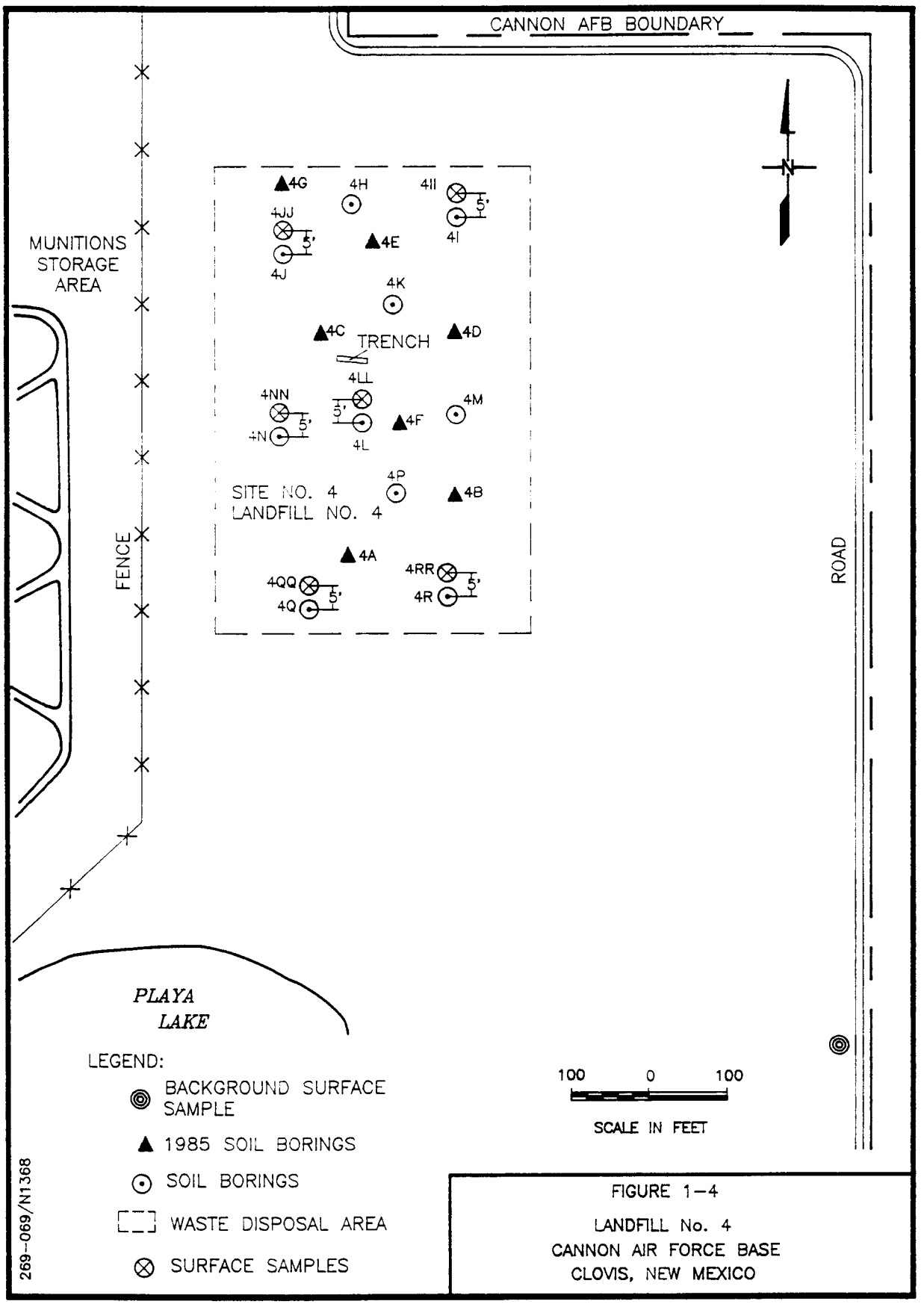


FIGURE 1-4

LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

requirements of both the IRP and RCRA corrective action program while ensuring that resources are not expended on duplicative efforts.

This site investigation report is presented in the CERCLA RI format but includes a reference table that outlines applicable RCRA corrective action RFI requirements and where they are addressed within this report (Table 1-1). Recommendations for further action or no action at Landfill No. 4 will be provided and will be based on the results of the baseline risk assessment.

1.3.2 Development of Conclusions and Recommendations

The IRP and RCRA corrective action program are similarly phased programs for site investigation and remediation. For IRP sites that are also RCRA SWMUs, the IRP and RCRA phases are implemented in parallel fashion. During the IRP RI and RCRA RFI the two major activities are, generally: 1) site characterization to identify and confirm the presence or absence of contamination and the degree of contamination; and 2) development of recommendations for the next phase of the IRP and RCRA corrective action program. Thus, this report presents the conclusions of the site characterizations and recommendations for further work. This section describes how the IRP and RCRA corrective action guidance were used to develop recommendations for additional work.

In the IRP, the risk assessment is the primary mechanism for the determination of whether or not remedial action is necessary for a particular site (*Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, USEPA 1988). The results of the risk assessment may indicate that the site poses little or no threat to human health and the environment, thereby eliminating the need for the feasibility study (FS) (Ibid).

Table 1-1

Directory of Responses to HSWA Permit Requirements for an RFI

Section	Permit Requirement *	Location in RI Report
A. ENVIRONMENTAL SETTING		
1. Hydrogeology		
a.	Regional and SWMU-specific geologic and hydrogeologic conditions affecting groundwater flow	Sections 2.2 and 2.3, Figures 2-4 and 2-5
b.	Topographic features influencing groundwater flow	Sections 2.2 and 2.3, Figures 2-4 and 2-5
c.	Hydrogeologic units in migration pathways	Sections 2.2 and 2.3
d.	Extent and characteristics of hydrogeologic units in migration pathways	Sections 2.2 and 2.3
e.	Water level monitoring	Section 2.3
f.	Man-made influences on hydrogeology	Section 2.3
2. Soils		
a.	Surface soil distribution	Section 2.2, Figure 2-3
b.	Soil profile and classification	Sections 2.2 and 2.3
c.	Soil stratigraphy	Section 2.3, Figures 2-2 and 2-3
d.	Saturated hydraulic conductivity	Section 2.3
e.	Porosity	NA
f.	Cation exchange capacity	NA
g.	Soil pH	NA
h.	Particle size distribution	Appendix B-2 - Geotechnical Results
i.	Depth to water table	Section 2.3
j.	Moisture	NA
k.	Effect of stratigraphy on unsaturated flow	Section 2.3
l.	Infiltration	Section 2.3
m.	Evapotranspiration	Section 2.1

Table 1-1

(Continued)

Section	Permit Requirement[a]	Location in RI Report
n.	Contaminant concentrations in soils	Section 5.0
o.	Metals concentrations in soils	Section 5.0
B. SOURCE CHARACTERIZATION		
1. Unit/Disposal Area Characteristics		
a.	Location	Sections 1.2 and 2.4
b.	Type	Section 2.4
c.	Design features	Section 2.4
d.	Operating practices	Section 2.4
e.	Period of operation	Section 2.4
f.	Age	Section 2.4
g.	Physical conditions	Section 2.4
h.	Closure method	Section 2.4
2. Waste Characteristics		
a.	Type	Section 2.4
b.	Physical and chemical characteristics	Section 6.0
c.	Migration and dispersal characteristics	Section 6.0
C. CONTAMINATION CHARACTERISTICS		
1. Groundwater Contamination		
a.	Horizontal and vertical extent of contamination	Sections 5.0, 6.1, and 6.3
b.	Horizontal and vertical direction of movement	Section 6.1 and 6.3

Table 1-1

(Continued)

Section	Permit Requirement[a]	Location in RI Report
c.	Velocity	Sections 2.3, 6.1, and 6.3
d.	Horizontal and vertical concentration profiles of any Appendix IX or radiochemical constituents	N/A
e.	Factors influencing plume movement	Sections 2.2, 2.3, 6.1, and 6.3; Appendix G-2
f.	Extrapolation of future movement	Sections 6.1 and 6.3, Appendix G-2
2. Soil Contamination		
a.	Vertical and horizontal extent	Section 5.0
b.	Contaminant and soil chemical properties	Section 6.2; Appendix D
c.	Contaminant concentrations	Sections 5.1 and 6.2
d.	Velocity and direction of contaminant movement	Sections 6.2 and 6.3
e.	Extrapolation of future contaminant movement	Sections 6.2 and 6.3
3. Surface Water Contamination		
a.	Horizontal and vertical extent of any immiscible or dissolved plumes originating from the facility, and the extent of contamination in the underlying sediments	NA
b.	Horizontal and vertical direction and velocity of contaminant movement	Sections 6.2 and 6.3
c.	Physical, biological, chemical, and radiochemical factors influencing contaminant movement	Sections 6.2 and 6.3
d.	Extrapolation of future contaminant movement	Sections 6.2 and 6.3
e.	Chemistry and radiochemistry of contaminated surface waters and sediments	NA

Table 1-1

(Continued)

Section	Permit Requirement *	Location in RI Report
4. Air Contamination		
a.	Horizontal and vertical direction and velocity	Sections 6.2 and 6.3; Appendix G-1
b.	Rate and amount of release	Sections 6.2 and 6.3; Appendix G-1
c.	Chemical, radiochemical, and physical composition of contaminants, including horizontal and vertical concentration profiles	Sections 6.2 and 6.3; Appendix G-1
D. POTENTIAL RECEPTORS		Sections 6.3 and 6.6

* - Reference HSWA Permit (Section B, Task III) issued 22 August 1991 by EPA Region VI.
NA - Not Available.

RCRA corrective action "action levels" are quantitative standards for a variety of pollutants, established by media (air, water, soil). In the specific context of the RCRA corrective action program, these action levels are used to determine the need for a Corrective Measures Study (CMS) (the FS under the IRP). Additionally, the action levels are "to be considered" ambient-based material for assessing the significance of site contamination under the IRP. This report has used the RCRA proposed corrective action "action levels" in the CAFB RFI as "to be considered" material for comparison with data collected at Landfill No. 4.

The risk assessment is the primary basis for the RFI recommendations contained in this report. This approach is consistent with both the IRP guidance referenced above and RCRA corrective action guidance. In the preamble to the proposed RCRA corrective action rule, the EPA recognizes that the RFI stage (the IRP RI stage) may show that suspected releases are nonexistent or of such a nature that poses minimal to no threat to human health and the environment. The agency further states that a "no further action" scenario at the end of the RFI may be appropriate, even where there is a release above the "action levels", where there are site-specific conditions that minimize the risk to affected populations (*55 Federal Register* 30798, 30813). The triggering of a CMS (IRP FS) based on an exceedance of an action level can, therefore, be rebutted by risk-based information.

In summary, the risk assessment under both the IRP and RCRA corrective action program provides an evaluation of the potential threat to human health and the environment for a particular site. At any time during the respective processes, the risk assessment can provide the basis for concluding that a site closeout under the IRP is warranted because of the absence of unacceptable risks to human health and the environment from the site. For site closeout, appropriate documentation in the form of a Decision Document will be prepared to record and summarize the data and risk assessment conclusions. Site closeout is equivalent to the RCRA corrective action term "no further action". Under the proposed corrective action rules (40 CFR Section

264.514), the corrective action process can be terminated for a SWMU if it can be demonstrated that the unit does not pose a threat to human health and the environment. If this is determined to be the case for Landfill No. 4, CAFB will submit a request to EPA for a Class III permit modification, with appropriate supporting documentation, to terminate the corrective action compliance schedule for this SWMU based on the RFI findings. The risk assessment can also indicate that a site should proceed beyond the RI/RFI stages into the FS/CMS and, if necessary, implementation of an IRP remedial action/RCRA corrective action remedy.

1.4 Report Organization

Following this introduction, the RFI report contains the following sections: Section 2.0 - Environmental Setting; Section 3.0 - Field Investigation Program; Section 4.0 - Applicable or Relevant and Appropriate Requirements (ARARs); Section 5.0 - Analytical Results; Section 6.0 - Risk Assessment; Section 7.0 - Conclusions and Recommendations; and Section 8.0 - References. The Environmental Setting (Section 2.0) presents information obtained from the literature review and data from this investigation regarding geographic setting, land use, soil, geology, hydrogeology, water use, and surface water. This information is critical to the technical development of the RFI and the baseline risk assessment, and provides background information that is referred to throughout the report.

Section 3.0, Field Investigation Program, summarizes the methods and procedures used to collect data for this RFI. Section 4.0 discusses the standards, requirements, criteria or limitations under any federal environmental law, or any more stringent standard or limitation promulgated under state statutes. Section 5.0 contains the analytical results from the Landfill No. 4 investigation. Topics covered in Section 5.0 include data validation, statistical analyses for background determination, and presentation of risk-based action levels. The conclusions and recommendations in Section 7.0 are based largely on the risk assessment presented in Section 6.0.

2.0 ENVIRONMENTAL SETTING

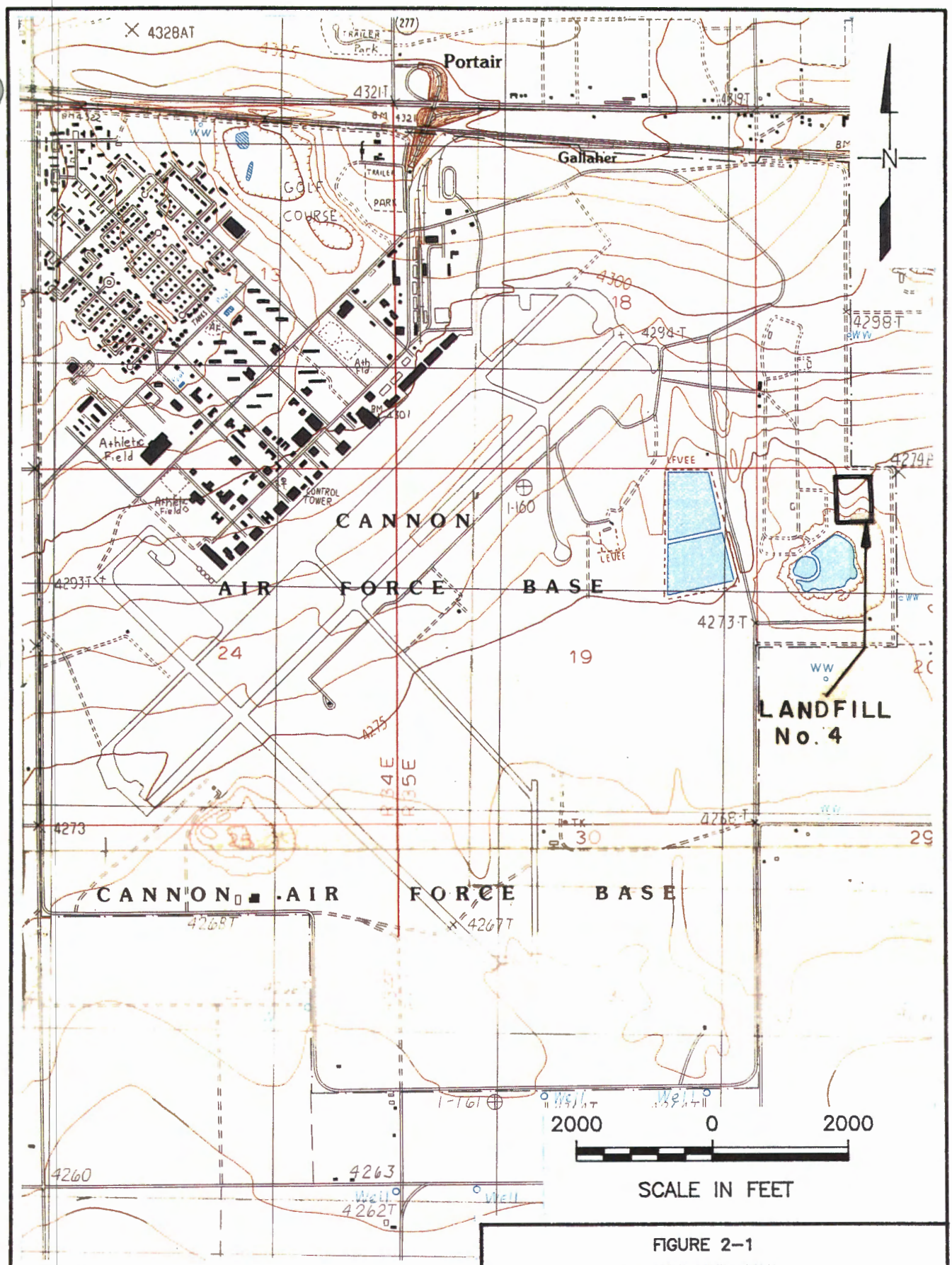
The following subsections describe the environmental setting of CAFB, New Mexico. Included in this section are geographic, geologic, and hydrogeologic data compiled from published literature, previous reports, and the field investigation.

2.1 Geographic Setting

2.1.1 Cultural Geography

CAFB is situated in eastern New Mexico, in the south-central part of Curry County. The base occupies about 4,320 acres in Sections 13, 24 and 25 in T2N, R34E and Sections 17, 18, 19, 20 and 30 of T2N, R35E. Figure 2-1 shows the local topography of CAFB.

The base is located about 110 miles northwest of Lubbock, Texas and about 7 miles west of Clovis, New Mexico. The major highway serving the base is U.S. Highway 60/84, which runs west from Clovis and forms the northern boundary of the base. The Atchison, Topeka, and Santa Fe Railway tracks run parallel and just south of U.S. 60/84. With a population in excess of 33,000 people, Clovis is the largest city close to the base and is the county seat of Curry County. The economy of Clovis depends largely on CAFB, but also is based on irrigated farming and cattle grazing for both beef and dairy production. The majority of the land surrounding CAFB is productive irrigated farmland or grassland. The major crops grown in the Clovis area are wheat, sorghum, sugar beets, corn, cotton, alfalfa, barley and peanuts. Approximately 12,340 people work at CAFB (projected for December 1992). The base is presently undergoing expansion to absorb personnel relocated from USAF bases scheduled to be closed or downsized.



REFERENCE;
USGS QUAD SHEETS "PORTAIR, NEW MEXICO"
AND "OASIS STATE PARK, NEW MEXICO."

FIGURE 2–1
TOPOGRAPHIC MAP
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

2.1.2 Physiography

The Southern High Plains consist of an isolated plateau composed of Cretaceous, Tertiary and Holocene age sediments. The regional slope of the Southern High Plains is about 6 to 10 feet per mile and the area around CAFB slopes about 10 to 15 feet per mile to the east and southeast, except in areas adjacent to Playa Lakes. Most of the plateau consists of sands, clays and gravels deposited by flowing water. All of these units comprise the Ogallala Formation. There are also minor amounts of wind blown and lake bottom sediments present. The surface of the plateau is formed by a resistant "caprock" of Pliocene age caliche. The caliche is composed of calcium carbonate and is a product of soil weathering. The caliche is overlain in most places by Pleistocene age sands and thin, fine-grained lake deposits (Reeves, 1970).

The Southern High Plains are bounded on the north by the Canadian River which lies 60 miles to the north of Clovis. The eastern and western sides of the Southern High Plains are bounded by escarpments that rise as much as 300 feet above the surrounding area (CH_2M Hill, 1983). CAFB is located near the center of this plateau where the topography is characterized by flat, featureless terrain having almost no relief (Figure 2-1). The High Plains surface is composed of flat, gently sloping surfaces that surround major drainage features and playa lakes. The land surface elevations at CAFB range from 4,327 feet above mean sea level (MSL) at the northwest corner of the base to about 4,260 feet above mean sea level at the southeast corner (CH_2M Hill, 1983). The land surface of the base generally slopes to the east and south-east, consistent with the regional slope, except in areas adjacent to playa lakes.

2.1.3 Climate

The climate of east-central New Mexico is classified as tropical semi-arid, with summer temperature and precipitation maxima. Average monthly temperatures range from a January low of 12° C (39° F) to a July high of 26° C (78° F). Extreme daily

temperatures range from -24° C (-11° F) to 41° C (106° F) (NWS Climatic Brief, 1986). Average monthly precipitation ranges from 1 cm (0.4 in) in winter to 6.9 cm (2.7 in) in July (NWS 1986). The maximum recorded 24 hour rainfall is 12.2 cm (4.8 in), which occurred in August. Rainfall occurs on eight or more days per month during the summer precipitation maximum. Mean annual precipitation is approximately 41 cm (15 in) with most of this resulting from thunderstorm activity from May through October. The mean annual evapotranspiration rate is 181.4 cm/yr (71.4 in/yr) Therefore, the net annual precipitation (mean annual precipitation minus mean annual evapotranspiration) for the CAFB area is approximately minus 55.4 inches per year, representing a net loss in groundwater caused by evapotranspiration. Prevailing winds are from the west at an average of 5 km/hr (8 mph) during fall, winter, and spring. During the summer, winds are from the south at an average of 3.7 km/hr (6 mph).

The atmosphere around the area of CAFB is generally well mixed. The seasonal and annual average mixing heights can vary from 400 meters in the morning to 4,000 meters in the afternoon. The afternoon mixing heights are typically greater during the spring and fall seasons. The morning mixing heights are usually low, because nighttime heat loss from the ground produces surface-based temperature inversions. After sunrise these inversions break up, and solar heating of the earth's surface causes vertical mixing in the atmosphere.

Dust is frequently entrained into the atmosphere in this region of the country because of gusty winds and the semi-arid climate. The Texas Panhandle-eastern New Mexico area is considered the worst area in the United States for windblown dust. Occasionally this windblown dust is of sufficient quantity to restrict visibility. Most of the seasonal dust storms occur in March and April, when the wind speeds are typically high (average 5 km/hr).

2.2 Geology

This subsection describes the regional geologic history and present day features of the Southern High Plains in relation to CAFB. This information was gathered from existing reports about the geology of the Southern High Plains. A discussion of the near surface geology on the base is also included.

2.2.1 Geologic Setting

The near-surface stratigraphic units of interest at CAFB are the Late Miocene-Late Pliocene age Ogallala Formation and the Early Triassic Dockum Group (Figure 2-2).

The Dockum Group consists of three formations. The stratigraphically lowest unit is the Santa Rosa Sandstone. Overlying the Santa Rosa Sandstone are the Chinle and Redonda Formations. The Chinle and Redonda Formations are composed mainly of red shales with lesser interbedded sands, and are known locally as "redbeds". The top of the Dockum Group is marked by an erosional unconformity having relief of up to several hundred feet.

Overlying the Dockum Group redbeds is the Ogallala Formation. The Ogallala Formation extends from eastern New Mexico and Colorado into Texas, Oklahoma, Kansas, Nebraska, and South Dakota. Drillers logs from CAFB indicate that the Ogallala Formation varies from 360 feet to 415 feet in thickness. The incised upper surface of Triassic redbeds strongly influences Ogallala thickness. Streamvalleys in the post-Triassic unconformity are deep and trend dominantly east-west. The Ogallala thickness may therefore vary significantly over short north-south distances.

The Ogallala is erosionally truncated to the south along the abandoned Portales Valley, to the west along the Pecos River Valley, and to the north in a series of

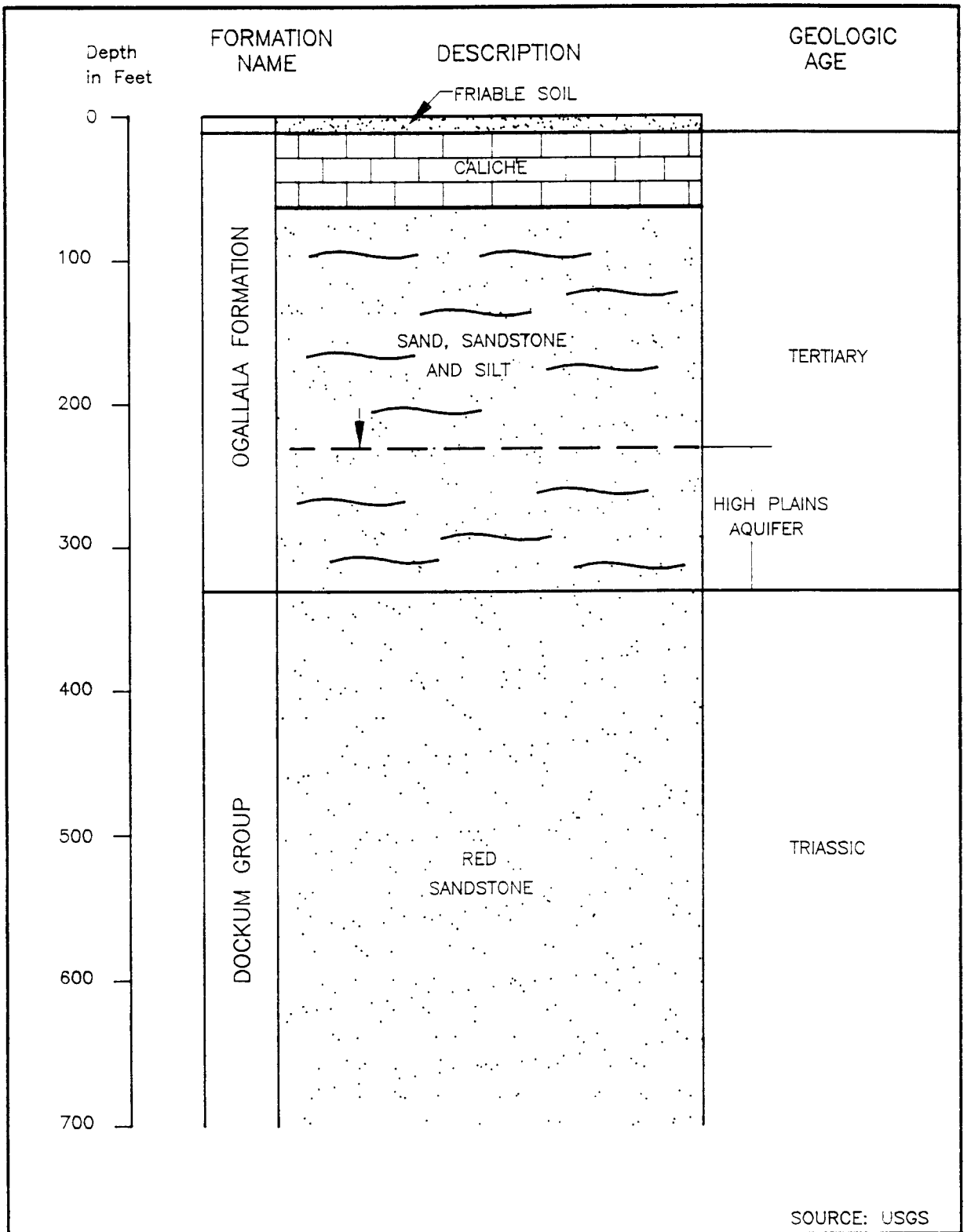


FIGURE 2–2

GEOLOGIC COLUMN
AT CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

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ephemeral stream valleys. The Ogallala Formation extends more than 125 miles to the east before terminating as an escarpment in Briscoe County, Texas. Springs and seeps are common along the erosional margins of the Ogallala.

The Ogallala dips gently and monoclinically to the southeast in the vicinity of CAFB. Frye and Leonard (1972) suggest that some Quaternary warping may have occurred. Most of the structures recognized by Frye and Leonard (1972) are well to the northwest and southwest of CAFB. No faults or buried structural lineaments are known in the vicinity of CAFB.

The Ogallala Formation is composed of unconsolidated, poorly sorted gravel, sand, silt, and clay. The base of the Ogallala is generally marked by a gravel, cobble, and boulder deposit. This basal member contains sediments derived from igneous and sedimentary rocks transported from mountains to the west. The Ogallala Formation was laid down by stream and overbank deposits formed within coalescing alluvial fans. These fans form a broad pediment along the eastern flank of the Rocky Mountains. As is typical of alluvial deposits, Ogallala internal stratigraphy varies vertically and horizontally over short distances.

Except where strongly cemented by calcium carbonate (caliche), the sediments of the Ogallala are loose and friable. Authigenic and allogenic clays are found as a trace to abundant matrix mineral (Glass, et al., 1973 and Frye, et al., 1974). Frye, et al., (1974) distinguished five zones within the Ogallala of east-central New Mexico on the basis of clay minerals. These zones are illustrated in Figure 2-2. Smectites (montmorillonites) and attapulgite (with sepeotite) are the dominant clays throughout the Ogallala. Illite is a lesser, but persistent clay, as is kaolinite. Smectite is a swelling clay, causing deep cracks to form in dry surface soils. Smectite in particular, and to a lesser extent attapulgite and illite, are clays with moderate to high cation exchange capacities (CEC). The formation as a whole should therefore have a relatively

high CEC, which should inhibit the migration of charged contaminants, and especially ionic forms of metals.

Caliche is a major feature of the Ogallala Formation, occurring as nearly continuous layers throughout (Figure 2-3). Caliche is hard, white to pale tan on fresh surfaces, weathering to gray, and has a chalky appearance. Caliche precipitates as calcium carbonate, leached from overlying sediments, in the pore space of the host sediments. Precipitation is caused by the evaporation of downward percolating water. The caliche may thus mark the position of ancient vadose zones. Frye, et al., (1974) gives radiocarbon dates for the upper "climax" caliche ranging from -27,000 yrs before the present (B.P.) to -42,000 yrs. B.P. Caliche is relatively soluble in acidic water ($pH<7$) or in waters containing dissolved CO_2. The top surface of the upper "climax" caliche in fresh outdrop shows solution etching.

The Ogallala has numerous continuous to discontinuous caliche layers throughout its thickness. The uppermost caliche, termed the "climax" caliche by Frye and Leonard (1972), is pisolitic. The pisolites are thought to have formed as the caliche was repeatedly chemically weathered and brecciated during Pleistocene pluvials and later recemented during drier intervals. This upper caliche outcrops around Playas and the bounding escarpments of the Ogallala, and is locally termed "caprock". The climax caliche is typically 3 to 5 feet thick. Caliches which occur lower in the Ogallala are platy and harder.

2.2.2 Soils

Soils in the vicinity of CAFB are classified as SM to SC under the Unified Classification Systems, and as aridisols (calciorthids) under the Soil Conservation Service Comprehensive Soil Classification System. The following summary is based on the Soil Conservation Service Curry County Soil Survey (1953).

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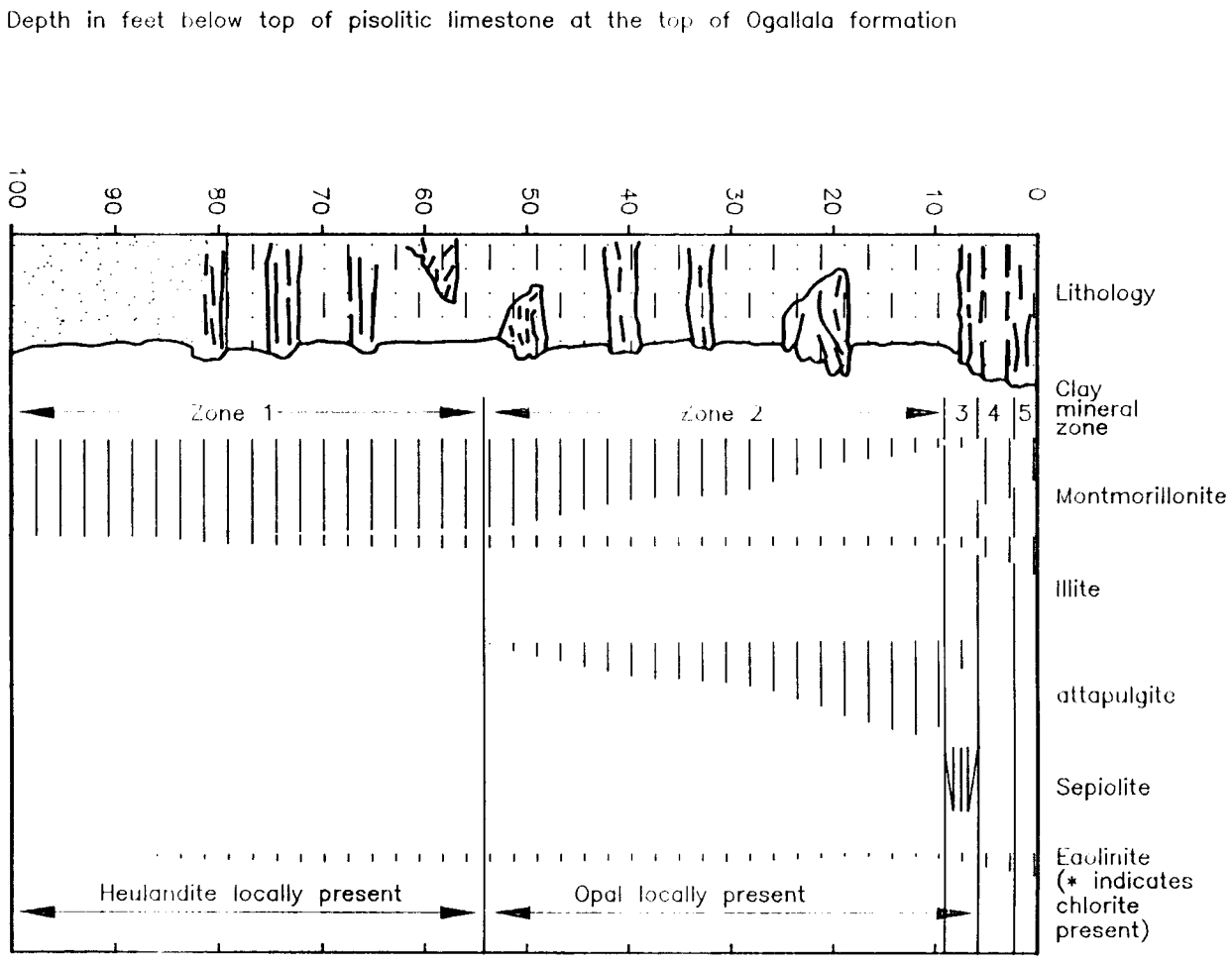

SOURCE: FRYE ETAL, 1974

FIGURE 2-3
GENERALIZED LITHOLOGY
OF THE OGALLALA GROUP
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

The most common soil type on the base is the Amarillo fine sandy loam, 0 to 2% slope phase (map symbol Ab, Figure 2-4). This soil consists of a thin sandy A horizon, well defined clayey B_{1-3} horizons, with a calcic B_3 horizon at depths below 40 inches. The calcic B_3 horizon lies on a calcic C horizon, or on caliche. The Amarillo fine sandy loam is present on all relatively flat surfaces at the base, but is also found on slopes associated with playas (Map symbol Ac). The Amarillo sandy loam and loamy sand are brown to yellowish red when exposed at the surface. The Amarillo series soil type is derived from stream erosion coupled with extensive reworking of the sediments by wind action (Radian, 1986).

There are several other soil associations at CAFB which are not as extensive or important as the Amarillo series. These soils are commonly found near the playas and draws. The Clovis soils occur in small areas within the broader areas of the Amarillo soils. They usually occupy the upper margins of draws and playas. The Clovis soils are similar to the Amarillo soils but have a shallower caliche zone (16 to 36 inches) and often have a poorly developed soil profile. The Clovis soils consist of three types of soil: the Clovis Loam, the Clovis Fine Sandy Loam and the Clovis Loamy Fine Sand (CH_2M Hill, 1983).

Two other soil groups are present in very limited areas at Cannon. The Mansker soils are strongly calcareous and occupy the slopes of draws and playas. The Mansker soils form where the higher horizons have been removed by erosion.

Clovis fine sandy loams, 0 to 2% slope phase (Map symbol Cb) and 2 to 5% slope phase (Map symbol Cc) are very similar to Amarillo fine sandy loams. In the Clovis soils, the depth to the calcic C horizon ranges from 28 to 56 inches. The depth to caliche exceeds 56 inches. Clovis and Amarillo fine sandy loams occur in close association.

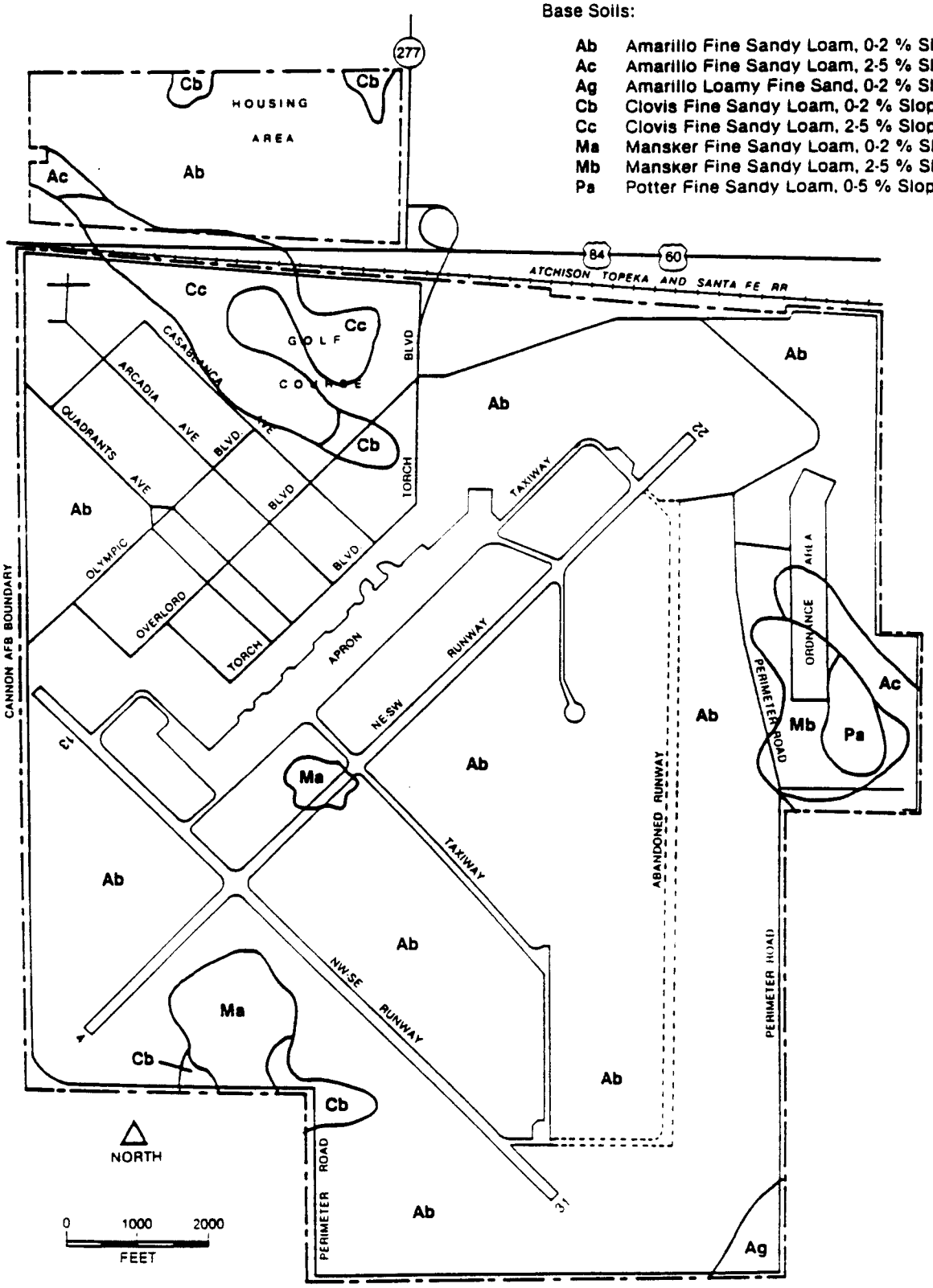

FIGURE 2-4

DISTRIBUTION OF SOILS, BY TYPE
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO (FROM CH_2M-HILL, 1983)

In a few limited areas, particularly along the steeper slopes around playas, Mansker fine sandy loam, 0 to 2% slope phase (Map symbol Ma), and 2 to 5% phase (Map symbol M6) are found. Mansker fine sandy loams have no B horizons and are very calcareous. The calcic C horizon is within 2 feet of the surface. The Potter soils are shallow and very calcareous soils which overlie hard, consolidated caliche. The areal distribution of these soils is shown in Figure 2-4.

The A and B horizons of Amarillo and Clovis fine sandy loams are rapidly to moderately permeable. Mansker fine sandy loam A and Ac horizons are rapidly permeable. Permeabilities in the calcic B and C horizons are moderate.

2.3 Hydrogeology

This subsection summarizes the regional hydrogeology, including surface water and groundwater in the vicinity of CAFB. This information was gathered from Base records and existing reports about CAFB.

2.3.1 Surface Water

The dominant surface features in the area around CAFB are small temporary lake basins known as playas. Playas are believed to result from soil erosion by wind. Playas have no external surface drainage so water is lost by infiltration to the soil and evaporation. Without recharge playa lakes persist for only a few days or weeks. A large example of these temporary lakes is located on CAFB and is known as Playa Lake. Playa Lake is used as a holding basin for treated effluent from the base sewage treatment lagoons. Another large playa lake located near the intersection of the primary and the northwest-southeast runways is used as a storm water retention pond.

Regional drainage in Curry County is predominantly to the southeast and the east. Stream drainage is poorly developed and ephemeral because of the low annual

rainfall and the minimal relief. The drainage patterns consist of long shallow valleys and locally termed draws that extend almost from the western edge of the Southern High Plains to the eastern boundary of the plateau. Running Water Draw and Patrick Draw, located about 10 and 20 miles, respectively, north of CAFB, are the nearest streams. Both of these streams are very straight, flow southeast, and have rectilinear drainage patterns with short laterals (second order streams). The valleys or draws eventually drain into one of three major river valleys; the Red, the Brazos or the Colorado. Although the draws extend to the river valleys as drainage systems, they seldom contribute actual flow to the rivers except during periods of unusually high rainfall. The bulk of the precipitation is lost to evapotranspiration and shallow infiltration before it has a chance to run off. In areas not drained by the draws, the playa lakes serve as low point collection areas for surface runoff. The playas have no surface outlet and any water that collects in the lakes is eventually lost to evapotranspiration or infiltration.

2.3.2 Groundwater

The lower portion of the Ogallala Formation is the primary regional aquifer for both potable and irrigation water. No deeper aquifers are utilized in the vicinity of CAFB. The Ogallala aquifer is part of the High Plains Aquifer that extends continuously from Wyoming and South Dakota into New Mexico and Texas. In east-central New Mexico, the Ogallala aquifer rests on Dockum Group redbeds, which serve as the basal confining layer (aquiclude). The Ogallala is a water table, or unconfined, aquifer (Weeks and Gutentag, 1981; Berkstresser and Mourant, 1966). The Ogallala aquifer has a southeasterly regional gradient of about 13 ft/mile. Well yields vary from less than 1 gallon per minute (gpm) in thin silts and sands up to 1600 gpm in thick sands and gravels (Berkstresser and Mourant, 1966). Water quality is generally good, with hardness and fluorides being somewhat high (ibid, 1966).

At CAFB the Ogallala aquifer has an average saturated thickness of 120 feet (mid-1960's). Saturated thickness ranges from 93 to 143 feet, and is influenced by

the configuration of the erosional unconformity surface marking the top of the Dockum Group. The local groundwater gradient is southeasterly at 7.5 feet/mile. Figure 2-5 shows water table elevation contours for 1984. Flow within the saturated zone may be influenced by the configuration of the top of the Dockum Group. Yields in tests of CAFB water wells have ranged from 776 L/min (205 gpm) to 4353 L/min (1150 gpm). Specific capacities range from 0.14 m^3/m (11.4 gal/ft.) to 0.35 m^3/m (27.9 gal/ft.).

Figure 2-6 shows the locations of water wells located within the boundaries of CAFB. Table 2-1 contains well information such as total depth and location of screened intervals for the CAFB wells. Water well number 5 is the closest well to Landfill No. 4. This well was drilled in 1977 and recently reworked and fitted with a new submersible pump. The static water level in Well No. 5 is 273 feet below ground level, and the red beds (lower aquifer limit) is at 410 feet below ground surface. This well is expected to be capable of producing 550 gpm with the new pump. CAFB personnel measure and record static water levels, pumping water levels and flow rates monthly.

Figure 2-7 shows the locations of all known off-base water wells within one-mile distance of Landfill No. 4. The well location information was obtained from the well records of the New Mexico State Engineer's Office. Table 2-2 contains well information such as total depth and location of screened intervals for the off-base wells.

Estimates of hydraulic conductivity were made from well pump tests in water wells 5 and 9 using the Theis equation (Lee Wan and Associates, 1990). An estimate of hydraulic conductivity for water well 8 was based on water level recovery data using the Bouwer and Rice (1976) approach. The data used in these calculations were obtained to evaluate pump rates, efficiency, and well yield, and were not intended for use in calculating aquifer properties. The results of these calculations should therefore be considered as first approximations (Lee Wan and Associates, 1990).

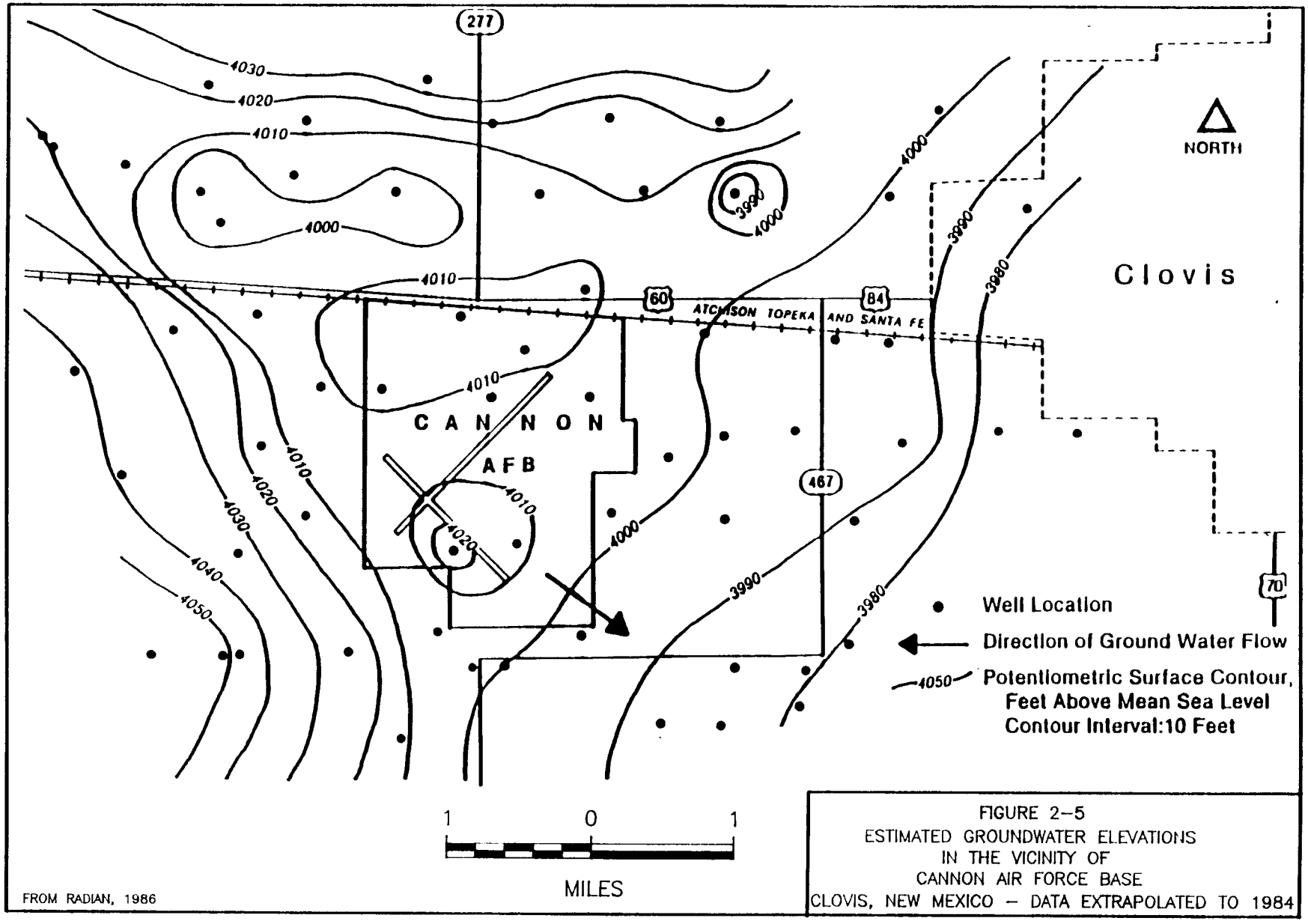

FIGURE 2–5
ESTIMATED GROUNDWATER ELEVATIONS
IN THE VICINITY OF
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO – DATA EXTRAPOLATED TO 1984

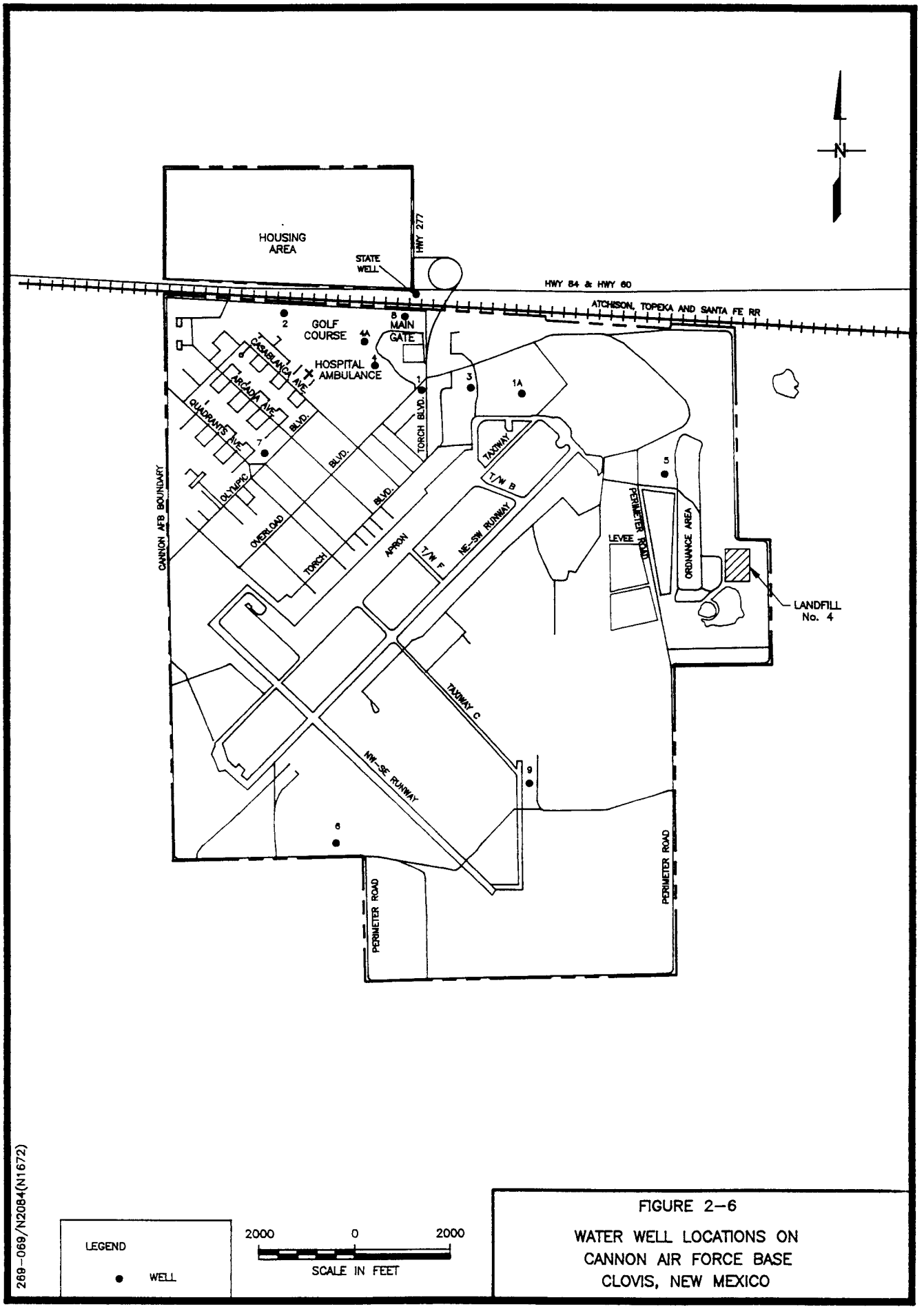

FIGURE 2–6

WATER WELL LOCATIONS ON CANNON AIR FORCE BASE CLOVIS, NEW MEXICO

269–069/N2084(N1672)

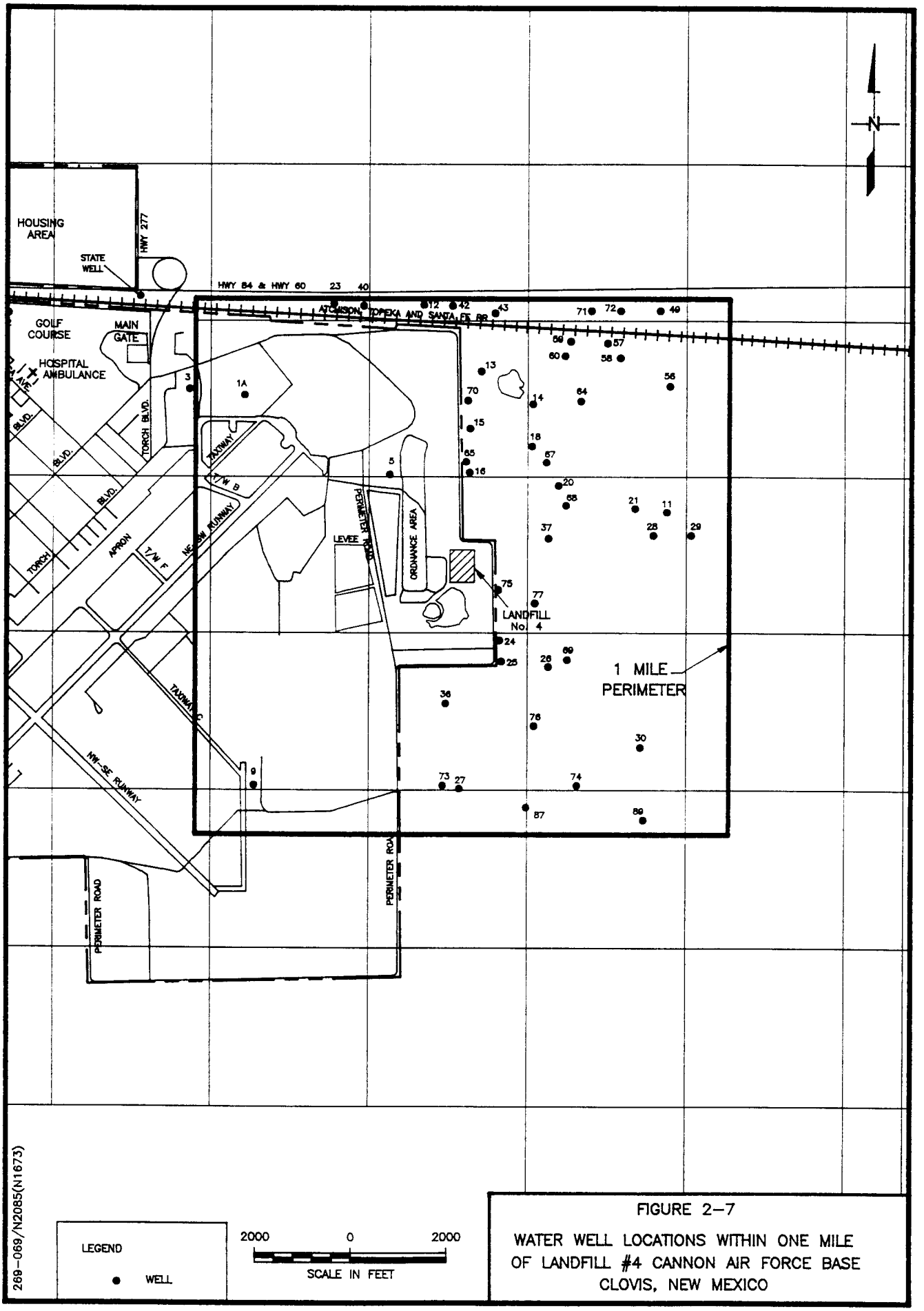

FIGURE 2-7

WATER WELL LOCATIONS WITHIN ONE MILE OF LANDFILL #4 CANNON AIR FORCE BASE CLOVIS, NEW MEXICO

Table 2-1

Water Wells Located on Cannon AFB
Clovis, New Mexico

Well No.	TD	Screen (feet bgs)	Pump Depth (feet bgs)	Date	Status
1	377	258 - 377	380	8-87	Probably Inactive
1A	407	347 - 397	NA	NA	Active
2	382	287 - 370	NA	NA	Active
3	402	310 - 397	NA	NA	Active
4	357	303 - 354	NA	NA	Active
4A	420	351 - 411	400	9-87	Active
5	400	282 - 342, 346 - 388	NA	NA	Active
6	365	310 - 365 estimated	300	2-64	Active
7	382	280 - 370	NA	NA	Active
8	415	301 - 401	NA	NA	Active
9	385	320 - 370	340	8-69	Active

bgs - below ground surface.
NA - Not Available.

Source: Well records of the New Mexico State Engineer's office.

Table 2-2

Water Wells Located Off-Base and Within One Mile of Landfill No. 4
Cannon Air Force Base, Clovis, New Mexico

Well Number	Location (Township & Range)	Total Depth (ft. bgs)	Screen Interval (ft. bgs)	Date	Owner	Status
11	2N.35.16.3330	380			SW Public Service Company	
12	2N.35.17.11214	350	320 - 350		L. Bunce	
13	2N.35.17.14140	334	307 - 322	5-90	L. Merrill	
14	2N.35.17.23332	335			L. Merrill	Active
15	2N.35.17.3211	350	300 - 325 estimated	3-64	L. Merrill	
16	2N.35.17.32311	350	290 - 350	3-64	L. Merrill	
18	2N.35.17.41123	324		4-66	L. Merrill	
20	2N.35.17.43212	341		4-66	L. Merrill	
21	2N.35.17.444444	337			L. Merrill	
23	2N.35.18.2243	318			Chilli B. Grocery	
24	2N.35.20.14231	357	297 - 357	5-78	L. Merrill	
26	2N.35.20.2343	340		7-64	L. Merrill	
27	2N.35.20.3343	385	294 - 374		H. House	
28	2N.35.21.1111	335			M. Blackburn	Active
29	2N.35.21.112112	420		1-72		
30	2N.35.21.3313	323		1-55	M. Blackburn	Active
36	2N.35.20.3124	365			O. William	Active
37	2N.35.20.2121	347		4-63	L. Merrill	
40	2N.35.7.44442	352	332 - 352	4-73	L. Ashley/Clovis Concrete	
42	2N.35.8.3344	396			K. Barnett	

Table 2-2

(Continued)

Well Number	Location (Township & Range)	Total Depth (ft. bgs)	Screen Interval (ft. bgs)	Date	Owner	Status
43	2N.35.8.3443	333		8-55	Smith & Jones	
49	2N.35.9.33334	370	360 - 370	9-63	Bridges	
55	2N.35.18.12130	362		1906	AT&SF	
56	2N.35.17.2244	334	284 - 334	4-68	Dr. Green	
57	2N.35.17.2212	355	345 - 355	6-60	C. Zellner	
58	2N.35.17.2212	355	325 - 355	7-62	C. Zellner	
59	2N.35.17.22112	357	337 - 357	11-91	G. Flinton	
60	2N.35.17.21242	347	337 - 347	5-59	Bell	
61	2N.35.17.11242	325			AT&SF	
64	2N.35.17.2			3-62	L. Merrill	Active
65	2N.35.17.3			9-62	L. Merrill	Active
67	2N.35.17.4			4-88	L. Merrill	Active
68	2N.35.17.4			4-88	L. Merrill	Active
69	2N.35.20.2			3-62	L. Merrill	Active
70	2N.35.17.1			4-83	L. Merrill	Active
71	2N.35.17.221			6-60	G. Flinton	Active
72						
73	2N.35.20.334			1954	W. Willmon	Active
74	2N.35.20.4			1965	L. Merrill	Active
75	2N.35.20.1			2-81	L. Merrill	Active
76	2N.35.20.4			3-90	W. Willmon	Active
77	2N.35.20.2			1965	L. Merrill	Active

Table 2-2

(Continued)

Well Number	Location (Township & Range)	Total Depth (ft. bgs)	Screen Interval (ft. bgs)	Date	Owner	Status
87	2N.35.29.21313	350	290 - 350 estimated	10-52	C. Willmon	Active
89	2N.35.29.242443	346	308 - 348	3-65	C. Willmon	Active

ft. bgs - feet below ground surface.
Source: Water well files of the New Mexico State Engineer's Office.

2N.25.29.21313:

Township 2N
Range 35
Section 29
Quadrant with Section 21313

Hydraulic conductivity values for water wells 5 and 9 are approximately 2.0 x 10^{3} cm/sec. The hydraulic conductivity for water well 8 is approximately 2.0 x 10^{2} cm/sec. These estimates appear to be too low when compared to published hydraulic conductivity data for sands and gravels. Kearney (1987) indicates a groundwater flow velocity of about 45 m/yr (150 ft/yr). Using this figure, the hydraulic conductivity is approximately 1.0 x 10^{1} cm/sec. Again, this appears to be low when compared with published data. The presence of interstitial clays may account for both the variability and low values of hydraulic conductivities. Boring logs from CAFB IRP projects and published reports (Frye, et al., 1974; Glass, et al., 1973) indicate that interstitial and interstratified clays are abundant in the Ogallala Formation. Additional aquifer testing is required to accurately determine hydraulic conductivity.

Recharge to the Ogallala is primarily through precipitation. Berkstresser and Mourant (1966) report a recharge rate of 0.5 in/yr as calculated by Theis (1936). Kearney (1987) indicates that the recharge rate may be as much as 1.0 in/yr. Because of the high evapotranspiration rate and low precipitation, recharge will occur only during heavy rainfall events during which the infiltration capacity of the soil is exceeded and runoff occurs, or during cool months when precipitation may exceed evapotranspiration. Table 2-3 shows that in an average year, the evaporation rate exceeds the precipitation rate for all 12 months. Any runoff that does occur will flow to playas.

Discharge from the Ogallala occurs through well pumping and springs along the eroded margins. Spring flow discharge does not occur on or near CAFB; however, domestic and irrigation water wells are common on and around the base. The rate of pumping water from the aquifer exceeds recharge, and consequently, water levels in the Ogallala have declined steadily since the 1930's. A decline of 50 to 100 feet has been observed in the area around Clovis, New Mexico for the period from the 1930's to 1980. Luckey, et al., (1981) states that "the largest area of water-level decline exceeding 100 feet occurs south of the Canadian River extending from Curry Co., New Mexico to Crosby Co., Texas."

Table 2-3

Precipitation Data Based on Average Monthly Values For Clovis, New Mexico [a]

Month	Average Precipitation (ft)	Pan Evaporation (ft)	Net Precipitation (ft)
January	0.0325	0.0333	-0.0008
February	0.0325	0.2833	-0.2508
March	0.0492	0.4167	-0.3675
April	0.1067	0.6167	-0.5100
May	0.1967	0.7083	-0.5116
June	0.2183	0.7750	-0.5567
July	0.2075	0.9833	-0.7758
August	0.2417	0.7583	-0.5606
September	0.1875	0.4583	-0.2708
October	0.1542	0.4167	-0.2625
November	0.0408	0.2917	-0.2509
December	0.0483	0.1833	-0.1350

[a] From Pan Evaporation Data collected by the Agricultural Science Station north of Clovis, New Mexico.

The dominant use of groundwater in the CAFB area is for potable and irrigation water. Numerous wells are located around CAFB, most of which provide only irrigation water (Figure 2-7). The Ogallala will continue to be used as the primary source of potable and irrigation water for eastern New Mexico. The New Mexico State Engineer designated Curry County as a Water Basin in 1989. This designation allows for regulations of water rights, usage, and well drilling.

2.4 Site Description

Figure 1-3 shows the location of the Landfill No. 4 site at CAFB and Figure 1-4 shows the soil boring locations. Landfill No. 4 is a rectangular plot approximately 573 feet by 479 feet (6.3 acres) and is located on the east perimeter of the base. The site is bounded on the north side by Perimeter Road, on the west side by a barbed wire fence, and on the east side by a vacant field. Landfill No. 4 now appears as an open field covered with native vegetation. The surface slopes very slightly to the south and remnant depressions of the disposal trenches are present.

Landfill No. 4 was used to dispose of a variety of wastes between 1967 and 1968. During operation, domestic solid wastes, waste oils, solvents, paints, paint thinners and strippers, pesticide containers and various empty cans and drums were burned in trenches and buried the following day. As trenches became filled, other trenches were excavated nearby and likewise filled.

During the excavation of an exploratory trench prior to collecting soil samples in August 1992, numerous soda pop and beer bottles were observed in the debris. An automobile tire, empty inoculum septum vials, a crushed and torn 55-gallon drum, and electrical conduit were also observed. Paper and pieces of plastic bags were also noted. Dark organic matter was observed in the trench cut face, showing the levels at which burning of refuse was done in the former disposal trenches. The unburned

material found suggests that either the burning was not done thoroughly or some material was buried without being burned.

3.0 FIELD INVESTIGATION PROGRAM

3.1 Organization and Development of the Field Program

The RFI was performed to investigate Landfill No. 4 for possible contamination and to provide recommendations for remedial action. The investigation included excavating a trench to locate the bottom of the landfill and collecting soil samples from 10 soil borings. These activities were guided by the RCRA Facility Investigation Work Plan (Lee Wan and Associates, 1990), and by the Quality Assurance Project Plan (QAPP), the Field Sampling Plan supplement (FSP), and the Site Specific Health Plan (SSHP) (Radian, 1992). These plans provided technical guidelines for performing the field investigations, procedures for the execution of field tasks, criteria for data collection, quality assurance/quality control (QA/QC) procedures, and guidelines to ensure the health and safety of field personnel. Detailed discussions of field procedures are documented in these plans. The following sections highlight the procedures outlined in the QAPP and FSP.

3.2 Data Quality Objectives

The objectives of this work effort were to gather information sufficient to determine if downward migration of contaminants is a problem at this site and whether there are any contaminants present that could pose a health risk to humans or the environment. The presence or absence of contamination was determined by detection or non-detection of chemicals in subsurface soil samples. Previous sampling performed at Landfill No. 4 left a data gap between the depths of between 15 and 50 feet, and this work effort was designed to fill the data gap.

Data quality objectives (DQOs) were to:

- Collect the samples specified in the QAPP to adequately determine the presence or absence of contamination beneath Landfill No. 4;
- Ensure data comparability through the use of standard analytical methods and controlled systems to collect and analyze samples;
- Provide analytical results of known and acceptable precision and accuracy; and
- Gather data to support an evaluation of the risks posed to human health and the environment.

A QA/QC protocol was followed to ensure that the DQOs were met for the CAFB Landfill No. 4 investigation. The QA/QC efforts provided the mechanism for ongoing control and evaluation of measurement data quality throughout the course of the project (i.e., system capability). They also specified QC data to be used to define natural-matrix data quality, in terms of precision and accuracy, for various measurement parameters.

3.3 Summary of Field Activities

3.3.1 Sequence of Field Activities

The field investigation began on 11 August 1992. Before drilling began, an exploratory trench was excavated to find the contact between the native soil and the base of the landfill. Sampling was conducted in the interval between this contact and 60 feet below grade. Drilling and sampling of the 10 boring locations shown in Figure 1-4 began on 11 August. Soil cuttings and decontamination water were drummed and temporarily stored at Landfill 5 on the southeast side of CAFB. Field activities were completed on 19 August 1992.

3.3.2 Identification and Role of Subcontractors

The following subcontractors were used to assist in this investigation:

- Geotechnical Laboratory - Lydick Engineers and Surveyors, Inc., of Clovis, New Mexico performed sieve analyses of all geotechnical samples collected.
- Analytical Laboratory - Radian Analytical Services (RAS) of Austin, Texas provided analytical services for all chemical analyses performed.
- Drilling Services - Sergent, Hauskins, and Beckwith of Albuquerque, New Mexico, provided all drilling services.
- Surveying - Lydick Engineers and Surveyors Inc., of Clovis, New Mexico provided surveying services.

3.4 General Information and Definitions

3.4.1 Utility Clearance

Digging permits were required for all activities that involved the disturbance of soils at CAFB. The dig permit for Landfill No. 4 was issued by the Base Civil Engineering Division. A scaled map showing the locations of the proposed drilling and trenching locations was sent to the Base Environmental Coordinator's office and circulated with the dig permit application to the base utility groups. The telephone company (U.S. West) did not locate any buried cables on the site. The base Safety, Fire, Security, and Environmental offices also signed the dig permit. A copy of the dig permit was kept on-site during the field investigation.

3.4.2 Sample Locations

Figure 1-4 shows the 10 locations sampled in August 1992 as well as the seven locations that were sampled in February 1985. The distribution of the August 1992 soil boring locations was made so as not to sample in the same places that were sampled in 1985 and to still collect a dispersed set of samples across the unit. These locations were changed slightly in the field so as to preferentially sample beneath the former trenches where wastes were dumped and burned before being buried. The locations of these former trenches were discernable by slight surface depressions. All August 1992 borings were drilled into the waste disposal trenches as evidenced by the subsidence patterns at the ground surface. Refuse was identified in four of the borings. Borings encountering refuse include 4H, 4I, 4L and 4M. Only backfill/cover soil was encountered in six of the borings.

Soil sampling was done systematically and began at the interface between the bottom of the landfill and the undisturbed soil below. Samples were collected at 5-foot intervals from the base of the landfill to a depth of 60 feet below grade. Up to two additional samples per borehole were collected at points of major lithology changes as indicated by changes in the drilling rate.

3.4.3 Decontamination Procedures

This section describes the procedures used to decontaminate field sampling equipment and associated equipment potentially contaminated during field activities. Decontamination was performed to prevent cross contamination of the samples and to maintain a clean working environment for the safety of all field personnel.

The following procedures were used to decontaminate:

- Wash with Liquinox® detergent;
- Rinse with potable water;
- Rinse with reagent grade isopropanol;
- Rinse twice with laboratory reagent grade water;
- Allow to air dry; and
- Wrap in foil or visqueen, if equipment not used immediately.

The drilling augers were decontaminated after each boring using a high pressure, high temperature steam cleaner. The back face of the rig was decontaminated between each boring using the steam cleaner. Rinse water was contained in pump sprayers to prevent used rinse water from contaminating subsequent samples. All decontamination water was considered to be potentially contaminated, so it was captured in a trough and subsequently pumped into a drum for storage.

Sample jars were pre-cleaned to EPA specifications and certified to be contaminant-free by the jar manufacturer. The jar lids remained on the jars until just before samples were placed into the jars so as to prevent contamination of the pre-cleaned jars. To prevent possible exposure of laboratory personnel to soil contaminants, the outside surfaces of the filled jars were cleaned as per Standard Operating Procedure (SOP) 13 (Appendix A of Field Sampling Plan).

3.4.4 Description of Calibration Procedures

Field health and safety monitoring instruments were calibrated every morning before use and recharged every evening for the following day. The instruments used were a photoionization detector (PID) with a 10.2 eV probe and an explosimeter (LEL). The PID was zeroed, then calibrated to a 100 ppm isobutylene gas mixture. The

LEL was zeroed, then calibrated to a 50% methane gas mixture. All calibration records were recorded in the field logbook.

3.4.5 Management and Disposal of Soil Cuttings and Decontamination Water

All drill cuttings and water from decontamination activities were considered to be potentially contaminated. The cuttings were drummed, labeled, and stored on pallets at each drilling location until all borings were drilled. When all drilling and trenching activities were completed, the drums were collected, transported, and stored on pallets at Landfill 5. Using a "Paint Pen", drums were labeled to identify the type of material contained, the site number, the boring number, the date of collection, and the telephone extension of the Base Environmental Coordinator.

If a drum contains any soil from a soil boring found to be contaminated, the entire contents of the drum will be considered contaminated. The laboratory analysis results will be used to prepare a cost estimate and plan for disposing of any contaminated soil and water generated during sampling of Landfill No. 4. Upon approval of the disposal plan by the USACE and the Base Environmental Coordinator, Radian will dispose of the waste off-site at an approved disposal facility. Uncontaminated cuttings and water will be disposed of at a site chosen by the Base Environmental Coordinator.

3.4.6 Site Restoration

The site was restored to its original condition at the completion of field activities to the approval of the Base Environmental Coordinator.

3.4.7 Survey of Borings

A registered land surveyor was retained to survey the elevations and horizontal coordinates of the boreholes. The survey requirements for boreholes were as follows:

- Determine ground elevations to the closest 0.1 foot;
- Determine elevation of the center-point of the grouted borehole to the closest 0.01 foot; and
- Determine coordinates of the well to 1.0 foot.

Elevations were referenced to the National Geodetic Vertical Datum of 1929 or to an existing local vertical datum. Coordinates were referenced to the State Plane Coordinate System. The enclosed map (Appendix J) shows the locations of the borings and the above information.

3.5 Sampling and Preservation Procedures

This section discusses sampling methodologies, field documentation, and QA/QC requirements.

3.5.1 Soil Boring and Geotechnical Samples

Soil samples were collected for chemical analysis and for geotechnical analysis from 10 soil borings. Figure 1-4 shows the soil boring locations.

Analytical Samples

Standard Operating Procedures (SOP) 4 - Drilling Operations and SOP 8 - Soil Sampling were followed for drilling and sampling procedures. Soil samples for

chemical analyses and for geotechnical analysis were collected with a CME-75 drill rig and 3 x 24-inch stainless steel split-spoon samplers. The split spoon sampler was driven through 6 ⅝-inch OD hollow stem augers in accordance with ASTM Methods D-1586-84 and D-3550. Copies of these standards are in Appendix B of the Field Sampling Plan. A 140-pound hammer was used to drive the split-spoon a maximum of 2 feet. Blow counts were counted every 6 inches and recorded on the drilling log. After removal, one side of the split-spoon was cracked open and screened for volatile organic emissions with a PID.

Immediately after the screening, two 60-mL soil samples for volatile organics (SW-846:8240) and purgeable TPH (SW-846:8015MP) analyses (VOAs) were collected. These samples were collected first to minimize the loss of target compounds by volatilization.

The VOAs were collected from the portion of the split spoon soil sample that showed the highest volatile organic content on the PID. The site geologist then described the physical characteristics of the sample recovered in the split spoon in accordance with the guidelines of Section 2.5 of the Scope of Services (Appendix C of the Field Sampling Plan). The remaining sample in the split spoon was then homogenized and composited in a decontaminated stainless steel bowl using a stainless steel trowel. Fresh gloves were worn by the geologist during the entire sampling procedure.

The composited soil was gently packed into three 250-mL (8 ounce) wide-mouth clear glass sample jars leaving some headspace. If the volume of soil recovered in the split spoon was inadequate to fill the 250-mL jars, the driller was instructed to auger out the interval just sampled and then push the split spoon to collect more soil. The recovered soil was composited with the previously recovered soil and packed into the three 250-mL jars. The sampling interval was recorded on the chain-of-custody form, on the jar sample label, and in the field log book.

The borings were backfilled with cement-bentonite grout after all sampling was completed. The grout mixture ratio was one bag of Portland cement (ASTM C150), seven gallons of water, and three to five pounds of bentonite powder. Grout was pumped from a cement truck into the boring until grout flowed from the top of the boring. The hole was topped off with grout after the initial pour settled.

Geotechnical Samples

Two soil samples were collected for geotechnical analysis from each soil boring. Geotechnical samples were selected at the discretion of the on-site geologist using the following criteria:

- Collect a variety of soil types across the site; and
- Collect samples from a range of depths.

The geotechnical samples were collected by the site geologist and put into Ziploc® freezer bags. The bags were marked with the boring number, sample depth, and the date and time of sample collection. The geotechnical samples were stored in a cooler (with no ice) until the analytical results indicated which of the geotechnical samples may have been contaminated. No geotechnical samples were found to be contaminated, so all were sent to the geotechnical lab for sieve analysis. The results of the sieve analyses are in Appendix B of this report.

3.5.2 Quality Assurance/Quality Control Samples

QA and QC Split Samples

QA and QC split samples (duplicates) were collected for all analyses at a rate of 10% for each analyte. The soil was homogenized and divided equally among all

containers for both standard and duplicate samples, with the exception of samples collected for volatile organics or purgeable (light) TPH analyses. To minimize volatilization, samples collected for either volatile organics or purgeable-TPH analyses were split but not homogenized. QA splits were sent to the USACE Missouri River Division (MRD) Laboratory as described in Section 4.0 of the Field Sampling Plan supplement for Landfill No. 4. QC samples were analyzed by Radian Analytical Services. The planned collection frequency for all subsurface QA/QC samples is shown in Table 3-1.

Matrix Spike and Matrix Spike Duplicate (MS/MSD)

Matrix spike and matrix spike duplicate samples were collected on a 5% frequency for each chemical analysis. For all analyses except volatile organics and purgeable TPH, soil was homogenized as described for QA and QC split samples. The matrix spike/matrix spike duplicate (MS/MSD) samples were not collected as separate samples in the field. The field personnel marked the labels of the samples chosen to be MS/MSDs with the letters "MS/MSD" in indelible ink and likewise marked the chain-of-custody in the left margin adjacent to the Sample ID. A note was also made in the remarks section of the chain-of-custody designating all MS/MSD samples included. Table 3-1 shows that for all analyses except herbicides and TPH, 24 MS/MSD analyses were performed by the Radian laboratory. This means that 12 samples were MS samples and 12 were MSD samples. Because each pair of MS and MSD analyses were run on soil collected from one soil sample, only 12 soil samples rather than 24 were designated as MS/MSD samples. The 12 MS/MSD samples were chosen to include the full diversity of soil types found at the site. The laboratory had the option of designating additional MS/MSD samples, if required, to ensure that MS/MSD analyses were performed for each sample batch.

Table 3-1

Analytical Sample Counts - Landfill No. 4

Chemical Analyses (Method [a] No.)	Base Samples	Field Dups	Equip Rinse	Trip Blank	Amb Blank	MS/ MSD	Analyt Dups	Radian Sample Count	QA Splits	QA Rinse	QA Trip Blanks	Total QA Sample Count [b]	Total Sample Count
Matrix	Soil	Soil	Water	Water	Water	Soil	Soil	--	Soil	Water	Water	--	--
Volatile Organics (8240)	120	12	0	12	0	16	0	160	12	0	12	24	184
Top 10 TIC's	120	12	0	12	0	0	0	144	0	0	0	0	144
SVOC's - soils - (8270)	120	12	7	0	0	16	0	155	12	7	0	19	174
SVOC Top 20 TIC's	120	12	7	0	0	0	0	139	0	7	0	0	139
Herbicides (8150)	30	3	2	0	0	6	0	41	3	2	0	3	46
Pesticides and PCBs - soils- (8080)	120	12	7	0	0	16	0	155	12	7	0	19	174
TPH by modified 8015	30	3	2	0	0	6	0	41	3	2	0	2	46
TRPH (EPA 418.1)	120	12	7	0	0	16	0	155	12	7	0	19	174
Metals [c] (6010, 7060, 7421, 7471, 7740)	120	12	7	0	0	16	0	155	12	7	0	19	174
% Moisture (SW-846) for corr. to dry weight	120	12	0	0	0	0	0	132	0	0	0	0	132
pH (9045)	120	12	0	0	0	0	0	132	0	0	0	0	132

TIC - Tentatively Identified Compounds.
SVOC - Semi-volatile Organic Compounds.
PCB - Polychlorinated Biphenols.
TPH - Total Petroleum Hydrocarbons.
TRPH - Total Recoverable Petroleum Hydrocarbons.
ICPES - Inductively Coupled Plasma Emission Spectroscopy.

[a] - Reference Methods from SW-846 Test Methods For Evaluating Solid Wastes. Physical/Chemical Methods. November 1986, third edition.
[b] - All QA samples will be submitted to USACE Missouri River Division (MRD) Laboratory for analysis.
[c] - ICPES metals: aluminum, antimony, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, magnesium, manganese, nickel, potassium, silver, sodium, thallium, tin, vanadium and zinc.
Other metals: arsenic, lead and mercury.

Trip Blanks

Trip blanks consisted of 40-mL VOA vials filled by the laboratory with organic free water and preserved with dilute hydrochloric acid. Trip blanks accompaniedall ice chests that contained volatile organic or purgeable-TPH (SW-846-8015MP) samples.

Equipment Rinse Samples

Equipment blanks were collected by pouring reagent-grade deionized water over decontaminated split-spoon sampling tubes and compositing equipment and then collecting the water in 1-liter bottles. The equipment that was rinsed was noted in the field log book. The rinsate samples were analyzed for metals, TRPH (EPA 418.1), semi-volatile organic compounds (SW-846:8270), TPH-extractables (SW-846:8015M), Pesticides/PCBs (SW-846:8080), and herbicides (SW-846:8150). The samples were collected in 1-liter glass bottles fitted with Teflon-lined caps (Table 3-2).

3.5.3 Additional Fieldwork

Radian performed additional RI field work at Landfill No. 4 during the period of 28 September 1992 to 30 September 1992. The scope of work was modified after completion of the initial field work to include the analysis of surface soil samples collected from five locations on the landfill. In addition, three soil borings, 4N, 4Q, and 4R, were re-drilled during this period to collect nine replacement samples for which the holding time of the pesticide/PCB (SW-846:8080) analysis was exceeded by the laboratory. All of the field procedures outlined in the FSP were followed for the additional field work.

Table 3-2

Summary of Rinse Sample Containers, Preservation, and Holding Times

Reference Method	Parameter	Container Type, No., and Volume	Preservation and Storage Requirements	Maximum Holding Time (Preparation)	Maximum Holding Time (Analysis)
SW-846:6010	Al, Ag, Ba, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni; Sb, Sn, Tl, V, Zn	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C HNO_3 pH <2	N/A	6 months [a]
SW-846:7060	As				
SW-846:7421	Pb				
SW-846:7471	Hg				
SW-846:7740	Se				
EPA 418.1	TRPH	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C HCl pH <2	N/A	28 days
SW-846:8270	Semi-volatile Organic Compounds	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C	7 days	40 days
SW-846:8015M	TPH (extractables)	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C	14 days	40 days
SW-846:8080	Organochlorine Pesticides/PCBs	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C	7 days	40 days
SW-846:8150	Chlorinated Herbicides	(1) 1-L glass, Teflon-lined cap	Refrigerated at 4°C	7 days	40 days

[a] - Hold time for Mercury is 28 days.

Surface Soil Samples

Surface soil samples were collected from Landfill No. 4 to provide data for assessment of risk to human health and the environment through the surface water runoff and air pathways. Soil samples were collected from five locations within Landfill No. 4 and from one background location. The samples were collected 5 feet north of borings 4I, 4J, 4L, 4R, and 4Q. The background sample was collected approximately halfway between Landfill 3 and Landfill 4 along the eastern property boundary fenceline. The full list of analytes were performed on these samples, i.e. metals, TRPH (EPA 418.1), semi-volatile organic compounds (SW-846:8270), TPH-extractables (SW-846:8015M), Pesticides/PCBs (SW-846:8080) and herbicides (SW-846-8150). The surface sample locations are shown in Figure 1-4.

Soil Boring Resampling

The new soil borings were placed approximately 5 feet north of 4N, 4Q, and 4R and were designated 4NN, 4QQ, and 4RR. One sample was collected at a depth of 15 feet below surface in boring 4QQ. One sample was collected from a depth of 60 feet below surface in boring 4RR. Samples were collected at 5 foot intervals from 40 to 60 feet below surface in boring 4NN. A split sample was collected from 45 feet below surface in boring 4NN. The sample from the 55 foot interval in 4NN required CLP validation. A duplicate sample from the 55 foot interval in 4NN was also collected. These soil boring samples were analyzed only for pesticides and PCBs. The soil boring locations are shown in Figure 1-4.

Additional Equipment Rinse Samples

An equipment rinse sample was collected from the equipment used to collect the surface soil samples. This sample was analyzed for the full list of analytes. In response to comments from the USACE, 1-liter polyethylene bottles were used for the

equipment rinse sample which was designated for metals analyses. This was the only difference in sample containers from the original field work.

An equipment rinse was also collected from the equipment used to collect the resampled subsurface samples. This rinse sample was analyzed for pesticides and PCBs only.

3.5.4 Analyses

All soil samples and equipment rinse samples except QA samples were sent to Radian Analytical Services (RAS) in Austin, Texas. QA samples were sent to the USACE MRD Laboratory in Omaha, Nebraska. The MRD laboratory identification number (LIN) for CAFB Landfill No. 4 samples was 1494 and this number was written on the chain-of-custody forms accompanying all sample shipments to the MRD laboratory.

3.5.5 Sample Containers, Preservation, and Holding Times

To preserve the integrity of the soil and QA/QC liquid samples before analysis, proper sample containment, preservation methods, holding times, chain-of-custody and shipping procedures outlined in the QAPP and the FSP supplement were followed. All sample bottles and containers were pre-cleaned according to EPA protocols by the sample bottle supplier, Eagle-Picher. Samples were kept cool during collection and shipment with ice in Ziploc® plastic bags. The samples were stored upright in a durable ice chest and sufficient packing material (e.g., styrofoam peanuts) was used to separate and protect the bottles.

4.0 ARARs EVALUATION

In 1980, Congress enacted the CERCLA, 42 U.S.C. Section 9601 *et seq.*, establishing the Superfund program. The regulations, adopted by USEPA, that implement this program are found in 40 CFR Part 300, also known as the NCP. CERCLA was amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986 which mandated that the level or standard of control specified in a remedial action for the site-specific pollutants be "at least that of any applicable or relevant and appropriate (ARAR) standard, requirement, criteria, or limitation under any federal environmental law, or any more stringent standard, requirement, criteria, or limitation promulgated pursuant to a state environmental statute." SARA established that the requirements of the NCP apply to federal facilities in their implementation of the IRP.

CERCLA, as amended by SARA, requires that federal facility remedial actions (for NPL as well as IRP sites) comply with requirements or standards under federal and state environmental laws. The 1990 NCP incorporates the new statutory requirement that remedies at such sites must comply not only with ARARs under federal laws, but also with promulgated standards, requirements, criteria, or limitations under state environmental or facility sitting laws that are more stringent than corresponding federal standards. "Promulgated" state requirements are those laws or regulations that are of general applicability and are legally enforceable. In terms of state ARARs, only those promulgated standards that are (1) identified by the state in a timely manner; and (2) more stringent than federal requirements may be ARARs.

The terms "applicable" and "relevant and appropriate" are defined as follows:

"Applicable" requirements, as defined at 40 CFR Section 300.4, are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility sitting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Applicable requirements are those that would be legally applicable if the remedial action had not been taken under CERCLA; the concept requires that all jurisdictional prerequisites and criteria of the particular statute have been met.

"Relevant and Appropriate" requirements are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility sitting law that, while not applicable (as defined above), address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well-suited to the particular site.

4.1 To Be Considered

Criteria, advisories or guidance documents that do not meet the definition of ARARs but may assist in determining what is necessary to be protective or otherwise be useful in developing Superfund remedies are described as information "to-be-considered" (TBCs). Three general categories of TBCs are: (1) health effects information with a high degree of credibility, i.e., reference doses; (2) technical information on how to perform or evaluate site investigations or response actions; and (3) policy, e.g., USEPA's groundwater policy. The 1990 amendments to the NCP emphasize that TBCs are to be used on an "as appropriate" basis and are intended to complement the use of ARARs, not be in competition with ARARs.

The preliminary ARARs for CAFB described below were identified in accordance with *CERCLA Compliance with Other Laws Manual* (EPA/540/G-89/006

and EPA/540/G-89/009) and *Guidance for Conducting Remedial Investigations Under CERCLA, Interim Final* (EPA/540/G-89/004). These ARARs will be reassessed in subsequent stages of the remediation at Landfill No. 4 and expanded or refined as needed. Ultimately, the preferred remedial action alternative will be assessed against the CERCLA and IRP cleanup criteria, including attainment of, or compliance with, ARARs.

The following preliminary ARAR identification is divided into three categories of ARARs: 1) ambient or "chemical-specific" requirements; 2) locational standards; and 3) performance, design, or other "action-specific" requirements.

4.2 Chemical-Specific ARARs

Chemical-specific ARARs are typically health-based or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values. These values, in turn, establish the acceptable amount or concentration of a chemical that may be found in, or discharged to, the environment (soil, groundwater, surface water or air) as a result of the remedial action. Potential federal and state chemical-specific ARARs for CAFB are summarized in the following subsections.

4.2.1 Drinking Water Standards

40 CFR Part 141
57 Fed. Reg. 31778, 17 July 1992
N.M. Water Quality Control Commission Regulations (NMWQCCR)
N.M. Drinking Water Regulations

As explained below, current drinking water standards may be an ARAR for the purpose of establishing cleanup levels for contaminated groundwater. The National Primary Drinking Water Regulations establish Maximum Contaminant Levels (MCLs)

that are enforceable standards under the Safe Drinking Water Act for specific contaminants in public water supplies. Maximum Contaminant Level Goals (MCLGs) are non-enforceable goals on which MCLs are based. MCLs are applicable in the selection of groundwater restoration levels. MCLGs are TBC information only.

Table 4-1 presents a side-by-side comparison of the federal MCLs, secondary drinking water standards, MCLGs, and New Mexico Human Health Standards. As noted in the footnotes to the table, the federal MCL and MCLG list includes a number of revisions adopted by the USEPA in 1991 and 1992, but which will not become effective until 1993 and 1994. The New Mexico Human Health Standards are found in Section 3-103 of the *New Mexico Water Quality Control Commission Regulations* (NMWQCCR) which specifies concentrations of pollutants that must not be exceeded in groundwater. These promulgated standards are applicable requirements that regulate discharges onto or below the surface of the ground. In addition to the NMWQCCR (regulating discharges onto or below the ground) the New Mexico Drinking Water Standards (a.k.a., "Water Supply Regulations") apply to each public water system supply in New Mexico.

4.2.2 Surface Water Quality Standards

USEPA Quality Criteria for Water 1986
N.M. Water Quality Control Commission Regulations (NMWQCCR)

Surface water quality standards may be an ARAR if the ultimate remedial action selected involves the discharge of pollutants to surface waters, (i.e., discharge of treated groundwater). The USEPA has developed ambient surface water quality criteria (SWQC) for protection of aquatic life, which are found in *Quality Criteria for Water 1986,* EPA 440/5-86-001 (1 May 1986). These federal water quality criteria are not an ARAR because they have not been promulgated by USEPA, but are TBC information. As discussed in Section 4.1, TBC information includes criteria, advisories or guidance

Table 4-1

National Drinking Water Standards and New Mexico Human Health Standards

Contaminants	National Primary MCLs[a] (mg/l)	New Mexico HHS[b] (mg/l)	National Secondary MCLs[c] (mg/l)	National MCLGs[d] (mg/l)
ORGANICS				
Acrylamide	–	–	–	zero
Alachlor	0.002	–	–	zero
Aldicarb Sulfone	0.003[e]	–	–	0.001[e]
Aldicarb Sulfoxide	0.004[e]	–	–	0.001[e]
Aldicarb	0.003[e]	–	–	0.001[e]
Atrazine	0.003	–	–	0.003
Benzene	0.005	0.01	–	zero
Benzo(a)pyrene	0.0002[f]	–	–	zero[f]
Carbofuran	0.04	–	–	0.04
Carbon Tetrachloride	0.005	0.01	–	zero
Chlordane	0.002	–	–	zero
2,4,-D	0.07	–	–	0.07
Dalapon	0.2[f]	–	–	0.2[f]
Di(2-ethylhexyl)adipate	0.4[f]	–	–	0.4[f]
Di(2-ethylhexyl)phthalate	0.006[f]	–	–	zero[f]
Dibromochloropropane	0.0002	–	–	zero
Para-Dichlorobenzene	0.075	–	–	0.075
o-Dichlorobenzene	0.6	–	–	0.6
Dichloromethane	0.005[f]	–	–	zero[f]
1,2-Dichloroethane	0.005	0.01	–	–
1,2-Dichloropropane	0.005	–	–	zero
1,1-Dichloroethylene	0.007	–	–	0.007
cis-1,2-Dichloroethylene	0.07	–	–	0.07
trans-1,2-Dichloroethylene	0.1	–	–	0.1
Dinoseb	0.007[f]	–	–	0.007[f]
Diquat	0.02[f]	–	–	0.02[f]
Endothall	0.1[f]	–	–	0.1[f]
Endrin	0.0002[h], 0.002[g]	–	–	0.002[g]
Epichlorohydrin	–	–	–	zero
Ethylbenzene	0.7	0.75	–	0.7
Ethylene Dibromide	0.00005	–	–	zero
Glyphosate	0.7[f]	–	–	0.7[f]
Heptachlor Epoxide	0.0002	–	–	zero
Heptachlor	0.0004	–	–	zero

Table 4-1

(Continued)

Contaminants	National Primary MCLs [a] (mg/l)	New Mexico HHS [b] (mg/l)	National Secondary MCLs [c] (mg/l)	National MCLGs [d] (mg/l)
Hexachlorobenzene	0.001 [f]	–	–	zero [f]
Hexachlorocyclopentadiene	0.05 [f]	–	–	0.05 [f]
Lindane	0.0002	–	–	0.0002
Methoxychlor	0.04	–	–	0.04
Monochlorobenzene	0.1	–	–	0.1
Oxamyl (Vydate)	0.2 [f]	–	–	0.2 [f]
Pentachlorophenol	0.001 [e]	0.005	–	zero [e]
Picloram	0.5 [f]	–	–	0.5 [f]
Polychlorinated biphenyls (PCBs as decachloro-biphenyl)	0.0005	–	–	zero
Simazine	0.004 [f]	–	–	0.004 [f]
Styrene	0.1	–	–	0.1
2,3,7,8-TCDD (dioxin)	3×10^{-8}	–	–	zero [f]
Tetrachloroethylene	0.005	–	–	zero
Toluene	1	–	–	1
2,4,5-TP (Silvex)	0.05	0.005	–	0.05
Total Trihalomethanes	0.10 [h,i]	–	–	–
Toxaphene	0.003	–	–	zero
1,2,4-Trichlorobenzene	0.07 [f]	–	–	0.07 [f]
1,1,1-Trichloroethane	0.2	–	–	0.20
1,1,2-Trichloroethane	0.005 [f]	–	–	0.003 [f]
Trichloroethylene	0.005	–	–	zero
Vinyl Chloride	0.002	–	–	zero
Xylenes (total)	10	–	–	10
INORGANICS				
Aluminum	–	–	0.05 to 0.2	–
Antimony	0.006 [f]	–	–	0.006 [f]
Arsenic	0.05 [h]	0.1	–	–
Asbestos	7 million fibers/liter (longer than 10 μm)	–	–	7 million fibers/liter (longer than 10 μm)
Barium	1 [h], 2 [e]	1	–	2 [e]
Beryllium	0.004 [f]	–	–	0.004 [f]
Cadmium	0.005	0.01	–	0.005
Chloride	–	–	250	–
Chromium	0.1	0.05	–	0.1
Copper	1.3 [h]	1	1.0	1.3

Table 4-1

(Continued)

Contaminants	National Primary MCLs [a] (mg/l)	New Mexico HHS [b] (mg/l)	National Secondary MCLs [e] (mg/l)	National MCLGs [d] (mg/l)
Cyanide (as free Cyanide)	0.2 [f]	–	–	0.2 [f]
Fluoride	4.0	–	2.0	4.0
Iron	–	–	0.3	–
Lead	0.015 [h]	0.05	–	zero
Manganese	–	–	0.05	–
Mercury	0.002	0.002	–	0.002
Nickel	0.1 [f]	–	–	0.1 [f]
Nitrate (as Nitrogen)	10	–	–	10
Nitrite (as Nitrogen)	1	–	–	1
Total Nitrate and Nitrile (as Nitrogen)	10	–	–	10
Selenium	0.05	0.05	–	0.05
Silver	0.05 [h]	0.05	0.1	–
Sulfate	–	–	250	–
TDS (total dissolved solids)	–	–	500	–
Thallium	0.002 [f]	–	–	0.0005 [f]
Zinc	–	10	5	–
PHYSICAL PROPERTIES				
Color	–	–	15 color units	–
Corrosivity	–	–	non-corrosive	–
Foaming Agents	–	–	0.5	–
Odor	–	–	3 threshold odor number	–
pH	–	–	6.5 - 8.5 S.U.	–

[a] - From 40 CFR, Section 141.61 for organics and Section 141.62 for inorganics (effective 30 July 1992, unless otherwise noted).
[b] - New Mexico Human Health Standards from N.M. Water Quality Control Commission Regulations as Amended through 18 August 1991.
[c] - From 40 CFR Section 143.3 (effective 30 July 1992, unless otherwise noted).
[d] - From 40 CFR Section 141.50 for organics and Section 141.51 for inorganics (effective 30 July 1992, unless otherwise noted).
[e] - Effective 1 January 1993.
[f] - Effective 17 January 1994.
[g] - Effective 17 August 1992.
[h] - From 40 CFR, Section 141.11 for inorganics and Section 141.12 for organics (effective 1 July 1991; however, the lead level is effective only until 7 December 1992). There is no longer an MCL for lead or copper (Federal Register, 7 June 1991); however, there is an action level of 0.015 mg/L for lead and 1.3 mg/L for copper.
[i] - Applies only to community water systems which serve a population of 10,000 or more that have a disinfectant added to the water.
– - MCL or MCLG not specified.

documents that do not meet the definition of ARARs but may assist in determining what is necessary to be protective or otherwise useful in developing Superfund remedies. The SWQC establish acceptable in-stream concentration of pollutants, for the protection of aquatic life, as set forth in Table 4-2.

4.2.3 USEPA RCRA Proposed Corrective Action Media Action Levels

40 CFR Part 264, Subpart S, Section 264.521 (proposed 27 July 1990, 55 Fed. Reg. 30798 et seq.)

The proposed Corrective Action Subpart S regulations contain methodology and criteria for calculating action levels for contaminants in soil, water, and air. Action levels are not cleanup standards; rather, an exceedence of a media action level potentially triggers the need for a corrective measures study (CMS) of a solid waste management unit (SWMU). RCRA Subpart S action levels are presented in Table 4-3. The USEPA health-based criteria used to calculate these action levels are presented in Table 4-4. The action levels in Table 4-3 were calculated using (1) the recommended exposure assumptions in Appendix D of the proposed Subpart S Corrective Action Rule; (2) the governing equations for calculating action levels presented in Appendix E of the Subpart S rule; and (3) the risk assessment values presented in Table 4-4 of this report. Appendix A of the Subpart S rule presents example action levels which are to be updated as new data on hazardous constituents are developed (preamble, 55 *Federal Register* 30798 at Section VI.E.2.b). Table 4-4 presents the risk assessment values (i.e., RfDs and CSFs) used in the calculation of the action levels presented in Table 4-3. Action levels under the proposed Subpart S are to be considered as points of departure for setting cleanup standards. RCRA corrective action cleanup standards (media protection standards) (discussed in Subsection 4.2.4) are established at the CMS stage and may be less stringent than the action levels depending on the site conditions.

Table 4-2

Federal Surface Water Quality Criteria

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
METALS		
Antimony	88 [a]	30 [a]
Barium	ND [a]	ND [a]
Beryllium	130 [a,b]	5.3 [a,b]
Cadmium	3.9+ [a]	1.1+ [a]
Chromium (total)	1,700+ [c]	210+ [c]
Cobalt	ND [a]	ND [a]
Copper	9.2+ [a]	6.5+ [a]
Nickel	1,400+ [a]	160+ [c]
Silver	0.92 [a]	0.12 [a]
Tin	–	–
Vanadium	ND [a]	ND [a]
Zinc	120+ [a]	110+ [a]
Arsenic	360 [a,d]	190 [a,d]
Lead	82+ [a]	3.2+ [a]
Mercury	2.4 [a]	0.012 [a]
Selenium	20 [a]	5 [a]
Thallium	1,400 [b,c]	40 [b,c]
ORGANOCHLORINE PESTICIDES AND PCBs		
Aldrin	3 [a]	ND [a]
alpha-BHC	100 [a]	ND [a]
beta-BHC	100 [a]	ND [a]
delta-BHC	100 [a]	ND [a]
gamma-BHC (Lindane)	2 [a]	0.08 [a]
Chlordane (technical)	2.4 [a]	0.0043 [a]
4,4'-DDD	ND [a]	ND [a]
4,4'-DDE	1,500 [a,b]	ND [a]
4,4'-DDT	1.1 [a]	0.001 [a]
Dieldrin	1 [a]	0.0019 [a]
Endosulfan I	0.22 [c]	0.056 [c]
Endosulfan II	0.22 [c]	0.056 [c]
Endosulfan sulfate	–	–
Endrin	0.18 [a]	0.0023 [a]

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
Endrin aldehyde	–	–
Heptachlor	0.52 [a]	0.0038 [a]
Heptachlor epoxide	0.52 [a]	0.0038 [a]
Isodrin	ND [a]	ND [a]
Kepone	–	–
Methoxychlor	ND [a]	0.03 [a]
Toxaphene	0.73 [a]	0.0002 [a]
PCB-1016	2 [a]	0.014 [a]
PCB-1221	2 [a]	0.014 [a]
PCB-1323	2 [a]	0.014 [a]
PCB-1242	2 [a]	0.014 [a]
PCB-1248	2 [a]	0.014 [a]
PCB-1254	2 [a]	0.014 [a]
PCB-1260	2 [a]	0.014 [a]
ORGANOPHOSPHORUS PESTICIDES		
Dimethoate	ND [a]	ND [a]
Disulfoton	ND [a]	ND [a]
Ethyl parathion (parathion)	0.065 [a]	0.013 [a]
Famphur	ND [a]	ND [a]
Parathion methyl	ND [a]	ND [a]
Phorate	ND [a]	ND [a]
Sulfotepp	ND [a]	ND [a]
Thionazin	–	–
o,o,o-Triethylphosphorthioate	–	–
CHLORINATED HERBICIDES		
2,4-D	ND [a]	ND [a]
2,4,5-T	ND [a]	ND [a]
2,4,5-TP (Silvex)	ND [a]	ND [a]
Dinoseb	ND [a]	ND [a]

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
VOLATILE ORGANICS		
Acetone	ND [a]	ND [a]
Acetonitrile	ND [a]	ND [a]
Acrolein	68 [a,b]	21 [a,b]
Acrylonitrile	7550 [a,b]	2600 [a,b]
Benzene	5300 [a,b]	ND [a]
Bromodichloromethane	11000 [a,b]	ND [a]
Bromomethane	11000 [a,b]	ND [a]
Carbon disulfide	ND [a]	2 [a]
Carbon tetrachloride	35200 [a,b]	ND [a]
2-Chloro-1,3-butadiene	ND [a]	ND [a]
Chlorobenzene	250 [a,b]	50 [a,b]
Chloroethane	860000 [a]	230000 [a]
Chloroform	28900 [a,b]	1240 [a,b]
Chloromethane	ND [a]	ND [a]
3-Chloropropene (allyl chloride)	860000 [a]	230000 [a]
Dibromochloromethane	11000 [a,b]	ND [a]
1,2-Dibromo-3-chloropropane	ND [a]	ND [a]
1,2-Dibromoethane	ND [a]	ND [a]
Dibromomethane	ND [a]	ND [a]
trans-1,4-Dichloro-2-butene	–	–
Dichlorodifluoromethane	11000 [a,b]	ND [a]
1,2-Dichloroethane	118000 [a,b]	20000 [a,b]
trans-1,2-Dichloroethene	11600 [a,b]	ND [a]
1,1-Dichloroethane	ND [a]	ND [a]
1,1-Dichloroethene	11600 [a,b]	ND [a]
1,2-Dichloropropane	ND [a]	ND [a]
cis-1,3-Dichloropropene	6060 [c,b]	244 [b,c]
trans-1,3-Dichloropropene	6060 [c,b]	244 [b,c]
Ethyl benzene	32000 [a,b]	ND [a]
Ethyl methacrylate	ND [a]	ND [a]
2-Hexanone	ND [a]	ND [a]
Iodomethane	–	–
Methylene chloride	11000 [a,b]	ND [a]

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
2-Butanone (MEK)	ND [a]	ND [a]
Methyl methacrylate	ND [a]	ND [a]
4-Methyl-2-pentanone (MIBK)	ND [a]	ND [a]
Propanenitrile (propionitrile)	–	–
Styrene	ND [a]	ND [a]
1,1,1,2-Tetrachloroethane	9.32e+03 [a]	ND [a]
1,1,2,2-Tetrachloroethane	9.32e+03 [a]	2400 [a,b]
Tetrachloroethene	ND [a]	ND [a]
Toluene	17500 [a,b]	ND [a]
Tribromomethane	11000 [a,b]	ND [a]
1,1,1-Trichloroethane	18000 [a,b]	ND [a]
1,1,2-Trichloroethane	18000 [a,b]	9400 [a,b]
Trichloroethene	45000 [a,b]	21900 [a,b]
Trichlorofluoromethane	11000 [a,b]	ND [a]
1,2,3-Trichloropropane	ND [a]	ND [a]
Vinyl Acetate	ND [a]	ND [a]
Vinyl Chloride	ND [a]	ND [a]
Xylenes (total)	ND [a]	ND [a]
VOLATILE ORGANICS (Direct Injection)		
1,4-Dioxane	ND [a]	ND [a]
Isobutanol	ND [a]	ND [a]
Methacrylonitrile	ND [a]	ND [a]
SEMI-VOLATILE ORGANICS		
Acenaphthene	[a,c]	[a,c]
Acenaphthylene	ND [a]	ND [a]
Acetophenone	ND [a]	ND [a]
2-Acetylaminofluorene	–	–
4-Aminobiphenyl	–	–
Aniline	ND [a]	ND [a]
Anthracene	ND [a]	ND [a]
Aramite	ND [a]	ND [a]
Benzo(a)anthracene	ND [a]	ND [a]
Benzo(a)pyrene	ND [a]	ND [a]
Benzo(b)fluoranthene	ND [a]	ND [a]

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
Benzo(g,h,i)perylene	ND [a]	ND [a]
Benzo(k)fluoranthene	ND [a]	ND [a]
Benzyl alcohol	--	--
4-Bromophenyl phenyl ether	360 [a,b]	120 [a,b]
Butylbenzylphthalate	940 [a,b]	3 [a,b]
4-Chloro-3-methylphenol	ND [a]	ND [a]
4-Chloroaniline	ND [a]	ND [a]
Chlorobenzilate	ND [a]	ND [a]
bis(2-Chloroethoxy)methane	11000 [a,b]	ND [a]
bis(2-Chloroethyl)ether	238000 [a,b]	ND [a]
bis(2-Chloroisopropyl)ether	--	--
2-Chloronaphthalene	2300 [a]	620 [a]
2-Chlorophenol	4380 [a,b]	ND [a]
4-Chlorophenyl phenyl ether	--	--
Chrysene	ND [a]	ND [a]
Diallate	--	--
Dibenz(a,h)anthracene	ND [a]	ND [a]
Dibenzofuran	ND [a]	ND [a]
1,2-Dichlorobenzene	1120 [a,b]	763 [a,b]
1,3-Dichlorobenzene	1120 [a,b]	763 [a,b]
1,4-Dichlorobenzene	ND [a]	ND [a]
3,3'-Dichlorobenzidine	ND [a]	ND [a]
2,4-Dichlorophenol	2020 [a,b]	365 [a,b]
2,6-Dichlorophenol	--	--
Diethylphthalate	940 [a,b]	3 [a,b]
p-Dimethylaminoazobenzene	--	--
7,12-Dimethylbenz(a)anthracene	--	--
3,3'-Dimethylbenzidine	ND [a]	ND [a]
Dimethylphenethylamine	--	--
2,4-Dimethylphenol	2120 [a]	ND [a]
Dimethylphthalate	940 [a,b]	3 [a,b]
4,6-Dinitro-2-methylphenol	--	--
Di-n-butylphthalate	940 [a,b]	3 [a,b]
Di-n-octylphthalate	ND [a]	ND [a]

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
1,3-Dinitrobenzene	ND [a]	ND [a]
2,4-Dinitrophenol	230 [a,b]	150 [a,b]
2,4-Dinitrotoluene	330 [a]	230 [a]
2,6-Dinitrotoluene	ND [a]	ND [a]
Diphenylamine	ND [a]	ND [a]
bis(2-Ethylhexyl)phthalate	400 [a]	360 [a]
Ethylmethane sulfonate	–	–
Fluoranthene	3980 [a]	ND [a]
Fluorene	ND [a]	ND [a]
Hexachlorobenzene	0.61 [a]	3.68 [a]
Hexachlorobutadiene	90 [a,b]	9.3 [a,b]
Hexachlorocyclopentadiene	7 [a,b]	5.2 [a,b]
Hexachloroethane	980 [a,b]	540 [a,b]
Hexachlorophene	ND [a]	ND [a]
Hexachloropropene	–	–
Ideno(1,2,3-c,d)pyrene	ND [a]	ND [a]
Isophorone	117000 [a,b]	ND [a]
Isosafrole	–	–
Methapyrilene	–	–
3-Methylchloanthrene	–	–
Methyl methanesulfonate	–	–
2-Methyl naphthalene	–	–
2-Methylphenol	ND [a]	ND [a]
3-Methylphenol	ND [a]	ND [a]
4-Methylphenol	ND [a]	ND [a]
Naphthalene	2300 [a]	620 [a]
1,4-Naphthoquinone	ND [a]	ND [a]
1-Naphthylamine	–	–
2-Naphthylamine	ND [a]	ND [a]
2-Nitroaniline	–	–
3-Nitroaniline	–	–
4-Nitroaniline	–	–
Nitrobenzene	27000 [a,b]	ND [a]
2-Nitrophenol	–	–

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
4-Nitrophenol	ND [a]	ND [a]
4-Nitroquinoline-N-oxide	–	–
N-Nitroso-di-n-butylamine	5850 [a,b]	ND [a]
N-Nitrosodiethylamine	5850 [a,b]	ND [a]
N-Nitrosodiphenylamine	5850 [a,b]	ND [a]
N-Nitrosodipropylamine	5850 [a,b]	ND [a]
N-Nitrosodimethylamine	5850 [a,b]	ND [a]
N-Nitrosomethylethylamine	5850 [a,b]	ND [a]
N-Nitrosomorpholine	–	–
N-Nitrosopiperidine	–	–
N-Nitrosopyrrolidine	5850 [a,b]	ND [a]
5-Nitro-o-toluidine	–	–
Pentachlorobenzene	250 [a,b]	50 [a,b]
Pentachloroethane	–	–
Pentachloronitrobenzene	250 [a,b]	50 [a,b]
Pentachlorophenol	22 pH [a]	13 pH [a]
Phenacetin	–	–
Phenanthrene	30 [a]	6.3 [a]
Phenol	10200 [a,b]	2560 [a,b]
p-Phenylenediamine	–	–
2-Picoline	–	–
Pronamide	ND [a]	ND [a]
Pyrene	ND [a]	ND [a]
Pyridine	ND [a]	ND [a]
Safrole	–	–
1,2,4,5-Tetrachlorobenzene	250 [a,b]	50 [a,b]
2,3,4,6-Tetrachlorophenol	ND [a]	ND [a]
o-Toluidine	–	–
1,2,4-Trichlorobenzene	250 [a,b]	50 [a,b]
2,4,5-Trichlorophenol	100 [a]	63 [a]
2,4,6-Trichlorophenol	ND [a]	970 [a,b]
DIOXINS AND FURANS		
2,3,7,8-Tetrachlorodibenzo-p-dioxin	.01 [b,c]	.00001 [b,c]
Tetrachlorodibenzo-p-dioxins	–	–

Table 4-2

(Continued)

Chemical	Freshwater SWQC	
	Acute (µg/L)	Chronic (µg/L)
Tetrachlorodibenzo-p-furans	–	–
Pentachlorodibenzo-p-dioxins	–	–
Pentachlorodibenzo-p-furans	–	–
Hexachlorodibenzo-p-dioxins	–	–
Hexachlorodibenzo-p-furans	–	–
GENERAL		
Cyanide	22[a]	5.2[a]
Sulfide	–	2[c]
Total Organic Carbon	–	–

Source: USEPA Quality Criteria for Water, 1986, unless otherwise noted.

NOTES:
[a] - U.S. Environmental Protection Agency (EPA), 1992b. Integrated Risk Information System (IRIS). May 28, 1992.
[b] - Lowest effect concentration, criteria not available.
[c] - U.S. Environmental Protection Agency (EPA), 1991c. "Amendments to The Water Quality Standards Regulation to Establish the Numeric Criteria for Priority Toxic Pollutants Necessary to Bring All States into Compliance with Section 303(c)(2)(B); Proposed Rule. Federal Register 56223, Tuesday, November 19, 1991.
[d] - Proposed criteria.
[e] - (Total NH_3) pH and temperature dependant.

HBL Health-Based Level
ND No data available.
U Under review.
– Not available.
+ Hardness dependent criteria (100 mg/l used).

Table 4-3

RCRA Proposed Subpart S Media Action Levels [a]

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
METALS						
Antimony	3.20e+01	–	–	–	1.40e-02	–
Barium	5.60e+03	–	–	–	2.45e+00	–
Beryllium	4.00e+02	1.63e-01	–	4.17e-04	1.75e-01	8.14e-06
Cadmium	8.00e+01	–	–	5.56e-04	1.75e-02	–
Chromium (III)	8.00e+04	–	–	–	3.50e+01	–
Chromium (VI)	4.00e+02	–	–	8.33-05	1.80e-01	–
Cobalt	–	–	–	–	–	–
Copper	3.20e+03	–	–	–	1.40e+00	–
Nickel	1.60e+03	–	–	–	7.00e-01	–
Silver	4.00e+02	–	–	–	1.75e-01	–
Tin	4.80e+04	–	–	–	2.10e+01	–
Vanadium	5.60e+02	–	–	–	2.45e-01	–
Zinc	1.60e+04	–	–	–	7.00e+00	–
Arsenic	2.40e+01	–	–	2.33e-04	1.05e-02	–
Lead	1.14e+02	–	–	–	1.50e-02[b]	–
Mercury	–	–	–	–	–	–
Selenium	4.00e+02	–	–	–	1.75e-01	–
Thallium	0.4e+01	–	–	–	2.45e-03	–
ORGANOCHLORINE PESTICIDES AND PCBs						
Aldrin	2.40e+00	4.12e-02	–	2.04e-04	1.05e-03	2.06e-06
alpha-BHC	–	1.11e-01	–	5.56e-04	–	5.56e-06
beta-BHC	–	3.89e+00	–	1.89e-02	–	1.94e-04
delta-BHC	–	–	–	–	–	–
gamma-BHC (Lindane)	2.40e+01	5.38e-01	–	–	1.05e-02	2.69e-05
Chlordane (technical)	4.80e+00	5.38e-01	–	2.70e-03	2.10e-03	2.69e-05
4,4'-DDD	–	2.92e+00	–	–	–	1.46e-04
4,4'-DDE	–	2.06e+00	–	–	–	1.03e-04
4,4'-DDT	4.00e+01	2.06e+00	–	1.03e-02	1.75e-02	1.03e-04
Dieldrin	4.00e+00	4.38e-02	–	2.17e-04	1.75e-03	2.19e-06
Endosulfan I	4.00e+00	–	–	–	1.75e-03	–
Endosulfan II	4.00e+00	–	–	–	1.75e-03	–
Endosulfan sulfate	4.00e+00	–	–	–	1.75e-03	–
Endrin	2.40e+01	–	–	–	1.05e-02	–
Endrin aldehyde	–	–	–	–	–	–
Heptachlor	4.00e+01	1.56e-01	–	7.69e-04	1.75e-02	7.78e-06

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
Heptachlor epoxide	1.04e+00	7.69e-02	--	3.85e-04	4.55e-04	3.85e-06
Isodrin	--	--	--	--	--	--
Kepone	--	1.00e+00 [c]	--	--	--	--
Methoxychlor	4.00e+02	--	--	--	1.75e-01	--
Toxaphene	--	6.36e-01	--	3.13e-03	--	3.18e-05
PCB-1016	--	9.09e-02	--	--	--	4.55e-06
PCB-1221	--	9.09e-02	--	--	--	4.55e-06
PCB-1323	--	9.09e-02	--	--	--	4.55e-06
PCB-1242	--	9.09e-02	--	--	--	4.55e-06
PCB-1248	--	9.09e-02	--	--	--	4.55e-06
PCB-1254	--	9.09e-02	--	--	--	4.55e-06
PCB-1260	--	9.09e-02	--	--	--	4.55e-06
ORGANOPHOSPHORUS PESTICIDES						
Dimethoate	1.60e+01	--	--	--	7.00e-03	--
Disulfoton	3.20e+00	--	--	--	1.40e-03	--
Ethyl parathion (parathion)	4.80e+02	--	--	--	2.10e-01	--
Famphur	--	--	--	--	--	--
Parathion methyl	2.00e+01	--	--	--	8.75e-03	--
Phorate	--	--	--	--	--	--
Sulfotepp	4.00e+01	--	--	--	1.75e-02	--
Thionazin	--	--	--	--	--	--
o,o,o-Triethylphosphorthioate	--	--	--	--	--	--
CHLORINATED HERBICIDES						
2,4-D	8.00e+02	--	--	--	3.50e-01	--
2,4,5-T	8.00e+02	--	--	--	3.50e-01	--
2,4,5-TP (Silvex)	6.40e+02	--	--	--	2.80e-01	--
Dinoseb	8.00e+01	--	--	--	3.50e-02	--
VOLATILE ORGANICS						
Acetone	8.00e+03	--	--	--	3.50e+00	--
Acetonitrile	4.80e+02	--	--	--	2.10e-01	--
Acrolein	8.00e+03	--	2.00e-02	--	3.50e+00	--
Acrylonitrile	--	1.30e+00	2.00e+00	1.47e-02	--	6.48e-05
Benzene	--	2.41e+01	--	1.20e-01	--	1.21e-03
Bromodichloromethane	1.60e+03	5.38e+00	--	--	7.00e-01	2.69e-04
Bromomethane	1.12e+02	--	5.00e-02	--	4.90e-02	--
Carbon disulfide	8.00e+03	--	--	--	3.50e+00	--

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
Carbon tetrachloride	5.60e+01	5.38e+00	--	6.67e-02	2.45e-02	2.69e-04
2-Chloro-1,3-butadiene	1.60e+03	--	--	--	7.00e+00	--
Chlorobenzene	1.60e+03	--	--	7.00e+02	7.00e-01	--
Chloroethane	--	--	1.00e+04	--	--	--
Chloroform	8.00e+02	1.15e+02	--	4.35e-02	3.50e-01	5.74e-03
Chloromethane	--	--	--	--	--	--
3-Chloropropene (allyl chloride)	--	--	1.00e+00	--	--	--
Dibromochloromethane	1.60e+03	8.33e+01	--	--	7.00e-01	4.17e-03
1,2-Dibromo-3-chloropropane	--	--	2.00e-01	4.2e-04	--	--
1,2-Dibromoethane	--	--	--	4.55e-03	--	--
Dibromomethane	--	8.24e-03	--	--	--	4.12e-07
trans-1,4-Dichloro-2-butene	--	--	--	3.85e-04	--	--
Dichlorodifluoromethane	1.60e+04	--	--	--	7.00e+00	--
1,2-Dichloroethane	--	7.69e+00	--	3.85e-02	--	3.85e-04
trans-1,2-Dichloroethene	1.60e+03	--	--	--	7.00e-01	--
1,1-Dichloroethane	8.00e+03	--	--	--	3.50e+00	--
1,1-Dichloroethene	7.20e+02	1.17e+01	--	2.00e-01	3.15e-01	5.83e-04
1,2-Dichloropropane	--	1.03e+01	4.00e+00	--	--	5.15e-04
cis-1,3-Dichloropropene	2.40e+01	3.89e+00	2.00e+01	2.70e-02	1.05e-02	1.94e-04
trans-1,3-Dichloropropene	2.40e+01	3.89e+00	2.00e+01	2.70e-02	1.05e-02	1.94e-04
Ethyl benzene	8.00e+03	--	1.00e+03	--	3.50e+00	--
Ethyl methacrylate	7.20e+03	--	--	--	3.15e+00	--
2-Hexanone	--	--	--	--	--	--
Iodomethane	--	--	--	--	--	--
Methylene chloride	4.80e+03	9.33e+01	--	2.13e+00	2.10e+00	4.67e-03
2-Butanone (MEK)	4.00e+03	--	--	--	1.75e+00	--
Methyl methacrylate	6.40e+03	--	--	--	2.80e+00	--
4-Methyl-2-pentanone (MIBK)	4.00e+03	--	--	--	1.75e+00	--
Propanenitrile (propionitrile)	--	--	--	--	--	--
Styrene	1.60e+04	--	1.00+03	--	7.00e+00	1.17e-03
1,1,1,2-Tetrachloroethane	2.40e+03	2.69e+01	--	--	1.05e+00	1.35e-02
1,1,2,2-Tetrachloroethane	--	3.50e+01	--	1.72e-02	--	1.75e-03
Tetrachloroethene	8.00e+02	1.37e+01	--	--	3.50e-01	6.86e-04
Toluene	1.60e+04	--	--	--	7.00e+00	--
Tribromomethane	1.60e+03	8.86e+01	--	9.09e-01	7.00e-01	4.43e-03
1,1,1-Trichloroethane	7.20e+03	--	--	--	3.15e+00	--

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
1,1,2-Trichloroethane	3.20e+02	1.23e+02	–	6.06e-01	1.40e-01	6.14e-03
Trichloroethene	–	–	–	–	–	3.18e-03
Trichlorofluoromethane	2.40e+04	–	–	–	1.05e+01	–
1,2,3-Trichloropropane	4.80e+02	–	–	–	2.10e-01	–
Vinyl Acetate	8.00e+04	–	2.00e+02	–	3.50e+01	–
Vinyl Chloride	–	3.68e-01	–	–	–	1.84e-05
Xylenes (total)	1.60e+05	–	–	–	7.00e+01	–
VOLATILE ORGANICS (Direct Injection)						
1,4-Dioxane	8.00e+03	6.40e+01	–	–	3.50e+00	3.18e-03
Isobutanol	2.40e+04	–	–	–	1.05e+01	–
Methacrylonitrile	8.00e+00	–	–	–	3.50e-03	–
SEMI-VOLATILE ORGANICS						
Acenaphthene	4.80e+03	–	–	–	2.10e+00	–
Acenaphthylene	–	–	–	–	–	–
Acetophenone	8.00e+03	–	–	–	3.50e+00	–
2-Acetylaminofluorene	–	–	–	–	–	–
4-Aminobiphenyl	–	–	–	–	–	–
Aniline	–	1.23e+02	1.00e+00	–	–	6.14e-03
Anthracene	2.40e+04	–	–	–	1.05e+01	–
Aramite	–	2.80e+01	–	1.40e-01	–	1.40e-03
Benzo(a)anthracene	–	8.33e-01	–	–	–	4.17e-05
Benzo(a)pyrene	–	1.21e-01	–	–	–	6.04e-06
Benzo(b)fluoranthene	–	8.64e-01	–	–	–	4.32e-05
Benzo(g,h,i)perylene	–	5.38e+00	–	–	–	2.69e-04
Benzo(k)fluoranthene	–	1.84e+00	–	–	–	9.21e-05
Benzyl alcohol	2.40e+04	–	–	–	1.05e+01	–
4-Bromophenyl phenyl ether	1.60e+03	–	–	–	7.00e-01	–
Butylbenzylphthalate	1.60e+04	–	–	–	7.00e+00	–
4-Chloro-3-methylphenol	–	–	–	–	–	–
4-Chloroaniline	3.20e+02	–	–	–	1.40e-01	–
Chlorobenzilate	1.60e+03	–	–	–	7.00e-01	–
bis(2-Chloroethoxy)methane	–	–	–	–	–	–
bis(2-Chloroethyl)ether	–	6.36e-01	–	3.03e-03	–	3.18e-05
bis(2-Chloroisopropyl)ether	–	–	–	–	–	–
2-Chloronaphthalene	6.40e+03	–	–	–	2.80e+00	–
2-Chlorophenol	4.00e+02	–	–	–	1.75e-01	–

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
4-Chlorophenyl phenyl ether	--	--	--	--	--	--
Chrysene	--	2.80e+01	--	--	--	1.40e-03
Diallate	--	1.15e+01	--	--	--	5.74e-04
Dibenz(a,h)anthracene	--	1.09e-01	--	--	--	5.47e-06
Dibenzofuran	--	--	--	--	--	--
1,2-Dichlorobenzene	7.20e+03	--	--	--	3.15e+00	--
1,3-Dichlorobenzene	--	--	--	--	--	--
1,4-Dichlorobenzene	--	2.92e+01	--	--	--	1.46e-02
3,3'-Dichlorobenzidine	--	1.56e+00	--	--	--	7.78e-05
2,4-Dichlorophenol	2.40e+02	--	--	--	1.05e-01	--
2,6-Dichlorophenol	--	--	--	--	--	--
Diethylphthalate	6.40e+04	--	--	--	2.80e+01	--
p-Dimethylaminoazobenzene	--	--	--	--	--	--
7,12-Dimethylbenz(a)anthracene	--	--	--	--	--	--
3,3'-Dimethylbenzidine	--	7.61e-02	--	--	--	3.80e-06
Dimethylphenethylamine	--	--	--	--	--	--
2,4-Dimethylphenol	1.60e+03	--	--	--	7.00e-01	--
Dimethylphthalate	--	--	--	--	--	--
4,6-Dinitro-2-methylphenol	--	--	--	--	--	--
Di-n-butylphthalate	8.00e+03	--	--	--	3.50e+00	--
Di-n-octylphthalate	1.60e+03	--	--	--	7.00e-01	--
1,3-Dinitrobenzene	8.00e+00	--	--	--	3.50e-03	--
2,4-Dinitrophenol	1.60e+02	--	--	--	7.00e-02	--
2,4-Dinitrotoluene	1.60e+02	--	--	--	7.00e-02	--
2,6-Dinitrotoluene	--	--	--	--	--	5.15e-05
Diphenylamine	2.00e+03	--	--	--	8.75e-01	--
bis(2-Ethylhexyl)phthalate	1.60e+03	5.00e+01	--	--	7.00e-01	2.50e-03
Ethylmethane sulfonate	--	--	--	--	--	--
Fluoranthene	3.20e+03	--	--	--	1.40e+00	--
Fluorene	3.20e+03	--	--	--	1.40e+00	--
Hexachlorobenzene	6.40e+01	4.38e-01	--	2.17e-03	2.80e-02	2.19e-05
Hexachlorobutadiene	1.60e+02	8.97e+01	--	4.55e-01	7.00e-02	4.49e-03
Hexachlorocyclopentadiene	5.60e+02	--	--	--	2.45e-01	--
Hexachloroethane	8.00e+01	5.00e+02	--	2.50e+00	3.50e-02	2.50e-02
Hexachlorophene	2.40e+01	--	--	--	1.05e-02	--
Hexachloropropene	--	--	--	--	--	--

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (µg/m3)	(carc) (µg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
Ideno(1,2,3-c,d)pyrene	--	5.38e-01	--	--	--	2.69e-05
Isophorone	1.60e+04	1.71e+03	--	--	7.00e+00	8.54e-02
Isosafrole	--	--	--	--	--	--
Methapyrilene	--	--	--	--	--	--
3-Methylchloanthrene	--	--	--	--	--	--
Methyl methanesulfonate	--	--	--	--	--	--
2-Methyl naphthalene	--	--	--	--	--	--
2-Methylphenol	4.00e+03	--	--	--	1.75e+00	--
3-Methylphenol	4.00e+03	--	--	--	1.75e+00	--
4-Methylphenol	4.00e+03	--	--	--	1.75e+00	--
Naphthalene	3.20e+03	--	--	--	1.40e-01	--
1,4-Naphthoquinone	--	--	--	--	--	--
1-Naphthylamine	--	--	--	--	--	--
2-Naphthylamine	--	--	--	--	--	--
2-Nitroaniline	--	--	--	--	--	--
3-Nitroaniline	--	--	--	--	--	--
4-Nitroaniline	--	--	--	--	--	--
Nitrobenzene	4.00e+01	--	--	--	1.75e-02	--
2-Nitrophenol	--	--	--	--	--	--
4-Nitrophenol	--	--	--	--	--	--
4-Nitroquinoline-N-oxide	--	--	--	--	--	--
N-Nitroso-di-n-butylamine	--	1.30e-01	--	6.25e-04	--	6.48e-06
N-Nitrosodiethylamine	--	4.67e-03	--	2.33e-05	--	2.33e-07
N-Nitrosodiphenylamine	--	1.43e+02	--	--	--	7.14e-03
N-Nitrosodipropylamine	--	1.00e-01	--	--	--	5.00e-06
N-Nitrosodimethylamine	--	1.37e-02	--	7.14e-05	--	6.86e-07
N-Nitrosomethylethylamine	--	3.18e-02	--	--	--	1.59e-06
N-Nitrosomorpholine	--	--	--	--	--	--
N-Nitrosopiperidine	--	--	--	--	--	--
N-Nitrosopyrrolidine	--	3.33e-01	--	1.64e-03	--	1.67e-05
5-Nitro-o-toluidine	--	--	--	--	--	--
Pentachlorobenzene	6.40e+01	--	--	--	2.80e-02	--
Pentachloroethane	--	--	--	--	--	--
Pentachloronitrobenzene	2.40e+02	--	--	--	1.05e-01	--
Pentachlorophenol	2.40e+03	5.83e+00	--	--	1.05e+00	2.92e-04
Phenacetin	--	--	--	--	--	--

Table 4-3

(Continued)

Chemical	Soil Action Levels		Air Action Level		Water Action Level	
	(noncarc) (mg/kg)	(carc) (mg/kg)	(noncarc) (μg/m3)	(carc) (μg/m3)	(noncarc) (mg/L)	(carc) (mg/L)
Phenanthrene	4.80e+00	–	–	–	2.10e-03	–
Phenol	4.80e+04	–	–	–	2.10e+01	–
p-Phenylenediamine	–	–	–	–	–	–
2-Picoline	–	–	–	–	–	–
Pronamide	6.00e+03	–	–	–	2.63e+00	–
Pyrene	2.40e+03	–	–	–	1.05e+00	–
Pyridine	8.00e+01	–	–	–	3.50e-02	–
Safrole	–	–	–	–	–	–
1,2,4,5-Tetrachlorobenzene	2.40e+01	–	–	–	1.05e-02	–
2,3,4,6-Tetrachlorophenol	2.40e+03	–	–	–	1.05e+00	–
o-Toluidine	–	2.92e+00	–	–	–	1.46e-04
1,2,4-Trichlorobenzene	8.00e+02	–	–	–	4.59e-02	–
2,4,5-Trichlorophenol	8.00e+03	–	–	–	3.50e+00	–
2,4,6-Trichlorophenol	–	6.36e+01	–	3.23e-01	–	3.18e-03
DIOXINS AND FURANS						
2,3,7,8-Tetrachlorodibenzo-p-dioxin	–	4.67e-06	–	3.3e-08	–	2.33e-10
Tetrachlorodibenzo-p-furans [c]	–	4.67e-05	–	–	–	2.33e-09
Pentachlorodibenzo-p-dioxins [c]	–	9.33e-06	–	–	–	4.67e-10
Pentachlorodibenzo-p-furans [c]	–	9.33e-06	–	–	–	4.67e-10
Hexachlorodibenzo-p-dioxins [c]	–	4.67e-05	–	–	–	2.33e-09
Hexachlorodibenzo-p-furans [c]	–	4.67e-05	–	–	–	2.33e-09
GENERAL						
Cyanide	1.60e+03	–	–	–	7.00e-01	–
Sulfide	–	–	–	–	–	–
Total Organic Carbon	–	–	–	–	–	–

Source: Proposed 40 CFR Section 264.521

[a] - Action levels are based on criteria outlined in Table 2-5.
[b] - Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper. Final rule. Federal Register 56110, Friday, June 7, 1991.
[c] - Value given for 2,3,7,8-isomers; other isomers considered non-carcinogenic and have no health-based action levels.

Table 4-4

USEPA Health-Based Criteria for the Calculation of Proposed Subpart S Action Levels

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
METALS					
Barium	D	7.00e-02 [a]	ND [a]	U [b]	ND [b]
Beryllium	B2	5.00e-03 [a]	4.30e+00 [a]	ND [b]	2.40e-03 [b]
Cadmium	B1	1.00e-03 [a]	ND [a]	U [b]	1.80e-03 [b]
Chromium (III)	D	1.00e+00 [c]	--	ND [c]	U [c]
Chromium (VI)	A	5.00e-03 [c]	--	U [c]	1.20e-02 [c]
Cobalt		U [a]	ND [a]	ND [b]	ND [b]
Copper	D	4.00e-02 [d]	ND [a]	ND [b]	ND
Nickel	D	2.00e-02 [a]	ND [a]	--	--
Silver	D	5.00e-03 [a]	ND [a]	ND [b]	ND [b]
Tin		6.00e-01 [e]	--	--	--
Vanadium		7.00e-03 [e]	ND [a]	ND [b]	ND [b]
Zinc	D	2.00e-01 [e]	ND [a]	ND [b]	ND [b]
Arsenic	A	3.00e-04 [a]	ND [a]	ND [b]	4.30e-03 [b]
Lead	B2	1.40e-03 [k]	ND [a]	ND [b]	ND [b]
Mercury	D	U [a]	ND [a]	U [b]	ND [b]
Selenium	D	5.00e-03 [a]	ND [a]	ND [b]	ND [b]
Thallium		8.00e-04	--	--	--
ORGANOCHLORINE PESTICIDES AND PCBs					
Aldrin	B2	3.00e-05 [a]	1.70e+01 [a]	ND [b]	4.90e-03 [b]
alpha-BHC	B2	ND [a]	6.30e+00 [a]	ND [b]	1.80e-03 [b]
beta-BHC	C	ND [a]	1.80e+00 [a]	ND [b]	5.30e-04 [b]
delta-BHC	D	ND [a]	--	ND [b]	ND [b]
gamma-BHC (Lindane)	B2/C	3.00e-04 [a]	1.30e+00 [e]	ND [b]	ND [b]
Chlordane (technical)	B2	6.00e-05 [a]	1.30e+00 [a]	ND [b]	3.70e-04 [b]
4,4'-DDD	B2	ND [a]	2.40e-01 [a]	ND [b]	ND [b]
4,4'-DDE	B2	ND [a]	3.40e-01 [a]	ND [b]	ND [b]
4,4'-DDT	B2	5.00e-04 [a]	3.40e-01 [a]	ND [b]	9.70e-05 [b]
Dieldrin	B2	5.00e-05 [a]	1.60e+01 [a]	ND [b]	4.60e-03 [b]
Endosulfan I	D	5.00e-05 [f]	--	--	--
Endosulfan II	D	5.00e-05 [f]	--	--	--

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
Endosulfan sulfate		5.00e-05 [f]	--	--	--
Endrin	D	3.00e-04 [a]	ND [a]	ND [b]	ND [b]
Endrin aldehyde		--	--	--	--
Heptachlor	B2	5.00e-04 [a]	4.50e+00 [a]	ND [b]	1.30e-03 [b]
Heptachlor epoxide	B2	1.30e-05 [a]	9.10e+00 [a]	ND [b]	2.60e-03 [b]
Isodrin		U [a]	ND [a]	ND [b]	ND [b]
Kepone		--	--	--	--
Methoxychlor		5.00e-03 [a]	ND [a]	U [b]	ND [b]
Toxaphene	B2	ND [a]	1.10e+00 [a]	ND [b]	3.20e-04 [b]
PCB-1016	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1221	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1323	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1242	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1248	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1254	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
PCB-1260	B2	ND [a]	7.70e+00 [a]	ND [b]	ND [b]
ORGANOPHOSPHORUS PESTICIDES					
Dimethoate	D	2.00e-04 [a]	ND [a]	ND [b]	ND [b]
Disulfoton	D	4.00e-05 [a]	ND [a]	ND [b]	ND [b]
Ethyl parathion (parathion)	C	6.00e-03	ND [a]	ND [b]	ND [b]
Famphur		U [a]	ND [a]	ND [b]	ND [b]
Parathion methyl	D	2.50e-04 [a]	ND [a]	ND [b]	ND [b]
Phorate		ND [a]	ND [a]	ND [b]	ND [b]
Sulfotepp		5.00e-04 [a]	ND [b]	ND [b]	ND [b]
Thionazin		--	--	--	--
o,o,o-Triethylphosphorthioate		--	--	--	--
CHLORINATED HERBICIDES					
2,4-D		1.00e-02 [a]	ND [a]	ND [b]	ND [b]
2,4,5-T		1.00e-02 [a]	ND [a]	ND [b]	ND [b]
2,4,5-TP (Silvex)		8.00e-03 [a]	ND [a]	ND [b]	ND [b]
Dinoseb		1.00e-03 [a]	ND [a]	ND [b]	ND [b]
VOLATILE ORGANICS					
Acetone	D	1.00e-01 [a]	ND [a]	ND [b]	ND [b]
Acetonitrile	D	6.00e-03 [a]	ND [a]	U [b]	ND [b]

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
Acrolein		1.00e-01 [a]	ND [a]	2.00e-05 [b]	ND [b]
Acrylonitrile	B1	ND [a]	5.40e-01 [a]	2.00e-03 [b]	6.80e-05 [b]
Benzene	A	--	2.90e-02 [a]	U [b]	8.30e-06 [b]
Bromodichloromethane	B2	2.00e-02 [b]	1.30e-01 [a]	ND [b]	ND [b]
Bromomethane	D	1.40e-03 [a]	ND [a]	5.00e-05 [b]	ND [b]
Carbon disulfide	D	1.00e-01 [a]	ND [a]	U [b]	ND [b]
Carbon tetrachloride	B2	7.00e-04 [a]	1.30e-01 [a]	ND [b]	1.50e-05 [b]
2-Chloro-1,3-butadiene		2.00e-02 [c]	--	7.00e-03	ND [b]
Chlorobenzene	D	2.00e-02 [a]	ND [a]	U [b]	ND [b]
Chloroethane		ND [a]	ND [a]	1.00e+01 [b]	ND [b]
Chloroform	B2	1.00e-02 [a]	6.10e-03 [a]	U [b]	2.30e-05 [b]
Chloromethane	C	U [a]	ND [a]	U [b]	ND [b]
3-Chloropropene (allyl chloride)		ND [a]	ND [a]	1.00e-03 [b]	ND [b]
Dibromochloromethane	C	2.00e-02 [a]	8.40e-02 [a]	ND [b]	ND [b]
1,2-Dibromo-3-chloropropane	B2	ND [a]	ND [a]	2.00e-04 [b]	2.4e-03
1,2-Dibromoethane	B2	U [a]	8.50e+01 [a]	U [b]	2.20e-04 [b]
Dibromomethane	B2	ND [a]	8.50e+01 [a]	U [b]	ND [b]
trans-1,4-Dichloro-2-butene		--	--	--	2.60e-03 [b]
Dichlorodifluoromethane	D	2.00e-01 [a]	ND [a]	ND [b]	ND [b]
1,2-Dichloroethane	B2	ND [a]	9.10e-02 [a]	ND [b]	2.60e-05 [b]
trans-1,2-Dichloroethene		2.00e-02 [a]	ND [a]	ND [b]	ND [b]
1,1-Dichloroethane	C	1.00e-01 [c]	ND [a]	U	ND [b]
1,1-Dichloroethene	C	9.00e-03 [a]	6.00e-01 [a]	U [b].	5.00e-05 [b]
1,2-Dichloropropane	B2	ND [a]	6.80e-02 [c]	4.00e-03 [b]	ND [b]
cis-1,3-Dichloropropene	B2	3.00e-04 [g]	1.80e-01 [g]	2.00e-02 [g]	3.70e-05 [g]
trans-1,3-Dichloropropene	B2	3.00e-04 [g]	1.80e-01 [g]	2.00e-02 [g]	3.70e-05 [g]
Ethyl benzene	D	1.00e-01 [a]	--	1.00e+00 [b]	ND [b]
Ethyl methacrylate		9.00e-02 [c]	ND [a]	ND [b]	ND [b]
2-Hexanone		--	ND [a]	ND [b]	ND [b]
Iodomethane		--	--	--	--
Methylene chloride	B2	6.00e-02 [a]	7.50e-03 [a]	U [b]	4.70e-07 [b]
2-Butanone (MEK)	D	5.00e-02 [c]	ND [a]	U [b]	ND [b]
Methyl methacrylate		8.00e-02 [c]	ND [a]	ND [b]	ND [b]
4-Methyl-2-pentanone (MIBK)		5.00e-02 [c]	--	U [b]	ND [b]

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(μg/m3)
Propanenitrile (propionitrile)		--	--	--	--
Styrene	B2	2.00e-01 [a]	--	1 [e]	ND [b]
1,1,1,2-Tetrachloroethane	C	3.00e-02 [a]	2.60e-02 [a]	ND [b]	ND [b]
1,1,2,2-Tetrachloroethane	C	U [a]	2.00e-01 [a]	ND [b]	5.80e-05 [b]
Tetrachloroethene	B2	1.00e-02 [a]	5.10e-02 [e]	ND [b]	ND [b]
Toluene	D	2.00e-01 [a]	ND [a]	U [b]	ND [b]
Tribromomethane	B2	2.00e-02 [a]	7.90e-03 [a]	ND [b]	1.10e-06 [b]
1,1,1-Trichloroethane	D	9.00e-02 [e]	ND [a]	U [b]	ND [b]
1,1,2-Trichloroethane	C	4.00e-03 [a]	5.70e-02 [a]	U [b]	1.65e-05 [b]
Trichloroethene	B2	U [a]	--	U [b]	ND [b]
Trichlorofluoromethane	D	3.00e-01 [a]	ND [a]	ND [b]	ND [b]
1,2,3-Trichloropropane		6.00e-03 [a]	ND [a]	ND [b]	ND [b]
Vinyl Acetate		1.00e+00 [e]	ND [a]	2.00e-01 [b]	ND [b]
Vinyl Chloride	A	ND [a]	1.90e+00 [e]	ND [b]	ND [b]
Xylenes (total)	D	2.00e+00 [a]	ND [a]	U [b]	ND [b]
VOLATILE ORGANICS (Direct Injection)					
1,4-Dioxane	B2	1.00e-01 [a]	1.10e-02 [a]	ND [b]	ND [b]
Isobutanol		3.00e-01 [a]	ND [a]	ND [b]	ND [b]
Methacrylonitrile		1.00e-04 [a]	ND [a]	ND [b]	ND [b]
SEMI-VOLATILE ORGANICS					
Acenaphthene		6.00e-02 [a]	ND [a]	ND [b]	ND [b]
Acenaphthylene		U [a]	ND [a]	ND [b]	ND [b]
Acetophenone	D	1.00e-01 [c]	--	U [b]	ND [b]
2-Acetylaminofluorene		--	--	--	--
4-Aminobiphenyl		--	--	--	--
Aniline	B2	ND [a]	5.70e-03 [e]	1.00e-03 [b]	ND [b]
Anthracene	D	3.00e-01 [a]	ND [a]	ND [b]	ND [b]
Aramite	B2	U [a]	2.50e-02 [a]	ND [b]	7.16e-06 [b]
Benzo(a)anthracene	B2	ND [a]	8.40e-01 [h]	ND [b]	ND [b]
Benzo(a)pyrene	B2	ND [a]	5.79e+00 [a]	ND [b]	ND [b]
Benzo(b)fluoranthene	B2	ND [a]	8.10e-01 [h]	ND [b]	ND [b]
Benzo(g,h,i)perylene		ND [a]	1.30e-01 [h]	ND [b]	ND [b]
Benzo(k)fluoranthene	B2	--	3.80e-01 [h]	ND [b]	ND [b]
Benzyl alcohol		3.00e-01 [e]	--	--	--

Table 4-4

(Continued)

Chemical	EPA Carc. Class[b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
4-Bromophenyl phenyl ether		2.00e-02[a]	ND[a]	ND[b]	ND[b]
Butylbenzylphthalate	C	2.00e-01[a]	ND[a]	ND[b]	ND[b]
4-Chloro-3-methylphenol		--	--	ND[b]	ND[b]
4-Chloroaniline		4.00e-03[a]	ND[a]	ND[b]	ND[b]
Chlorobenzilate		2.00e-02[a]	ND[a]	ND[b]	ND[b]
bis(2-Chloroethoxy)methane		ND[a]	ND[a]	ND[b]	ND[b]
bis(2-Chloroethyl)ether	B2	ND[a]	1.10e+00[a]	U[b]	3.30e-04[b]
bis(2-Chloroisopropyl)ether		--	--	--	--
2-Chloronaphthalene		8.00e-02[a]	ND[a]	ND[b]	ND[b]
2-Chlorophenol	D	5.00e-03[a]	ND[a]	ND[b]	ND[b]
4-Chlorophenyl phenyl ether		--	--	--	--
Chrysene		ND[a]	2.50e-02[h]	ND[b]	ND[b]
Diallate	B2	--	6.10e-02[e]	--	--
Dibenz(a,h)anthracene	B2	ND[a]	6.40e+00[h]	ND[b]	ND[b]
Dibenzofuran		ND[a]	ND[a]	U[b]	ND[b]
1,2-Dichlorobenzene		9.00e-02[a]	ND[a]	ND[b]	ND[b]
1,3-Dichlorobenzene		ND[a]	ND[a]	ND[b]	ND[b]
1,4-Dichlorobenzene	C	ND[a]	2.40e-02[e]	ND[b]	ND[b]
3,3'-Dichlorobenzidine	B2	ND[a]	4.50e-01[a]	U[b]	ND[b]
2,4-Dichlorophenol	D	3.00e-03[a]	ND[a]	ND[b]	ND[b]
2,6-Dichlorophenol		--	--	--	--
Diethylphthalate	D	8.00e-01[a]	ND[a]	ND[b]	ND[b]
p-Dimethylaminoazobenzene		--	--	--	--
7,12-Dimethylbenz(a)anthracene		--	--	--	--
3,3'-Dimethylbenzidine	B2	ND[a]	9.20e+00[e]	U[b]	ND[b]
Dimethylphenethylamine		--	--	--	--
2,4-Dimethylphenol		2.00e-02[a]	ND[a]	ND[b]	ND[b]
Dimethylphthalate		U[a]	ND[a]	U[b]	ND[b]
4,6-Dinitro-2-methylphenol		--	--	--	--
Di-n-butylphthalate	D	1.00e-01[a]	ND[a]	U[b]	ND[b]
Di-n-octylphthalate		2.00e-02[e]	ND[a]	ND[b]	ND[b]
1,3-Dinitrobenzene	D	1.00e-04[a]	ND[a]	ND[b]	ND[b]
2,4-Dinitrophenol	D	2.00e-03[a]	ND[a]	U[b]	ND[b]
2,4-Dinitrotoluene		2.00-03[c]	ND[a]	U[b]	ND[b]

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
2,6-Dinitrotoluene	B2	U[a]	ND[c]	ND[b]	ND[b]
Diphenylamine	D	2.50e-02[a]	ND[a]	ND[b]	ND[b]
bis(2-Ethylhexyl)phthalate	B2	2.00e-02[a]	1.40e-02[a]	ND[b]	ND[b]
Ethylmethane sulfonate		--	--	--	--
Fluoranthene		4.00e-02[a]	ND[a]	ND[b]	ND[b]
Fluorene		4.00e-02[a]	ND[a]	ND[b]	ND[b]
Hexachlorobenzene	B2	8.00e-04[a]	1.60e+00[a]	U[b]	4.60e-04[b]
Hexachlorobutadiene	C	2.00e-03[a]	7.80e-02[a]	U[b]	2.20e-05[b]
Hexachlorocyclopentadiene	D	7.00e-03[a]	ND[a]	ND[b]	ND[b]
Hexachloroethane	C	1.00e-03[a]	1.40e-02[a]	U[b]	4.00e-06[b]
Hexachlorophene	D	3.00e-04[a]	ND[a]	ND[b]	ND[b]
Hexachloropropene		--	--	--	--
Ideno(1,2,3-c,d)pyrene	B2	ND[a]	1.30e+00[h]	ND[b]	ND[b]
Isophorone	C	2.00e-01[a]	4.10e-03[a]	U[b]	ND[b]
Isosafrole		--	--	--	--
Methapyrilene		--	--	--	--
3-Methylchloanthrene		--	--	--	--
Methyl methanesulfonate		--	--	--	--
2-Methyl naphthalene		--	--	--	--
2-Methylphenol	D	5.00e-02[a]	ND[a]	U[b]	ND[b]
3-Methylphenol	D	5.00e-02[a]	ND[a]	U[b]	ND[b]
4-Methylphenol	C	5.00e-02[e]	ND[a]	U[b]	ND[b]
Naphthalene	D	4.00e-02[e]	ND[a]	ND[b]	ND[b]
1,4-Naphthoquinone		U[a]	ND[a]	ND[b]	ND[b]
1-Naphthylamine		--	--	--	--
2-Naphthylamine		ND[a]	ND[a]	ND[b]	ND[b]
2-Nitroaniline		--	--	--	--
3-Nitroaniline		--	--	--	--
4-Nitroaniline		--	--	--	--
Nitrobenzene		5.00e-04[a]	ND[a]	U[b]	ND[b]
2-Nitrophenol		--	--	--	--
4-Nitrophenol		U[a]	ND[a]	U[b]	ND[b]
4-Nitroquinoline-N-oxide		--	--	--	--
N-Nitroso-di-n-butylamine	B2	ND[a]	5.40e+00[a]	U[b]	1.60e-03[b]

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(µg/m3)
N-Nitrosodiethylamine	B2	ND [a]	1.50e+02 [a]	ND [b]	4.30e-02 [b]
N-Nitrosodiphenylamine	B2	ND [a]	4.90e-03 [a]	ND [b]	ND [b]
N-Nitrosodipropylamine	B2	ND [a]	7.00e+00 [a]	ND [b]	ND [b]
N-Nitrosodimethylamine	B2	ND [a]	5.10e+01 [a]	ND [b]	1.40e-02 [b]
N-Nitrosomethylethylamine	B2	ND [a]	2.20e+01 [a]	ND [b]	ND [b]
N-Nitrosomorpholine		--	--	--	--
N-Nitrosopiperidine		--	--	--	--
N-Nitrosopyrrolidine	B2	ND [a]	2.10e+00 [a]	ND [b]	6.10e-04 [b]
5-Nitro-o-toluidine		--	--	--	--
Pentachlorobenzene	D	8.00e-04 [a]	ND [a]	ND [b]	ND [b]
Pentachloroethane		--	--	--	--
Pentachloronitrobenzene	C	3.00e-03 [a]	ND [a]	ND [b]	ND [b]
Pentachlorophenol	B2	3.00e-02 [a]	1.20e-01 [a]	U [b]	ND [b]
Phenacetin		--	--	--	--
Phenanthrene	D	6.00e-05 [i]	ND [a]	ND [b]	ND [b]
Phenol	D	6.00e-01 [a]	ND [c]	U [b]	ND [b]
p-Phenylenediamine		--	--	--	--
2-Picoline		--	--	--	--
Pronamide	D	7.50e-02 [a]	ND [a]	ND [b]	ND [b]
Pyrene	D	3.00e-02 [a]	ND [a]	ND [b]	ND [b]
Pyridine	D	1.00e-03 [a]	ND [a]	ND [b]	ND [b]
Safrole		--	--	--	--
1,2,4,5-Tetrachlorobenzene	D	3.00e-04 [a]	ND [a]	ND [b]	ND [b]
2,3,4,6-Tetrachlorophenol	D	3.00e-02 [a]	ND [a]	ND [b]	ND [b]
o-Toluidine	B2	--	2.40e-01 [c]	--	--
1,2,4-Trichlorobenzene	D	1.00e-02 [c]	ND [a]	ND [b]	ND [b]
2,4,5-Trichlorophenol	D	1.00e-01 [a]	ND [a]	ND [b]	ND [b]
2,4,6-Trichlorophenol	B2	ND [a]	1.10e-02 [a]	U [b]	3.10e-06 [b]

Table 4-4

(Continued)

Chemical	EPA Carc. Class [b]	Oral RfD (mg/kg/d)	Oral SF 1/(kg/kg/d)	Inhalation RfC (mg/m3)	Inhalation Unit Risk 1/(μg/m3)
DIOXINS AND FURANS					
2,3,7,8-Tetrachlorodibenzo-p-dioxin	B2	--	1.50e+05 [e]	--	3.30e-11 [e]
Tetrachlorodibenzo-p-furans [c]		--	1.5e+04 [j]	--	--
Pentachlorodibenzo-p-dioxins		--	7.5e+04 [j]	--	--
Pentachlorodibenzo-p-furans		--	7.5e+04 [j]	--	--
Hexachlorodibenzo-p-dioxins	B	--	1.5e+04 [j]	--	--
Hexachlorodibenzo-p-furans		--	1.5e+04 [j]	--	--
GENERAL					
Cyanide	D	2.00e-02 [a]	ND [a]	ND [b]	ND [b]
Sulfide		--	--	--	--
Total Organic Carbon		--	--	--	--

Notes:

[a] - U.S. Environmental Protection Agency (EPA), 1992b. Integrated Risk Information System (IRIS). May 12, 1992.

[b] - U.S. Environmental Protection Agency (EPA), 1992b. Integrated Risk Information System (IRIS). May 28, 1992.

[c] - IRIS, September 15, 1992.

[d] - Calculated based on drinking water MCL from: U.S. Environmental Protection Agency (EPA), 1991a. Drinking Water Regulations and Health Advisories. Office of Water, Washington, D.C. April, 1991.

[e] - U.S. Environmental Protection Agency (EPA), 1992a. Health Effects Assessment Summary Tables (HEAST). Annual FY-1992. NTIS No. PB92-921199. March, 1992.

[f] - RFD for endosulfan used (HEAST FY1992).

[g] - Calculated based on HBLs for 1,3-dichloropropene from IRIS, May 12 and 28 1992.

[h] - Calculated using comparative potency approach in: Clement Associates, Inc., 1988. Comparative Potency Approach for Estimating the Cancer Risk Associated with the Exposure to Mixtures of Polycyclic Aromatic Hydrocarbons. ICF-Clements Associates, Inc., Fairfax, Virginia. April 1, 1988.

[i] - Calculated based on HBL from: U.S. Environmental Protection Agency (EPA), 1990. Docket Report on Health-Based Levels and Solubilities Used in the Evaluation of Delisting Petitions Submitted Under 40 CFR Parts 260.20 and 260.22. EPA 68-W9-0091, 1990.

[j] - Calculated based on toxicity equivalency factor (TEF) approach in: U.S. Environmental Protection Agency (EPA), 1989. "1989 Update to the Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and -Dibenzofurans (CDDs and CDFs)." EPA Risk Assessment Forum, Washington D.C. March, 1989. Value given is for 2,3,7,8-isomer, other isomers are considered non-carcinogenic and have no HBLs or action levels.

[k] - Calculated based on action level for lead in water at the tap in: U.S. Environmental Protection Agency (EPA), 1991b. "Maximum Contaminant Level Goals and National Primary Drinking Water Regulations for Lead and Copper; Final Rule." Federal Register 56110, Friday, June 7, 1991.

ND - No data available.

U - Under review.

-- Not listed on IRIS or HEAST.

Because the RCRA Subpart S rules have not been promulgated, the media action levels are TBC information only.

4.2.4 USEPA RCRA Proposed Corrective Action Media Protection (Cleanup) Standards

40 CFR Part 264, Subpart S, Section 264.521 (proposed 27 July 1990, 55 Fed. Reg. 30798 et seq.)

Media cleanup standards are contaminant concentrations that must be achieved by the remedial action under the proposed RCRA corrective action program. Media cleanup standards must (1) ensure protection of human health and the environment; (2) be set for each medium of concern during the remedy selection process; and (3) be met at the "point of compliance" specified in Section 264.525(e) of Subpart S. The USEPA is proposing to set media cleanup standards within the overall context of the remedy selection process. Because media cleanup standards are still in the proposed stage, they are TBC information for Landfill No. 4 and, if used, would be based on action levels in conjunction with site-specific risk assessments.

4.2.5 Polychlorinated Biphenyls (PCBs)

In 1987, USEPA adopted amendments to the PCB regulations establishing spill cleanup requirements ("PCB cleanup policy"). These requirements apply to PCB spills which occur after 4 May 1987 (effective date). Spills that occurred before the effective date are excluded from the scope of the PCB cleanup policy. The cleanup requirements for those "historic" spills are established on a discretionary basis through the USEPA regional offices.

4.2.6 Total Petroleum Hydrocarbons (TPH) Standards

New Mexico Underground Storage Tank Regulations

New Mexico Underground Storage Tank (UST) Regulations are the only standards available for remediation of soils contaminated with petroleum hydrocarbons. The New Mexico UST regulations, which are to be considered during remediation, state that decontamination of soil will be complete when:

1. Soil contamination has been reduced to a level which will not contaminate groundwater;

2. No highly contaminated soils remain in the ground; and

3. An analysis of what appears to be the most contaminated soil reveals, for soils contaminated by jet aviation fuel or other heavy petroleum product, that the total petroleum hydrocarbon value is less than 100 ppm, total aromatic hydrocarbon value is less than 50 ppm, and the benzene concentration is less than 10 ppm using an appropriate laboratory test in areas where the underlying groundwater contains 10,000 milligrams per liter or less total dissolved solids and the contaminated soil is 50 feet or less above the seasonal high static groundwater level.

4.3 Location-Specific ARARs

Location-specific ARARs are requirements that affect the management of hazardous constituents, or the units in which they are managed, due to the location of the units. Location-specific ARARs might be triggered, for example, if groundwater remediation were selected as a remedial action which required the construction of new surface wastewater treatment units. Examples of sensitive locations for such units include wetlands, floodplains, historic areas, and wildlife refuges. Federal and state location-specific ARARs are set forth in Table 4-5.

Table 4-5

Potential Location-Specific ARARs

Statutory, Regulatory Basis	Citation	Description
Resource Conservation and Recovery Act	40 CFR Sec. 264.18 18 AAC Sec. 63.040	Prohibits or restricts siting of hazardous waste management units in certain sensitive areas (100-year floodplain, active seismic area, wetlands).
Migratory Bird Treaty Act of 1972	16 USC Sec. 703-712 50 CFR Parts 10, 20, 21	If migratory birds are present, provides protection of almost all species of native birds in the U.S. from unregulated activities. Unregulated activities can include poisoning at hazardous waste sites.
Fish and Wildlife Conservation Act of 1980	16 USC Sec. 2901 50 CFR Part 83	Requires the submittal of conservation plans outlining provisions to conserve non-game fish and wildlife. Approved conservation plans are enforced by state agencies.
Federal Land Policy and Management Act	13 USC Sec. 1700 et seq.	Establishes requirements concerning utilization of public lands, particularly rights-of-way regulation, land use planning and land acquisition and appropriation of waters on public lands.
Fish and Wildlife Improvement Act	16 USC Sec. 661-666c	Provides for development, protection, rearing, and stocking of all species of wildlife, wildlife resources, and their habitat.
Endangered Species Act	16 USC 1531 et seq. 50 CFR Part 200 50 CFR Part 402	Provides for protection and conservation of various species of fish, wildlife, and plants.
New Mexico Wildlife Conservation Act	NMSA, Sections 17-2-37 through 17-2-46	Includes an amended listing of endangered wildlife in New Mexico.
Clean Water Act, Section 404	33 USC 1251 et seq. Sec. 404 40 CFR Part 230	Prohibits discharge of dredged or fill material into wetlands without a permit.
Fish and Wildlife Improvement Act	33 CFR 320-330	Provides for management of dredged material; establish requirements for structures affecting navigable waterways; and provides for certain permitting requirements.
Archaeological and Historic Preservation Act	16 USC Sec. 469 40 CFR 6.301(c)	Establishes procedures for preservation of historical and archaeological resources when terrain is altered as a result of a federal or federally licensed construction activity.
National Historic Preservation Act	16 USC Sec. 470 40 CFR Sec. 6.301(b) 36 CFR Part 800	Provides for the protection of historic places.
Historic Sites, Buildings, and Antiquities Act	16 USC Sec. 461-467	Provides for the protection of natural landmarks.

4.4 Action-Specific ARARs

Action-specific ARARs are technology-based or activity-based requirements that may be triggered by the particular remedial activities chosen. The action-specific requirements do not in themselves determine the remedial alternatives, rather they place restrictions on the manner in which a selected alternative may be achieved. Table 4-6 lists potential action-specific requirements pursuant to each federal and state environmental law. Because this landfill does not fall strictly under the RCRA requirements for closure, a risk-based "no further action" under CERCLA is an option.

Table 4-6

Potential Action-Specific Federal ARARs

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Solid Waste Disposal Act	42 USC Sec. 6901-6987	Resource Conservation and Recovery	
Criteria for Classification of Solid Waste Disposal Facilities and Practices	40 CFR Part 257	Establishes criteria for use in determining which solid waste disposal facilities and practices pose a reasonable probability of adverse effects on health or the environment and thereby prohibit open dumps.	Landfilling
Criteria for Municipal Solid Waste Disposal Facilities	40 CFR Part 258	Establishes minimum federal criteria for design, construction, operation, and permitting of municipal solid waste landfills.	
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste.	
Standards Applicable to Generators of Hazardous Waste	40 CFR Part 262	Establishes standards for generators of hazardous waste	Remedial action causes hazardous waste to be generated
Standards Applicable to Transporters of Hazardous Waste	40 CFR Part 263	Establishes standards which apply to persons transporting hazardous waste within the U.S.	Transport of wastes offsite
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 264	Establishes minimum national standards which define the acceptable management of hazardous waste for owners and operators of facilities which treat, store, or dispose of hazardous waste.	

Table 4-6

(Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Interim Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR Part 265	Establishes minimum national standards that define the acceptable management of hazardous waste during the period of interim status and until certification of final closure or, if the facility is subject to post-closure requirements, until post-closure responsibilities are fulfilled.	
Standards for Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	40 CFR Part 266	Establishes requirements which apply to recyclable materials used in a manner constituting disposal or hazardous waste burned for energy recovery.	Hazardous wastes are recycled on or offsite
Interim Standards for Owners and Operators of New Hazardous Waste Land Disposal Facilities	40 CFR Part 267	Establishes minimum national standards that define acceptable management of hazardous waste land disposal facilities.	Landfilling onsite
Land Disposal Restrictions Program	40 CFR Part 268	Sets treatment standards for hazardous wastes based on the levels achievable by current technology; sets two-year national variances from the statutory effective dates due to insufficient treatment capacity.	Off-site land disposal of liquid wastes
Hazardous Waste Permit Program	40 CFR Part 270	Establishes provisions covering basic EPA permitting requirements.	
Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (USTs)	40 CFR Part 280	Provides regulations pertaining to underground storage tanks.	Operation or removal of an UST
Clean Water Act	33 USC Sec. 1251-1376		
EPA-Administered Permit Programs: The National Pollutant Discharge Elimination System	40 CFR Part 122	Requirements for the discharge of pollutants from any point source into waters of the U.S.	Applicable if remedial action requires outfall discharge

Table 4-6

(Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Criteria and Standards for the National Pollutant Discharge Elimination System	40 CFR Part 125	Provides discharge criteria, chemical standards, and permit forms for existing industrial operations.	Applicable to remedial actions which cause discharge to waters of the U.S.
Occupational Safety and Health Act of 1970	29 USC Sec. 657 and 667		
Occupational Safety and Health Standards	29 CFR Part 1910	Sets standards for safety in the work environment.	Applicable to all remedial actions
Safety and Health Regulations for Construction	29 CFR Part 1926	Sets standards for safety in the construction work environment.	
Safety and Health Standards for Federal Service Contracts	29 CFR Part 1925	States that safety and health standards are applicable to work performed under Federal Service Contracts.	
Clean Air Act			
National Emissions Standards for Hazardous Air Pollutants	40 CFR Part 61	Establishes emissions standards for hazardous air pollutants that may reasonably be anticipated to result in an increase in mortality or an increase in serious irreversible, or incapacitating illness.	Incineration, storage of petroleum liquids; air stripping
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare.	
Safe Drinking Water Act	40 USC Sec. 300G		
Underground Injection Control Program	40 CFR Part 144	Provides for protection of underground sources of drinking water.	Underground injection of wastes/ contaminated water
Underground Injection Control Program: Criteria and Standards	46 CFR Part 146	Provides technical requirements for UIC programs.	

Table 4-6

(Continued)

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments/ Applicability
Department of Transportation - Hazardous Materials Regulations			
Shipping and Manifesting Requirements for Hazardous Waste	49 CFR Parts 171-179	Provides requirements for packaging, manifesting, and transportation of hazardous waste.	Applicable to all Remedial Actions

5.0 ANALYTICAL RESULTS

This section contains the field data from the 1985 (Radian, 1986) and 1992 sampling events at Landfill No. 4 and relevant conclusions made from these data. The following subsections present:

- Overview of the 1985 and 1992 sampling events and the tabulation of the detailed analytical results;
- Comparison of the field metals data to background soil metals data;
- Description of organic contaminants founds at the site;
- Comparison of the field data to the recommended soil action levels listed in the RCRA proposed Subpart S Media Action Levels (40 CFR, Section 264.521); and
- Conclusions and recommendations.

5.1 Background Information

In 1985, seven boreholes were drilled at the Landfill No. 4 site. Five of these boreholes were sampled at depth intervals corresponding to 1 to 4.5 feet, 7 to 11 feet, and deeper than 52.5 feet, resulting in three samples per borehole. Borehole B was sampled at the first two depth intervals only. Borehole D was sampled at four depth intervals: 1.5 to 3 feet, 15 to 17 feet, 27.5 to 28.5 feet, and 47.5 to 49 feet. The 1985 sampling effort resulted in 28 field samples which were analyzed for halogenated volatile organics, aromatic volatile organics, metals, and oil and grease. Table 5-1 lists the analytical methods used to determine each of the parameters used to characterize the Landfill No. 4 samples. The results for these analyses are given in Appendix C, Table C-1 and will be discussed in following subsections.

Table 5-1

Analytical Methods Used to Characterize Cannon Landfill No. 4

Parameter	Method
1985 Analytical Methods	
Halogenated Volatile Organics	SW 8010
Aromatic Volatile Organics	SW 8020
Metals - ICPES Hg by CVAAS As by GFAAS Pb by GFAAS Se by GFAAS	SW 6010 SW 7471 SW 7060 SW 7421 SW 7740
Oil and Grease	E418.1 Modified
1992 Analytical Methods	
Organochlorine Pesticides and PCBs	SW 8080
Volatile Organic Compounds	SW 8240
Semivolatile Organic Compounds	SW 8270
Total Recoverable Petroleum Hydrocarbons	SW 9071/EPA 418.1 [a]
TAL Metals - ICPES Hg by CVAAS As by GFAAS Pb by GFAAS Se by GFAAS Sb by GFAAS Tl by GFAAS	SW 6010 SW 7471 SW 7060 SW 7421 SW 7740 SW 7041 SW 7841
Total Extractable Hydrocarbons	SW 8015 ME [b]
Total Purgeable Hydrocarbons	SW 8015 MP [b]
Chlorinated Herbicides	SW 8150

[a] - EPA 418.1 was used to analyze the extract generated using SW 9071.
[b] - SW 8015 was modified according to California LUFT.

The 1985 results (included in the 1986 Radian report) indicated that there was no evidence of past waste disposal activities associated with Landfill No. 4 which would result in a threat to human health or the environment. However, further review of the Decision Document based on the 1985 data (EA Engineering, 1990) resulted in a request to perform additional sampling and analyses of the soils in the 20 to 60 foot depth interval at Landfill No. 4.

Ten additional boreholes were drilled in 1992. Ten to twelve samples were generated at depth intervals ranging from 15 to 62 feet for each borehole. Six surface soils were also sampled. One of these surface soils (CAN-104-BG-01) was taken along the fenceline and designated a background surface soil. This effort resulted in one hundred and thirty field samples which were analyzed for organochlorine pesticides, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), total recoverable petroleum hydrocarbons (TRPH), and total analyte list (TAL) metals. In addition, forty-nine of these samples were also analyzed for total extractable hydrocarbons (diesel, jet fuel, and kerosene), total purgeable hydrocarbons (gasoline and its components), and chlorinated herbicides. Table 5-1 lists the analytical methods used to analyze these samples. The results of these analyses are presented in Appendix C, Tables C-2 through C-3, and will be discussed in the following subsections.

5.2 Comparison of Field and Site Specific Background Metals Data

Site specific background metals data were determined from background soil boring samples taken in areas adjacent to Landfill No. 2 at depths ranging from 0 to 74 feet (Woodward-Clyde, 1992). These data were used to calculate an upper tolerance limit (UTL) for the background data. The UTL was calculated based on a 95% confidence level, where the UTL(95%) defines a limit such that 95% of the background results should be less than the UTL at least 95% of the time. For metals not detected in more than one of the background soil samples (i.e., antimony, cadmium, copper,

mercury, selenium, silver, sodium, thallium, and zinc), the maximum detection limit is used as the UTL. The UTLs for the background soil are listed in Table 5-2. The calculations and data used to determine the UTLs are provided in Appendix F.

The metals data for the 1985 and 1992 field samples were then compared to the UTLs. Those samples containing metals concentrations greater than the UTLs are listed in Table 5-3. Approximately 50% of the Landfill No. 4 samples exceeded the background concentration for zinc (15 mg/kg). Barium and cobalt also exceeded the background UTLs of 230 mg/kg and 2.2 mg/kg, respectively, for at least 20% of the field samples. Aluminum, beryllium, cadmium, chromium, copper, iron, mercury, potassium, selenium and vanadium concentrations also exceeded the background concentrations in 21 of the 151 field samples.

Atomic absorption data were used to compare arsenic, lead, and selenium data (1992) to the background soil UTLs. The remainder of the metals were analyzed by inductively coupled plasma emission spectroscopy (ICPES). The field samples contained high concentrations of calcium which interfered with the antimony analyses. In addition, the ICPES thallium detection limits were not low enough to adequately evaluate the data. Therefore, 17 field samples, selected based on high detection limits or apparent hits when analyzed by ICPES, were submitted for analyses by graphite furnace atomic absorption (GFAAS). These results for "worst case" samples are given in Table 5-4. Thallium and antimony were not detected in these samples.

Matrix spike recoveries indicate that the GFAAS results may have been biased low. In order to provide the most conservative assessment of the site contamination, the field data were corrected for these biases: thallium - 30% low; antimony - 80% low; arsenic - 30% low; selenium - 50% low, and lead - 25% low. The adjusted data were then compared to the background soil UTLs. Four of the surface soil samples: CAN-104-4II-01, CAN-104-4JJ-01, CAN-104-4LL-01, and CAN-104-4QQ-01 were found to exceed the arsenic UTL. Arsenic concentrations given in Table 5-3 have

Table 5-2

Upper Tolerance Limits for Background Soil Cores
Confidence Level = 95%, Tolerance Level = 95%

Analyte	Number Detected	Percent Detected	Total Number of Results	Mean (mg/kg)	Standard Deviation (mg/kg)	Upper Tolerance Limit (mg/kg)[a]	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
Aluminum	17	100	17	4900	2600	12,250	--[c]	--[c]
Antimony	0	0	17	--	--	--[b]	<6.1	<13
Arsenic	17	100	17	1.9	1.3	5.6	--[c]	--[c]
Barium	17	100	17	78	53	230	--[c]	--[c]
Beryllium	13	76.5	17	0.3	0.18	0.81	<0.17	<0.21
Cadmium	0	0	17	--	--	--[b]	<0.51	<1.1
Calcium	17	100	17	56,000	65,000	241,000	--[c]	--[c]
Chromium	17	100	17	6.9	2.9	15	--[c]	--[c]
Cobalt	14	82.4	17	2.1	1.3	5.7	<1.0	<2.2
Copper	1	5.9	17	--	--	--[b]	<2.0	<4.4
Iron	17	100	17	4,100	2,100	10,000	--[c]	--[c]
Lead	17	100	17	3.4	3.5	13	--[c]	--[c]
Magnesium	17	100	17	4900	3,300	14,500	--[c]	--[c]
Manganese	17	100	17	56	46	190	--[c]	--[c]
Mercury	0	0	17	--	--	--[b]	<0.10	<0.12

Table 5-2

(Continued)

Analyte	Number Detected	Percent Detected	Total Number of Results	Mean (mg/kg)	Standard Deviation (mg/kg)	Upper Tolerance Limit (mg/kg)[a]	Minimum Detection Limit (mg/kg)	Maximum Detection Limit (mg/kg)
Nickel	16	94.1	17	4.0	2.3	10	<4.1	<4.1
Potassium	17	100	17	1100	590	2,800	-- [c]	-- [c]
Selenium	0	0	17	--	--	-- [b]	<0.51	<2.2
Silver	0	0	17	--	--	-- [b]	<0.51	<2.2
Sodium	1	5.9	17	--	--	-- [b]	<510	<1090
Thallium	1	5.9	17	--	--	-- [b]	<0.51	<1.1
Vanadium	17	100	17	12	4.1	24	-- [c]	-- [c]
Zinc	1	5.9	17	--	--	-- [b]	<4.3	<15

[a] - Upper tolerance limit calculated as [mean + (std x K-factor)].
[b] - Insufficient detected results to calculate upper tolerance limit.
[c] - All the data detected. Detection limit not reported.

Table 5-3

Metals Found at Concentrations Greater Than Background Soil UTLs in Field Samples from Cannon Landfill No. 4, 1985 [a] and 1992

Sample ID	Depth, ft.	Target Metals, mg/kg											
		Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Mercury	Potassium	Vanadium	Zinc
Background UTL		12000	5.3	230	1.1	15	2.2	4.4	10000	0.12	2800	24	15
1985 Samples [a]													
4A-1	1-2	--	--	--	--	--	--	--	--	--	--	--	94
4A-2	7-9	--	--	--	--	--	--	--	--	--	--	--	45
4A-3	62.5-63	--	--	--	--	--	--	--	--	--	--	--	54
4B-1	1-3	--	--	--	--	--	--	--	--	--	--	--	29
4C-1	3-4.5	--	--	--	--	--	--	--	--	--	--	--	70
4C-2	9.4-6	--	--	--	--	--	--	--	--	--	--	--	26
4D-2	15-17	--	--	--	--	--	--	--	--	--	--	--	260
4D-3	27.5-28.5	--	--	240	--	--	--	--	--	--	--	--	--
4D-4	47.9-49	--	--	320	--	--	--	--	--	--	--	--	--
4E-1	3-4.5	--	--	--	--	--	--	--	--	--	--	--	85
4E-3	52.5-54	--	--	--	--	--	--	--	--	--	--	--	31
4F-1	2-3.5	--	--	--	--	--	--	--	--	--	--	--	32
4F-2	8-9	--	--	290	--	--	--	--	--	--	--	--	15
4F-3	57.9-59	--	--	--	--	--	--	--	--	--	--	--	190
4G-1	2-4	--	--	--	--	--	--	6.5	--	--	--	--	16
4G-2	52.5-53	--	--	--	--	--	--	--	--	--	--	--	31

Table 5-3

(Continued)

Sample ID	Depth, ft.	Target Metals, mg/kg											
		Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Mercury	Potassium	Vanadium	Zinc
Background UTL		12000	5.3	230	1.1	15	2.2	4.4	10000	0.12	2800	24	15
1992 Samples													
CAN-104-4H-01	15-16.7	--	--	--	--	--	3.8	--	--	--	--	--	--
CAN-104-4H-13 [b]	15-16.7	--	--	--	--	--	3.4	--	--	--	--	--	--
CAN-104-4H-02	20-20.7	--	--	--	--	--	3.8	--	--	--	--	--	19
CAN-104-4H-03	25-27	--	--	--	--	--	3.2	--	--	--	--	--	--
CAN-104-4H-05	35-37	--	--	--	--	--	2.5	--	--	--	--	--	--
CAN-104-4H-06	40-41	--	--	--	--	--	--	--	--	--	--	--	--
CAN-104-4H-07	45-46	--	--	--	--	--	2.6	--	--	--	--	--	--
CAN-104-4H-08	50-51.3	--	--	--	--	--	2.2	--	--	--	--	--	--
CAN-104-4I-01	15-17	--	--	--	--	--	3.2	--	--	--	--	--	--
CAN-104-4I-02	20-22	--	--	--	--	--	4.0	--	--	--	--	--	16
CAN-104-4I-03	32.5-33.1	--	--	--	--	--	2.4	--	--	--	--	--	--
CAN-104-4I-04	35-36.5	--	--	230	--	--	--	--	--	--	--	--	--
CAN-104-4II-01	Surface	15000	5.6 [j]	--	--	--	4.1	6.6	11000	--	2800	--	29
CAN-104-4J-01	15-17	--	--	--	--	--	2.3	--	--	--	--	--	--
CAN-104-4J-02	20-22	--	--	560	--	--	2.4	--	--	--	--	--	--
CAN-104-4J-03	25-27	--	--	310	--	--	3.0	--	--	--	--	--	--
CAN-104-4J-04	27.5-28	--	--	420	--	--	2.4	5.0 [B]	--	--	--	--	--
CAN-104-4J-05	30-32	--	--	--	--	--	2.5	--	--	--	--	--	--
CAN-104-4J-06	35-35.7	--	--	--	--	--	--	--	--	--	--	--	--
CAN-104-4J-07	45-46.8	--	--	350	--	--	2.6	--	--	--	--	--	--
CAN-104-4J-08	50-50.8	--	--	950	--	--	--	--	--	--	--	--	--

Table 5-3

(Continued)

Sample ID	Depth, ft.	Target Metals, mg/kg											
		Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Mercury	Potassium	Vanadium	Zinc
Background UTL		12000	5.3	230	1.1	15	2.2	4.4	10000	0.12	2800	24	15
CAN-104-4JJ-01	Surface	13000	6.2[j]	250	--	--	4.4	--	--	--	--	--	25
CAN-104-4K-01	15-17	--	--	--	--	--	3.9	4.4[B]	--	--	--	--	16
CAN-104-4K-13[c]	15-17	--	--	--	--	--	3.6	--	--	--	--	--	--
CAN-104-4K-02	20-22	--	--	360	--	--	3.0	--	--	--	--	--	--
CAN-104-4K-07	45-47	--	--	--	--	--	2.3	--	--	--	--	--	--
CAN-104-4L-01	15-17	--	--	350	--	--	2.7	--	--	--	--	--	--
CAN-104-4L-13[d]	15-17	--	--	--	--	--	2.4	--	--	--	--	--	--
CAN-104-4L-02	20-22	--	--	--	--	--	3.4	--	--	--	--	--	--
CAN-104-4L-03	25-27	--	--	--	--	--	3.3	--	--	--	--	--	--
CAN-104-4L-05	35-37	--	--	--	--	--	2.6	--	--	--	--	--	--
CAN-104-4L-06	37.5-37.6	--	--	--	--	--	4.0	--	--	--	--	--	--
CAN-104-4L-07	40-42	--	--	--	--	--	2.2	--	--	--	--	--	--
CAN-104-4L-08	45-47	--	--	--	--	--	2.7	--	--	--	--	--	--
CAN-104-4L-09	50-52	--	--	--	--	--	2.6	--	--	--	--	--	--
CAN-104-4LL-01	Surface	14000	7.3[j]	--	--	--	3.9	5.6	--	--	2900	--	25
CAN-104-4M-01	15-16.3	--	--	--	4.8	--	2.3	--	--	--	--	--	--
CAN-104-4M-02	20-22	--	--	360	--	--	--	--	--	--	--	--	--
CAN-104-4M-03	22.5-23.2	--	--	1100	--	--	--	--	--	--	--	--	--
CAN-104-4M-04	25-27	--	--	820	--	--	--	--	--	0.12[B]	--	--	--
CAN-104-4M-05	30-31	--	--	400	--	--	2.7	--	--	--	--	--	--
CAN-104-4M-06	35-37	--	--	580	--	--	--	--	--	--	--	--	--
CAN-104-4M-08	45-47	--	--	390	--	--	--	--	--	--	--	--	--

Table 5-3

(Continued)

Sample ID	Depth, ft.	Target Metals, mg/kg											
		Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Mercury	Potassium	Vanadium	Zinc
Background UTL		12000	5.3	230	1.1	15	2.2	4.4	10000	0.12	2800	24	15
CAN-104-4M-09	50-51.5	--	--	--	--	--	2.3	--	--	--	--	--	--
CAN-104-4M-13[e]	50-51.5	--	--	--	--	--	2.2	--	--	--	--	--	--
CAN-104-4N-01	15-17	16000	--	570	--	--	3.7	6.5	--	--	2900	--	21
CAN-104-4N-02	17.5-19.5	15000	--	--	--	--	3.8	5.2	--	--	3200	--	20
CAN-104-4N-03	20-21.7	--	--	230	--	--	3.1	4.7	--	--	--	--	17
CAN-104-4N-13[f]	20-21.7	15000	--	--	--	--	3.7	4.9	--	--	3200	--	19
CAN-104-4N-04	25-26	--	--	--	--	--	2.2	--	--	--	--	--	--
CAN-104-4N-05	30-31.5	--	--	1300	--	--	2.2	--	--	--	--	--	--
CAN-104-4N-07	40-40.5	--	--	--	--	16	2.4	--	--	--	--	--	--
CAN-104-4N-08	45-47	--	--	--	--	--	2.4	--	--	--	--	--	--
CAN-104-4P-01	15-17	16000	--	--	--	--	4.1	4.6	--	--	3100	--	21
CAN-104-4P-13[g]	15-17	16000	--	260	--	--	3.9	4.7	--	--	3000	--	22
CAN-104-4P-02	17.5-18.1	--	--	--	--	--	2.7	--	--	--	--	27	--
CAN-104-4P-03	20-22	--	--	--	--	--	2.3	--	--	--	--	--	46
CAN-104-4P-14[h]	20-22	--	--	--	--	--	2.5	--	--	--	--	--	48
CAN-104-4P-04	25-27	--	--	970	--	--	2.7	--	--	--	--	--	18
CAN-104-4P-05	30-32	--	--	230	--	--	2.3	--	--	--	--	--	--
CAN-104-4P-06	32.5-34.5	--	--	--	--	--	3.0	--	--	--	--	--	--
CAN-104-4Q-01	15-17	--	--	750	--	--	3.0	--	--	--	--	--	--
CAN-104-4Q-02	20-22	--	--	--	--	--	2.6	--	--	--	--	--	--
CAN-104-4Q-05	40-40.5	--	--	--	--	--	2.3	--	--	0.12[B]	--	--	--
CAN-104-4QQ-01	0-0.5	13000	7.7[j]	--	--	--	4.3	5.5	--	--	--	--	24

Table 5-3

(Continued)

Sample ID	Depth, ft.	Target Metals, mg/kg											
		Aluminum	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Iron	Mercury	Potassium	Vanadium	Zinc
Background UTL		12000	5.3	230	1.1	15	2.2	4.4	10000	0.12	2800	24	15
CAN-104-4R-01	15-17	–	–	260	–	–	2.7	–	–	–	–	–	–
CAN-104-4R-13 [i]	15-17	–	–	–	–	–	2.5	–	–	–	–	–	–
CAN-104-4R-06	30-32	–	–	330	–	–	–	–	–	–	–	–	–
CAN-104-4RR-01	Surface	15000	–	–	–	–	3.7	5.3	–	–	–	–	24
CAN-104-4RR-02 [k]	Surface	15000	–	–	–	–	3.9	5.5	11000	–	–	–	25
CAN-104-BG-01	Surface	–	–	–	–	–	3.3	5.2	–	–	–	–	23

[a] - Radian, 1986.
[b] - CAN-104-4H-13 is a field duplicate of CAN-104-4H-01.
[c] - CAN-104-4K-13 is a field duplicate of CAN-104-4K-01.
[d] - CAN-104-4L-13 is a field duplicate of CAN-104-4H-01.
[e] - CAN-104-4M-13 is a field duplicate of CAN-104-4H-09.
[f] - CAN-104-4N-13 is a field duplicate of CAN-104-4H-03.
[g] - CAN-104-4P-13 is a field duplicate of CAN-104-4H-01.
[h] - CAN-104-4P-13 is a field duplicate of CAN-104-4H-03.
[i] - CAN-104-4R-13 is a field duplicate of CAN-104-4H-01.
[j] - Data have been corrected for a 30% low bias determined by matrix spike analyses.
[k] - CAN-104-4RR-02 is a field duplicate of CAN-104-4RR-01.
[B] - Analyte was observed in the method blank associated with this sample. Sample results have not been corrected for the concentration in the blank.

Note: Atomic absorption data were used to compare arsenic, lead, and selenium data (1992) to the UTLs. All field samples were anlayzed for antimony and thallium by ICPES. Due to the high concentrations of calcium in these samples, the antimony and thallium results were biased high. Ten percent of the field samples (the 17 exhibiting the highest apparent concentrations or detection limits for Sb and Tl) were submitted for analylses by graphite atomic absorption spectroscopy. These analyses indicate Sb and Tl results (corrected for bias) are below the UTLs for this site. The uncorrected field data is given in Appendix C.

Table 5-4

Cannon Landfill No. 4 1992 Samples Reanalyzed for Antimony and Thallium by Graphite Furnace Atomic Absorption Spectroscopy

Sample ID	Depth, ft	Sb mg/kg	Tl mg/kg
CAN-104-4H-01	15-16.7	<0.61	<0.51
CAN-104-4H-13 [a]	15-16.7	<0.62	<0.52
CAN-104-4I-03	32.5-33	<0.58	<0.49
CAN-104-4J-02	20-22	<0.52	<0.55
CAN-104-4J-04	27.5-28	<0.46	<0.45
CAN-104-4JJ-01	Surface	<0.47	NA
CAN-104-4K-03	25-27	<0.57	NA
CAN-104-4K-04	30-32	<0.57	<0.47
CAN-104-4L-04	30-30.5	<0.55	<0.46
CAN-104-4M-02	20-22	<0.57	<0.61
CAN-104-4M-04	25-27	<0.61	<0.51
CAN-104-4N-03	20-21.7	<0.57 [b]	<0.48 [c]
CAN-104-4N-05	30-31.5	<0.56	<0.47
CAN-104-4N-07	40-40.5	<0.58	<0.46
CAN-104-4P-02	17.5-18.1	<0.58	<0.48
CAN-104-4Q-03	25-25.7	<0.56	<0.46
CAN-104-4R-07	35-36.5	<0.52	<0.44

[a] - CAN-104-4H-13 is a field duplicate of CAN-104-4H-01.
[b] - MS/MSD recoveries 18% and 20 percent.
[c] - MS/MSD recoveries both 70 percent.

been corrected for the analytical bias. A detailed listing of the analytical results for all target metals are given in Appendix C, Tables C-1, C-2, and C-3. These tables list the original field data which were not corrected for the GFAAS biases.

5.3 Organic Compounds Detected at Landfill No. 4

Landfill No. 4 1985 soil samples were analyzed for halogenated volatile organics and aromatic volatile organics. None of the target compounds were detected in the 1985 samples (where the detection limit was 1 μg/kg for all target compounds). A list of the 1985 target organic compounds is given in Appendix C, Table C-1.

Several organochlorine pesticides and PCBs were detected in one or more of the samples from the 1992 Landfill No. 4 effort. These include 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, endosulfan II, endrin, heptachlor expoxide, beta-BHC, delta-BHC, gamma-BHC, and PCB-1260. Table 5-5 lists only the samples found to contain one or more of the organochlorine pesticides or PCBs detected at the Cannon Landfill No. 4 site. Organochlorine pesticide and PCB data with a G flag denotes that the second column confirmation analyses confirms the presence of the compound but that the concentration was estimated due to matrix interferences. Low levels of organochlorine pesticides were found distributed throughout the site. The most prevalent pesticides were delta-BHC, gamma-BHC, 4,4-DDE, 4,4'-DDD, and 4,4'-DDT.

Borehole M contained significant levels of 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE in samples taken at 15, 20, 22.5, and 30 feet. These samples contain 10 to 640 μg/kg 4,4'DDT, 0.6 to 64 μg/kg 4,4'DDD, and <0.37 to 23 μg/kg 4,4'-DDE. These compounds were not detected in samples taken below 35 feet.

Diesel, total recoverable petroleum hydrocarbons (TRPH), 2,4,5-TP, dichloroprop, MCPP, acetone, methylene chloride, toluene, and xylenes were detected in one or more of the samples from this site. Table 5-6 lists only the results for samples

Table 5-5

Organochlorine Pesticides and PCBs Found in Soil Samples from Cannon Landfill No. 4, 1992

Sample ID	Depth, ft	Organochlorine Pesticides and PCBs (8080), µg/kg										
		4,4'-DDD	4,4'-DDE	4,4'-DDT	Aldrin	Endosulfan II	Endrin	Heptachlor Epoxide	PCB-1260	beta-BHC	delta-BHC	gamma-BHC
CAN-104-4H-01	15-16.7	<0.38	<0.38	<0.75	<0.38	<1.1	<0.38	<0.38	<7.5	<.38	0.57 @	<0.38
CAN-104-4H-13[a]	15.16.7	<0.38	<0.38	<0.75	<0.38	<1.1	<0.38	<0.38	<7.5	<0.38	0.7 @	<0.38
CAN-104-4H-02	20-20.7	<0.36	<0.36	<0.73	<0.36	<1.1	<0.36	33G	7.3 @	<0.36	<0.36	0.62G @
CAN-104-4H-09	52.5-54	<0.35	<0.35	<0.70	<0.35	<1.1	<0.35	16G	<7.0	<0.35	0.38 @	<0.35
CAN-104-4I-07	47.5-48.8	<0.35	<0.35	<0.70	<0.35	<1.1	<0.35	<0.35	<7.0	<0.35	<0.35	1
CAN-104-4I-13[b]	47.5-48.8	<0.35	<0.35	<0.70	<0.35	<1.1	<0.35	<0.35	<7.0	<0.35	<0.35	<0.35
CAN-104-4I-10	55-57	<0.34	<0.34	<0.69	<0.34	<1.0	<0.34	<0.34	<6.9	<0.34	1.5G @	0.95G @
CAN-104-4II-01	Surface	<0.36	0.97 @	<0.73	0.67G @	<1.1	<0.36	<0.36	<7.3	<0.36	<0.36	<0.36
CAN-104-4J-04	27.5-28	<0.35	<0.35	<0.71	<0.35	<1.1	<0.35	<0.35	<7.1	<0.35	0.71 @	<0.35
CAN-104-4K-03	25-27	<0.36	<0.36	<0.73	<0.36	<1.1	<0.36	<0.36	<7.3	<0.36	<0.36	0.38 @
CAN-104-4K-04	30-32	<0.36	<0.36	<0.72	<0.36	<1.1	<0.36	<0.36	<7.2	<0.36	<0.36	0.38 @
CAN-104-4LL-01	Surface	<0.37	0.88 @	<0.74	<0.37	<1.1	<0.37	<0.37	<7.4	<0.37	<0.37	<0.37
CAN-104-4M-01	15-16.3	64G	23	670	<0.35	<1.1	1.3 @	<0.35	<7.0	<0.35	<0.35	0.57 @
CAN-104-4M-02	20-22	5.4G	1.4 @	42	<0.36	<1.1	<0.36	<0.36	<7.3	<0.36	<0.36	<0.36
CAN-104-4M-03	22.5-23.2	0.59G @	<0.37	10	<0.37	<1.1	<0.37	<0.37	<7.4	<0.37	<0.37	<0.37
CAN-104-4M-05	30-31	5.3G	1.8 @	54	<0.37	<1.1	<0.37	<0.37	<7.3	<0.37	<0.37	<0.37
CAN-104-4N-01	15-17	<0.36	1.8	<0.73	<0.36	<1.1	<0.36	<0.36	<7.3	<0.36	<0.36	<0.36
CAN-104-4NN-01	40-42	<0.37	<0.37	<0.73	<0.37	<1.1	<0.37	<0.37	<7.3	1.6G @	0.55 @	0.57 @
CAN-104-4NN-03	50-52	<0.35	<0.35	<0.70	<0.35	<1.1	<0.35	<0.35	<7.0	<0.35	0.38 @	<0.35

Table 5-5

(Continued)

Sample ID	Depth, ft	Organochlorine Pesticides and PCBs (8080), µg/kg										
		4,4'-DDD	4,4'-DDE	4,4'-DDT	Aldrin	Endosulfan II	Endrin	Heptachlor Epoxide	PCB-1260	beta-BHC	delta-BHC	gamma-BHC
CAN-104-4NN-04	55-57	<0.35	<0.35	<0.69	<0.35	<1.0	<0.35	<0.35	<6.9	<0.35	0.37G @	<0.35
CAN-104-4NN-05	60-62	<0.34	<0.34	<0.68	<0.34	<1.0	<0.34	<0.34	<6.8	<0.34	<0.34	0.68G @
CAN-104-4P-10	50-52	<0.35	<0.35	<0.69	<0.35	<1.0	<0.35	<0.35	<6.9	<0.35	0.48G @	<0.35
CAN-104-4Q-08	55-57	<0.34	<0.34	<0.68	<0.34	<1.0	<0.34	<0.34	<6.8	<0.34	0.49 @	<0.34
CAN-104-4Q-14 [c]	55-57	<0.34	<0.34	<0.68	<0.34	<1.0	<0.34	<0.34	<6.8	<0.34	<0.34	<0.34
CAN-104-4RR-03	60-62	<0.34	<0.34	<0.69	<0.34	<1.0	<0.34	<0.34	<6.9	<0.34	0.4G @	<0.34
CAN-104-BG-01	Surface	<0.35	1.9	<0.69	0.58G @	1.2G @	<0.35	<0.35	<6.9	<0.35	<0.35	<0.35

[a] - CAN-104-4H-13 is a field duplicate of CAN-104-4H-01.
[b] - CAN-104-4I-13 is a field duplicate of CAN-104-4I-07.
[c] - CAN-104-4Q-14 is a field duplicate of CAN-104-4Q-08.
@ - Result listed is leess than five times the method detection limit.
G - Result is estimated due to matrix interferences.

Table 5-6

VOCs, Herbicides, Diesel, and TRPH Concentrations Found in Soil Samples from Cannon Landfill No. 4, 1992

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) μg/kg	Chlorinated Herbicides (8150), μg/kg			Volatile Organic Compounds (8240), μg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
CAN-104-4H-01	15-16.7	<28					<110	11@	<5.6	<5.6
CAN-104-4H-13[c]	15-16.7	<28					<110	17@	<5.7	<5.7
CAN-104-4H-02	20-20.7	<27					<110	13@	<5.5	<5.5
CAN-104-4H-03	25-27	<27	6200 G@[B]	<6.2	<24	<7000	<110	15@	<5.5	<5.5
CAN-104-4H-04	30-31	<27					<110	16@	<5.5	<5.5
CAN-104-4H-05	35-37	<27	5000 G@[B]	<6.1	<23	<6900	<110	11@	<5.4	<5.4
CAN-104-4H-14[d]	35-37	<27	4800 G@[B]	<6.1	<23	<6900	<110	14@	<5.4	<5.4
CAN-104-4H-06	40-41	<28					<110	11@	<5.6	<5.6
CAN-104-4H-07	45-46	<27					<110	16@	<5.4	<5.4
CAN-104-4H-08	50-51.3	<26					<100	11@	<5.2	<5.2
CAN-104-4H-09	52.5-54	<26					<110	12@	<5.3	<5.3
CAN-104-4H-10	55-56	28@	4200 G@[B]	<5.8	<22	<6600	<100	12@	<5.2	<5.2
CAN-104-4H-11	60-62	<26					<100	11@	<5.2	<5.2
CAN-104-4I-01	15-17	<26	4400 G@[B]	<5.9	<23	<6700	<110	6.8@[C]	<5.3	<5.3
CAN-104-4I-03	32.5-33	34@					<110	6.5@[C]	<5.6	<5.6
CAN-104-4I-04	35-36.5	<27	4800 G@[B]	<6.2	<24	<7000	<110	6.7@[C]	<5.5	<5.5
CAN-104-4I-05	40-41	<28					<110	7.6@[C]	9.7@	<5.7
CAN-104-4I-06	45-46.8	<27					<110	6.9@[C]	<5.3	<5.3
CAN-104-4I-13[e]	47.5-48.8	<26					<110	9.2@[C]	<5.3	<5.3

Table 5-6

(Continued)

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) µg/kg	Chlorinated Herbicides (8150), µg/kg			Volatile Organic Compounds (8240), µg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
CAN-104-4I-08	50-51.8	<27	4000 G@[B]	<6.0	<23	<6800	<110	<5.3[C]	<5.3	<5.3
CAN-104-4I-09	52.5-54.5	29@	4300 G@[B]	<6.0	<23	<6800	<100	<5.2[C]	<5.2	<5.2
~~CAN-104-4I-14[f]~~	52.5-54.5	<26	4200 G@[B]	<5.8	<22	<6600	<100	5.5@[C]	<5.2	<5.2
CAN-104-4I-10	55-57	32@					<100	5.4@[C]	<5.2	<5.2
CAN-104-4I-11	60-62	<26					<100	9@[C]	<5.2	<5.2
CAN-104-4II-01	Surface	28@	8000 G@[B]	12@	<24	11000@	<110	8.7@	<5.5	<5.5
CAN-104-4J-01	15-17	<27	4100 G@[B]	<6.0	<23	<6800	<110	<5.4	<5.4	<5.4
~~CAN-104-4J-13[g]~~	15-17	<26	4500 G@[B]	<6.0	<23	<6800	<110	6.9@	<5.3	<5.3
CAN-104-4J-05	30-32	29@	4600 G@[B]	<6.0	<23	<6800	<110	<5.3	<5.3	<5.3
CAN-104-4J-08	50-50.8	44@					<110	<5.4	<5.4	<5.4
CAN-104-4J-09	55-57	33@	3300 G@[B]	<5.8	<22	<6500	<100	<5.1	<5.1	<5.1
CAN-104-4J-10	60-62	47@					<100	<5.1	<5.1	<5.1
CAN-104-4JJ-01	Surface	36@	12000 G@[B]	<6.2	<24	<6900	<110	<5.5	<5.5	<5.5
CAN-104-4K-01	15-17	<26	5300 G@[B]	<6.0	<23	<6800	<110	<5.3[C]	<5.3	<5.3
~~CAN-104-4K-13[h]~~	15-17	<26	4700 G@[B]	<6.0	<23	<6800	<110	<5.3[C]	<5.3	<5.3
CAN-104-4K-02	20-22	<27					170@	<5.4[C]	<5.4	<5.4
CAN-104-4K-03	25-27	42@					<110	<5.4[C]	<5.4	<5.4
CAN-104-4K-04	30-32	28@					<110	<5.4[C]	<5.4	<5.4
CAN-104-4K-05	35-37	35@					<110	7.2@	<5.4	<5.4

Table 5-6

(Continued)

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) µg/kg	Chlorinated Herbicides (8150), µg/kg			Volatile Organic Compounds (8240), µg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
CAN-104-4K-06	40-41	<27					<110	5.4@	<5.4	<5.4
CAN-104-4K-07	45-47	49@					<110	<5.3	<5.3	<5.3
CAN-104-4K-08	50-51.7	29@					<110	<5.3	<5.3	<5.3
CAN-104-4K-09	57.5-59.5	50@					<100	<5.1	<5.1	<5.1
CAN-104-4K-10	60-62	34@					<100	<5.2	<5.2	<5.2
CAN-104-4L-01	15-17	<27	11000 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
CAN-104-4L-13[i]	15-17	58@[B]	9300 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
CAN-104-4L-02	20-22	<27					<110	8@	<5.5	<5.5
CAN-104-4L-03	25-27	41@	7800 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
CAN-104-4L-04	30-30.5	49@					<110	<5.3	<5.3	<5.3
CAN-104-4L-05	35-37	<27					<110	7.9@	<5.4	<5.4
CAN-104-4L-07	40-42	<27					<110	7.4@	<5.4	<5.4
CAN-104-4L-08	45-47	49@					<110	<5.3	<5.3	<5.3
CAN-104-4L-10	55-57	<26	6700 G@[B]				<100	<5.2	<5.2	<5.2
CAN-104-4L-14[j]	55-57	42@	7400 G@[B]				<100	<5.2	<5.2	<5.2
CAN-104-4L-11	60-62	28@[B]					<100	22@	<5.2	<5.2
CAN-104-4LL-01	Surface	58@	11000 G@[B]	<6.3	<24	<7100	<110	<5.5	<5.5	<5.5
CAN-104-4M-01	15-16.3	41@[B]					<110	11@	<5.3	<5.3
CAN-104-4M-02	20-22	28@[B]	8000 G@[B]	<6.2	<24	<7000	<110	<5.5	<5.5	<5.5

Table 5-6

(Continued)

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) µg/kg	Chlorinated Herbicides (8150), µg/kg			Volatile Organic Compounds (8240), µg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
CAN-104-4M-03	22.5-23.2	41@[B]					<110	7.6@	<5.6	<5.6
CAN-104-4M-04	25-27	41@[B]					<110	<5.6	<5.6	<5.6
CAN-104-4M-05	30-31	<27	7300 G@[B]	<6.2	<24	<7000	<110	<5.5	<5.5	<5.5
CAN-104-4M-06	35-37	<27					<110	7.3@	<5.4	<5.4
CAN-104-4M-07	40-42	27@[B]					<110	<5.3	<5.3	<5.3
CAN-104-4M-08	45-47	37@[B]					<110	<5.5	<5.5	<5.5
CAN-104-4M-09	50-51.5	<26	8700 G@[B]	<6.0	<23	<6800	<110	<5.3	<5.3	<5.3
~~CAN-104-4M-13[k]~~	~~50-51.5~~	~~30@[B]~~	~~7300 G@[B]~~	~~<6.0~~	~~<23~~	~~<6800~~	~~<110~~	~~<5.3~~	~~<5.3~~	~~<5.3~~
CAN-104-4M-11	60-62	32@[B]					<100	<5.2	<5.2	<5.2
CAN-104-4N-01	15-17	<27	9400 G@[B]	<6.2	<24	<7000	<110	<5.5	<5.5	<5.5
CAN-104-4N-02	17.5-19.5	77@					130@	<6.3	18@	<6.3
CAN-104-4N-03	20-21.7	37@	8800 G@[B]	<6.2	<24	<7000	<110	<5.5	13@	<5.5
~~CAN-104-4N-13[l]~~	~~20-21.7~~	~~<27~~	~~8300 G@[B]~~	~~<6.2~~	~~<24~~	~~<7000~~	~~<110~~	~~12@~~	~~<5.5~~	~~<5.5~~
CAN-104-4N-04	25-26	38@					<110	11@	5.7	<5.7
CAN-104-4N-05	30-31.5	<27					<110	8.2@	<5.4	<5.4
CAN-104-4N-07	40-40.5	29@					<120	10@	5.8	<5.8
CAN-104-4N-08	45-47	<26	8600 G@[B]	<5.9	<22	<6600	<110	5.7@	<5.3	<5.3
CAN-104-4N-09	50-52	<26					<100	7.5@	<5.2	<5.2
CAN-104-4N-10	55-57	<26	7900 G@[B]	<5.8	<22	<6600	<100	<5.2	<5.2	<5.2

Table 5-6

(Continued)

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) µg/kg	Chlorinated Herbicides (8150), µg/kg			Volatile Organic Compounds (8240), µg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
~~CAN-104-4N-14[m]~~	~~55-57~~	49@	8100 G@[B]	<5.8	<22	<6600	<100	<5.2	<5.2	<5.2
CAN-104-4N-11	60-62	87@					<100	<5.1	<5.1	<5.1
CAN-104-4P-01	15-17	<27	10000 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
~~CAN-104-4P-13[n]~~	15-17	<27	7500 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
CAN-104-4P-02	17.5-18.1	38@[B]					<110	<5.5	<5.5	<5.5
CAN-104-4P-03	20-22	38@[B]	7700 G@[B]	<6.2	<24	<7000	<110	6.7@	7.4@	<5.5
CAN-104-4P-14[o]	20-22	38@[B]	10000 G@[B]	<6.2	188 G	<7000	<110	5.6@	14@	<5.5
CAN-104-4P-04	25-27	<27					<110	5.5@	<5.4	<5.4
CAN-104-4P-05	30-32	<27					<110	6.3@	<5.5	<5.5
CAN-104-4P-06	32.5-34.5	<28					<110	5.9@	<5.5	<5.5
CAN-104-4P-07	35-36	31@[B]					<110	<5.7	<5.7	<5.7
CAN-104-4P-09	45-47	39@[B]					<120	9.5@	<6.0	<6.0
CAN-104-4P-11	55-57	30@[B]					<100	<5.1	<5.1	<5.1
CAN-104-4P-12	60-62	27@[B]					<100	<5.1	<5.1	<5.1
CAN-104-4Q-02	20-22	45@					<110	<5.4	<5.4	<5.4
CAN-104-4Q-03	25-25.7	<27					<110	5.9@	<5.4	<5.4
CAN-104-4Q-04	30-32	<26	8800 G@[B]	<6.1	<23	<6900	<100	<5.2	<5.2	<5.2
~~CAN-104-4Q-13[p]~~	30-32	<26	9400 G@[B]	<5.8	<22	<6600	<100	<5.2	<5.2	<5.2
CAN-104-4Q-05	40-40.5	60@					<110	<5.4	<5.4	<5.4

Table 5-6

(Continued)

Sample ID	Depth, ft	TRPH (9071/418.1) mg/kg	Diesel (8015ME) µg/kg	Chlorinated Herbicides (8150), µg/kg			Volatile Organic Compounds (8240), µg/kg[a,b]			
				2,4,5-TP	Dichloroprop	MCPP	Acetone	Methylene Chloride	Toluene	Xylenes
CAN-104-4Q-06	50-50.5	<27					<110	6.1@	<5.3	<5.3
CAN-104-4Q-07	52.5-54.5	29@	8900 G@[B]	<5.7	<22	<6500	<100	<5.1	<5.1	<5.1
CAN-104-4Q-10	60-62	26@	5200 G@[B]	<5.7	<22	<6500	<100	<5.1	<5.1	<5.1
CAN-104-4QQ-01	Surface	30@	9900 G@[B]	<6.1	<23	<6900	<110	<5.4	<5.4	<5.4
CAN-104-4R-01	15-17	<27	9300 G@[B]	<6.1	<23	<6800	<110	<5.4	<5.4	<5.4
~~CAN-104-4R-13[q]~~	15-17	<27	16000 G@[B]	<6.0	<23	<6800	<110	<5.4	<5.4	<5.4
CAN-104-4R-02	17.5-19	<27	19000 G@[B]	<6.5	<25	<7300	<110	5.3@	<5.3	<5.3
CAN-104-4R-05	27.5-29.5	27@					<110	<5.3	<5.3	<5.3
CAN-104-4R-10	55-57	26@	9000 G@[B]	<5.7	<22	<6500	<100	<5.1	<5.1	<5.1
CAN-104-4RR-01	Surface	<27	8300 G@[B]	8.3@	<24	<7000	<110	<5.5	<5.5	<5.5
~~CAN-104-4RR-02[r]~~	~~Surface~~	~~<27~~	~~14000 G@[B]~~	~~<6.2~~	~~<24~~	~~<7000~~	~~<110~~	~~<5.5~~	~~<5.5~~	~~<5.5~~
CAN-104-BG-01	Surface	<26	4800 G@[B]	<5.9	<22	8000@	<100	<5.2	72	7.7@

[a] - 8240 TICs include 2-ethyl-1-hexanol, 2-propanol, decanal, ethyl acetate, methyl acetate, nonanal, and bromocyclohexane. Ethyl acetate was present in most samples at concentrations ranging from 0 to 210 ug/kg.
[b] - 8270 TICs include 1,2-cyclohexanediol, cyclohexenone, trichloropropene, alpha-pinene, DDD, and hydroxymethyl pentanone. Cyclohexenone was present in roughly half the samples at concentrations ranging from 140 to 380 ug/kg.
[c] - CAN-104-4H-13 is a field duplicate of CAN-104-4H-01.
[d] - CAN-104-4H-14 is a field duplicate of CAN-104-4H-05.
[e] - CAN-104-4I-13 is a field duplicate of CAN-104-4I-07. No target analytes were detected in CAN-104-4I-07.
[f] - CAN-104-4I-14 is a field duplicate of CAN-104-4I-09.
[g] - CAN-104-4J-13 is a field duplicate of CAN-104-4J-01.
[h] - CAN-104-4K-13 is a field duplicate of CAN-104-4K-01.
[i] - CAN-104-4L-13 is a field duplicate of CAN-104-4L-01.
[j] - CAN-104-4L-14 is a field duplicate of CAN-104-4L-10.
[k] - CAN-104-4M-13 is a field duplicate of CAN-104-4M-09.
[l] - CAN-104-4N-13 is a field duplicate of CAN-104-4N-03.
[m] - CAN-104-4N-14 is a field duplicate of CAN-104-4N-10.
[n] - CAN-104-4P-13 is a field duplicate of CAN-104-4P-01.
[o] - CAN-104-4P-14 is a field duplicate of CAN-104-4P-03.
[p] - CAN-104-4Q-13 is a field duplicate of CAN-104-4Q-03.

Table 5-6

(Continued)

[q] - CAN-104-4R-13 is a field duplicate of CAN-104-4R-01.
[r] - CAN-104-4RR-02 is a field duplicate of CAN-104-4RR-02.
[B] - Presence may be due to laboratory contamination. Analyte was found in the associated blanks. The sample results were not corrected for the concentration in the blank.
[C] - Presence of the analyte was observed in the trip blank associated with this sample. Sample results have not been corrected for the concentration in the blank.
@ - Result listed is less than five times the method detection limit.
G - Result does not match the characteristic diesel pattern but elutes in the retention time window, so result is quantitated as diesel.

Note: When no result is listed, the sample was not analyzed for that parameter.

containing TRPH, or diesel, herbicides or VOCs in one or more of the Cannon Landfill No. 4 samples. Target SVOCs were not detected in these samples.

Methylene chloride, diesel, and TRPH reported in these samples appear to be due to laboratory contamination (Radian, December 1992). Methylene chloride was detected in three trip blanks associated with the field samples. These results indicate that low concentrations of methylene chloride may be due to contamination during sample handling and shipping. Two of the eight solid method blanks contained up to 50 μg/kg TRPH. Therefore, field sample concentrations up to 50 μg/kg TRPH may be attributed to laboratory contamination. Diesel was detected in the equipment and method blanks analyzed with the field samples. Although the laboratory reported this compound as diesel based on its retention time, the chromatograph did not match the characteristic diesel pattern in the blanks or field samples. Therefore, field results up to 15000 μg/kg (three times the reporting limit) are attributed to laboratory contamination. Appendix K contains a supplemental report which addresses this compound reported as "diesel" in detail.

Toluene, xylenes, dichloroprop and MCPP were detected at low (sub-ppm) concentrations in less than 10% of the Landfill No. 4 1992 field samples. The background surface soil samples collected near a fenceline on the perimeter of Landfill No. 4 contained the highest levels of toluene (72 μg/kg) and xylenes (7.7 μg/kg) found at the site during this investigation.

A number of volatile and semi-volatile tentatively identified compounds (TICs) were detected in the Landfill No. 4 samples. The mass spectral analyses of samples for VOCs and SVOCs result in the identification and quantitation of compounds given in the Target Compound List (TCL). Sometimes the mass spectra indicate the presence of additional organic compounds that are not on the TCL. These spectra are compared to library spectra, and the compounds are tentatively identified based on similarities to the library spectra. These compounds are called tentatively identified

compounds (TICs), and the assigned identity of the compound is, in most cases, highly uncertain. SW-846 provides procedures to estimate the concentration of TICs. These estimates, however, are highly uncertain and could be orders of magnitude higher or lower than the actual concentration. When evaluating TIC data, it is important to note that the assigned identity may be incorrect and that the quantitation is likely to be inaccurate. The results for TICs are semi-quantitative and are listed only when a TIC is detected in a sample (see Appendix C, Table C-2). Therefore, reporting limits are not available for TICs.

Ethyl acetate, a volatile TIC, was present in most of the field samples at concentrations as high as 210 μg/kg. Ethyl acetate has been used as a solvent for coatings and plastics, and in lacquers, varnishes, and airplane dope. The remaining volatile TICs, 2-ethyl-1-hexanol, 2-propanol, decanal, methyl acetate, nonanal, and bromocyclohexane, are either solvents, components of antifreeze, cleansers, and oils, or minor contaminants in varnish driers.

Six semi-volatile TICs were also observed in the Landfill No. 4 samples. Cyclohexanone, which is used in degreasers, paint and varnish removers, polishes, and pesticides, was found in about half the samples at concentrations ranging from 140 to 380 μg/kg. Other semi-volatile TICs, 1,2-cyclohexanediol, trichloropropene(s), alpha-pinene, DDD, and hydroxymethyl pentanone, were also detected in one or more of the field samples. These compounds have been used in paint, varnish, tar, and grease removers, in dopes and coatings, or as an insecticide.

The maximum concentrations of selected target analytes found at each borehole location drilled in 1992 are presented in Figures 5-1 through 5-3. The

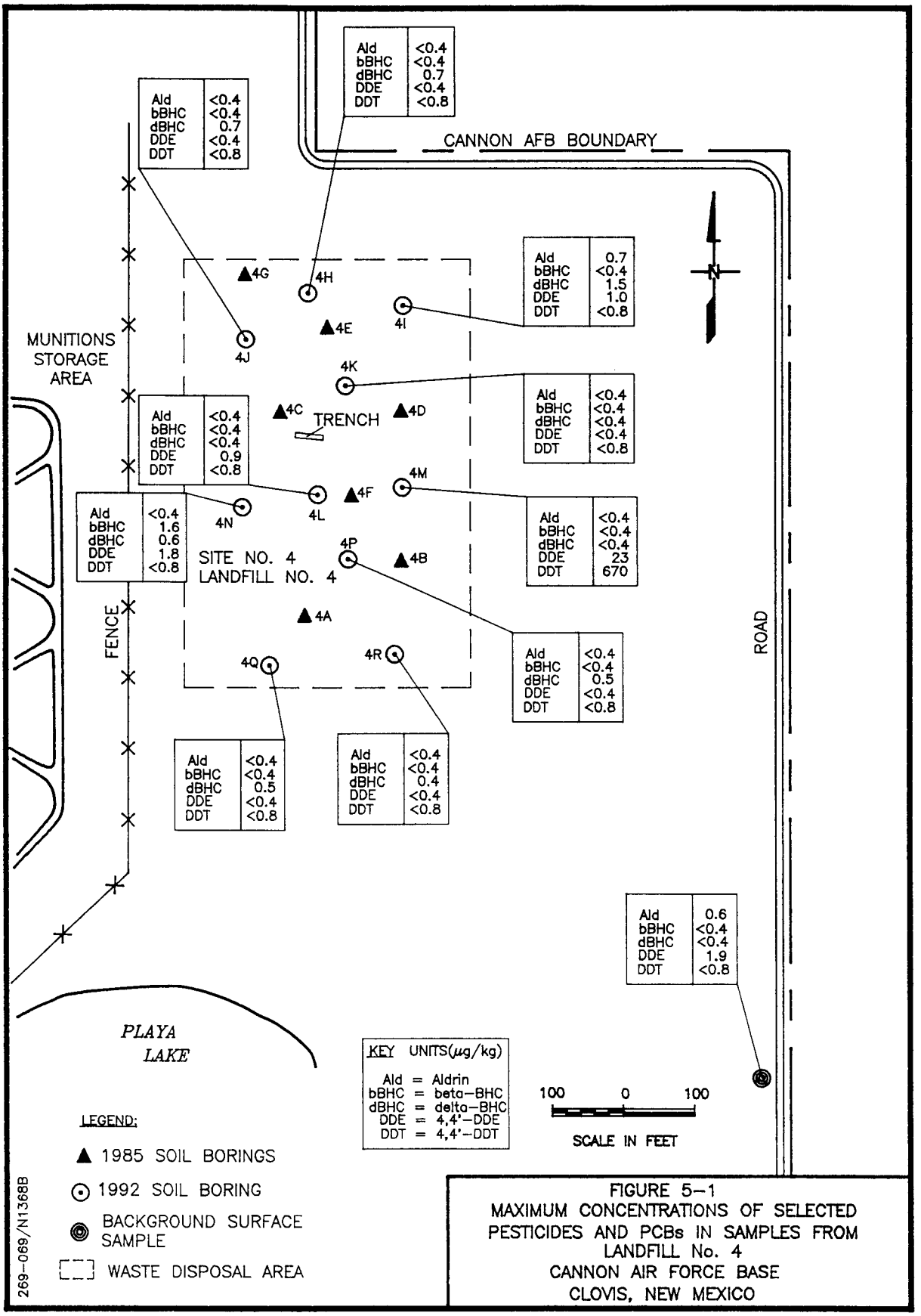

FIGURE 5-1
MAXIMUM CONCENTRATIONS OF SELECTED PESTICIDES AND PCBs IN SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

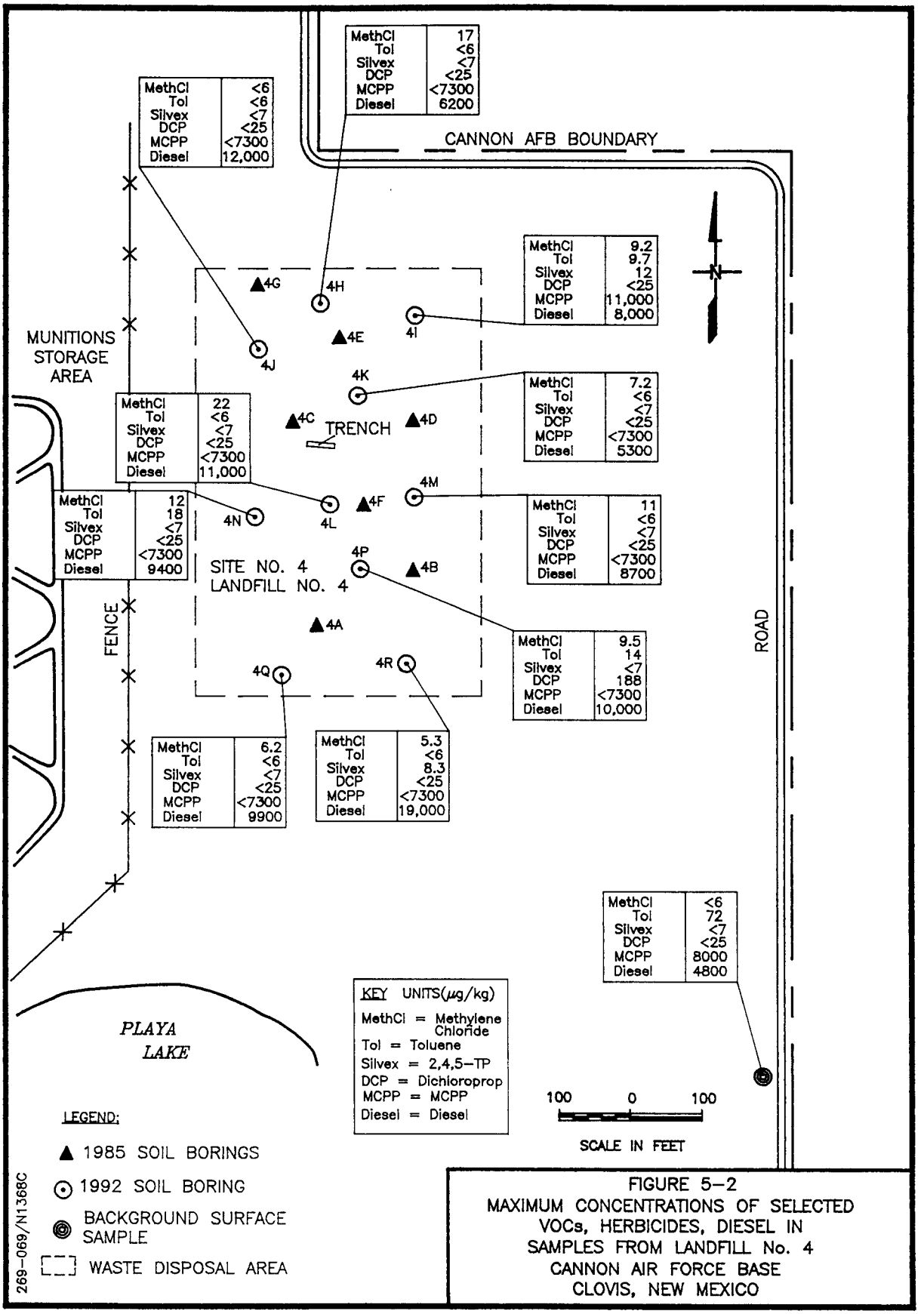

FIGURE 5-2
MAXIMUM CONCENTRATIONS OF SELECTED VOCs, HERBICIDES, DIESEL IN SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

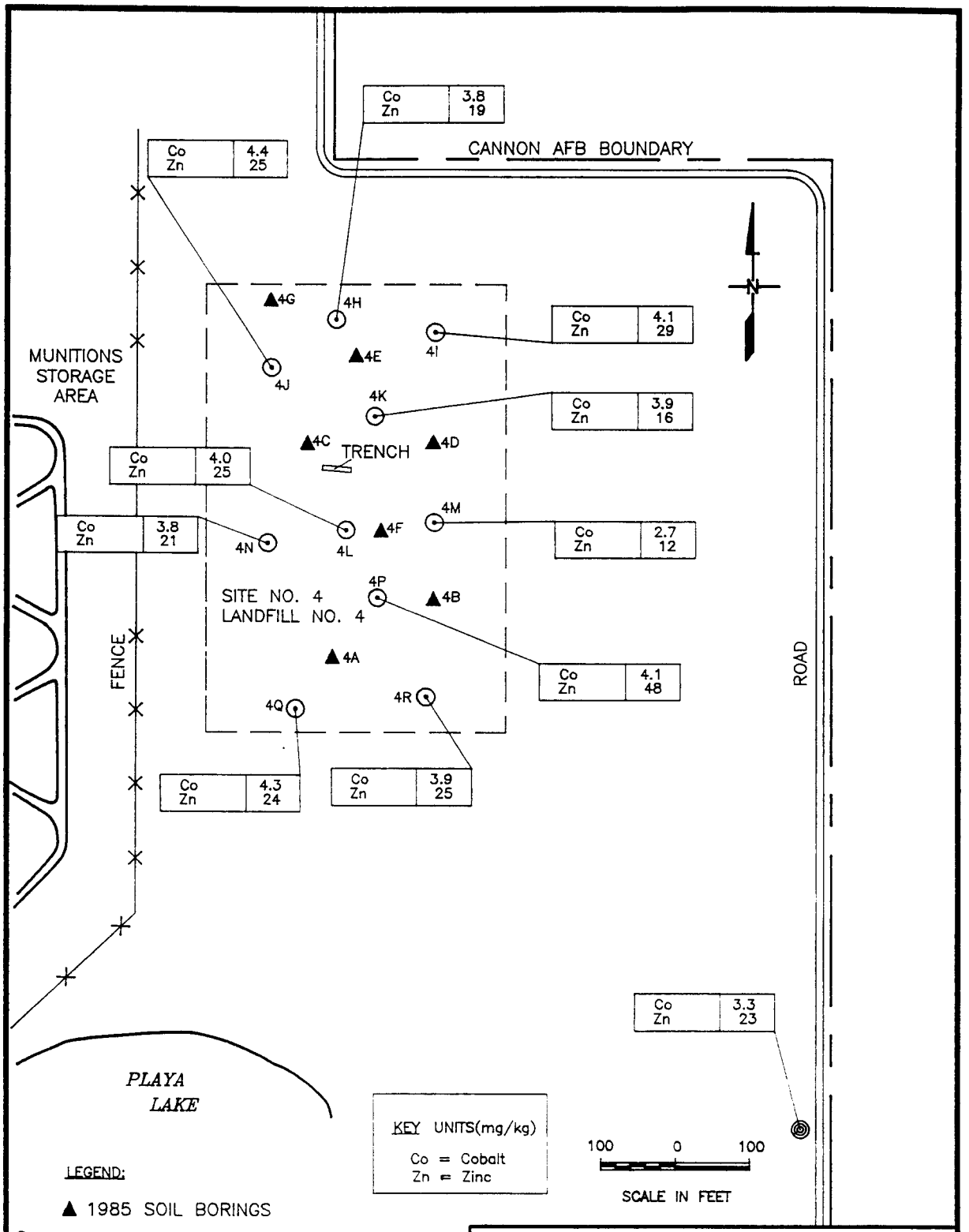

FIGURE 5-3
MAXIMUM CONCENTRATIONS OF
COBALT AND ZINC
SAMPLES FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

compound list is based on compounds used for the risk assessment which is presented in Section 6. Detailed listings of the analytical results for all target compounds are given in Appendix C.

5.4 Comparison of Field Data to Soil Action Levels

The field data from the 1992 and 1985 sampling efforts were compared to the soil action levels given in Section 4, Table 4-3, RCRA Proposed Subpart S Media Action Levels. The concentrations of all target analytes in the Landfill No. 4 samples, including those which exceeded background soil metals concentrations, were less than the proposed noncarcinogenic actions levels.

The CAFB background soil concentration for beryllium exceeds the carcinogenic soil action level listed in RCRA Subpart S, indicating that this criteria is not appropriate for the site. None of the Cannon Landfill No. 4 samples exceeded the background soil beryllium concentration (0.81 mg/kg) established for CAFB.

In 27 of the samples, the detection limits or sample concentrations for antimony determined by ICPES exceeded the soil action level of 32 mg/kg. Seventeen of these samples (approximately 10%) were submitted for reanalyses by atomic absorption, which does not experience the strong interelemental effect of calcium on antimony as experienced by the ICPES method. The 17 samples were selected in such a fashion as to provide a spatial representation of all the samples. All of these 17 samples were determined to contain less than 3 mg/kg antimony (corrected for analytical bias) when measured by atomic absorption, which is well below the soil action level.

Thallium was not detected in any of the field samples. However, the detection limit for thallium by ICPES was about 10 mg/kg and exceeded the soil action criteria of 4 mg/kg. The USACE instructed Radian to submit 10% of the samples for analyses by atomic absorption. These samples were selected in such a fashion as to

provide information across the site at each depth interval. These samples all contained less than 1 mg/kg of thallium (corrected for analytical bias) when measured by atomic absorption, which was well below the soil action level. All other metals concentrations were below all listed soil action levels.

6.0 RISK ASSESSMENT

This section of the report presents the risk assessment and receptor and pathway identification conducted in support of conclusions drawn from the 1985 and 1992 investigations. Section 6.1 presents a brief narrative description of Landfill No. 4 and characterization of the exposure setting. Section 6.2 describes the process used to identify the chemicals of potential concern and presents those chemicals that are quantified for risk in this report. Section 6.3 presents an assessment of the exposure to these chemicals of potential concern, including a conceptual site model. A toxicity assessment of the chemicals of potential concern is presented in Section 6.4. Potential health risks are described in the risk characterization presented in Section 6.5. Section 6.6 presents a qualitative environmental evaluation. Section 6.7 presents conclusions of the baseline risk assessment.

6.1 Characterization of Exposure Setting

Landfill No. 4 is an inactive waste disposal site. The landfill is located on the east side of the base, north of the Playa Lake, and covers 6.3 acres as shown in Figure 6-1. The landfill was operated from 1967 to 1968 during which time domestic solid wastes, waste oils, solvents, paints, paint thinners and strippers, pesticide containers, and various empty cans and drums were burned in trenches, and the ash and remaining debris were buried. The maximum excavation depth of the landfill during operation was 16 feet. The inactive site currently appears as a rectangular open field covered by prairie grasses.

The topography at Landfill No. 4 slopes to the southwest toward the playa lake, located near the southern boundary of the landfill. Landfill No. 4 is covered by surficial soils which vary in thickness from approximately 2 to 4.5 feet. The soils are typically brown to red-brown, loamy sands. The caliche profile across Landfill No. 4 extends from the base of the topsoil to a depth of probably less than 60 feet. The

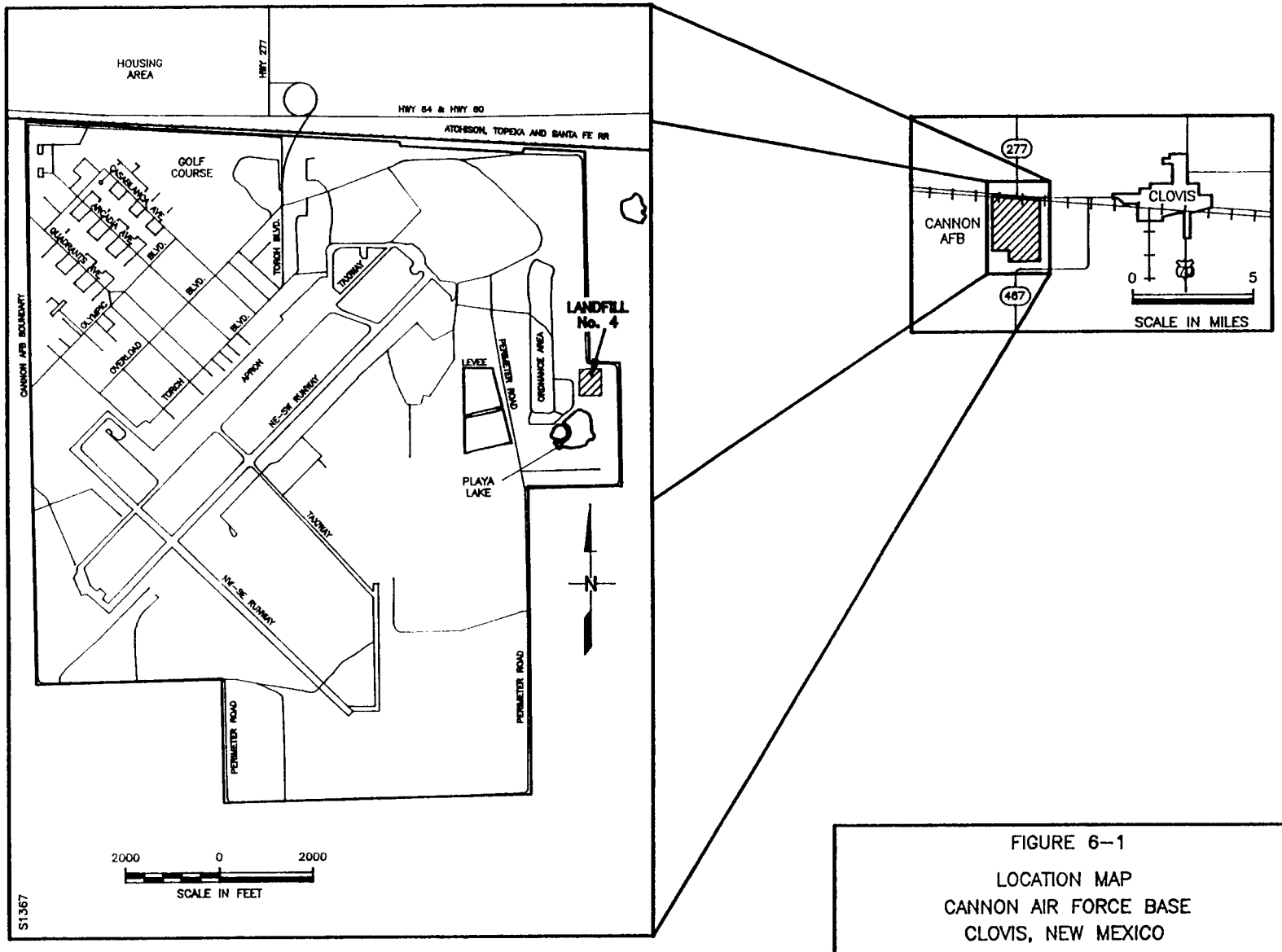

FIGURE 6-1

LOCATION MAP
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

269-069/N1554

physical properties of the caliche are highly variable but are similar to those at the adjacent Landfill No. 3 site, just south of the playa lake. The caliche may serve as a barrier between the landfill base and the underlying Ogallala aquifer. The potential for migration of leachate to contaminate groundwater is low, because the amount of precipitation in the arid environment is not sufficient to saturate the vadose zone or recharge the Ogallala aquifer located 260 feet below ground level (BGL). However, weakly consolidated sand deposits between depths of about 15 and 25 feet may indicate the presence of a locally significant sand lens which could impact the path of potential contaminant migration at the site. The unconsolidated sand at the base of the caliche profile is similar to that at Landfill No. 3 but the caliche/sand contact is more gradational (Radian, 1986).

A thin (1.5-foot thick) caliche layer exists at a depth of 3 feet in the area of Landfill No. 4. Fill material which includes domestic and construction-type wastes (e.g., wood, paper, and metal scrap) underlays the shallow caliche. The fill extends to a depth of approximately 16.5 feet and is underlain by a largely unconsolidated 5-foot thick sand body. Therefore, it is likely that any leachate migrating downward from the fill material would enter the sand and migrate laterally along this relatively permeable zone.

6.1.1 Population Demographics

CAFB had a resident population of approximately 3,800, including military personnel and their dependents, in 1990. Currently, there are 1,841 housing units at CAFB. Base housing is located in the northwest quarter of the base and north of the base, west of New Mexico Highway 277. Base-related employment at CAFB includes approximately 4,900 positions (Woodward-Clyde, 1992). The city of Clovis, New Mexico is located approximately seven miles to the east of the base. In 1990, the population of Clovis was 30,954 persons. Currently, the population potentially exposed to contaminants originating from Landfill No. 4 includes on-base residents and workers, off-base residents and consumers of locally produced agricultural crops and beef and dairy products.

Future on-base land use is not expected to change. The results of groundwater modeling indicate that future contamination of the groundwater is likely to be insignificant. However, in order to assess a worst-case scenario, further supporting a no action decision, the future off-base residential scenario was evaluated in this risk assessment.

6.1.2 Current and Future Land Use

Land use is primarily agricultural within Curry County. As of 1992, total land area in the county is 897,000 acres with 837,200 designated as farm land. Lands surrounding CAFB are classified as irrigated farm land with principal crops including corn, grain, sorghum, wheat, barley, oats, alfalfa, cotton and various vegetables. Cattle ranching and dairy farming occur throughout the county. Currently no land use or zoning controls restrict the type and amount of construction in the proximity of CAFB. The U.S. Air Force has designated Compatible Use Zones (CUZs) around CAFB and provides recommendations for compatible uses in areas subject to noise and accident hazards (Woodward-Clyde, 1992).

CAFB is an active military installation and the home of the 27th Tactical Fighter Wing. There are no plans for closure of the facility in the foreseeable future. The use of CAFB as a military installation is highly specialized and land use cannot be significantly altered (i.e., converted to private commercial or residential use) without the approval of the U.S. Congress and the Secretary of Defense. For security and safety reasons, ingress and egress to the base is restricted (Landfill No. 4 is fenced on the north and east sides, although a local farmer may enter through a private gate and pump water from the playa lake for irrigation purposes). Future land use is not expected to differ significantly from current land use practices.

6.1.3 Current Water Use

The lower portion of the Ogallala Formation is the primary regional aquifer in the vicinity of CAFB for potable and irrigation water. The dissolved solids in the aquifer range from 250 to 500 mg/L (Woodward-Clyde, 1992). The Ogallala aquifer extends continuously from Wyoming and South Dakota into New Mexico and Texas. The Ogallala aquifer rests on Dockum Group redbeds, which serve as the basal confining layer in east central New Mexico. The aquifer has a southeasterly regional gradient of about 10 to 15 feet per mile. CAFB presently obtains water from a system of nine on-base water wells. All of the wells located on the base are completed in the Ogallala aquifer and range from 357 to 415 feet deep and have yields ranging from 50 to 820 gallons per minute (gpm). The wells incorporate multiple screens and derive water from interbedded sands of the Ogallala Formation (Radian, 1992). The location and construction of all on-site wells and all off-site wells located within one-mile of the landfill are presented in Section 2.3.2.

6.2 Identification of Chemicals of Potential Concern

Contaminants of potential concern for Landfill No. 4 were identified following guidance in Chapter 5 (Data Evaluation) of the *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A)* (USEPA, 1989a). USEPA guidance stipulates the following nine steps to evaluate analytical data for a comprehensive risk assessment:

1. Gather all data available from the site investigation and sort by medium;
2. Evaluate the analytical methods used;
3. Evaluate the quality of data with respect to sample quantitation limits;

4. Evaluate the quality of data with respect to qualifiers and codes;

5. Evaluate the data with respect to blanks;

6. Evaluate tentatively identified compounds;

7. Compare potential site-related contamination with background;

8. Develop a set of data for use in the risk assessment; and

9. If appropriate, further limit the number of chemicals to be carried through the risk assessment.

6.2.1 Step 1: Data Available from Site Investigation

Analytical data from an RI and on RFI performed at Landfill No. 4 have been used in this risk assessment. The RI was performed in February 1985 under the Installation Restoration Program (IRP) with results reported in a September 1986 document titled *Installation Restoration Program, Phase II - Confirmation/Quantification Stage 1*. The RFI was performed in the fall of 1992 and results are reported in this document which complies with both CERCLA and RCRA requirements.

During the 1985-86 RI, seven borings were drilled 60-feet deep. Soil samples were collected and analyzed for organic and inorganic constituents. All samples were collected between 0 and 12 feet BGL, which was within the landfill confines, and below the landfill between 55 and 60 feet BGL. Metal concentrations were within background levels, oil and grease detections were considered to be from natural sources, and no organic constituents were detected (Radian, 1986). Analytical methods used to determine metal concentrations in soil samples in 1985 were the same as the analytical methods performed in 1992. The 1985 organic analysis reported all concentrations as non-detects; however, the detection limits for the 1985 data were higher than for the 1992 data. Because the organic data were not comparable and Quality Assurance/

Quality Control (QA/QC) were not available, the 1985 organic analyses were not used in this risk assessment.

The purpose of the 1992 RFI was to supplement the 1985 RI data. In the 1992 investigation, 10 borings were drilled 62 feet deep and soil samples were collected at intervals from below the bottom of the landfill to approximately 62 feet BGL. In addition, surface soil samples were collected at five locations. Both organic and inorganic data from the 1992 samples were evaluated in this risk assessment. Appendix D presents analytical data used in the risk assessment.

6.2.2 Step 2: Evaluation of Analytical Methods and Results

A detailed evaluation of the analytical methods used and a QA/QC evaluation of the data are presented under separate cover in the *Quality Control Summary Report* (QCSR) (Radian, December 1992). The QA/QC evaluation of the data was a factor in choosing the list of chemicals of potential concern. Some of the QA/QC concerns presented in the QCSR have been resolved through reanalysis of antimony and thallium. A summary of the QA/QC concerns and resolutions that pertain to this risk assessment are discussed below.

- All 3 equipment blanks and all 7 method blanks analyzed with the field samples were reported as containing diesel. Reporting limits ranged from 47 to 50 μg/L and 2500 to 5000 μg/kg. Although reported as diesel (the contaminant eluted within the diesel retention time), the chromatographic pattern for the blank and field results do not match the characteristic pattern for diesel. Since the chromatographic pattern for the field sample results and the blank results match, the contaminant listed as diesel in the report may be due to laboratory contamination (see Appendix K for further detail). To provide the most conservative estimate of risk, the contaminant was included as diesel in this risk assessment.

- Methylene chloride was detected in 8 of 19 trip blanks. In 3 trip blanks, methylene chloride was reported at less than three time the reporting limit (5 μg/L). In 5 trip blanks, methylene chloride was reported at less than the reporting limit (5 μg/L). Based on the detention in the trip blanks, methylene chloride detected in samples CAN-104-4I-01, CAN-104-4I-03, CAN-104-4I-04, CAN-104-4I-05, CAN-104-4I-06, CAN-104-4I-10, CAN-104-4I-11, CAN-104-4I-13, and CAN-104-4I-14 may be due to contamination.

- Matrix spike results for arsenic may be biased low by about 30 percent. Sample results corrected for this bias were not significantly different from background.

- Seven of the sixteen lead matrix spike samples were recovered below the accuracy objectives which may suggest that lead results are biased low. Sample results corrected for this bias were not different from background.

- All of the selenium matrix spike results are below the acceptance criteria of 75-125% which suggests that the selenium results may be biased low by 50 percent. Sample results corrected for this bias were not different from background.

- Ten percent of the samples for antimony were reanalyzed by graphite furnace atomic absorption (AA). Antimony was not detected in these samples at detection limit of 0.60 mg/kg; however, matrix spikes associated with these samples indicate that the results may be biased low by about 80% which could result in an actual detection limit of 3.0 mg/kg. Sample results corrected for this bias were not different from background.

- Ten percent of the samples were reanalyzed for thallium by graphite furnace AA to achieve a detection limit of 0.5 mg/kg. No thallium was detected in these samples. However, matrix spikes associated with these samples indicate that the results may be biased low by about 30% which could result in an actual detection limit of 0.7 mg/kg.

6.2.3 Step 3: Quantitation Limits

RFI data reports provide reporting limits (RLs) specific to each sample. Sample RLs take into account sample characteristics (e.g., matrix, dry weight), sample

preparation (e.g., sample volumes), and analytical dilutions. RLs represent the lower bound of reliable laboratory data using multiple instruments and are the equivalent of method quantitation limits (the minimum concentration that can be measured and reported). The RL reported for each sample is the lowest concentration available and is used as the sample quantitation limit (SQL) for this risk assessment. RLs are not available for tentatively identified compounds (TICs).

For the purposes of this risk assessment, a positive result included values at and below the RL. If a chemical was not detected in any sample, it was eliminated from the list of chemicals of potential concern. If a chemical was detected in some but not all samples, one-half the RL was used as a proxy concentration for non-detects.

One half the RL was not used as a proxy concentration for chemicals with unusually high RLs to avoid incorporating a high bias in the data. Therefore, for these chemicals (2,4-D, 2-Hexanone, 4-Methyl-2-pentanone (MIBK) and Xylenes) only those samples showing detections were used in this risk assessment.

Chemicals for which positive data are available in at least one sample are listed in Table 6-1. Data associated with the chemicals to which no uncertainties are attached concerning the assigned identity of the chemical or the significance of site-related concentrations compared to background concentrations (inorganic chemicals only) are appropriate for use in the quantitative risk assessment.

6.2.4 Step 4: Data Qualifiers or Codes

Data qualifiers or codes were presented with the analytical results so that uncertainties could be identified and evaluated. Data with qualifiers that indicate known identities, but uncertain concentrations, were used in this risk assessment. Laboratory qualifier codes associated with the 1992 analytical data are described in this subsection.

Table 6-1

Contaminants Positively Detected in Soil at Cannon AFB Landfill No. 4

Analytes	Chemical of Potential Concern	Rationale for Assessment
ORGANICS		
Acetone	yes	Potential historical importance
Aldrin	yes	Detected frequently
alpha-Pinene	no	Tentatively Identified Compound
Benzothiazole	no	Tentatively Identified Compound
beta-BHC	yes	Detected frequently
Bis(2-ethylhexyl)phthalate	no	Less than 10 times the EB
Bromocyclohexane	no	Tentatively Identified Compound
Butoxyethanol	no	Tentatively Identified Compound
Cyclohexenone	no	Tentatively Identified Compound
Cyclohexenol	no	Tentatively Identified Compound
delta-BHC	yes	Detected frequently
Decanal	no	Tentatively Identified Compound
2,4-D	yes	Potential historical importance
4,4'-DDD	yes	Potential historical importance
4,4'-DDE	yes	Detected frequently
4,4'-DDT	yes	Detected frequently
Dichloroprop	yes	Detected frequently
Diesel	yes	Detected frequently*
Endrin	yes	Potential historical importance
2-Ethyl-1-hexanol	no	Tentatively Identified Compound
Ethylacetate	no	Tentatively Identified Compound
gamma-BHC	yes	Potential historical importance
Heptachlor epoxide	yes	Potential historical importance
2-Hexanone	yes	Potential historical importance

Table 6-1

(Continued)

Analytes	Chemical of Potential Concern	Rationale for Assessment
Hydrocarbons	yes	Detected frequently
Hydroxymethylpentanone	no	Tentatively Identified Compound
MCPP	yes	Detected frequently
4-Methyl-2-pentanone	yes	Potential historical importance
Methyl acetate	no	Tentatively Identified Compound
Methylene chloride	yes	Detected frequently
Nonanal	no	Tentatively Identified Compound
2-Propanol	no	Tentatively Identified Compound
2,4,5-T	yes	Detected frequently
Terpineol	no	Tentatively Identified Compound
Trichloropropene	no	Tentatively Identified Compound
Toluene	yes	Detected frequently
Unknown	no	Tentatively Identified Compound
Unknown alchol	no	Tentatively Identified Compound
Unknown aldehyde	no	Tentatively Identified Compound
Unknown alkane	no	Tentatively Identified Compound
Unknown amide	no	Tentatively Identified Compound
Unknown B	no	Tentatively Identified Compound
Unknown carboxylic acid	no	Tentatively Identified Compound
Unknown cyclic ether B	no	Tentatively Identified Compound
Unknown dimethyl naphthalene	no	Tentatively Identified Compound
Unknown phosphates	no	Tentatively Identified Compound
Unknown sterol	no	Tentatively Identified Compound
Xylenes	yes	Potential historical importance

Table 6-1

(Continued)

Analytes	Chemical of Potential Concern	Rationale for Assessment
INORGANICS		
Aluminum	no	Within background concentrations
Antimony	no	Within background concentrations
Barium	no	Within background concentrations
Beryllium	no	Within background concentrations
Cadmium	no	Within background concentrations
Calcium	no	Necessary nutrient
Chromium	no	Within background concentrations
Cobalt	no	Within background concentrations
Copper	no	Within background concentrations
Iron	no	Necessary nutrient
Lead	no	Within background concentrations
Magnesium	no	Necessary nutrient
Manganese	no	Within background concentrations
Mercury	no	Less than 5 times MB
Nickel	no	Within background concentrations
Potassium	no	Necessary nutrient
Sodium	no	Necessary nutrients
Vanadium	no	Within background concentrations
Zinc	yes	Detected frequently

EB - Equipment Blank
MB - Method Blank
* - Result did not match characteristic diesel pattern, but elutes in the assigned retention time window. To provide the most conservative estimate of risk, the contaminant was quantitated or diesel.

6.2.4.1 All Methods

Q Outside acceptance criteria.

C Analyte identification and concentration confirmed by second column.

B Blank subtraction was not performed for analytes detected in associated system, method, or field blank. Use of these data in the risk assessment is discussed in Section 6.2.5.

@ Reported result was less than five times the RL. The reported value was used in the risk assessment.

J The RL is higher than the reported result. The value was used in the risk assessment.

D Sample diluted for analysis of analyte identity.

6.2.4.2 Methods 8080/8150

G Presence of analyte confirmed by second column analyses but concentration is uncertain.

6.2.4.3 Method 8015M

G Result does not match the characteristic diesel pattern, but elutes in the retention time window, so was quantited as diesel (see Appendix K).

6.2.5 Step 5: Blanks

Field and laboratory blanks were included in the analytical program to provide an indication of the introduction of constituents into samples during collection or analysis. Positive results qualified by the presence of the analyte in associated blanks were evaluated according to USEPA guidance (USEPA, 1989a). Sample results for

common laboratory contaminants (acetone, methyl ethyl ketone, methylene chloride, toluene, and the phthalate esters) were considered positive only if the concentration in the sample exceeded ten times the maximum amount detected in any associated blank. If the concentration of a common laboratory contaminant was less than or equal to ten times the blank concentration, the constituent was considered a laboratory contaminant; the blank concentration was considered to be the RL. Chemicals that are not common laboratory contaminants were evaluated in a similar way, using five times the maximum blank-related concentration to distinguish between non-detects and contamination. Table 6-1 identifies those analytes eliminated for these reasons. Appendix D presents analytical data and blank data for the list of positive chemicals.

As discussed in Section 6.2.2 a contaminant listed as diesel was reported in all 3 equipment blanks and all 7 method blanks. All reported blank results were within three times the reporting limit. However, the chromatographic pattern of the contaminant did not match the characteristic pattern for diesel. Therefore, this contaminant may not be diesel. All data reported for this analyte was flagged with a G as discussed in Section 6.2.4.3. Since this analyte appeared in all the blanks and does not match the pattern for diesel, this analyte is considered a laboratory contaminant (see Appendix K).

6.2.6 Step 6: Tentatively Identified Compounds (TICs)

The mass spectral analyses of samples for VOCs and SVOCs result in the identification and quantitation of compounds given in the Target Compound List (TCL). Sometimes the mass spectra indicate the presence of additional organic compounds that are not on the TCL. These spectra are compared to spectra in the mass spectral data library, and the compounds are tentatively identified based on similarities to the library spectra. These compounds are called tentatively identified compounds (TICs), and the assigned identity and quantitation of the compound is, in most cases, highly uncertain. If a compound cannot be identified by the mass spectral data library, then the compound is

listed as an unknown compound or an unknown of a specific organic group (e.g., ester, carboxylic acid, alkane, etc.). TICs listed as unknowns cannot be identified. TICs that are assigned a tentative name could be quantified relative to a standard of the compound. However, this would require recollecting a sample and obtaining a standard containing the TIC. This is not typically done. TICs may be intermediate breakdown or degradation products of larger organic compounds.

Compounds which are unknowns are not included in the list of concern since risk assessments can only be conducted on an identified or tentatively identified compound (a named TIC). The risk associated with a TIC is always uncertain since the actual identity and concentration of the compound is uncertain. SW-846 provides procedures to estimate the concentration of TICs. These estimates, however, are highly uncertain and could be orders of magnitude higher or lower than the actual concentration. When evaluating TIC data, it is important to note that the assigned identity may be incorrect and that the quantitation is likely to be inaccurate. For the Landfill No. 4 evaluation, TICs were eliminated from the risk assessment, as per EPA risk assessment guidance, after reviewing frequencies of detection and estimated concentration ranges.

6.2.7 Step 7: Background Concentration Comparison

Samples for analysis of background metals concentrations at CAFB were collected in December of 1991. Soil samples were taken from two on-base sites outside landfill areas. Analytical results from these two sites were compiled and a range for background concentrations was developed for each metal collected. Appendix F presents background information for metals documented in the Woodward-Clyde (1992) report. Averages of analytical results and the highest detected concentrations for metals collected at Landfill No. 4 in 1992 and 1985 were compared to these background ranges. An evaluation of background versus landfill concentration was performed on the following metals:

- Aluminum;
- Antimony;
- Barium;
- Beryllium;
- Cadmium;
- Chromium;
- Cobalt;
- Copper;
- Lead;
- Manganese;
- Nickel;
- Vanadium; and
- Zinc.

There were no differences between background concentrations and site samples for these metals with the exception of zinc. Concentrations of zinc at the landfill were high enough to be considered in the list of chemicals of potential concern.

The Wilcoxon rank sum test was performed on landfill and background results for aluminum, barium, chromium, cobalt, lead, manganese, nickel, and vanadium. The number of detects in the background data for antimony, copper, cadmium, and zinc were insufficient to run a statistical analysis. For these metals, sample and background concentrations were compared using reporting limit ranges, maximum concentrations detected and averages that included half the detection limit as a proxy result for all non-detects. These comparisons provided a valid method for determining if site samples differed from naturally occurring background concentrations. A discussion of statistical methods and background concentrations is presented in Appendix E.

6.2.8 Steps 8 and 9: Data Set Used in the Risk Assessment

USEPA guidance (USEPA, 1989a) stipulates that the list of chemicals of potential concern include chemicals that were:

1) Positively detected in at least one sample in a given medium, including: a) chemicals with no qualifiers attached (excluding samples with unusually high RLs); and b) chemicals with qualifiers attached that indicate known identities but unknown concentrations (e.g.; J-qualified data);

2) Detected at levels significantly above levels of the same chemicals detected in associated blank samples; and

3) Detected at levels significantly above naturally occurring levels of the same chemicals.

Appendix D presents all analytical data used in this risk assessment for chemicals of potential concern.

6.2.9 Data Limitations/Data Gaps

During this investigation only soil samples were collected and analyzed. Groundwater and air samples were not taken, which limits the assessment of chemicals of concern to contaminants found in the soil on or beneath Landfill No. 4. Limitations of analytical methods in detection of chemicals below the instrument RL, use of estimated values below the RL and values that were close to the RL further limit the data used in this risk assessment. Limited background data prevented a more extensive evaluation of site metal concentration versus background metal concentrations. The limitations associated with analytical methods tend to result in the underestimation of risks. Use of estimated values may result in overestimation of risks, while the use of values close to the RL could either over or underestimate risks.

6.3 Exposure Assessment

Exposure assessment is the determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, and route of human exposure for the chemicals of potential concern that are present at, or may have migrated from, a site. Sections 2 and 3 of this report provide the detailed description of the physical characteristics of the base and the surrounding area, and a brief description of the exposure setting is presented in Section 6.1. These characterizations were used to assess the potential exposures associated with Landfill No. 4.

A conceptual site model was prepared for the human health and ecological risk assessment. It includes sources of contamination, potential migration pathways and potentially exposed populations.

Human exposure to the chemicals of potential concern were evaluated by performing the following tasks and are discussed separately in this subsection.

1. Identification of releases into various media;
2. Determination of fate and transport in release media;
3. Evaluation of exposure points and exposure routes;
4. Determination of exposure scenarios;
5. Quantification of estimated exposure concentrations; and
6. Estimation of chemical intakes for individual pathways.

The following subsections discuss the conceptual site model, the tasks used to evaluate human exposure for the chemicals of potential concern, and uncertainties associated with the exposure assessment. Appendices G and H present a detailed discussion of how estimated exposure concentrations were calculated.

6.3.1 Conceptual Site Model

Based on available information, a conceptual site model was developed to provide an understanding of the sources of contaminants, potential migration pathways of contaminants, and potential receptors considering geologic and hydrologic information. The conceptual site model is presented schematically in Figure 6-2 and provides the basis for the human health and ecological risk assessment. As discussed in Section 6.2, chemicals of potential concern identified for use in this risk assessment include:

- Acetone;
- Aldrin;
- beta-BHC;
- delta-BHC;
- gamma-BHC;
- 2,4-D;
- 4,4'-DDD;
- 4,4'-DDE;
- 4,4'-DDT;
- Dichloroprop;
- Diesel;
- Endrin;
- Heptachlor epoxide;

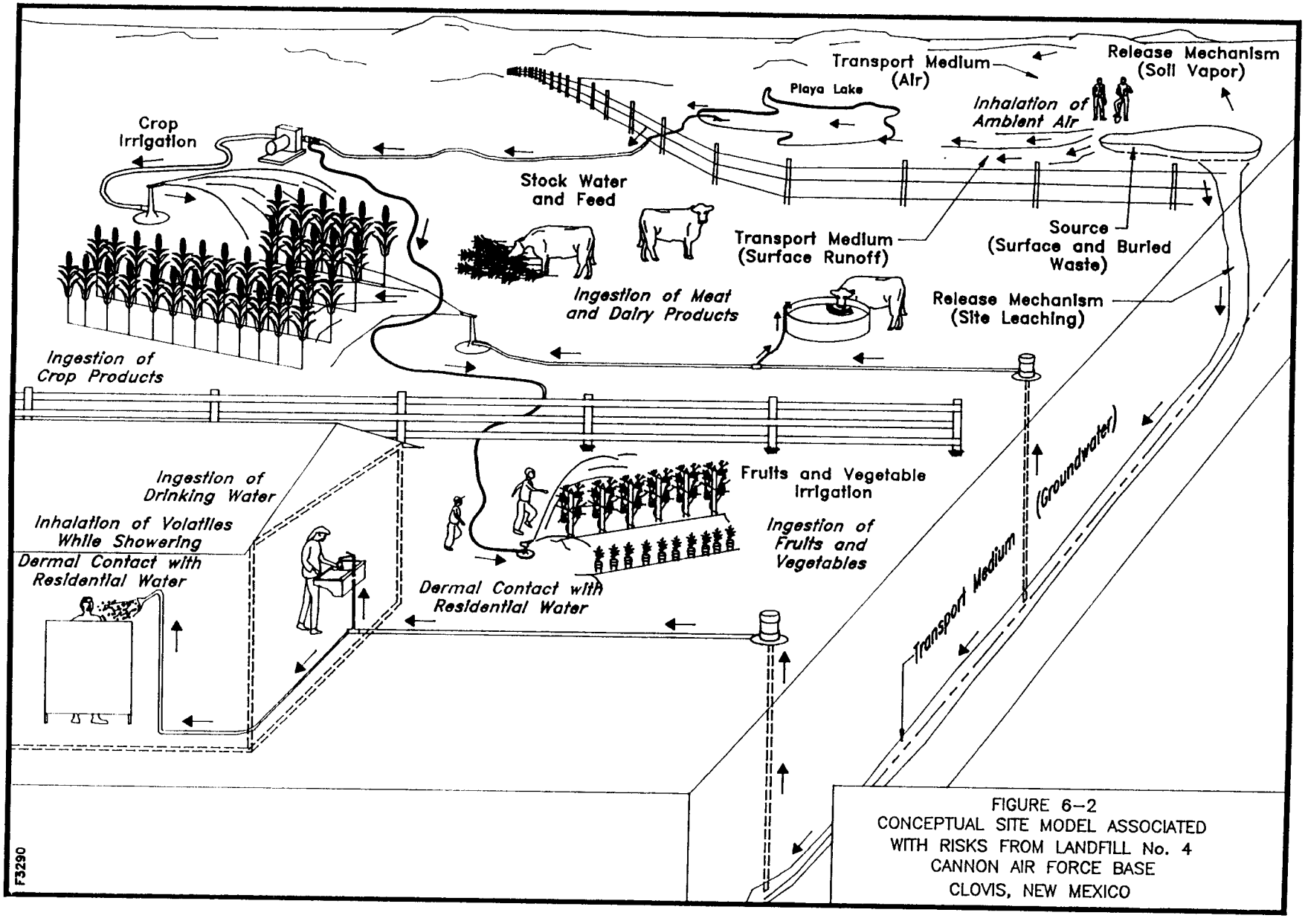

FIGURE 6–2
CONCEPTUAL SITE MODEL ASSOCIATED
WITH RISKS FROM LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

- 2-Hexanone;
- Hydrocarbons;
- Methylene chloride;
- 4-Methyl-2-pentanone;
- MCPP;
- Toluene;
- 2,4,5-T;
- Xylenes; and
- Zinc.

Potentially sensitive members of the population that may be exposed to chemicals originating from Landfill No. 4 include: children, the elderly, and those with preexisting conditions that may be aggravated by exposure to chemicals of potential concern. Locations where sensitive members of the population might reside include hospitals, retirement/nursing homes, schools, nurseries, and day care centers. Medical services for CAFB personnel and their dependents are provided by two general hospitals in the surrounding communities and by the base hospital. The High Plains Hospital is located several miles east of the base, toward Clovis, New Mexico. On-base support facilities, including schools, hospitals, and day care centers are located primarily northwest of the airfield area upgradient and generally upwind of Landfill No. 4. Nearby off-base facilities include a dairy, a barber shop, and a convenience store (Allsups). However, these facilities represent the general population and not sensitive subpopulations.

6.3.2 Task 1: Identification of Releases into Various Media

For the purposes of this risk assessment, the source of contamination is represented by the wastes that have been applied to Landfill No. 4 in the past. No further waste application to Landfill No. 4 is projected in the future. These wastes are the sole source of soil, and potential air, groundwater, and surface water, contamination from the landfill. The potential releases to media from contaminants originating at Landfill No. 4 addressed in this risk assessment are those to 1) ambient air, 2) groundwater, and 3) surface water (playa lake) via runoff from the landfill. Releases to the groundwater have been included even though the time required for the constituents to travel to the groundwater and the assumed attenuation factor indicate that the concentrations of chemicals in the groundwater will be insignificant (See Appendix G-2).

Results of chemical analyses of soil samples collected during the RFI indicated that contaminants are present in the soil beneath Landfill No. 4 to depths of 62 feet BGL. Sections 5.1 through 5.3 summarize the analytical data characterizing contamination at the site. Chemicals detected in soil samples that are above reporting limits and the selection of contaminants of potential concern are discussed in Section 6.2.

The primary source of contamination considered in this risk assessment is soil. While not analyzed during the site investigation, ambient air, groundwater, and surface water could potentially be contaminated with the chemicals of potential concern and may represent a secondary source of contamination. Both primary and secondary sources of contamination are considered in this risk assessment.

6.3.2.1 Releases to Air

Volatilization of organic compounds from surface soil contamination, volatilization of organic compounds from buried wastes and wind entrainment of

contaminated dust were considered to evaluate potential releases to air from Landfill No. 4.

Air impacts were estimated using predictive equations recommended by the USEPA. Emission rates of chemical compounds derived from volatilization and wind entrainment of contaminated dust from Landfill No. 4 were estimated and entered into the USEPA approved Industrial Source Complex Short-Term (ISCST2) dispersion model to estimate worst-case maximum short-term (hourly) and average annual chemical concentrations in the atmosphere at the periphery of the landfill.

Volatile compounds entrained in the soil may volatilize and eventually disperse into the atmosphere above the ground surface by simple diffusion. The chemicals detected at the site during this investigation with the potential to volatilize were hydrocarbons, toluene, methylene chloride, diesel fuel, acetone, 4-methyl-2-pentanone, and 2,4,5-T. No purgeable halocarbons or aromatic compounds were detected in the surficial soil (ranging between 0 to 12 feet) covering the landfill during the previous investigation (Radian, 1986). There is a potential for volatile chemicals to migrate through the soil pores and eventually volatilize to the atmosphere. Release of volatile organics from surface and subsurface soils is considered to occur for purposes of this risk assessment. Metals were also detected in surficial soils, but only zinc was significantly different from background soil concentrations (Radian, 1986 and 1992). However, volatilization of metals is not considered a significant environmental fate mechanism.

Non-volatile chemicals and metals can potentially enter the atmosphere as a result of wind entrainment of contaminated surface soil. Waste must be present in surface soil and uncovered by impervious materials or vegetation to be subject to fugitive dust generation. The generation of fugitive emissions in the form of dust/particulates may be effectively prevented, since Landfill No. 4 is currently vegetated. However,

because of wind conditions in the area, fugitive dust generation was evaluated in order to assume a worst-case scenario that would further support a no-action decision.

Organic materials in the waste are subject to microbial decomposition and will begin to generate a variety of gases that may vent to the atmosphere. Low soil moisture content inhibits waste decomposition resulting in a decreased rate of gas formation. Negligible amounts of organic materials were detected at the site; therefore, soil gases generated at Landfill No. 4 were considered to be negligible and were not evaluated for human health risks.

The playa lake, south of Landfill No. 4, is recharged primarily by treated effluent from the sewage lagoons and by storm water runoff from the site. Without recharge, playa lakes persist for only a few days or weeks. Water is lost from playa lakes by infiltration to the soil and by evaporation (Radian, 1986). Volatilization of organic compounds from the surface water is possible; however, volatilization of organics from the playa lake is not expected to be significant because contamination of the playa lake with volatile organic compounds is predicted to be minimal. Several contaminants were detected at or near the surface soil at Landfill No. 4. However, surface water runoff modeling presented in Appendix G-2 indicates that the concentration of contaminants in the playa lake are low. Therefore, this scenario was not evaluated in the risk assessment.

6.3.2.2 Releases to Groundwater

A secondary release mechanism from the soil includes the potential for leaching of chemicals into groundwater. Leachate is composed of liquid present in the waste, liquid entering the unit from precipitation, and chemical compounds that are dissolved or suspended in this liquid. Many factors affect the potential for contaminant migration including: 1) chemical characteristics; 2) waste application practices; and 3) soil characteristics. Landfill No. 4 is underlain by a caliche profile that extends from the base of the topsoil to a depth of probably less than 60 feet. The physical properties of

the caliche are highly variable. The caliche may serve as a barrier between the landfill and the underlying Ogallala aquifer, 260 feet BGL. Alternately, the caliche could serve as a conduit to the groundwater depending on its porosity. However, the potential for production of leachate to contaminate groundwater is generally considered to be low because of the limited rainfall and high evaporation rate in this arid environment.

Groundwater flow and contaminant transport were modeled using analytical solutions for estimating the time of travel of soil moisture through unsaturated soil from the bottom of the landfill to the Ogallala aquifer, assuming steady-state conditions in the soil column. Appendix G-2 contains a discussion of the methodology used to calculate groundwater concentrations.

Initially, the time of travel of unsaturated soil moisture from the bottom of the landfill to the water table was estimated. The time of travel was estimated to be 173 years. The fate and movement of organic materials in subsurface environments are governed largely by sorption and biodegradation. Sorption affects the rate of travel of organic material, relative to that of water through subsurface systems (McCarty et. al., 1981). Solutes which may be sorbed/desorbed on soil, such as metals and pesticides, are expected to migrate at a slower apparent velocity than the soil moisture, and will require a longer period of time to reach the water table.

The ultimate fate of organic compounds in the subsurface system depends upon biodegradative processes. The attenuation of organic species from biological, chemical, and physical degradation was estimated assuming a first-order decay mechanism. Fate and transport data were obtained from the *Soil Transport and Fate Database* (Sims et. al., 1991).

Significant contamination of the water table with contaminants originating at Landfill No. 4 is highly unlikely in the future. However, in order to assume a worst-

case scenario, further evaluating the basis for a no-action decision, this scenario was evaluated in the risk assessment.

6.3.2.3 Releases to Surface Water

One of the most prominent geomorphic features in the vicinity of CAFB are blowouts. Blowouts are broad shallow depressions which form as a result of soil erosion by wind. Runoff collects in blowouts to form ephemeral playa lakes during periods of rainfall. Generally, drainage in the area of Landfill No. 4 is to the south toward the playa lake. Therefore, direct release of surface contaminants detected at the landfill to surface water may occur at the site. Several contaminants were detected in surficial soils. Results from surface water modeling indicated that contaminants associated with runoff from the site may potentially contaminate the playa lake located just south of the landfill. Modeling results are presented in Appendix G-2.

6.3.3 Task 2: Determination of Fate and Transport in Release Media

Several of the contaminants detected at Landfill No. 4 may be transported from one medium to another by processes of solubilization, adsorption, bioaccumulation, or volatilization. Primary transport media for chemical substances in the environment include the air, groundwater, surface water, and soil. The potentially significant contaminant transport mechanisms considered for this risk assessment include:

- Emissions to ambient air;
- Migration of contaminated groundwater;
- Discharge of groundwater to surface water (playa lake);
- Direct release of contaminants in soil to surface water; and
- Uptake by plants and animals.

6.3.3.1 Release to and Transport in Ambient Air

Organic chemicals in the surficial soils of Landfill No. 4 have the potential to volatilize to the atmosphere. Ambient air monitoring has not been conducted at the landfill to determine the contaminants and/or contaminant concentrations in the air. Several of the contaminants detected in soils at Landfill No. 4 have the potential for volatilization from the soil. Non-volatile organics and metals can enter the atmosphere via wind entrainment of contaminated surface soil. Small particles which carry pesticides or their degradation products may be distributed through the air. Potential contamination of the air at the perimeter of Landfill No. 4 was estimated using conservative assumptions such as: 1) no plume rise; 2) concentration over a reduced area of the landfill; and 3) uniform distribution of subsurface contamination.

6.3.3.2 Release to and Transport in Groundwater

The detection of contaminants beyond the maximum excavation depths of the landfill indicate that contaminants may have migrated downward and suggests a potential for leaching into the underlying Ogallala aquifer. The lower portion of the Ogallala Formation is the primary regional aquifer for both potable and irrigation water. Factors affecting the mobility of waste constituents or their metabolities include potential for adherence to soil particles, and water solubility.

Any leachate reaching the aquifer would mix with the groundwater and flow laterally, generally in the direction of groundwater flow. Groundwater flows to the southeast with a regional gradient of about 10 feet/mile. Some chemicals can float on top of groundwater in a separate immiscible phase because of differing physical and chemical properties. Other chemicals may dissolve and move with the groundwater, or sink to the bottom of the aquifer and move more slowly. The majority of the contaminants detected at Landfill No. 4 were pesticides, which generally are only slightly soluble in water.

6.3.3.3 Discharge to and Transport in Surface Water

Most precipitation that falls in the Clovis area is lost to evapotranspiration and shallow infiltration before runoff occurs. Generally, drainage in the Landfill No. 4 area is to the south, toward the playa lake (Radian, 1986) which was chosen as the closest surface water receptor. Therefore, direct release of contaminants detected at the surface of the landfill to the playa lake is possible. Toluene and methylene chloride are readily leached from soils with low organic content and are moderately soluble in water. However, the majority of the contaminants detected at Landfill No. 4 were pesticides which generally are only slightly soluble in water. The transport of these compounds (pesticides) in runoff is primarily caused by transport of particulates to which these compounds are bound. Because these compounds are bound strongly to soil, they are likely to be subject to sedimentation. Zinc was also detected in surficial soils. Metals are generally not very mobile in most soil systems although the rate of transportation is dependent upon characteristics of the soil. Therefore, erosion by surface water, which is unlikely because of the arid climate, would be required for transport of this contaminant to the playa lake.

Contaminant levels in the playa lake water may also be affected by the rate of groundwater discharge. However, the small concentration of contaminants estimated in the groundwater indicate that groundwater discharge to the playa lake is insignificant.

The playa lake does not discharge to any waterway, but is used to irrigate nearby crops by a local farmer.

6.3.3.4 Uptake by Plants

Land use in the area surrounding CAFB is primarily agricultural. During the site visit, agricultural fields were noted to the east and south of Landfill No. 4. The crops grown on the fields vary depending on the season and the market price. Wheat,

used for human consumption, is the primary crop grown on the fields near Landfill No. 4. However, alfalfa, corn, and milo are also grown on these fields and are used as cattle feed (base Natural Resources Environmental Group, 1992). Agricultural crops are subject to accumulation of contaminants via root uptake of any contaminants present in the soil or water used for irrigation.

The effluent to the playa lake located just south of Landfill No. 4 and groundwater is used by a local farmer for irrigation purposes. Therefore, plants may be potentially exposed to contaminants originating from Landfill No. 4 and it is important to examine the possible accumulation of contaminants in crops. The majority of the chemicals detected at Landfill No. 4 are lipophilic and some have long half lives. As a result, they tend to bioaccumulate in the food chain. While the groundwater modeling (Appendix G-2) indicates that these chemicals are not predicted to enter the groundwater in significant quantities, this pathway was assessed in order to assume a worst-case scenario, further supporting a no-action decision. In addition, irrigation using playa lake water was assessed because several contaminants were predicted to migrate to the playa lake (via runoff).

6.3.3.5 Uptake by Livestock

There is a dairy located within a mile to the northeast of Landfill No. 4 and cattle were seen at the perimeter of the base, northeast of the site during the site visit. Cattle ranching occurs throughout Curry County and the land surrounding CAFB consists of irrigated crops and pasture land used in the cattle ranching and dairy business (Radian, 1986). Livestock, including beef and dairy cattle, may be subject to accumulation of contaminants originating from Landfill No. 4 via ingestion of contaminants in feed. Several crops that are typically used for livestock feed are grown nearby. As cattle ingest contaminated feed, the contaminants can be absorbed by the gastrointestinal tract. The more lipophilic compounds may accumulate in the milk and edible meat following gastrointestinal absorption, providing a mechanism for human

exposure. Locally raised beef and dairy cattle are sustained primarily on locally grown (approximately 80%) agricultural products (New Mexico Agricultural Extension Office, 1992). To evaluate a worst-case scenario, 100% of the feed for beef cattle and dairy cows was assumed to come from crops grown near Landfill No. 4. Although this worst-case scenario is conservative, it provides additional justification for a no-action decision.

6.3.4 Task 3: Evaluation of Exposure Points and Exposure Routes

Normally, potential pathways are segregated into those that currently exist and those that may exist in the future. Current potential exposure pathways are those that may exist as a result of the current extent of contamination combined with existing land use and activity patterns. Future exposure pathways are considered to be those which may exist at some time in the future as a result of the current extent of contamination, combined with future land use and activity patterns. Human exposure to contaminants originating at Landfill No. 4 could potentially occur on-site and in areas adjacent to the landfill. Access to the site is limited and currently there are no ongoing invasive activities occurring. Therefore, direct human contact is currently considered to be unlikely. Incidental ingestion of and dermal contact with soil were assessed as potential sources of exposure to contaminants at Landfill No. 4 for the future occupational scenario, since land use at the site could change in the future. Use of potentially contaminated surface water from the playa lake and groundwater for irrigation of agricultural crops consumed by humans and for feed crops consumed by livestock may serve as indirect pathways of human exposure to contaminants from the landfill. Volatilization of volatile chemicals and fugitive dust generation at the site were also assessed as potential sources of exposure to contaminants originating at Landfill No. 4. Potential site releases are expected to be low-level and relatively continuous in nature. Short-term high level releases are unlikely to occur because the site has been closed since 1968.

6.3.4.1 Receptors

Potential receptors considered in this risk assessment are: 1) animal and plant receptors; 2) people who consume commercially produced agricultural crops grown at the perimeter of the site; 3) people who consume meat and/or milk from livestock fed on crops grown at the site perimeter and; 4) CAFB personnel, on-site workers, and nearby residents exposed to fugitive dust and volatilized chemicals from the site. A groundwater pathway was not considered in the current residential exposure scenario because migration of contaminants was estimated to take 173 years. Future land uses in the vicinity of the base will not significantly alter the exposure points and exposure routes. The size of the potentially exposed populations could change in the future; however, it would likely increase for some exposure routes and decrease for others.

6.3.4.2 Exposure Pathways

Potential exposure pathways associated with identified receptors were evaluated in order to determine whether they were complete and significant. The route can include media other than the source and the receptor must engage in activity that will cause the exposure to occur. Figure 6-3 depicts potential pathways for contaminants originating at Landfill No. 4 to move from the point of release to the point of human exposure. Pathways that are not complete have been crossed out and numbered to correspond with explanatory footnotes. Pathways that are completed but judged insignificant are indicated with dashed-lines. Potentially significant pathways that exist at the site are indicated with a bold, solid line and include:

1) Ingestion of groundwater: leaching to groundwater; groundwater migration to groundwater well; ingestion of groundwater.

2) Dermal contact with groundwater: leaching to groundwater; groundwater migration to groundwater well; dermal contact while showering.

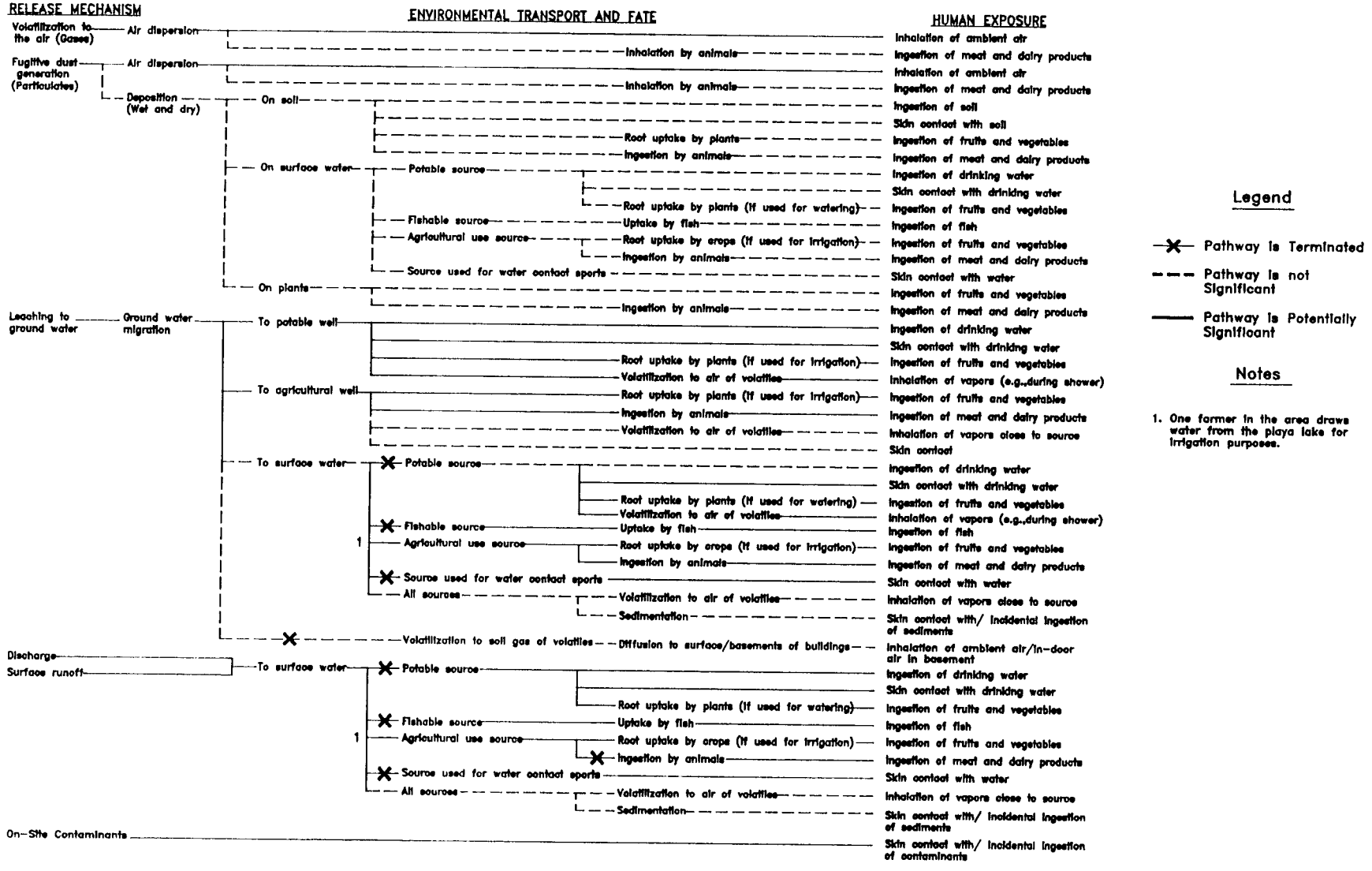

FIGURE 6-3
ENVIRONMENTAL FATE AND TRANSPORT
LANDFILL No. 4
CANNON AIR FORCE BASE
CLOVIS, NEW MEXICO

F3371

3) Inhalation of vapor phase chemicals from groundwater: leaching to groundwater; groundwater migration to groundwater well; inhalation of vaporized chemicals while showering.

4) Ingestion of agricultural crops: migration to surface or groundwater; irrigation of crops with surface or groundwater; uptake by plants; ingestion of plants by humans.

5) Ingestion of milk and meat: consumption of contaminated crops by cattle; transfer of contaminants to beef or milk; ingestion of beef or milk by humans.

6) Inhalation of vapor phase chemicals at the site: volatilization from soil; inhalation of volatilized chemicals in ambient air.

7) Inhalation of fugitive dust generated at the site: entrainment of contaminants in soil; dispersion into the atmosphere above the site; inhalation of fugitive dust.

8) Ingestion of/dermal contact with soil: leaching to soil; ingestion of and/or skin contact with soil.

These eight pathways were quantified in this risk assessment.

Pathways that may be complete but are likely to pose insignificant human health risks include: 1) inhalation of vapors volatilized from the playa lake; 2) dermal contact with surficial soils at the site; and 3) dermal contact with surface water drawn from the playa lake for agricultural purposes. The contribution of these exposure pathways is likely to be minor by comparison to exposure following ingestion of groundwater, agricultural crops, and beef or milk. Potentially exposed populations, exposure media, exposure points and exposure routes for complete pathways are identified in Table 6-2. Also noted in this table are the decisions to select pathways for quantitative evaluation and the justification for including or excluding each pathway in the risk assessment.

Table 6-2

Potentially Complete Exposure Pathways at Landfill No. 4, CAFB, New Mexico

Exposure Route, Medium, and Exposure Point	Potentially Exposed Population	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Inhalation of volatile chemicals in ambient air at or nearby site	Base personnel, nearby residents, on-site workers	Yes	Emissions of volatile chemicals can result in inhalation exposure of Base personnel, on-site workers and nearby residents.
Inhalation of fugitive dust in ambient air	Base personnel, residents living nearby, and on-site workers.	Yes	Wind entrainment of contaminated soils can result in inhalation exposure of Base personnel, on-site workers and nearby residents.
Dermal contact with contaminated soil	Future on-site workers.	Yes	There are currently no invasive activities at the site; however, construction may occur on-site in the future.
Ingestion of contaminated soil	Future on-site workers.	Yes	Incidental ingestion of soil could occur during construction activities.
Ingestion of meat and dairy products from cattle exposed to contaminants from playa lake or groundwater (stock water, irrigation of pasture/feed crops).	Consumers of locally produced meat and dairy products and nearby farm families.	Yes	A dairy exists to the northeast of Landfill No. 4 and several stockyards are located in the vicinity of Cannon AFB.
Dermal contact with chemicals in water during agricultural use.	Off-base farmer drawing water from playa lake potentially contaminated with discharge from site and farmers using potentially contaminated groundwater for agricultural purposes.	No	Contribution of dermal contact with water is likely to be minor by comparison to the contribution of ingestion of agricultural products and livestock.
Dermal contact with chemicals in groundwater during home use.	Off-base residents (On-base residents are upgradient).	Yes	This risk assessment assumes use of potentially contaminated groundwater for bathing/showering and other uses, during which dermal contact occurs.
Inhalation of chemicals volatilized from groundwater during home use (while showering).	Off-base residents (On-base residents are upgradient)	Yes	This risk assessment assumes use of potentially contaminated groundwater for bathing/showering and other uses during which inhalation of vapor may occur.

Table 6-2

(Continued)

Exposure Route, Medium, and Exposure Point	Potentially Exposed Population	Pathway Selected for Evaluation	Reason for Selection or Exclusion
Ingestion of contaminated groundwater migrating from site to potable water wells downgradient from site.	On-base workers, base personnel, off-base residents living downgradient from site (on-base residents are upgradient).	Yes	Although groundwater modeling indicates that leaching of contaminants into the water table will only occur in insignificant quantities and far in the future, residents connected to the municipal water supply may be exposed to a limited extent in the future.
Ingestion of fruits and vegetables irrigated with surface water drawn from playa lake currently impacted by runoff from site or potentially contaminated groundwater in the future.	Consumers of locally grown agricultural crops and nearby farm families.	Yes	One farmer draws water from the potentially contaminated playa lake for agricultural purposes. There are agricultural wells in the vicinity of Landfill No. 4 that may potentially be contaminated with groundwater migrating from the site.

6.3.5 Task 4: Determination of Exposure Scenarios

CAFB personnel, on-site workers, and individuals living in areas downgradient and down wind from Landfill No. 4 represent the significant populations potentially exposed to chemicals originating from the site that leach into groundwater, migrate to the playa lake, or are emitted into the atmosphere above the site. The concentration of contaminants in the air originating from Landfill No. 4 is expected to be highest at the site perimeter and this assumption was corroborated by air dispersion modeling results. In order to assume a worst-case scenario that would further evaluate the basis for a no-action decision, contaminant concentrations at the site perimeter (highest) were used for predicting risks associated with all inhalation exposure scenarios.

For chemicals released to the air, the highest concentrations are typically found in the direction that is predominantly downwind of the site. It is anticipated that inhalation exposure will primarily occur on-site and downwind from the site. Therefore, on-base residents (located north of the site) are not likely to be significantly exposed to airborne contaminants via dispersion because prevailing winds in the area are to the south. CAFB personnel and on-site workers working at or near Landfill No. 4 may be exposed chronically or subchronically to air emissions originating from the site depending on length of employment (tour of duty).

If contaminants originating from Landfill No. 4 reach the groundwater, direct human exposure to contaminants could occur in homes where groundwater is used as a potable source or for showering, etc. Human exposure could also occur from the consumption of beef and dairy products from farm animals exposed to potentially contaminated groundwater and feed crops, as well as from human consumption of contaminated agricultural products. Residents living adjacent to the site, who grow and consume agricultural crops grown at the site perimeter as well as beef and dairy products from livestock fed with these crops, represent a "worst-case" scenario. These individuals may be subject to chronic (long-term) exposure to site-related contaminants. Individuals

who consume commercially produced crops grown at the site perimeter and commercially produced beef and milk from livestock sustained on crops grown on the site perimeter were not assessed because any contaminated commercial products would be widely distributed, thus reducing the potential for individual exposure by comparison to the farm family scenario.

Chronic and subchronic exposure scenarios are based on current and future predicted lifetime exposures. These scenarios assume exposure to contaminant levels predicted by modeled results at the nearest receptor. The scenarios that were evaluated in the risk assessment are:

Lifetime, off-base residential (current and future)

1) adult, average
2) adult, reasonable maximum
3) child, average
4) child, reasonable maximum

Occupational (current and future)

1) adult, average
2) adult, reasonable maximum

Chronic exposure to adults and children was evaluated for: 1) an average case, using 50th percentile values for exposure parameters (i.e. exposure duration and frequency) when available and appropriate; and 2) a reasonable maximum case, using 90th or 95th percentile values for exposure parameters when available and appropriate. Risk estimates for noncarcinogenic effects were predicted for adults and children. Risk estimates for carcinogenic effects were predicted based on an exposure duration of 70 years.

6.3.6 Task 5: Quantification of Estimated Exposure Concentrations

This section describes the methodology used to estimate the magnitude, frequency, and duration of exposures for the populations and exposure pathways selected for quantitative evaluation. The various exposure media quantified for this risk assessment included ambient air, indoor air from residential water use, groundwater, surface water, fruits, vegetables, meat and dairy. The exposure concentration estimates in the various exposure media and the methodologies used to obtain these estimates are discussed. Table 6-3 summarizes the average measured soil concentrations used to estimate exposure concentrations from the various media. Tables 6-4, 6-5A and 6-5B summarize the exposure concentration estimates for all exposure media (i.e., groundwater, surface water, meat, dairy, fruits, vegetables). In addition, the exposure assumptions and algorithms used to calculate human intake are described.

6.3.6.1 Ambient Air

Emission rates of chemical compounds derived from volatilization and wind entrainment of contaminated dust from Landfill No. 4 were estimated using predictive equations recommended by the USEPA. The emission rates were input into the ISCST2 dispersion model to estimate average chemical concentrations in the atmosphere at on-site occupational and off-site residential receptors. The estimated average and reasonable maximum concentrations in air are presented in Table 6-4. The predicted concentrations were then used to estimate health risks to the exposed populations. The maximum contaminant concentrations predicted at the site perimeter were used to assess risks associated with all inhalation exposure scenarios.

The area source algorithm is based on the equation for a finite crosswind line source and requires that each individual area source have the same north-south and east-west dimensions. Since the landfill is irregularly shaped, it was modeled as several area sources by dividing the area into multiple squares that approximate the geometry of

Table 6-3

Average Measured Soil Concentrations From 12 Soil Borings at Landfill No. 4, CAFB, New Mexico

Chemicals	Surface Soil Concentration (μg/kg)	Subsurface Soil Concentration (μg/kg)
Aldrin	3.1E-01	1.7E-01
β-BHC	2.0E-01	1.8E-01
δ-BHC	1.8E-01	2.1E-01
Dichloroprop	1.0E+01	1.8E+01
Diesel Fuel	0.0E+00	4.0E+03
4,4'-DDE	4.0E-01	4.4E-01
4,4'-DDT	7.3E-01	7.7E+00
Hydrocarbons	3.0E+04	2.4E+04
Methylene chloride	3.7E+00	5.4E+00
MCPP	6.30E+03	3.3E+03
Toluene	2.4E+00	2.8E+00
2,4,5-Trichlorophenol	5.5E+00	3.0E+00
Acetone	5.5E+01	5.2E+00
γ-BHC	1.8E-01	1.8E-01
4,4'-DDD	1.8E-01	8.8E-01
2,4'-D	0.0E+00	8.2E+00
Endrin	1.8E-01	1.9E-01
Heptachlor epoxide	1.8E-01	6.3E-01
2-Hexanone	0.0E+00	2.0E+00
4-Methyl 2-pentanone	0.0E+00	1.1E+00
Xylenes	0.0E+00	1.2E+00
Zinc	3.1E+04	1.6+04

Table 6-4

Estimated Exposure Concentrations Associated with Landfill No. 4 CAFB, New Mexico

Chemical	Ambient Air mg/m³				Indoor Air from Showing mg/m³		Groundwater mg/L		Surface Water mg/L	
	Chronic		Subchronic							
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
Acetone	1.25E-02	1.25E-02	3.30E-01	3.30E-01	0.00+00	0.00+00	0.00+00	0.00+00	5.5E-02	5.50E-02
Aldrin	2.94E-09	2.94E-09	7.74E-08	7.74E-08	0.00+00	0.00+00	0.00+00	0.00+00	2.07E-03	2.07E-03
β-BHC	1.88E-09	1.88E-09	4.95E-08	4.95E-08	0.00+00	0.00+00	0.00+00	0.00+00	5.60E-04	5.60E-04
δ-BHC	1.73E-09	1.73E-09	4.56E-08	4.56E-08	0.00+00	0.00+00	0.00+00	0.00+00	5.00E-04	5.00E-04
γ-BHC	1.74E-09	1.74E-09	4.57E-08	4.57E-08	2.64E-74	4.76E-74	6.70E-73	6.70E-73	5.05E-04	5.05E-04
2,4-D	0.00+00	0.00+00	0.00+00	0.00+00	1.75E-06	3.2E-06	4.45E-05	4.45E-05	NA	NA
4,4'-DDD	1.74E-09	1.74E-09	4.57E-08	4.57E-08	0.00+00	0.00+00	0.00+00	0.00+00	3.00E-05	3.00E-05
4,4'-DDE	3.85E-09	3.85E-09	3.85E-09	3.85E-09	1.99E-17	3.43E-17	9.70E-16	9.70E-16	6.00E-05	6.00E-05
4,4'-DDT	3.48E-09	3.48E-09	3.48E-09	3.48E-09	3.90E-51	6.72E-51	1.90E-49	1.90E-49	1.20E-04	1.20E-04
Dichloroprop	9.82E-08	9.82E-08	9.82E-08	9.82E-08	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
Diesel Fuel	6.47E-07	6.47E-07	6.47E-07	6.47E-07	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
Endrin	1.74E-09	1.74E-09	4.57E-08	4.57E-08	3.57E-44	6.44E-44	9.07E-43	9.07E-43	1.82E-04	1.82E-04
Heptachlor epoxide	1.74E-09	1.74E-09	4.57E-08	4.57E-08	0.00+00	0.00+00	0.00+00	0.00+00	1.82E-04	1.82E-04
2-Hexanone	9.19E-07	9.19E-07	2.42E-05	2.42E-05	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
MCPP	3.00E-05	3.00E-05	3.00E-05	3.00E-05	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
4-Methyl 2-pentanone	2.74E-08	2.74E-08	7.21E-07	7.21E-07	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
Methylene chloride	1.90E-03	1.90E-03	1.90E-03	1.90E-03	6.30E-09	1.14E-08	1.60E-7	1.60E-7	5.33E-03	5.33E-03

Table 6-4

(Continued)

Chemical	Ambient Air mg/m³				Indoor Air from Showing mg/m³		Groundwater mg/L		Surface Water mg/L	
	Chronic		Subchronic							
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
2,4,5-Trichlorophenol	1.10E-05	1.10E-05	1.10E-05	1.10E-05	0.00+00	0.00+00	0.00+00	0.00+00	2.72E-03	2.72E-03
Toluene	8.66E-05	8.66E-05	8.66E-05	8.66E-05	0.00+00	0.00+00	0.00+00	0.00+00	2.56E-03	2.56E-03
Xylenes	2.00E-08	2.00E-08	5.28E-07	5.28E-07	0.00+00	0.00+00	0.00+00	0.00+00	NA	NA
Zinc	2.01E-03	2.01E-03	5.28E-02	5.28E-02	0.00+00	0.00+00	1.17E-01	1.17E-01	3.06E+01	3.06E+01

NA - Not Available

Table 6-5A

Estimated Future Exposure Concentrations in Foods Associated with Landfill No. 4 CAFB, New Mexico

Chemical	Fruits mg/kg		Vegetables mg/kg		Meat mg/kg		Dairy mg/kg	
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
Acetone	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Aldrin	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
β-BHC	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
δ-BHC	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
γ-BHC	9.94E-79	9.94E-79	9.94E-79	9.94E-79	8.71E-78	8.71E-78	2.68E-78	2.68E-78
2,4-D	2.22E-10	2.22E-10	2.22E-10	2.22E-10	7.12E-11	7.12E-11	2.22E-11	2.22E-11
4,4'-DDD	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
4,4'-DDE	1.05E-19	1.05E-19	1.05E-19	1.05E-19	1.16E-15	1.16E-15	3.88E-16	3.88E-16
4,4'-DDT	1.03E-53	1.03E-53	1.03E-53	1.03E-53	1.08E-48	1.08E-48	3.42E-49	3.42E-49
Dichloroprop	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Diesel Fuel	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Endrin	1.43E-49	1.43E-49	1.43E-49	1.43E-49	1.45E-45	1.45E-45	1.81E-46	1.81E-46
Heptachlor epoxide	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
2-Hexanone	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
MCPP	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
4-Methyl-2-pentanone	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Methylene chloride	0.00+00	0.00+00	0.00+00	0.00+00	8.00E-12	8.00E-12	3.20E-12	3.20E-12
2,4,5-Trichlorophenol	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00

Table 6-5A

(Continued)

Chemical	Fruits mg/kg		Vegetables mg/kg		Meat mg/kg		Dairy mg/kg	
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
Toluene	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Xylenes	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Zinc	5.70E-04	5.70E-04	9.50E-04	9.50E-04	1.17E+00	1.17E+00	1.17E-01	1.17E-01

Table 6-5B

Estimated Present Exposure Concentrations in Foods Associated with Landfill No. 4 CAFB, New Mexico

Chemical	Fruits mg/kg		Vegetables mg/kg		Meat mg/kg		Dairy mg/kg	
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
Acetone	0.00+00	0.00+00	0.00+00	0.00+00	1.14E-11	1.14E-11	3.74E-12	3.74E-12
Aldrin	3.77E-07	3.77E-07	3.77E-07	3.77E-07	1.68E-07	1.68E-07	5.85E-08	5.85E-08
β-BHC	7.00E-07	7.00E-07	7.00E-07	7.00E-07	2.77E-09	2.77E-09	1.17E-09	1.17E-09
δ-BHC	6.25E-07	6.25E-09	6.25E-07	6.25E-07	2.48E-09	2.48E-09	1.04E-09	1.04E-09
γ-BHC	7.49E-07	7.49E-07	7.49E-07	7.49E-07	1.75E-09	1.75E-09	7.78E-10	7.78E-10
2,4-D	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
4,4'-DDD	2.73E-09	2.73E-09	2.73E-09	2.73E-09	7.44E-09	7.44E-09	2.43E-09	2.43E-09
4,4'-DDE	6.50E-09	6.50E-09	6.50E-09	6.50E-09	1.13E-08	1.13E-08	3.96E-09	3.96E-09
4,4'-DDT	6.50E-09	6.50E-09	6.50E-09	6.50E-09	1.04E-07	1.04E-07	3.38E-09	3.38E-09
Dichloroprop	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Diesel Fuel	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Endrin	2.87E-08	2.87E-08	2.87E-08	2.87E-08	4.67E-08	4.67E-08	6.29E-09	6.29E-09
Heptachlor expoxide	2.87E-08	2.87E-08	2.87E-08	2.87E-08	1.75E-08	1.75E-08	6.29E-09	6.29E-09
2-Hexanone	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
4-Methyl-2-pentanone	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
MCPP	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Methylene chloride	0.00+00	0.00+00	0.00+00	0.00+00	3.93E-11	3.93E-11	1.57E-11	1.57E-11
2,4,5-Trichlorophenol	0.00+00	0.00+00	0.00+00	0.00+00	5.22E-09	5.22E-09	1.69E-09	1.69E-09
Toluene	0.00+00	0.00+00	0.00+00	0.00+00	1.51E-10	1.51E-10	4.54E-11	4.54E-11

Table 6-5B

(Continued)

Chemical	Fruits mg/kg		Vegetables mg/kg		Meat mg/kg		Dairy mg/kg	
	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum	Average	Reasonable Maximum
Xylenes	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00	0.00+00
Zinc	1.49E-01	1.49E-01	2.48E-01	2.48E-01	2.44E-01	2.44E-01	4.43E-02	4.43E-02

the land. Contaminants with a Henry's Law constant of 1×10^5 atm-m^3/mole or greater and molecular weight less than 200 g/mole were considered volatile. These compounds were evaluated for various volatilization emission mechanisms. The remaining compounds were considered to be non-volatile and were evaluated for various entrained dust emission mechanisms. Appendix G-1 presents a detailed discussion of the air dispersion calculations.

EPA recommends comparing the concentrations of chemicals in ambient air with a reference concentration (RfC) rather than a reference dose (RfD) for assessing inhalation exposure (EPA, 1990). The estimated concentrations and the effective air concentrations (EAC) were equivalent for the residential exposure scenario because RfCs assume 24-hour exposure and an inhalation rate of 20 m^3/day for adults and 16 to 24 m^3/day for children. For the occupational or recreational exposure, an EAC is derived by normalizing the exposure duration on site, at the moderate inhalation rate, to a 24-hour day at the average daily inhalation rate. This EAC is then compared to the RfC when available for a chemical. Refer to Appendix H, Table H-6, for the equation used to estimate the EAC.

6.3.6.2 Indoor Air from Residential Water Use

Use of contaminated water for bathing/showering may contribute concentrations of volatile chemicals to indoor air. The method used to estimate concentrations in air while showering is based on results of shower volatilization experiments (Andelman, 1986). The experiments involved pumping a tracer chemical (aqueous trichloromethane) solution through an experimental shower chamber and measuring resulting concentrations of the tracer in the air.

Experimental data on percent volatilization in showers are not available for the chemicals of potential concern for this assessment. By considering the relative volatility of a specific chemical compared to the volatility of trichloromethane, the

volatilization transfer coefficient can be estimated for the chemicals of potential concern. This approach is applicable to chemicals with vapor pressures lower than the vapor pressure of trichloromethane as well as chemicals with vapor pressures higher than the vapor pressure of trichloromethane but less than or equal to 400 mm. The model utilizes the following assumptions:

1) Water flow rate = 20 L/min [based on a U.S. Department of Housing and Urban Development survey which found the mean and maximum value for water flow rate in showers to be between 10 L/min and 30 L/min (Andelman, 1989)];

2) Air exchange rate = 1 per hour [a conservative value suggested by Andelman et. al., 1989 (Andelman, 1989)];

3) Dimensions of the shower stall = 5.5 × 3 × 8 ft (volume = 3.736 m^3); and

4) Shower duration = 7 minutes for the average shower duration and 15 minutes for the reasonable maximum (EPA, 1989a).

A detailed discussion of the calculations is presented in Appendix H, Section 3. Table 6-4 summarizes the estimated average and reasonable maximum concentrations in the shower stall used in the risk assessment to estimate indoor inhalation exposures from residential water use.

EPA recommends comparing the concentrations of chemicals in the shower stall with a reference concentration (RfC) rather than a reference dose (RfD) for assessing inhalation exposure (EPA, 1990). Because RfCs assume 24-hour exposure, and an adult inhalation rate of 20 m^3/day, a direct comparison of inhalation in the shower to an RfC is inappropriate. Instead, an EAC was derived by normalizing the short-duration exposure received in the shower, at the shower inhalation rate, to a 24-hour day at the average daily inhalation rate. This EAC was then compared to the RfC when available for a chemical. Table H-11, presented in Appendix H, summarizes the assumptions and algorithms used to estimate exposure to volatile chemicals while showering.

6.3.6.3 Groundwater

A series of mathematical models was used to estimate the transport and fate of groundwater contaminants migrating from Landfill No. 4 at CAFB. The objective of the analysis was to provide conservative estimates of the maximum concentrations of chemicals of potential concern that would be expected at targeted receptor sites. Appendix G-2 presents a detailed discussion of calculations.

Migration of soil water and contaminants in the vadose zone beneath Landfill No. 4 was analyzed using analytical solutions for steady state unsaturated flow. Groundwater flow and contaminant transport in the unconfined aquifer were analyzed with a separate analytical model. From a hydraulic perspective, two categories of receptors were considered to represent the potential for human exposure to contaminants originating at Landfill No. 4. These are hydraulically active and hydraulically passive receptors.

Hydraulically active receptors are defined as those that impact the nature of the groundwater flow field and therefore the contaminant concentrations at the receptor as well. A hypothetical agricultural well placed at the southeast perimeter of Landfill No. 4 and the nine potable water wells located on-base fall into this category. Hydraulically, the wells draw groundwater towards them by creating a cone of depression that does not exist naturally. The hypothetical well was positioned to capture groundwater and contaminants migrating from site.

The travel time of soil moisture through unsaturated soil from the bottom of the landfill to the water table was estimated to be 173 years. Solutes that may be sorbed/desorbed on soil, such as metals and pesticides, are expected to migrate at a slower apparent velocity than the soil moisture and will require a longer period of time to reach the water table. The attenuation of organic species from biological, chemical, and physical degradation was estimated assuming a first-order decay mechanism. Given

the extended time of travel, even the most persistent species for which data were available (2,4-D) is expected to be attenuated by a factor of more than 10^8. Less persistent species are expected to be attenuated to a greater degree. Therefore, organic chemicals of potential concern are predicted to be reduced to near zero concentrations in the water table.

6.3.6.4 Surface Water

An estimated concentration at the surface water receptor was derived for several chemicals. Although zinc was detected in the surficial soils, it adsorbs strongly to soils. Metals generally are not very mobile in most soil systems although the rate of transportation is dependent on characteristics of the soil. Even though erosion, which is unlikely because of the arid climate, would be required for transport of this contaminant to the playa lake, this scenario was addressed in order to further evaluate the basis for a no-action decision.

The concentration of contaminants in the playa lake was estimated based on their distribution coefficients (K_d) in sandy soils. The K_d describes the equilibrium concentration ratio of the solute sorbed to the solid phase (the soil) to the solute in the liquid phase (soil water). The estimated concentrations are presented in Table 6-4 and were used to estimate the average and reasonable maximum concentrations of chemicals in fruits, vegetables, meat and dairy products for the chronic and subchronic exposure scenarios for off-base residents. Under actual field conditions, contaminant concentrations in the playa lake water are likely to be less because of non-equilibrium conditions. Appendix G-2 presents a detailed discussion of the calculations.

6.3.6.5 Fruits and Vegetables

Potentially contaminated surface water in the vicinity of Landfill No. 4 (playa lake) is used by a local farmer for irrigation purposes. In addition, many agricultural wells are located in the vicinity of CAFB. For this risk assessment, it was assumed that the use of contaminated water for irrigating farm crops contributes to concentrations of contaminants in edible portions of plants. The concentration of chemicals in plants irrigated with contaminated water depends on the concentration of the chemical in the irrigation water, subsequent concentration of the chemical in the soil, the plant type, and other factors.

To derive a concentration in soil from irrigation with water containing contaminants, an irrigation rate of 3,000 L/m^2/year was assumed (an average of approximately 39 inches of water applied over a six-month growing period in this geographic region) (Base, et. al., 1984; Base Natural Resources Environmental Group, 1992). Irrigation was assumed to continue for 30 years for evaluation of long-term exposures because soil concentration of inorganic chemicals may build up over time. Degradation, chemical transformation, or other soil removal processes were not considered, although these processes likely occur. It was further assumed that the total mass of contaminants resides in the top 15 cm of soil and the soil bulk density was 1333 kg/m^3. Volatile organic chemicals (acetone, diesel fuel, 2-hexanone, hydrocarbons, toluene, methylene chloride, 2,4,5-T and xylenes) were not evaluated for this pathway because these chemicals can be largely expected to volatilize from the irrigation water and soil surface before significant plant uptake can occur.

Appendix H provides the algorithm and spreadsheet calculations for quantifying concentrations in soil as a result of irrigation and subsequent uptake into fruits and vegetables. The estimated average and reasonable maximum contaminant concentrations in vegetables resulting from irrigation of farm crops with water potentially contaminated with toluene are listed in Tables 6-5A and 6-5B.

6.3.6.6 Meat and Dairy Products

The use of potentially contaminated groundwater for stock water is assumed to contribute to concentrations of contaminants in the edible meat of beef cattle and in milk and dairy products. However, there is no evidence to suggest that surface water (playa lake) is currently being used or will be used in the future for stock water (Base Natural Resources Environmental Group, 1992). While grazing, cattle also ingest surface soil, which can build up contaminant concentrations if the pasture is irrigated with contaminated water sources. As cattle ingest contaminated feed, water, and soil, some chemicals may be absorbed in the animals' gastrointestinal tract. The more lipophilic chemicals may then accumulate in meat.

To estimate the chemical concentration in meat and dairy products, an equation derived from the *Multi-Pathway Health Risk Assessment Input Parameters Guidance Document* (Clement, 1988) was used. Appendix H provides the algorithm and spreadsheet calculations for quantifying concentrations in meat and dairy products as a result of contaminated stock water and feed crops irrigated with contaminated surface water.

Contaminated food sources included in the evaluation are stock water from potentially contaminated groundwater, feed crops irrigated with surface water drawn from the playa lake or groundwater, and incidentally ingested soil. The fraction of feed from a contaminated source was assumed to be 100% for water (groundwater scenario), feed, and soil. One-hundred percent of all contaminants in the water, feed, and soil was assumed to be bioavailable. While these assumptions are not necessarily realistic and tend to be overly conservative, they allow assessment of a worst-case scenario and assess the basis for a no-action decision. A cattle water ingestion rate of 150 kg/day, and a consumption rate of 16 kg/day for lactating cows and 8 kg/day for nonlactating cows and cattle (Base Natural Resources Environmental Group, 1992), and a soil ingestion rate of

0.6 kg/day, or 4% of the feed consumption rate (Clement, 1988), per head of cattle was assumed.

Significant accumulation in meat and milk is not expected because of the relatively low concentrations of non-volatiles estimated to reach surface and groundwater (refer to Appendix H). The estimated average and reasonable maximum concentrations in beef and dairy products, assuming the cattle feed on corn, milo, and alfalfa irrigated with potentially contaminated surface water drawn from the playa lake and potentially contaminated groundwater, are presented in Table 6-5A and 6-5B.

6.3.7 Task 6: Estimation of Chemical Intakes for Individual Pathways

Exposure is defined as the contact rate of an organism with a chemical or physical agent. Intake is defined as exposure normalized for time and body weight and is expressed in units of mg chemical/kg body weight-day (USEPA, 1989a).

There are three categories of variables that are used to estimate intake:

1) Chemical-related variables (exposure concentration);

2) Variables that describe the exposed population (contact rate, exposure frequency and duration, and body weight); and

3) Assessment-related variables (averaging time).

The chemical-related variables (exposure concentrations) are presented in Tables 6-4, 6-5A and 6-5B. Tables H-11 through H-19 presented in Appendix H, summarize the assumptions and algorithms used to estimate exposure for each exposure pathway. The rationale for selecting individual values is explained in footnotes to the tables. The tables in Appendix H also document the equations used for calculating

pathway-specific intakes. The generic equation for calculating chemical intakes is presented in Appendix H. Calculated intakes are presented in Appendix I.

Exposure assumptions recommended in the *Human Health Evaluation Manual, Supplemental Guidance: Standard Default Exposure Factors* (USEPA, 1991), the *Risk Assessment Guidance for Superfund* (USEPA, 1989a), and the *Exposure Factors Handbook* (USEPA, 1989b) were used when available and applicable. Site-specific and chemical-specific values were used when available data justified their use; otherwise conservative default values were substituted.

6.3.8 Exposure Assessment Uncertainties

Major sources of uncertainty associated with the exposure assessment include:

1) The ability of fate and transport models to realistically simulate the behavior of chemicals in the environment; and

2) The accuracy of exposure assumptions in representing the degree and way in which individuals are exposed.

Uncertainty is addressed in this risk assessment by:

1) Incorporating both average and reasonable maximum values to provide a range of results rather than single values.

2) Using conservative estimates when defining reasonable maximum exposure assumptions in order to protect human health and the environment; and

3) Identifying and discussing the major sources of uncertainty and their effects on the exposure estimates in order that the results can be properly interpreted and used for estimation of risks.

6.3.8.1 Fate and Transport Modeling

Release rates to the air, groundwater, and surface water were based on analytical data from the 1992 RFI. Estimated releases to various media were assumed to be steady state, indicating that they will not increase or decrease over the assumed periods of time for exposure duration. Therefore, the estimated release rates are biased toward conservatism and most likely are overestimated because contaminant concentrations in the soil should decrease over time as chemicals volatilize to the air, degrade in the soil, and are flushed from the site.

Modeling the fate and transport of contaminants in air and water requires the use of overly simplistic assumptions that do not simulate the environment. Realistically, migration of contaminants from the source to receiving media involves numerous complex processes that are not necessarily addressed by the available models.

In many cases, conservative values were used for model input parameters. No pollutant removal processes were considered and a decay coefficient of 0 was used in the ISCST2 dispersion model for calculating ambient air concentrations. Therefore, concentrations predicted at each receptor are conservative estimates. These conservative assumptions result in higher ground level concentration estimates. In addition, subsurface contamination was assumed to be uniformly mixed. This assumption may or may not be overly conservative. The model used for transport of contaminants in groundwater and surface water uses conservative modeling assumptions to provide estimates of the maximum concentrations at the receptor sites. For groundwater modeling, results were based on time of travel calculations for soil moisture. Solutes, which may sorb/desorb on soil, would be expected to migrate at a slower apparent velocity than soil moisture and, therefore, would require a longer period of time to reach the water table. In addition, the most conservative K_d values were used to estimate concentrations of contaminants in the playa lake and may have resulted in overestimation of the exposure concentration.

6.3.8.2 Exposure Parameter Estimation

The standard assumptions regarding body weight, exposure period, life expectancy, population characteristics, and lifestyle may not accurately represent site-specific exposure situations. The assumptions used most likely overestimate human exposures but may underestimate them in some cases. The purpose of exposure parameter estimations are to reflect realistic, site-specific exposures. However, because exact current and future exposure that more accurately depict all scenarios cannot be determined, assumptions were made which most likely err on the conservative (safe) side to protect human health.

Assumptions regarding exposure parameters that are conservative and may overestimate exposures include:

1) The use of modeled concentrations to represent exposure point concentrations for most exposure scenarios.

2) The amount of media intake is assumed to be constant and representative of the exposed population.

3) Exposure is assumed to occur 350 days/year for chronic exposure scenarios for off-base residents involving inhalation of ambient air and consumption of locally produced agricultural, beef, and dairy products. Hypothetical on-site workers are assumed to be exposed by inhalation of ambient air at the perimeter of Landfill No. 4, where contaminant concentrations are expected to be highest, 100 or 200 days/year or for 2 or 8 hours/day. It is conservative to assume that off-base residents would consume milk, meat, fruit, or vegetables that come from the contaminated source 350 days/year. It is even more conservative to assume that on-site workers would be at the site perimeter 250 days/year for 8 hours/day, since there are no known activities which take place at the site presently. All future occupational exposures were assumed to occur over a 25 year (chronic) time period, which represents an upperbound estimate for occupational exposures, and may further overestimate exposures.

4) Ambient air concentrations predicted at the site perimeter were used to estimate risks associated with residential exposure. This assumption is overly conservative because contaminant concentrations in the air would be expected to be diluted at distant sites, such as off-base residences.

5) The use of feed-to-beef and feed-to-milk transfer coefficients that do not account for metabolism and/or disposition of chemicals may also lead to overestimation of exposure.

6) One hundred percent absorption of inhaled and ingested contaminants is assumed. 100% bioavailability is assumed for all inhaled, ingested, and dermally absorbed contaminants.

All of the above exposure assumptions tend to overestimate exposures. No assumptions that tend to underestimate exposures have been identified with respect to exposure parameter estimation.

Exposure parameters used in the assessment represent exposures that may occur considering both current and future land use. Future off-base land use is not expected to differ significantly from current land use practices. However, CAFB is an expanding base and, therefore, current land use at Landfill No. 4 may not reflect future uses.

6.4 Toxicity Assessment

Toxicity assessment involves determining whether exposure to an agent can increase the incidence of a particular adverse effect (e.g., cancer, birth defects) in humans, characterizing the nature and strength of evidence of causation, and, if sufficient data are available, quantifying the relationship between the dose of the contaminant and the incidence of adverse health effects in the exposed population. Toxicity values are derived from the quantitative dose-response relationship. These values can be used to estimate the incidence of or potential for adverse effects as a function of human

exposure to the contaminant. This section summarizes the toxicity values used for the risk assessment.

6.4.1 Background

USEPA has performed the toxicity assessment step for numerous chemicals, and the resulting toxicity information and toxicity values have undergone extensive peer review. Toxicity values used to evaluate noncarcinogenic effects (effects other than cancer) include:

- Reference dose (RfD) in units of mg/kg-day; and
- Reference concentration (RfC) in units of mg/m^3.

The RfD and RfC are estimates (with uncertainty spanning an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a portion of the lifetime, in the case of a subchronic RfC or RfD, or during the lifetime in the case of a chronic RfC or RfD. The RfD is used to evaluate oral and dermal exposures and the RfC is used to evaluate inhalation exposures.

Toxicity values used to evaluate carcinogenic effects include:

- Weight of evidence classification;
- Slope factor (SF) in units of $(mg/kg\text{-}day)^{-1}$; and
- Unit risk for inhalation exposure in units of $(\mu g/m^3)^{-1}$.

The weight of evidence classification is a USEPA classification system for characterizing the extent to which the available data indicate that an agent is a human carcinogen. In assessing the carcinogenic potential of a chemical, USEPA classifies the chemical into

one of the following groups, according to the weight of evidence from epidemiological studies and animal studies:

Group A	-	Human Carcinogen (sufficient evidence of carcinogenicity in humans);
Group B	-	Probable Human Carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans);
Group C	-	Possible Human Carcinogen (limited evidence of carcinogenicity in animals and inadequate or lack of human data);
Group D	-	Not Classifiable as to Human Carcinogenicity (inadequate or no evidence); or
Group E	-	Evidence of Noncarcinogenicity for Humans (no evidence of carcinogenicity in adequate studies).

USEPA performs quantitative carcinogenic risk assessments for chemicals in Groups A and B, and on a case-by-case basis for chemicals in Group C. Classification of a chemical as Group D or E precludes performance of quantitative risk assessment. Cancer slope factors are estimated through the use of mathematical extrapolation models, most commonly the linearized multistage model, for estimating the largest possible linear slope (within the 95% confidence limit) at low extrapolated doses that is consistent with the data. The slope factor is characterized as a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. The unit risk for drinking water and inhalation is the risk per concentration unit in water (risk per $\mu g/L$) and air (risk per $\mu g/m^3$), respectively.

6.4.2 Sources of Information

This assessment used only toxicity values that have been developed by USEPA. The following sources of information, in order of priority, were consulted to identify toxicity values for chemicals of concern with potential for human exposure:

- USEPA's Integrated Risk Information System (IRIS) - IRIS is updated monthly, provides verified RfDs and slope factors, and is the Agency's preferred source of toxicity information;
- USEPA's Health Effects Assessment Summary Tables (HEAST) - HEAST provides information on interim (not yet verified by US EPA Workgroups) as well as verified RfDs and slope factors and is used only to obtain toxicity values for chemicals not listed in IRIS;
- Other USEPA documents, such as the Drinking Water Regulations and Health Advisories (USEPA, 1991c).

6.4.3 Toxicity Values Used in the Risk Assessment

This section summarizes the available toxicity information for each of the chemicals of concern with potential for human exposure. Chemicals of concern that were screened out by the exposure assessment (see Section 6.3, Exposure Assessment) are not included in the toxicity assessment. The relevant information includes standard USEPA toxicity values and toxicity values derived for use in risk assessment. The information in this section was used in determining the risks associated with noncarcinogenic effects RfDs, carcinogenic potential (slope factors), and weight of evidence classification. These values are defined and discussed in Section 6.4.1 of the report.

6.4.3.1 Toxicity Values for Noncarcinogenic Effects

The RfD values for the chemicals of concern are presented in Table 6-6 and were obtained from IRIS dated November 24, 1992, or from the USEPA, HEAST, 1992. Oral RfD values were not available for β-BHC, δ-BHC, 4,4'-DDD, 4,4'-DDE, dichloroprop and 2-hexanone. Unless a specific dermal RfD was listed by IRIS or HEAST, the RfD for dermal exposures was assumed to be the same as for oral exposures. When available, inhalation RfDs or RfCs were included.

6.4.3.2 Toxicity Values for Carcinogenic Effects

The slope factors for chemicals of potential concern classified by USEPA as carcinogens are also presented in Table 6-6 and were obtained from an IRIS search dated 24 November 1992 or from HEAST, 1992. When available, inhalation unit risk factors were included.

6.4.4 Health Effects Summaries

This section of the report summarizes the toxicity information available for the noncarcinogenic and carcinogenic effects associated with the chemicals of potential concern. General information on the potential health effects of exposures to the chemicals of potential concern is provided. Toxicity information on noncarcinogenic effects is provided for each contaminant that has an RfD value and includes the data that formed the basis for the determination of the RfD. Information on the potential carcinogenic risks includes supporting data for the USEPA carcinogenic classification. Table 6-7 summarizes the available information on human health effects of exposure to chemicals of potential concern. Unless otherwise stated, the information presented below on each of the chemicals of concern is summarized from the information available on IRIS as of 12 October 1992.

Table 6-6

Toxicity Values for Chemicals Specific to Landfill No. 4

Chemical	EPA Class	Chronic Oral RfD (mg/kg-day)	Subchronic Oral RfD (mg/kg-day)	Chronic Inhalation RfC (mg/m³)	Subchronic Inhalation RfC (mg/m³)	Oral Slope Factor (mg/kg-day)⁻¹	Inhalation Unit Risk 1/(μg/m³)	Inhalation Slope Factor (mg/kg-day)⁻¹
Acetone	D	1.00E-01 [i]	1.00E+00 [h]	–	–	–	–	–
Aldrin	B2	3.00E-05 [i]	3.00E-05 [h]	–	–	1.70E+01 [i]	4.90E-03 [i]	1.70E+01 [h]
beta-BHC	C	–	–	–	–	1.80E+00 [i]	5.3E-04 [i]	–
delta-BHC	D	–	–	–	–	–	–	–
gamma-BHC	B2/C	3.00E-04 [i]	3.00E-03 [h]	–	–	1.30E+00 [h]	3.70E-05 [i]	–
2,4'-D		1.00E-02 [i]	1.00E-02 [h]	–	–	–	–	–
4,4'-DDD	B2	–	–	–	–	2.40E-01 [i]	–	–
4,4'-DDE	B2	–	–	–	–	3.40E-01 [i]	–	–
4,4'-DDT	B2	5.00E-04 [i]	5.00E-04 [h]	–	–	3.40E-01 [i]	9.70E-05 [i]	3.40E-01 [h]
Dichloroprop	–	–	–	–	–	–	–	–
Diesel	D	8.00E-03 [p]	8.00E-03 [p]	–	–	–	–	–
Endrin	D	3.00E-04 [i]	3.00E-04 [h]	–	–	–	–	–
Heptachlor epoxide	B2	1.30E-05 [i]	1.30E-05 [h]	–	–	9.1E+00 [i]	2.60E-03 [i]	–
2-Hexanone		–	–	–	–	–	–	–
MCPP	–	1.00E-03 [i]	1.00E-02 [h]	–	–	–	–	–
Methylene chloride	B2	6.00E-02 [i]	6.0E-02 [h]	3.00E+00 [h]	3.00E+00 [h]	7.50E-03 [i]	4.7E-07 [i]	–
4-Methyl-2-pentanone		5.00E-02 [h]	5.00E-01 [h]	8.00E-02 [h]	8.00E-01 [h]	–	–	–
Toluene	D	2.00E-01 [i]	2.00E+00 [h]	4.00E-01 [i]	2.00E+00 [h]	–	–	
2,4,5-T	–	1.00E-01 [i]	1.00E+00 [h]	–	–	–	–	–
Xylenes	D	2.00+00 [i]	4.00E+00 [h]	–	–	–	–	–
Zinc	D	3.00E-01 [i]	2.00E-01 [h]	–	–	–	–	–

[h] - HEAST, March 1992
[i] - IRIS on line search (1/92).
[p] - Provisional Oral RfD.

Table 6-7

Chronic Toxicities

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
Acetone	Liver Kidney	Increased relative and absolute organ weights have been noted following oral intubation of rats with acetone. Tubular degeneration of the kidneys and hyalin droplet formation have also been observed.		D - Not Classifiable as to Human Carcinogenicity.
Aldrin/Dieldrin	Liver Kidney	Lesions occur in both the liver and kidneys after chronic ingestion by laboratory animals.	Liver - hepatomas, hyperplasia, carcinoma.	B2 - Probable Human Carcinogen.
	Central Nervous System (CNS)	Chronic exposure to moderate levels in humans can cause headaches, dizziness, irritability, vomiting, or uncontrolled muscle movements.		

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
BHC (beta, delta, and gamma)	Liver	Hypertrophy was seen in a chronic ingestion study in rats.	Liver - hepatocellular carcinomas	C - Possible Human Carcinogen (beta-BHC) D - Not Classifiable as to Human Carcinogenicity (delta-BHC). B2/C - Probable/ Possible Human Carcinogen (gamma-BHC)
	Kidney	Tubular degenerating hyalin droplet accumulation, and interstitial nephritis have been observed in rats fed BHC in the diet.		
4,4'-DDD	Thyroid	Atrophy of the thymus has been observed following short-term exposure of mice to 4,4'-DDD in the diet.	Thyroid - tumors Lung - tumors	B2 - Probable Human Carcinogen
4,4'-DDE	Liver Thyroid	Hypertrophy may result after chronic oral exposure of rodents.	Liver - hepatocellular carcinomas.	B2 - Probable Human Carcinogen.

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
4,4'-DDT	Liver	Chronic exposure may result in changes in enzyme levels in rodents.	Liver - carcinomas.	B2 - Probable Human Carcinogen.
	Reproductive System	Some evidence in laboratory animals indicates that heptachlor may decrease fertility and may adversely affect offspring.		
2,4'-D	Blood	Reduced hemoglobin levels, hematocrit values, red blood cells, and reticulocytes have been observed in rats following ingestion of 2,4-D.		Not Classified
	Liver	Decreases in liver enzymes, SGOT and SGPT have been reported in rats exposed orally.		
	Kidney	Increased organ weight (relative and absolute) has been reported following subchronic exposure to high levels of 2,4-D.		

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
Dichloroprop	Liver	Slight liver hypertrophy has been observed in mice following administration of dichloroprop in the diet.		Not Classified
Diesel Fuel	Liver	Fatty changes in the livers of mice have been reported following subchronic inhalation exposure.		D - Not Classifiable as to Human Carcinogenicity
Endrin	Liver	Slightly increased relative liver weights and mild histopathological effects in the liver have been noted in dogs fed endrin.		D - Not Classifiable as to Human Carcinogenicity
2-Hexanone	Liver Kidney	Hepatic and renal effects have been noted in rats following acute and intermediate exposures to 2-hexanone via gavage.		Not Classified

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
MCPP	Liver	Increased absolute and relative organ weight has been observed in rats exposed to MCPP in the diet.		Not Classified
	Kidney	Increased absolute and relative organ weight, increased creatinine and decreased glucose levels have been observed in rats exposed to MCPP in the diet.		
Methylene Chloride	Liver	Histological alterations of the liver were noted in a chronic drinking water study conducted on rats.	Liver-hepatocellular neoplasms. Lung-alveolar/bronchiolar neoplasms. Hematopoietic-leukemia.	B2 - Probable Human Carcinogen

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
4-Methyl-2-pentanone (MIBK)	Liver Kidney	Increased relative and absolute organ weights have been noted in laboratory animals exposed to MIBK.		Not Classified
	CNS	Inhalation of MIBK causes headache and nausea in humans. Narcosis may occur with additional symptoms of weakness, light-headedness, dizziness, and incoordination.		
Toluene	Skin	Irritation to the skin and eyes has been seen in humans.		D - Not Classifiable as to Human Carcinogenicity.
	Liver Kidney	The weights of the liver and kidneys increased in a subchronic study in rats at moderate to high levels.		

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
2,4,5-Trichlorophenol	Liver	Degenerative changes in the liver have been observed in rats exposed to 2,4,5-Trichlorophenol in the diet.		Not Classified (pending)
	Kidney	Degenerative changes in the kidney as well as mild diuresis have been observed in rats exposed to 2,4,5-Trichlorophenol in the diet.		
Xylenes	CNS	Mice given high doses of xylene mixtures experience hyperactivity.		D - Not Classifiable as to Human Carcinogenicity
	Liver Kidneys	Possible changes in the liver and kidneys have been noted in humans following short-term exposure to high concentrations of xylenes.		

Table 6-7

(Continued)

Chemical	Noncarcinogenic Effect		Carcinogenic Effect	
	Target Organ	Critical Effect	Target Organ/ Tumor Type	EPA Class
Zinc	Gastrointestinal System	Signs of zinc intoxication may include gastrointestinal distress, emesis, and decreased food consumption.		D - Not Classifiable as to Human Carcinogenicity
	Blood	Anemia and hemorrhage have been noted in several species following exposure to high zinc concentrations.		

6.4.4.1 Acetone

Studies indicate that exposure to less than 2150 ppm acetone for less than 8 hour/day causes no significant toxic effects although transient eye and nose irritation have been reported by some exposed workers (EPA, 1984). In two occupational exposure studies, workers exposed to acetone vapors at concentrations of 19-920 ppm reported irritation of the mucosal membranes which included conjunctivitis, pharyngitis, inflammatory bronchitis, and gastroduodenitis. Data regarding the teratogenicity of acetone were not located in the literature, however, acetone has been reported to cross the placenta (USEPA, 1984). Several studies indicate that acetone potentiates the hepatotoxic effects of carbon tetrachloride (Plaa, et. al., 1975, 1982) and 1,1,1-trichloromethane (Plaa, et. al., 1975; Hewitt, et. al., 1983). Data regarding the carcinogenic potential of acetone in humans or laboratory animals were not located in the available literature, however, acetone does not demonstrate mutagenic activity in microbial assay systems or in cell transformations systems. Acetone was reported to cause chromosomal aberrations but not sister chromatid exchange in one study (Kawachi, et. al., 1980) but gave negative results in all other assays that tested for chromosomal aberrations, sister chromatid exchange, point mutations, and transfection (USEPA, 1984).

IRIS lists the chronic oral RfD for acetone as 1.0E-01 mg/kg-day while HEAST lists the subchronic oral RfD as 1.0E+00 mg/kg-day. These values were determined from a ninety-day study in albino rats using acetone. The experimental groups were orally intubated at 0, 100, 500, or 2500 mg/kg-day. Body weights, food consumption, clinical chemistry, hematology, and histopathology parameters, as well as organ weights and organ-to-body weight ratios, were measured and analyzed. After sacrifice, no effects were seen in the 100 mg/kg-day group. Statistical analysis of the absolute and relative organ weight data revealed significantly increased kidney weights for females in the 500 and 2500 mg/kg-day groups and increased kidney-to-body and brain weight ratios for males and females in the 2500 mg/kg-day groups. Liver weight and liver/body weight ratios were elevated in both sexes for the high dose group.

and liver/body weight ratios were elevated in both sexes for the high dose group. Histopathologic studies revealed a marked increase of severity in tubular degeneration of the kidneys and hyaline droplet accumulation. A dose response was observed.

The No Observable Adverse Effect Level (NOAEL) is set at 100 mg/kg-day and the Lowest Observable Adverse Effect Level (LOAEL) is 500 mg/kg-day due to the increased liver and kidney weights in conjunction with nephrotoxicity found in the above study. An uncertainty factor of 1000 is incorporated in the RfD calculation since uncertainty of 10X exists when extrapolating from each: inter- and intraspecies, and subchronic to chronic exposure. Confidence in this study is medium since a moderate number of animals was used and an extensive number of clinical parameters were analyzed. However, the overall confidence rating for the acetone RfD is low because of the small number of studies on this compound and the lack of significant supporting data.

Inhalation RfDs and RfCs were not available in IRIS or HEAST. The EPA has designated acetone as Group D (Not Classifiable as a Human Carcinogen) based on lack of data concerning carcinogenicity in humans or animals.

6.4.4.2 Aldrin

Exposure to aldrin is limited because it is broken down very rapidly to dieldrin in the environment. No increase in mortality from any cause has been reported in workers who had been employed in the manufacture of aldrin for more than four years. Information regarding the respiratory effects of aldrin in humans is limited and conflicting. One occupational exposure study indicated that exposed workers demonstrated no new pulmonary disease or deterioration of existing pulmonary disease (ATSDR, *Toxicological Profile for Aldrin/Dieldrin*, 1991) although a similar study reported significantly increased incidence of pneumonia and other pulmonary diseases (ATSDR, *Draft Toxicological Profile for Aldrin/Dieldrin*, 1991). Central nervous system (CNS)

excitation culminating in convulsions was the principal toxic effect noted in occupational studies of workers employed in the manufacture or application of aldrin. Short-term exposure to high levels of aldrin caused convulsions and kidney damage. Long-term exposures to lower levels of aldrin may also cause convulsions as a result of aldrin's potential to accumulate within the body. Long-term exposure to moderate levels of aldrin caused headaches, dizziness, irritability, vomiting, or uncontrollable muscle movements. A condition in which aldrin causes the body to destroy its own blood cells has been noted in some sensitive people.

The carcinogenic and reproductive/developmental effects of aldrin in humans are currently unknown. Experimental studies indicate that animals born to mothers that were fed aldrin did not live long. Conflicting results have been obtained in animal studies with regard to the teratogenic potential of aldrin as well as its effects on reproductive performance. One study revealed detectable levels of dieldrin (a lipid soluble metabolite of aldrin that is toxic and is stored in adipose tissue) in the human placenta, amniotic fluid, and fetal blood. These results suggest that dieldrin can pass through the human placenta and accumulate in the developing fetus. A limited number of epidemiologic studies examining the incidence of cancer in workers exposed to aldrin or dieldrin exist. No evidence for a carcinogenic effect of aldrin in humans was observed in these studies (ATSDR, *Toxicological Profile for Aldrin/Dieldrin*, 1991).

IRIS lists the chronic oral RfD for aldrin as 3.0E-05 mg/kg-day. This value was determined from a two year chronic study in rats using aldrin. The experimental groups were orally dosed with 0, 0.5, 2, 10, 50, 100 or 150 ppm (in the diet) for two years. Liver lesions characteristic of chlorinated insecticide poisoning were observed at dose levels of 0.5 ppm and greater. These lesions were characterized by enlarged centrilobular hepatic cells, with increased cytoplasmic oxyphilic, and peripheral migration of basophilic granules. A statistically significant increase in liver-to-body weight ratio was observed at all dose levels. Kidney lesions occurred at the highest dose levels.

Survival was markedly decreased at dose levels of 50 ppm and greater. A LOAEL of 0.5 ppm was established in this study. A NOAEL was not established.

Additional data are fairly supportive of the findings from the critical study. Effect and no-effect levels are similar to those found for rats and for liver effects in dogs after 15 months exposure to aldrin in the diet. Liver effects were observed at slightly higher doses in several other subchronic-to-chronic rat and dog studies. Short-term exposure to higher doses resulted in mortality for a number of species.

The uncertainty factor used to derive the RfD for aldrin is 1,000. This factor encompasses the uncertainty of extrapolation from animals to humans, the uncertainty in the range of human sensitivities, and an additional uncertainty because the RfD is based on a LOAEL rather than a NOAEL. The confidence level for the RfD value is medium. The supporting study performed histopathologic analysis but lacked other toxicologic parameters. Confidence in the data base was also medium. There is no inhalation RfD or RfC for aldrin. HEAST lists the subchronic RfD as 3.0E-05 mg/kg-day.

Human carcinogenicity studies are inadequate but animal carcinogenicity studies are sufficient to classify aldrin as Group B2 - Probable Human Carcinogen. The oral slope factor for aldrin is listed in IRIS as 1.7E+01 $(mg/kg\text{-}day)^{-1}$ and the inhalation unit risk is listed as 4.9E-03 $(\mu g/m^3)^{-1}$. After chronic ingestion of 10 ppm in the diet of mice, a statistically significant increase in hepatomas was observed. Most of these tumors were evaluated to be liver carcinomas. Adequate numbers of animals were treated for a large proportion of their lifetime and the route of treatment was appropriate. HEAST listed an inhalation slope factor of 1.70E+01 $(mg/kg\text{-}day)^{-1}$.

6.4.4.3 BHC (Beta and Delta)

People generally are not exposed to the beta and delta-forms of benzene hexachloride (BHC) separately but to lindane (gamma-BHC) or to technical-grade BHC (a mixture of the alpha, beta, and delta-forms). Therefore, the health effects of the BHC isomers are considered jointly. The adverse health effects of lindane and the other BHC isomers (alpha, beta, and delta) that have been seen in humans include lung irritation, heart disorders, blood disorders, headache, convulsions, and alterations in levels of sex hormones. These effects were observed in individuals exposed to BHC vapors during its manufacture and/or in individuals accidentally exposed to very large quantities of BHC. Death can result in humans and animals exposed to large amounts of BHC. Liver disease has been reported in animals fed lindane or alpha, beta, or technical-grade BHC and liver cancer has been reported in rodents which received long-term administration of these compounds (ATSDR *Toxicological Profile for α,β,γ, and δ-Hexachlorocyclohexane*, 1989).

Beta-BHC--There are no oral or inhalation RfD or RfC values listed in IRIS or HEAST for beta-BHC. Beta-BHC is listed as Class C - Possible Human Carcinogen. This classification is supported by an increase in benign liver tumors when mice were exposed to beta-BHC in the diet. The oral slope factor is listed in IRIS as 1.8E+00 $(mg/kg/day)^{-1}$ and the inhalation slope factor is listed in HEAST as 1.8E+00 $(mg/kg\text{-}day)^{-1}$. IRIS lists an inhalation unit risk of 5.3E-04 $(\mu g/m^3)^{-1}$.

Delta-BHC--Neither a RfD nor a slope factor is given for delta-BHC in IRIS or HEAST. It is classified as Group D - Not Classifiable as to Human Carcinogenicity.

6.4.4.4 Gamma-BHC (Lindane)

The oral RfD for gamma-BHC is listed in IRIS as 3.0E-04 mg/kg-day. This value is supported by a 12 week study which dosed rats with 0, 0.2, 0.8, 4, 20, or 100 ppm gamma-BHC in the diet. After 12 weeks, 15 animals/sex/group were sacrificed. The remaining rats were fed the control diet for an additional six weeks before sacrifice. Treatment-related effects were noted in mortality, hematology, clinical chemistry, and urinalysis. Rats receiving 20 and 100 ppm gamma-BHC were observed to have greater-than-control incidence of the following: liver hypertrophy, kidney tubular degeneration, hyaline droplets, tubular distension, interstitial nephritis, and basophilic tubules. Because these effects were mild or rare in animals receiving 4 ppm, this value represents a NOAEL. The reviewers of the study calculated the dose to be 0.29 mg/kg/day for males and 0.33 mg/kg/day for females based on measured food intake. A LOAEL of 20 ppm (converted to 1.55 mg/kg-day for males) was also established.

An uncertainty factor of 1,000 was used to determine the RfD for gamma-BHC. A factor of 10 each was employed for use of a subchronic assay, to account for interspecies variation and to protect sensitive human subpopulations. A confidence rating of medium is associated with the RfD for gamma-BHC. This rating reflects that the principal study used an adequate number of animals and measured multiple endpoints. There are no inhalation RfD or RfC values currently available. However, a risk assessment for development of an inhalation RfD is under review for this agent. HEAST listed the subchronic RfD as 3.0E-03 mg/kg-day.

Gamma-BHC is classified as a Group B2/C - Carcinogen. HEAST lists the oral slope factor as 1.3E+00 $(mg/kg\text{-}day)^{-1}$. No inhalation unit risk was given.

6.4.4.5 2,4-D

2,4-Dichlorophenoxyacetic acid (2,4-D) is a defoliant and a major component of Agent Orange. Studies in laboratory animals suggest that conjugates of 2,4-D induce allergic antibody production in mice following intraperitoneal exposure (Dean and Murray, 1991).

An oral RfD of 1.0E-02 mg/kg-day was listed in IRIS for 2,4-D. This value was based on a 90-day oral bioassay and a 1-year Interim Report from a 2-year oral bioassay conducted in rats. 2,4-D (97% pure) was added to lab chow and rats were fed doses calculated to be 0, 1, 5, 15, or 45 mg/kg-day for 91 days. The critical effects noted in the study were significantly reduced hemoglobin levels, hematocrit values, red blood cells, and reticulocyte levels (males only) at the 5 mg/kg-day dose. One and 5 mg/kg-day were established as the NOAEL and LOAEL, respectively. Statistically significant reductions in liver enzymes, LDH (lactate dehydrogenase), SGOT (serum glutamate oxylate transaminase), SGPT (serum glutamate pyruvate transaminase), and alkaline phosphatase were observed at week 14 in animals treated with 15 mg/kg-day. Histopathologic examinations indicated cortical and subcortical pathology. Statistically significant increases in kidney weight (absolute and relative) at 15 mg/kg-day and higher were also noted at the end of the treatment protocol.

In the second part of the study, mice were fed lab chow mixed with 2,4-D and received doses calculated to be 0, 5, 15, 45, or 90 mg/kg-day for 91 days. Increased weight of the adrenals in females (5 mg/kg-day) was the only adverse effect noted. Chronic toxicity and reproduction studies indicate that 2,4-D causes no adverse effects at doses up to 500 ppm in dogs (14.5 mg/kg-day), 1,250 ppm in rats (62.5 mg/kg-day), or at levels of 1,000 ppm in drinking water (50-100 mg/kg-day) in pregnant rats or their offspring. An uncertainty factor of 100 was used in derivation of the RfD to account for both interspecies and interhuman variability in lieu of specific data. A confidence rating in the RfD of medium reflects that a moderate number of animals of each sex was used,

multiple doses were given, and a number of parameters were examined. Several studies support both the observation of critical toxic effects and the levels at which they occur. HEAST lists a subchronic oral RfD of 1.0E-02 mg/kg-day.

USEPA has not classified 2,4-D as to its carcinogenic potential.

6.4.4.6 4,4'-DDD, 4,4'-DDE and 4,4'-DDT

Typically, people are not exposed to 4,4'-DDT, -DDD, or -DDE individually, but rather to a mixture of all three, since 4,4'-DDE and 4,4'-DDD are contaminants of and degradation and metabolic products of 4,4'-DDT. Therefore, the toxicities of DDT, DDE, and DDD should be considered jointly. The human and animal health effects that result from inhalation of 4,4'-DDT, -DDE, or -DDD are currently unknown. The health effects resulting from human exposure to 4,4'-DDT, -DDE, or -DDD in water are also unknown at this time. However, single human exposures to 4,4'-DDT, -DDE, or -DDD in food at doses of 214-571 ppm have resulted in headache, nausea, vomiting, increased heart rate, and convulsions. Long-term human exposures (18 months) to lower doses (22 ppm) of the three compounds in food caused no adverse health effects (ATSDR, *Toxicological Profile for p,p'-DDT, DDE, DDD*, 1989).

4,4'-DDD--The health effects resulting from exposure of animals to 4,4'-DDD in water are not known. A NOAEL of 26 mg/kg-day was identified during short-term exposure (1 week) of mice to 4,4'-DDD in the diet. Exposure of rats to 1221 mg/kg-day 4,4'-DDD for 16 days resulted in atrophy of the thymus. NOAELs of 165 and 107 mg/kg-day were identified in chronic studies (78 weeks) using rats and mice, respectively. However, at 85 mg/kg-day, exposure to 4,4'-DDD resulted in thyroid tumors in rats. In a separate study, exposure to 32.5 mg/kg-day 4,4'-DDD caused lung tumors in mice (ATSDR, *Toxicological Profile for p,p'-DDT, DDE, DDD*, 1989).

Neither IRIS nor HEAST list an oral RfD, inhalation RfD or inhalation RfC.

4,4'-DDD is a Group B2 - Probable Human Carcinogen. This classification is based on the induction of lung tumors in male and female mice, liver tumors in male mice and thyroid tumors in male rats. There are no human carcinogenicity data. The oral slope factor is 2.4E-01 $(mg/kg\text{-}day)^{-1}$. The supporting study used an adequate number of animals, but the slope factor was derived using tumor incidence data from one dose. There is no inhalation unit risk at this time.

4,4'-DDE--The health effects resulting from exposure of animals to 4,4'-DDE in water are not known. Exposure of mice (by gavage) to 26 mg/kg/day 4,4'-DDE for 24 hr/day for one week caused alterations in the liver. When rats were exposed to 28 mg/kg/day 4,4'-DDE by gavage on gestation days 15-19, a decrease in the weight of the ovaries was noted. A NOAEL of 42 mg//kg/day was identified in a long-term (78 weeks) study in which rats were fed 4,4'-DDE in the diet. Hamsters fed 41.5 mg/kg/day 4,4'-DDE for 128 weeks exhibited necrosis of the liver and when 4,4'-DDE was administered by gavage, tumors of the liver were observed. When mice were exposed to 19 mg/kg/day 4,4'-DDE in the diet for 78 weeks, liver tumors were also observed (ATSDR, *Toxicological Profile for p,p'-DDT, DDE, DDD*, 1989).

4,4'-DDE is classified as a group B2 - Probable Human Carcinogen. This classification is based on increased incidence of liver tumors including carcinomas in two strains of mice and in hamsters and thyroid tumors in female rats when 4,4'-DDE is given in the diet. Human data are not available. The oral slope factor is 3.4E-01 $(mg/kg/day)^{-1}$. This value is the geometric mean of six slope factors computed from incidence data by sex.

4,4'-DDT--The primary effect of short-term exposure to high levels of 4,4'-DDT is on the nervous system. Oral ingestion of large quantities of 4,4'-DDT have

resulted in excitability, tremors, and seizures in humans. Irritation of the eyes, nose, and ythroat have been reported by people who have come in contact with 4,4'-DDT. Exposure to low doses of DDT on a long-term basis has resulted in changes in the levels of liver enzymes involved in metabolism of drugs and chemicals but there was no indication that 4,4'-DDT caused irreversible damage (ATSDR *Toxicological Profile for p,p' - DDT, DDE, DDD*, 1989).

Studies conducted in laboratory animals suggest that exposure to 4,4'-DDT may have harmful effects on reproduction and may result in an increased occurrence of liver tumors. However, five studies of 4,4'-DDT exposure in humans did not show increases in the number of deaths or cancers (ATSDR, *Toxicological Profile for p,p' - DDT, DDE, DDD*, 1989). Increasing evidence indicates that pesticides, including 4,4'-DDT, can alter immune function in rodents although studies in humans are limited and ambiguous. In a study of pesticide formulators in India, 73% of workers exposed to 4,4'-DDT had altered levels of serum immunoglobulins although no increase in infections was noted (Dean, et. al., 1991).

The oral RfD for 4,4'-DDT is listed in IRIS as 5E-04 mg/kg-day. This value is based on a chronic rat feeding study in which 4,4'-DDT was provided in the diet. Weanling rats were fed commercial DDT in doses of 0, 1, 5, 10, or 50 ppm for 15-27 weeks. Increasing hepatocellular hypertrophy was seen at doses of 5 ppm and greater. Therefore, 5 ppm was established as a LOAEL. A NOAEL of 1 ppm (converted to 0.05 mg/kg-day) was also established in the study. An uncertainty factor of 100 was used to account for interspecies conversion and to protect sensitive human subpopulations (10x each). An uncertainty factor for subchronic to chronic conversion was not included because of corroborating chronic data in the data base. A confidence rating of medium was associated with the RfD and reflects that the principal study was adequate but of shorter duration than desired. There are no values for the inhalation RfD or RfC at this time. HEAST lists the subchronic oral RfD as 5.0E-04 mg/kg-day.

4,4'-DDT is classified as Group B2 - Probable Human Carcinogen. This classification is based on tumors (usually liver) in various mouse strains and three rat studies. Human carcinogenicity data is inadequate. The oral slope factor listed in IRIS is 3.4E-01 $(mg/kg\text{-}day)^{-1}$. The inhalation unit risk is listed in IRIS as 9.7E-05 $(mg/m^3)^{-1}$. HEAST lists an inhalation slope factor of 3.4E-01 $(mg/kg\text{-}day)^{-1}$.

6.4.4.7 Diesel Fuel

Fuels are complex hydrocarbon mixtures produced by distillation of crude oil. Therefore, they may contain hundreds of hydrocarbon components as well as additives. Diesel fuels are middle distillates that are composed of less volatile hydrocarbons, generally coming off the distillation column at temperatures of 150-360 °C. Diesel fuels consist primarily of C_9 and C_{20} hydrocarbons. Marine diesel fuels are comprised roughly of 13% paraffins, 44% aromatics, and 44% naphthalenes (NTP, 1986). Marine diesel fuel may also contain greater than 10% PAHs (polyaromatic hydrocarbons). Soluble, volatile components of these fuel mixtures may consist of benzene, toluene, xylenes, and ethylbenzene.

The data are sufficient to derive a provisional oral RfD for marine diesel fuel based on subchronic inhalation studies. Studies on marine diesel fuel were conducted in beagle dogs, Fischer-344 rats, and C57BL/6 mice. Animals were exposed continuously to 300 mg/m^3 marine diesel fuel for 90 days. A LOAEL of 50 mg/m^3 (converted to 81 mg/kg-day) was identified in the study. This value was based on findings of fatty changes in the livers of female C57BL/6 mice. A provisional RfD of 8.0E-03 mg/kg-day was calculated for diesel fuel. An uncertainty factor of 10,000 was used and accounts for five areas of uncertainty: variation between and within species, use of a LOAEL (in lieu of a NOAEL), extrapolation to chronic duration, and deficiencies in the database (10x each). Overall confidence in this provisional RfD is low reflecting that only two doses were examined, the failure to identify a NOAEL, and the use of subchronic inhalation studies for development of a chronic oral RfD (USEPA, 1992).

Based on the available data, diesel fuel can be classified as Group D - Not Classifiable as to Human Carcinogenicity. Epidemiological studies provided no conclusive evidence for carcinogenicity of diesel fuels to humans and skin painting studies in laboratory animals were inconclusive. Classification of a chemical in weight-of-evidence Group D precludes quantitative risk assessment (USEPA, 1992)

6.4.4.8 Dichloroprop

Dichloroprop is considered to be a moderately toxic herbicide (Hawley, 1981). The acute LD_{50} (Lethal Dose for 50% of experimental animals) is 800 mg/kg for rats and 400 mg/kg for mice. The acute percutaneous LD_{50} in mice is 1400 mg/kg. It is not an irritant to the eyes at 10 g/L or to skin at 24 g/L. In a 98-day feeding study conducted in rats, no toxic effects were observed in animals receiving 12.4 mg/kg-day although slight liver hypertrophy was observed at the 50 mg/kg-day dose (Worthington and Walker, 1983).

Neither IRIS nor HEAST list an oral RfD for dichloroprop. However, a risk assessment for this compound is currently under review by an USEPA work group.

6.4.4.9 Endrin

No long-term health effects have been noted in workers employed in endrin manufacture or field application that were exposed dermally or by inhalation. Endrin causes death within a few hours upon ingestion of large quantities. Acute studies demonstrate that death due to CNS stimulation is the primary acute lethal effect associated with endrin exposure. In less severe cases of exposure to high levels, endrin causes headache, dizziness, nausea, vomiting, nervousness, and confusion. Some of these symptoms can continue for weeks. Liver, kidney, heart, and brain damage was reported following oral and inhalation exposures. However, endrin is no longer used commercially and, therefore, the general public is not likely to encounter levels sufficient

to lead to toxic neurological effects or to cause death (ATSDR, *Toxicological Profile for Endrin/Endrin aldehyde*, 1990).

Studies conducted on laboratory animals confirm that the primary target organ for endrin toxicity is the brain and nervous system. Birth defects, such as abnormal bone formation, have been observed in some animals studies. These data suggest that endrin exposure during pregnancy could pose a human health risk to the developing fetus at relatively high levels, although no human data are available concerning the developmental effects of endrin (ATSDR, *Toxicological Profile for Endrin/Endrin aldehyde*, 1990).

It is not known whether endrin can be expected to increase the risk of humans for developing certain types of cancer. Studies using rodents and dogs indicated that endrin did not cause cancer in these animals. However, there were deficiencies in these studies that precluded accurately evaluating the carcinogenic potential of endrin (ATSDR, *Toxicological Profile for Endrin/Endrin aldehyde*, 1990).

IRIS lists the oral RfD for endrin as 3E-04 mg/kg/day. This value was derived from a chronic oral bioassay in dogs. Three to seven dogs/sex were fed diets containing 0.1, 0.5, 1.0, 2.0, or 4.0 ppm endrin for two years. The 2 and 4 ppm dose groups experienced occasional convulsions, slightly increased relative liver weights, and mild histopathological effects in the liver. The NOEL was 1 ppm while the LOAEL was 2 ppm. The 1 ppm dose was equivalent to 0.025 mg/kg/day. The uncertainty factor is 100 to account for uncertainty in the extrapolation of dose levels from animals to humans and for uncertainty in the threshold for sensitive humans. The confidence level is medium because information on reproductive effects is lacking. A subchronic RfD of 3E-04 is listed in HEAST.

Endrin is classified as Group D - Not Classifiable as to Human Carcinogenicity. This classification is based on the fact that it did not produce carcinogenic

effects in two strains of rats or three strains of mice when given orally. Several of the bioassays had inadequacies which cast doubt on the strength of the negative findings. Human carcinogenicity data is inadequate for use in classification. No slope factor was given for endrin.

6.4.4.10 Heptachlor Epoxide

Upon entering the body, heptachlor is metabolized to heptachlor epoxide and other related chemicals. Heptachlor is a major component of the pesticide chlordane. Information regarding human health effects from exposures to heptachlor is sparse. Tremors and convulsions have been reported in experimental animals exposed orally to high levels of heptachlor for short periods of time. Long-term exposure to heptachlor may adversely affect the liver. Animals fed heptachlor in an experimental setting have been reported to have enlarged livers, liver damage, kidney damage, and increased red blood cell count. Tremors and convulsions have also been reported in animals exposed to heptachlor on a long-term basis (ATSDR *Toxicological Profile for Heptachlor/Heptachlor Epoxide*, 1992).

Heptachlor epoxide is more harmful than heptachlor, primarily because of its ability to be stored in fat for long periods of time. The other breakdown products of heptachlor epoxide generally are less toxic. Long-term exposure to heptachlor epoxide may adversely affect the liver. Animals fed heptachlor epoxide in an experimental setting have been reported to have enlarged livers, liver damage, kidney damage, and increased red blood cell count.

Placental transfer of heptachlor epoxide has been reported following inhalation exposure. Heptachlor epoxide has also been identified in breast milk. This compound has been detected in stillborn infant brain, adrenal, lung, heart, liver, kidney, spleen, and adipose tissues. However, the studies reporting these findings were limited by lack of data concerning route, duration, extent of exposure, and number of cases

examined. No gross malformations were reported in any of the stillborn infants. Although a developing fetus could be exposed to heptachlor epoxide transplacentally, the existing data are inadequate to establish a relationship between exposure and human developmental toxicity (ATSDR *Toxicological Profile for Heptachlor/Heptachlor Epoxide*, 1992).

The oral RfD for heptachlor epoxide is listed as 1.3E-05 mg/kg-day in IRIS. This value is based on a chronic feeding study conducted in beagle dogs. Dogs from 23 to 27 weeks of age were fed diets containing 0,0.5, 2.5, 5, or 7.5 ppm of heptachlor epoxide for 60 weeks. The critical effect noted in the study was treatment-related increases in liver-to-body weight ratios. Effects were noted in both males and females and a LEL of 0.5 ppm was established. A NOAEL was not established in this study. An uncertainty factor of 1000 was used to account for inter- and intraspecies differences and to account for the fact that a NOAEL was not established in the study. The confidence associated with the oral RfD was low, reflecting that the principal study was of low quality and that the database on chronic toxicity is complete but consists of low quality studies. The subchronic RfD listed in HEAST is the same as the chronic RfD (1.3E-05 mg/kg-day) listed in IRIS.

Heptachlor epoxide is classified by the USEPA as Group B2 - Probable Human Carcinogen. Sufficient evidence exists from rodent studies in which liver carcinomas were induced in two strains of mice of both sexes and in CFN female rats. It is also structurally similar to several other liver carcinogens. There are no published epidemiologic evaluations of heptachlor epoxide. The oral slope factor listed in IRIS is 9.1E+00 $(mg/kg\text{-}day)^{-1}$. An inhalation unit risk of 2.63E-03 $\mu g/m^{-3}$ was calculated from oral data.

6.4.4.11 2-Hexanone

Workers exposed to 2-Hexanone for almost a year experienced weakness, numbness, and tingling in the skin of the hands and feet. In animals that ingested or breathed 2-Hexanone, weakness, clumsiness and paralysis were seen. Subchronic effects in animals that inhaled pure 2-Hexanone included nerve damage, weakness in the legs, a decreased number of white blood cells, and decreased weight of testes. Paralysis was seen in rats who ingested 2-Hexanone for more than 14 days and similar effects were seen after dermal contact (*Toxicological Profile for 2-Hexanone*, 1991).

An outbreak of distal polyneuropathy was reported in a fabric plant using 2-hexanone for about 10 months. Eight of 86 employees showing symptoms had weight losses of 3 to 60 pounds and moderate to severe neurological impairment. Other employees had mild sensory impairment and electrodiagnostic abnormalities. The concentration of 2-hexanone averaged 9.2 ppm in front of fabric printing machines and about 36 ppm behind the machines. After use of 2-hexanone was discontinued, weight gain was uniformly noted in those that had lost weight. Other chemicals, such as methyl ethyl ketone, may have been present in the atmosphere *(Toxicological Profile for 2-Hexanone*, 1991).

Developmental effects in rats exposed to 1,000 ppm or 2,000 ppm 2-hexanone (purity not stated) during gestation included hyperactivity in the young and decreased activity in the geriatric stage. Also noted was decreased rate of avoidance learning in puberty-aged females of treated dams and increased random movement in puberty-aged and adult offspring of treated dams (*Toxicological Profile for 2-Hexanone*, 1991).

Toxicity values for 2-hexanone were not available in IRIS or HEAST. An LD_{50} of 2,590 mg/kg was calculated for gavage administration of 2-hexanone to rats. No deaths occurred in 24 hours in rats given 1,500 mg/kg by gavage. The NOAEL for acute

exposure resulting in hepatic and renal effects was reported to be 1,500 mg/kg-day in rats. A LOAEL of 660 mg/kg-day was reported for a 90 day study resulting in weight loss in rats. For intermediate exposure (40 weeks), a NOAEL of 400 mg/kg-day resulting in hepatic and renal effects in rats was reported. In guinea pigs, a LOAEL of 600 mg/kg-day resulted in abnormal pupil response and in hens, a LOAEL of 100 mg/kg-day resulted in ataxia (*Toxicological Profile for 2-Hexanone*, 1991).

6.4.4.12 2-(2-Methyl-4-Chlorophenoxy)Propionic Acid

The RfD for 2-(2-methyl-4-chlorophenoxy)propionic acid (MCPP) is listed in IRIS as 1E-03 mg/kg/day. This is supported by a 90-day study in which rats were dosed with 0, 50, 150, or 450 ppm (0, 3, 9, or 26 mg/kg/day) MCPP in the diet. There was an increase in absolute and relative kidney weights in males and increased relative kidney weights in females at 150 ppm (9 mg/kg-day). Increased relative and absolute kidney weights in both sexes, increased creatinine levels in females and decreased glucose levels in males were observed at 450 ppm (26 mg/kg-day). The NOAEL established in this study was 3 mg/kg-day. A LEL (Lowest Effect Level) of 9 mg/kg-day was also established. An uncertainty factor of 1000 accounts for the inter- and intraspecies differences and for the duration of the study (10x each). An additional factor of 3 accounts for the lack of a second species toxicity feeding study (e.g. dog) and lack of a reproductive study in rats (total UF = 3000). The confidence level for the oral RfD is medium due to the lack of a second species and a reproductive study. HEAST lists a subchronic RfD of 1E-02 mg/kg/day.

No information on carcinogenicity is available in IRIS or HEAST at this time.

6.4.4.13 Methylene Chloride

Based on the results from experimental studies, exposure to methylene chloride vapors may cause eye irritation and cornea damage. One study reported these effects at 400 ppm, however, the effects usually disappeared within a few days. Inhalation of 300 ppm or greater concentrations of methylene chloride for short periods of time (3 to 4 hours), may result in a slight, but temporary hearing loss and slight vision impairment. Inhalation of higher concentrations (800 ppm) may result in slowed reaction time, loss of balance and stability, and decreased ability to perform tasks requiring fine motor skills. Longer exposures may cause dizziness, nausea, tingling or numbness of the fingers and toes, and drunkenness. In most cases, these effects disappear upon cessation of exposure. Studies conducted in experimental animals suggest that exposure to higher concentrations (greater than 1,000 ppm) can lead to unconsciousness and death (ATSDR, *Draft Toxicological Profile for Methylene Chloride*, 1992).

Inhalation of methylene chloride has been reported to cause changes in the liver and kidneys of animals but similar effects have not been observed in humans. Studies conducted with laboratory animals indicated that inhalation of methylene chloride does not cause birth defects or affect reproduction, even at high concentrations. Methylene chloride has not been associated with cancer in humans exposed to vapors in the workplace. However, inhalation of high concentrations for long periods of time did cause cancer in mice. No information was located in the available literature regarding the effects of methylene chloride in humans following oral exposure. Methylene chloride has resulted in the death of rats orally exposed to large quantities over a short period of time. No information was located on the health effects associated with dermal contact with methylene chloride (ATSDR, *Draft Toxicological Profile for Methylene Chloride*, 1992).

IRIS lists a chronic oral RfD of 6.0E-02 mg/kg-day. The subchronic RfD listed in HEAST is the same value. This is based on a chronic drinking water bioassay conducted in rats. Rats received 5, 50, 125 or 250 mg/kg-day methylene chloride for two years. Histologic alterations of the liver were evident at doses of 50 mg/kg-day or higher. The low dose of 5 mg/kg-day was established as a NOAEL.

An uncertainty factor of 100 was applied to account for intra- and interspecies variability to the toxicity in lieu of specific data (10x each). The level of confidence in the oral RfD is medium. This rating reflects that the critical study was well performed but that only a few studies support the NOAEL. HEAST listed both the chronic and subchronic inhalation RfC as 3.0E+00 mg/m^3. However, the chronic RfC is currently under review by USEPA work group and, therefore, the number may change.

USEPA has classified methylene chloride as a Group B2 - Probable Human Carcinogen. There is sufficient evidence of carcinogenicity in animals including increased incidence of hepatocellular neoplasms and alveolar/bronchiolar neoplasms in mice, benign mammary tumors in rats, salivary gland sarcomas in male rats and leukemia in female rats. However, the human carcinogenicity data are considered inadequate for use in classifying this compound. IRIS lists the oral slope factor as 7.5E-03 (mg/kg-day)$^{-1}$. IRIS also lists an inhalation unit risk factor of 4.7E-07 (μg/m^3)$^{-1}$.

6.4.4.14 4-Methyl-2-pentanone

High vapor concentrations of 4-methyl-2-pentanone (MIBK) cause irritation of the conjunctiva and mucous membranes of the nose and throat. Narcosis may occur with additional symptoms of weakness, headache, nausea, light headedness, vomiting, dizziness, and incoordination.

Rats, mice, and dogs exposed to 100 and 200 ppm MIBK exhibited no signs of toxicity during two weeks of exposure. Increased relative and absolute kidney weights

were reported. Increased absolute liver weights were noted at the 200 ppm dose. Microscopic examination revealed toxic nephrosis of the proximal tubules in rats at both doses.

Twelve men and women were subjected to various concentrations of MIBK for 15 minute time periods in a sensory threshold study. Most subjects considered 100 ppm to be satisfactory for 8 hours. MIBK vapor was irritating to the eyes at 200 ppm.

A group of workers exposed to 100 ppm of MIBK during the waterproofing of boots complained of headache and nausea. Tolerance to MIBK was developed by this group but was lost over the weekend when the workers were no longer exposed. Another group with similar exposures reported respiratory irritation. Based on these reports and the animal data cited, a time-weighted average threshold limit value (TWA-TLV) of 50 ppm and a STEL of 75 ppm were adopted to protect workers from the irritant effects of MIBK and its potential adverse effects on the kidney (ACGIH Documentation, 1986).

Neither IRIS or HEAST listed toxicity values for MIBK. USEPA has not classified MIBK as to carcinogenic potential.

6.4.4.15 Toluene

Toluene has the ability to dissolve fats. As a result, it causes pain when it comes in contact with the eye. Damage to the skin may occur upon dermal contact as a result of scattered loss of epithelial cells and solution of some of the fats that occur in these cells. Factory workers handling organic solvents such as toluene have been reported to have low sperm counts, abnormal sperm and varying degrees of infertility (Thomas, 1991). Toluene has also been reported to cause a decrement of pulmonary function (FEV_1) (Gordon and Amdur, 1991).

A chronic oral RfD value of 2.0E-01 mg/kg-day is listed in IRIS. The subchronic oral RfD listed in HEAST is 2.0E-00 mg/kg-day. These values are based primarily on a subchronic gavage study in which rats were administered varying doses of toluene for 13 weeks. All animals receiving the highest dose (5000 mg/kg) died within the first week. In males, absolute and relative weights of both the liver and kidney were significantly increased at doses greater than or equal to 625 mg/kg. Absolute and relative weights of the liver, kidney, and heart were significantly increased at doses greater than or equal to 1250 mg/kg in females. The NOAEL for this study was 312 mg/kg-day based on liver and kidney weight changes in male rats at 625 mg/kg. Because the exposure was for 5 days/week, this dose is converted to 223 mg/kg-day. The LOAEL was 625 mg/kg, which is 446 mg/kg-day when converted.

An uncertainty factor of 1000 was applied to derive the RfD to account for inter- and intraspecies extrapolations, for subchronic to chronic extrapolation and for limited reproductive and developmental toxicity data. The level of confidence in the oral RfD was medium. This rating reflects that a sufficient number of animals/sex were tested in six dose groups and that many parameters were studied, but that there was no reproductive study and that the oral studies were all subchronic. The chronic RfC of 4.0E-01 mg/m^3 has been verified according to the new interim methods for developing RfCs and is listed in IRIS. The subchronic inhalation RfC is listed in HEAST as 2.0E+00 mg/m^3.

USEPA has classified toluene as Group D - Not Classifiable as to Human Carcinogenicity. This classification reflects the lack of human carcinogenicity data and inadequate animal data. Therefore, no slope factor is listed.

6.4.4.16 2,4,5-Trichlorophenol

A chronic RfD for 2,4,5-trichlorophenol (2,4,5-T) of 1.0E-01 mg/kg-day is listed in IRIS. HEAST lists a subchronic RfD of 1.0E+00 mg/kg-day. These values are

based on a subchronic feeding study conducted in rats. Ten rats of each sex group were exposed to different levels (100-1000 ppm) of 2,4,5-T in the diet for 98 days. The critical effects observed in the study were liver and kidney pathology. Mild diuresis and degenerative changes in the liver and kidneys were observed in rats of both sexes in the 3000 ppm and higher dose groups. Therefore, a LOAEL of 3000 ppm was established. 1000 ppm of diet (or 100 mg/kg-day based on food consumption as 10% of body weight in young adults) was considered to be a NOAEL based on behavior, mortality, food consumption, growth, body and organ weights, and histopathology.

An uncertainty factor of 1000 was applied to derive the RfD and accounts for both intra- and interspecies variability to the toxicity of 2,4,5-T in lieu of specific data (10x each) and for extrapolation of a subchronic effect level to its chronic equivalent. The confidence in the RfD is low reflecting that an adequate number of doses were employed and several parameters were monitored but that only a few animals were tested per dose and that additional chronic/reproductive toxicity studies are needed. This was the only subchronic oral study in rodents found in the available literature. Until further chronic/reproductive studies become available, this RfD is recommended. The health effects of 2,4,5-T were reviewed by the USEPA RfD/RfC workgroup and determined to be inadequate for derivation of an inhalation RfC. The status of the chronic RfC for this substance is currently not verifiable.

The USEPA has not classified 2,4,5-T as to its carcinogenicity.

6.4.4.17 Xylenes

Short-term exposure of humans to high levels of xylene or chemical mixtures containing xylene causes irritation of skin, eyes, nose, and throat, increased reaction time to visual stimuli, impaired memory/stomach discomfort, and possible changes in the liver and kidneys. Short-term exposure of individuals to very high concentrations of xylene can result in death. Both short- and long-term exposure of

humans to xylenes can also cause a number of effects on the nervous system such as headaches, lack of muscle coordination, dizziness, confusion, and loss of balance (ATSDR, *Toxicological Profile for Total Xylenes*, 1990).

Information obtained from experimental studies conducted on animals is not adequate to determine whether xylene causes human cancer. However, studies on animals indicate that xylene may cause increased numbers of deaths, decreased weight, skeletal changes, delayed skeletal development, birth defects, and enzyme changes in organs of unborn animals (ATSDR, *Toxicological Profile for Total Xylenes*, 1990).

An oral RfD of 2.00E+00 mg/kg-day is listed in IRIS for the xylenes. This value is based on a chronic rat gavage study in which males and females were given doses of 0, 250, or 500 mg/kg/day, 5 days/week for 103 weeks. In addition, similar studies were conducted in male and female mice at doses of 0, 500, or 1000 mg/kg/day. A dose-related increase in mortality was observed in male rats at the high-dose level (500 mg/kg-day converted to 357 mg/kg-day). Increases in mortality were also seen at the 250 mg/kg-day dose (converted to 179 mg/kg-day) but these increases were not statistically significant. Many of the early deaths were caused by gavage error. Mice given the high-dose (1000 mg/kg-day) exhibited CNS toxicity (hyperactivity). No treatment-related histopathologic lesions were observed and the high-dose (500 mg/kg-day) is a FEL (Frank Effect Level) and the low dose (250 mg/kg-day) a NOAEL. An uncertainty factor of 100 was chosen for species extrapolation and to protect sensitive individuals (10x each). A confidence rating of medium was given for the RfD even though the study was well designed and contained adequately sized groups of two species which were tested over a substantial portion of their lifespan. This rating reflects the fact that clinical chemistries, blood enzymes, and urinalyses were not performed. HEAST lists a subchronic RfD of 4.0E+00 mg/kg-day.

EPA classifies xylene as Group D - Not Classifiable as to Human Carcinogenicity due to an inability of orally administered technical grade xylene to induce increased tumor response in rats and mice and lack of human data.

6.4.4.18 Zinc

Zinc is an important essential element and is only acutely toxic at relatively high levels. For most species, overt signs of toxicoses appear around 1000 ppm in a natural-ingredient diet. Signs of intoxication may include gastrointestinal distress, emesis, decreased food consumption, decreased growth, anemia, poor bone mineralization, damage to the pancreas, arthritis, and internal hemorrhaging. Patients taking 10 times the Recommended Daily Allowance for zinc for a chronic duration have not shown any adverse health effects. Long-term inhalation exposure may produce gastrointestinal disturbances, clinically latent liver dysfunction, or bouts with metal fume fever (Carson, et al., 1987); however, there is limited evidence in humans or laboratory animals supporting this (ATSDR, *Toxicological Profile for Zinc*, 1989).

IRIS lists an oral RfD of 3.0E-01 mg/kg-day for zinc. This value was based on a clinical study which investigated the effects of oral zinc supplements on copper and iron balance. This study is supported by several other studies which indicate that zinc supplementation can alter copper and iron biochemistry. Alterations in iron and copper balance are of concern since deficiencies have the potential to cause significant adverse effects such as anemia and alterations in high density lipoproteins, antioxidant defense mechanisms, and various enzyme activities. Declines in serum ferritin and hematocrit values have also been noted.

An intake of 50 mg/day (1.0 mg/kg-day) of supplemental zinc is considered a LOAEL. Healthy men given 25 mg of zinc twice daily for a 6-week duration displayed a significant decrease in erythrocyte superoxide dismutase. A NOAEL was not established in this study. An uncertainty factor of 3 was used in derivation of the RfD

based on a minimal LOAEL from a moderate duration study of the most sensitive humans and consideration of a substance that is an essential nutrient. A confidence rating in the RfD of medium reflects that the clinical studies were well-conducted and investigated numerous biochemical parameters but that only a few people were tested. HEAST lists a subchronic RfD of 2.0E-01 mg/kg-day. This is based on a human study in which 2.14 mg/kg-day of zinc was administered for therapeutic reasons. Anemia was the critical effect.

Zinc is classified as Group D -- Not Classifiable as to Human Carcinogenicity. This classification reflects the lack of both human and animal evidence.

6.4.5 Uncertainties Associated with Toxicity Information

Toxicity information for some of the chemicals of concern for this risk assessment was limited. Therefore, varying degrees of uncertainty are associated with the toxicity values presented in this document. Uncertainty associated with toxicity values used in this risk assessment arises from several sources.

A primary source of uncertainty results from the use of information obtained from alternate sources when USEPA-verified toxicity values are not available. It is difficult to assign a level of confidence to these values, although it is appropriate and necessary to use them. Greater uncertainty would result if chemicals that do not have published toxicity values were to be excluded from the assessment.

Physical and chemical descriptions of the exposure atmospheres, amounts to which individuals are exposed, and tissue retention patterns are generally not available for accidental human exposures. Therefore, studies conducted on laboratory animals (under controlled experimental conditions) must, of necessity, be used to provide the exposure, dose, and biological effects data needed to evaluate the toxicity of potentially hazardous materials to which humans may be exposed. However, there are striking

differences between laboratory animals and humans in anatomy and physiology. These differences are sources for variation in the toxic responses exhibited between different species. Complicating extrapolations from animals to man are differences in life span, body size, metabolic routes, and routes of exposure. Occasionally adjustments are made, on a case-by-case basis, for species differences in the rate of metabolism or retention within tissues. However, comparisons between species are usually made by use of standardized sizes or weights. These dose terms do not scale-up identically and are in some cases sources of uncertainty themselves.

Another source of uncertainty related to toxicity information is the use of dose-response information from effects observed at high doses to predict adverse health effects that may occur at the low levels to which humans are likely to be exposed in the environment. Sources of uncertainty occur in the USEPA potency estimates (slope factors) when they are applied to humans exposed to levels of putative carcinogens far below those administered to laboratory animals under experimental conditions. Many substances induce or enhance cancer in animals through processes for which a possible threshold can be identified. These effects usually only occur at very high doses and assuming that a lesser degree of the same effect occurs at lower doses is not necessarily an accurate portrayal of toxicity. This assumption may result in gross overestimation of the health risks associated with a particular chemical.

Two major factors that influence toxicity of chemicals are the duration and frequency of exposure. For many agents, the toxic effects following a single exposure are quite different from those produced by repeated and long-term exposures. In general, fractionation of the dose (or exposure) of a chemical reduces its toxicity. Therefore, a single exposure to a substance may produce an immediate severe effect and yet the same dose divided into multiple exposures may produce an attenuated response or no response at all. Such fractionation effects are generally the result of excretion between successive doses or to partial or full reversal of the injury produced by each exposure prior to the next exposure. Chronic (long-term) toxic effects occur if a chemical accumulates

(absorption exceeds excretion), if it produces irreversible toxic effects, or if there is insufficient time for the individual to recover from the injury within the exposure interval. Therefore, use of information obtained from short-term exposure studies to predict health effects in humans exposed on a long-term basis may be a source of uncertainty.

Uncertainties arise when information gathered in studies using homogenous animal populations (inbred strains) or healthy human populations (occupational exposures) to predict the effects that are likely to occur in the general human population. Human populations are a heterogenous group with variations in genetic constitution, diet, living environments (previous environmental exposures), activity patterns, and cultural patterns. All of these factors may influence metabolism, distribution of chemicals within the body, and susceptibility to the damaging effects of those chemicals. It is now well established that individuals exposed to several chemicals simultaneously or sequentially may exhibit altered pharmacologic or toxicologic responses. Interactions have been noted with respect to hepatotoxicity. For example, many of the chlorinated solvents induce enzymes in the liver that are involved in metabolism of chemicals. Therefore, an individual who is exposed to these chemicals may experience increased or decreased toxicity subsequent to exposure to other chemicals that undergo metabolism.

6.4.6 Summary of Toxicity Assessment

An understanding of the degree of uncertainty associated with toxicity information is an important part of interpreting and using that information to calculate toxicity values. The degree of confidence ascribed to toxicity values depends on both the quality of the critical study from which it was derived and the quantity of supporting data. USEPA-verified RfDs published in IRIS are accompanied by a statement of the confidence that the evaluators have in the RfD. A discussion of confidence ratings and USEPA's classification as to carcinogenicity are presented below.

Oral RfD values were available for 15 of the 21 individual contaminants of potential concern. Diesel fuel was the only chemical for which EPA-derived toxicity values were available that was not published in IRIS or HEAST. USEPA has derived a provisional oral RfD for diesel fuel. This value was obtained from a USEPA memorandum in response to a request for oral systemic and carcinogenic toxicity values for JP-4, JP-5, diesel fuel, and gasoline (AVGAS) found to contaminate soils and groundwater at McChord AFB (Wash Rack/Treatment), Tacoma, WA. The level of confidence in the 13 RfDs given on IRIS ranged from low (one chemical) to medium (five chemicals). One RfD (4-Methyl-2-pentanone) was obtained from HEAST, which does not provide information regarding the level of confidence associated with RfDs. Confidence in the provisional RfD for diesel fuel developed by the USEPA was low. Low confidence indicates that the toxicity value may change if additional toxicity data become available. Oral RfDs were not available for six chemicals of potential concern.

Inhalation RfCs were available only for toluene and methylene chloride. Confidence ratings cannot be ascribed to these values.

Fifteen of the 21 contaminants of potential concern have been classified by the USEPA as to carcinogenic potential. Seven chemicals were classified as Group D (Not Classifiable as to Human Carcinogenicity), indicating inadequate or no evidence of carcinogenicity. One of the chemicals of concern (β-BHC) was classified as Group C (Possible Human Carcinogen) based on limited evidence of carcinogenicity in animals and inadequate or lack of human data. Six chemicals were classified as Group B (Probable Human Carcinogen), indicating that there is sufficient evidence of the chemical's carcinogenicity in animals and inadequate or no evidence in humans. One chemical (γ-BHC) was classified as Group B2/C because of uncertainty about its weight-of-evidence classification. No chemicals were classified as Group A (Human Carcinogen) or Group E (Evidence of Noncarcinogenicity for Humans).

USEPA-derived oral slope factors were available for all of the chemicals of potential concern that have been classified as Group A, B, or C carcinogens. Inhalation slope factors (USEPA-derived) were available for two chemicals. Inhalation unit risk factors were available for six of the chemicals.

6.5 Risk Characterization

Risk characterization involves integrating the possible exposure pathways and estimated chemical intakes with the appropriate toxicity values to form quantitative and qualitative expressions of potential health risk. Measured contaminant exposure levels, as well as those predicted by fate and transport modeling, are compared to chemical-specific toxicity information to determine if current or future levels of contamination, at or near the site, warrant concern for human health. The following subsections briefly describe the methodology used to characterize risk, present and future noncarcinogenic and carcinogenic risk estimates for each exposure scenario, uncertainties associated with predicting risk, and identify the key chemicals of potential concern and exposure pathways that drive the risk assessment.

6.5.1 Risk Characterization Methodology

6.5.1.1 Carcinogenic Effects

The cancer slope factor converts estimated daily intakes to an estimate of incremental risk. Because the slope factor is often an upper 95th percentile confidence limit of the probability of a response based on experimental animal data and an assumption of linearity in the low dose portion of a dose-response curve, the carcinogenic risk estimate is generally an upper-bound estimate. This means "true risk" probably does not exceed the risk estimates generated in this assessment and is likely to be less than the predicted risk (USEPA, 1991).

For carcinogens, probabilities that an individual will develop cancer over a lifetime of exposure are estimated from projected exposure and the cancer slope factor. Exposure is quantified as the amount of a chemical available at the exchange boundary (i.e., skin, lungs, etc.) and available for absorption. The carcinogenic risk is calculated for each exposure scenario using the following equation:

$$\text{Risk} = \text{Exposure} \times \text{Slope Factor.}$$

The USEPA Superfund site remediation goal set forth in the NCP allows a cancer risk of 1.0E-5 (1 in 10,000) to 1.0E-8 (1 in 10,000,000). This range is designed to be protective of human health.

6.5.1.2 Noncarcinogenic Effects

To characterize potential noncarcinogenic effects, comparisons are made between projected intakes of substances over a specified time period and toxicity values, primarily oral, dermal, and inhalation reference doses. The ratio of exposure to toxicity value is the hazard quotient (HQ) and the HQ is calculated for each exposure scenario using the following equation:

$$\text{HQ} = \text{Exposure/RfD or RfC}$$

Note that the HQ is not a statistical probability of a noncarcinogenic effect occurring and should not be interpreted as such. If the exposure level exceeds the appropriate toxicity value (i.e., the hazard quotient is greater than one), there may be cause for concern regarding the potential noncarcinogenic effects as set forth in the NCP.

6.5.2 Potential Exposure Scenarios

To ensure adequate characterization of risk that may be incurred at Landfill No. 4 presently or in the future, two chronic scenarios and one subchronic scenario were identified for human exposure. The chronic exposure scenarios are: 1) off-site residential; and 2) on-site worker. The subchronic exposure scenario is for the on-site worker.

6.5.3 Combining Risks Associated with Chemicals and Exposure Pathways

For each scenario addressed in this risk assessment, the estimated carcinogenic risk for potential carcinogens is generated on a chemical-specific basis for each relevant pathway of exposure. The estimated risk is then summed for each chemical associated with a specific pathway to determine total risk by pathway. To determine the total exposure scenario risk, total risks for all pathways are summed.

The total risk number assumes that different carcinogens affect the same target organ to produce a cancer response, ignoring potential antagonistic or synergistic effects or disparate effects on different target organs. It also assumes that the individual in the exposure scenario is exposed to site-related contaminants at estimated exposure concentrations by all pathways that compose the scenario. The scenarios were constructed to include all potential pathways of exposure and it is possible for a single individual to be exposed by all pathways in a scenario. It is less likely, however, that a single individual will be exposed by each pathway at the conservatively estimated concentrations in the exposure media. For example, it is unlikely that an individual would be chronically exposed to maximum on/off-site ambient air concentrations and to maximum off-site concentrations predicted in agricultural products, because the sources of contamination are in different locations.

Likewise, the estimated hazard quotient for noncarcinogenic effects is generated on a chemical-by-chemical basis for each relevant pathway of exposure. The hazard quotients are then summed for each chemical associated with a specific pathway to determine the hazard index by pathway. The hazard indices for all pathways are finally summed to determine the total hazard index for the exposure scenario.

6.5.4 Documentation of Risk Characterization Results

The exposure and risk calculations were performed by a model (QSMART) developed by Radian to automate the exposure quantification and risk characterization process. The model automates the equations for chemical intake and generates chemical-specific hazard indices for noncarcinogenic effects using RfDs and chemical-specific carcinogenic risk estimates using cancer slope factors. The model sums the resultant values for chemicals in each of the exposure pathways, and across pathways, to generate a total scenario hazard index for noncarcinogenic effects and a total scenario cancer risk for carcinogenic effects. The program also calculates the percentage of the total risk contributed by each individual chemical and pathway of exposure. Appendix I contains the exposure and risk model output.

6.5.5 Risk Characterization for the Present Off-Site Residential Exposure Scenario

This scenario addresses pathways of exposure considered to be complete for off-site residents at the present time based on current use of the land and water. It assumes that land and water use will not change significantly over the duration of exposure.

The present off-site residential scenario assumes exposure to site-related contaminants at off-base locations via three pathways of exposure: 1) ingestion of fruits and vegetables; 2) ingestion of meats and dairy products; and 3) inhalation of volatiles

and particulates in the ambient air. There is little likelihood that contaminants detected in the soil at Landfill No. 4 will impact off-site surface soils because there is no feasible migration pathway. Therefore, surface soil pathways are not applicable. Currently, one farmer uses surface water drawn from the playa lake for agricultural purposes. Widespread exposure resulting from dermal contact or inhalation of volatiles is unlikely because of the single user of this potentially contaminated source. Therefore, these pathways have not been included in this risk assessment.

Exposure concentrations were based on: 1) modeled on-site concentrations in surface water for purposes of predicting uptake and accumulation in fruits, vegetables, meat, and dairy products; 2) predicted contaminant concentrations in groundwater; and 3) predicted contaminant concentrations in ambient air, based on concentrations in on-site surficial and deep soil samples.

Carcinogenic effects were estimated for adults only. Chronic exposure was evaluated for 1) an average case, using average or 50th percentile values for exposure parameters (e.g., contaminant concentration, body weight, intake rates, exposure duration and frequency); and 2) a reasonable maximum case, using the 95th (occasionally 90th) percentile values for exposure parameters when available and appropriate. Noncarcinogenic effects were evaluated for adults and children with both average and reasonable maximum exposure parameters.

Several chemicals were detected in surficial soil samples and were therefore modeled to the playa lake in order to estimate the potential contribution of surface runoff from Landfill No. 4 to human exposure scenarios associated with the site. based on modeled air emission results, several chemicals are predicted to enter the atmosphere above the site via volatilization or wind entrainment of contaminated dust.

6.5.5.1 Carcinogenic Effects

Adults--Tables 6-8 and 6-9 characterize the average and reasonable maximum carcinogenic risk for adults, respectively. The total hazard indices for average and reasonable maximum exposure were 1E-9 and 1E-8, respectively. These hazard indices are well within the Superfund site remediation risk range goal and suggest that contaminants migrating off-site are not likely to cause adverse carcinogenic health effects in residential adults under current exposure conditions. Aldrin contributes 81% and 86% of the average and reasonable maximum chemical-specific risk, respectively. Ingestion pathways contribute the majority of the risk for average and reasonable maximum exposure scenarios. Ingestion of fruit, vegetables, meat, and milk contribute 26%, 47%, 16%, and 11%, respectively, of the pathway-specific risk for average exposure and 18%, 34%, 31%, and 18% of the pathway-specific risk for reasonable maximum exposure.

6.5.5.2 Noncarcinogenic Effects

Adults--Tables 6-10 and 6-11 characterize the average and reasonable maximum noncarcinogenic risk for adults, respectively. The total hazard indices were 2E-3 and 5E-3 for average and reasonable maximum exposure, respectively. These hazard indices suggest that contaminants migrating off-site are not likely to cause adverse noncarcinogenic health effects in residential adults under current exposure conditions. Zinc contributed 64% of the average and 83% of the reasonable maximum chemical-specific risk. Methylene chloride contributed 26% and 12% of the average and reasonable maximum chemical-specific risks. The inhalation pathway contributed 35% of the total average risk. Ingestion of meat contributed 47% of the total reasonable maximum risk.

USEPA recommends comparing the concentrations of chemicals in ambient air with a reference concentration (RfC) rather than a reference dose (RfD) for

Table 6-8

Average Cancer Risk for Off-Site Residential Adult - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Aldrin	2E-15	3E-10	6E-10	2E-10	2E-10	1E-09	81
beta-BHC	1E-16	6E-11	1E-10	4E-13	4E-13	2E-10	11
gamma-BHC	8E-18	5E-11	9E-11	2E-13	2E-13	1E-10	8
4,4'-DDD	0E+00	3E-14	6E-14	2E-13	1E-13	3E-13	<1
4,4'-DDE	0E+00	1E-13	2E-13	3E-13	2E-13	8E-13	<1
4,4'-DDT	4E-17	1E-13	2E-13	3E-12	2E-12	5E-12	<1
Methylene chloride	1E-13	0E+00	0E+00	3E-17	2E-17	1E-13	<1
Total by pathway	1E-13	4E-10	7E-10	3E-10	2E-10		
% Contribution by pathway	<1	26	47	16	11		
Scenario Total						1E-09	

Table 6-9

Reasonable Maximum Cancer Risk for Off-Site Residential Adult - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Aldrin	6E-15	2E-09	3E-09	4E-09	2E-09	1E-08	86
beta-BHC	4E-16	3E-10	6E-10	6E-12	5E-12	9E-10	8
gamma-BHC	3E-17	2E-10	5E-10	3E-12	2E-12	7E-10	6
4,4'-DDD	0E+00	2E-13	3E-13	2E-12	1E-12	4E-12	<1
4,4'-DDE	0E+00	5E-13	1E-12	5E-12	3E-12	9E-12	<1
4,4'-DDT	1E-16	5E-13	1E-12	4E-11	2E-11	6E-11	<1
Methylene chloride	4E-13	0E+00	0E+00	4E-16	3E-16	4E-13	<1
Total by pathway	4E-13	2E-09	4E-09	4E-09	2E-09		
% Contribution by pathway	<1	18	34	31	18		
Scenario Total						1E-08	

Table 6-10

Average Non-Cancer Risk for Off-Site Residential Adult - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Acetone	0E+00	0E+00	0E+00	8E-14	5E-14	1E-13	<1
Aldrin	0E+00	5E-06	9E-06	4E-06	3E-06	2E-05	<1
gamma-BHC	0E+00	1E-06	2E-06	4E-09	3E-09	3E-06	<1
4,4'-DDT	0E+00	5E-09	9E-09	1E-07	9E-08	2E-07	<1
Endrin	0E+00	4E-08	7E-08	1E-07	3E-08	2E-07	<1
4-Methyl-2-pentanone	3E-07	0E+00	0E+00	0E+00	0E+00	3E-07	<1
Methylene chloride	6E-04	0E+00	0E+00	4E-13	3E-13	6E-04	26
Toluene	2E-04	0E+00	0E+00	5E-13	3E-13	2E-04	9
2,4,5-T	0E+00	0E+00	0E+00	4E-11	2E-11	6E-11	<1
Zinc	0E+00	2E-04	6E-04	5E-04	2E-04	2E-03	64
Total by pathway	8E-04	2E-04	6E-04	5E-04	2E-04		
% Contribution by pathway	35	8	25	24	9		
Scenario Total						2E-03	

Table 6-11

Reasonable Maximum Non-Cancer Risk for Off-Site Residential Adult - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Acetone	0E+00	0E+00	0E+00	3E-13	2E-13	5E-13	<1
Aldrin	0E+00	7E-06	1E-05	2E-05	1E-05	5E-05	<1
gamma-BHC	0E+00	1E-06	3E-06	2E-08	1E-08	4E-06	<1
4,4'-DDT	0E+00	7E-09	1E-08	6E-07	3E-07	9E-07	<1
Endrin	0E+00	6E-08	1E-07	5E-07	1E-07	7E-07	<1
4-Methyl-2-pentanone	3E-07	0E+00	0E+00	0E+00	0E+00	3E-07	<1
Methylene chloride	6E-04	0E+00	0E+00	2E-12	1E-12	6E-04	12
Toluene	2E-04	0E+00	0E+00	2E-12	1E-12	2E-04	4
2,4,5-T	0E+00	0E+00	0E+00	2E-10	8E-11	2E-10	<1
Zinc	0E+00	3E-04	9E-04	2E-03	7E-04	4E-03	83
Total by pathway	8E-04	3E-04	9E-04	2E-03	8E-04		
% Contribution by pathway	16	6	18	47	14		
Scenario Total						5E-03	

assessing inhalation exposure (USEPA, 1990). USEPA has been involved for the last three years in developing a method for derivation of inhalation RfCs. This decision was meant to more clearly distinguish between oral and inhalation exposure. Currently, RfCs are available only for a limited number of compounds. Inhalation RfCs were not available for some contaminants predicted to enter the atmosphere via volatilization (acetone, diesel fuel, 2-hexanone, hydrocarbons, 2,4,5-T and xylenes) or wind entrainment of contaminated surface soil (aldrin, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, dichloroprop, endrin, heptachlor epoxide, MCPP, β-BHC, δ-BHC, γ-BHC, and zinc). Therefore, the contribution of these chemicals to the total noncarcinogenic risks associated with the inhalation pathway could not be assessed.

Children--Tables 6-12 and 6-13 illustrate the average and reasonable maximum noncarcinogenic risk for children, respectively. The hazard index was 7E-3 for average and 1E-2 for reasonable maximum exposure, suggesting that estimated exposure to children is unlikely to result in adverse noncarcinogenic health effects. Zinc contributed the majority (86% and 93% for average and reasonable maximum, respectively) of the chemical-specific risk. Ingestion of vegetables was responsible for 41% of the total risk for average exposure and ingestion of meat was responsible for 36% of the risk for reasonable maximum exposure.

6.5.6 Risk Characterization for the Present On-Site Worker Exposure Scenario

This scenario addresses pathways of exposure considered to be complete for an on-site worker at the present time. Surficial and deep soil samples were taken at the site. Laboratory analyses indicated contamination with a variety of chemicals, primarily pesticides, at depths ranging from 0 to 60 feet. The presence of snakes, small animals, and tall grasses indicates little or no disturbances by humans in the area. There are currently no invasive activities at the site. Therefore, direct human contact with contaminants in the soil is currently unlikely.

Table 6-12

Average Non-Cancer Risk for Off-Site Residential Child - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Acetone	0E+00	0E+00	0E+00	2E-13	2E-13	4E-13	<1
Aldrin	0E+00	2E-05	4E-05	9E-06	1E-05	8E-05	1
gamma-BHC	0E+00	4E-06	8E-06	9E-09	2E-08	1E-05	<1
4,4'-DDT	0E+00	2E-08	4E-08	3E-07	4E-07	8E-07	<1
Endrin	0E+00	2E-07	3E-07	2E-07	1E-07	8E-07	<1
Methylene chloride	6E-04	0E+00	0E+00	1E-12	2E-12	6E-04	9
4-Methyl-2-pentanone	3E-07	0E+00	0E+00	0E+00	0E+00	3E-07	<1
Toluene	2E-04	0E+00	0E+00	1E-12	1E-12	2E-04	3
2,4,5-T	0E+00	0E+00	0E+00	8E-11	1E-10	2E-10	<1
Zinc	0E+00	9E-04	3E-03	1E-03	9E-04	6E-03	86
Total by pathway	8E-04	9E-04	3E-03	1E-03	9E-04		
% Contribution by pathway	12	14	41	19	14		
Scenario Total						7E-03	

Table 6-13

Reasonable Maximum Non-Cancer Risk for Off-Site Residential Child - Present

Chemical	Inhalation of Ambient Air	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
Acetone	0E+00	0E+00	0E+00	8E-13	9E-13	2E-12	<1
Aldrin	0E+00	3E-05	6E-05	4E-05	5E-05	2E-04	1
gamma-BHC	0E+00	7E-06	1E-05	4E-08	6E-08	2E-05	<1
4,4'-DDT	0E+00	3E-08	7E-08	1E-06	2E-06	3E-06	<1
Endrin	0E+00	3E-07	5E-07	1E-06	5E-07	2E-06	<1
Methylene chloride	6E-04	0E+00	0E+00	5E-12	6E-12	6E-04	4
4-Methyl-2-pentanone	3E-07	0E+00	0E+00	0E+00	0E+00	3E-07	<1
Toluene	2E-04	0E+00	0E+00	5E-12	5E-12	2E-04	1
2,4,5-T	0E+00	0E+00	0E+00	4E-10	4E-10	8E-10	<1
Zinc	0E+00	1E-03	4E-03	6E-03	3E-03	1E-02	93
Total by pathway	8E-04	1E-03	4E-03	6E-03	3E-03		
% Contribution by pathway	5	9	28	36	22		
Scenario Total						1E-02	

The present on-site worker scenario assumes exposure to site-related contaminants via inhalation of contaminants emitted to the atmosphere above the site. Exposure concentrations were based on predicted concentrations at the site perimeter calculated from measured concentrations in surficial and deep soil samples taken from soil borings within the confines of the landfill. Concentrations of contaminants in the air are expected to be highest at this location.

On-site workers were assumed to be adults. Therefore, noncarcinogenic and carcinogenic effects were evaluated with both average and reasonable maximum exposure parameters. Noncarcinogenic effects were evaluated assuming both chronic (25 years) and subchronic (7 years) exposures.

6.5.6.1 Carcinogenic Effects

Tables 6-14 and 6-15 show the carcinogenic risk resulting from average and reasonable maximum on-site worker exposure, respectively. For average exposure, the risk value was 2E-14. The risk value associated with reasonable maximum on-site worker exposure was 7E-14. Both of these risk values are within the Superfund site remediation goal. Inhalation of methylene chloride accounts for 98% of the chemical-specific risk for both average and reasonable maximum exposure scenarios.

6.5.6.2 Noncarcinogenic Effects

Tables 6-16 and 6-17 illustrate the noncarcinogenic risks resulting from average and reasonable maximum on-site worker chronic exposure scenarios, respectively. Tables 6-18 and 6-19 characterize the noncarcinogenic risks resulting from average and reasonable maximum on-site worker subchronic exposure scenarios, respectively. The hazard indices for the average chronic and subchronic exposure scenarios were 5E-5 and 1E-3, respectively. The hazard indices associated with the

Table 6-14

Average Cancer Risk for On-Site Worker - Present

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Aldrin	3E-16	3E-16	<1
beta-BHC	2E-17	2E-17	<1
gamma-BHC	1E-18	1E-18	<1
4,4'-DDT	7E-18	7E-18	<1
Methylene chloride	2E-14	2E-14	98
Total by pathway	2E-14		
% Contribution by pathway	100		
Scenario Total		2E-14	

Table 6-15

Reasonable Maximum Cancer Risk for On-Site Worker - Present

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Aldrin	1E-15	1E-15	2
beta-BHC	8E-17	8E-17	<1
gamma-BHC	5E-18	5E-18	<1
4,4'-DDT	3E-17	3E-17	<1
Methylene chloride	7E-14	7E-14	98
Total by pathway	7E-14		
% Contribution by pathway	100		
Scenario Total		7E-14	

Table 6-16

Average Non-Cancer Risk for On-Site Worker - Present (Chronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	4E-05	4E-05	74
4-Methyl-2-pentanone	2E-08	2E-08	<1
Toluene	1E-05	1E-05	26
Total by pathway	5E-05		
% Contribution by pathway	100		
Scenario Total		5E-05	

Table 6-17

Reasonable Maximum Non-Cancer Risk for On-Site Worker - Present (Chronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	1E-04	1E-04	74
4-Methyl-2-pentanone	8E-08	8E-08	<1
Toluene	5E-05	5E-05	26
Total by pathway	2E-04		
% Contribution by pathway	100		
Scenario Total		2E-04	

Table 6-18

Average Non-Cancer Risk for On-Site Worker - Present (Subchronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	1E-03	1E-03	93
4-Methyl-2-pentanone	5E-08	5E-08	<1
Toluene	7E-05	7E-05	7
Total by pathway	1E-03		
% Contribution by pathway	100		
Scenario Total		1E-03	

Table 6-19

Reasonable Maximum Non-Cancer Risk for On-Site Worker - Present (Subchronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	4E-03	4E-03	95
4-Methyl-2-pentanone	2E-07	2E-07	<1
Toluene	2E-04	2E-04	5
Total by pathway	4E-03		
% Contribution by pathway	100		
Scenario Total		4E-03	

reasonable maximum chronic and subchronic exposure scenarios were 2E-4 and 4E-3, respectively. Inhalation of methylene chloride was responsible for 74% of the total risk associated with average and reasonable maximum chronic exposure. Inhalation of toluene contributed the other 26 percent. The risks associated with the subchronic exposure scenarios were calculated from maximum hourly average concentrations and therefore, resulted in higher hazard indices. Hourly averages are a function of local turbulence and meteorological conditions and represent the highest estimated air concentrations. Inhalation of methylene chloride was responsible for 93% and 95% of the total risk associated with average and reasonable maximum subchronic exposure, respectively. Inhalation of toluene contributed the rest of the risk.

6.5.7 Risk Characterization for the Future Off-Site Residential Exposure Scenario

This scenario addresses pathways of exposure considered to be complete for off-site residents at a point in the future, assuming that contaminants originating from Landfill No. 4 migrate to the groundwater. Although groundwater samples were not taken during the 1992 sampling event, groundwater modeling based on soil contaminant concentrations found at Landfill No. 4 indicated that future contamination of the groundwater with contaminants originating at Landfill No. 4 is likely to be insignificant. However, the groundwater ingestion, dermal contact and inhalation of vapor phase chemicals during domestic use pathways were included in this assessment in order to reflect the potential, although limited, for future exposure to contaminants present at Landfill No. 4. The scenario is based on predicted future lifetime exposures using current on-site contaminant concentrations in the soil and assuming that the release of contaminants will remain constant over time.

The future off-site residential scenario assumes exposure to contaminants via five exposure pathways: 1) ingestion of contaminated drinking water; 2) inhalation of vapor phase chemicals while showering; 3) dermal contact with residential water; 4)

ingestion of fruits and vegetables irrigated with contaminated groundwater; and 5) ingestion of meat and milk from farm animals exposed to contaminants in the groundwater and contaminated feed crops.

Exposure concentrations are based on: 1) predicted contaminant concentrations in groundwater (off-site), based on measured concentrations in deep soils and sediments and assuming steady state conditions; 2) predicted concentrations in the shower, based on predicted groundwater concentrations; 3) calculated uptake and accumulation in fruits, vegetables, meat, and milk, based on predicted groundwater concentrations; and 4) predicted contaminant concentrations in ambient air, based on soil concentrations.

Carcinogenic effects were estimated for adults only, using average and reasonable maximum exposure parameters. Noncarcinogenic effects were estimated for both adults and children, assuming average and reasonable maximum exposure parameters.

6.5.7.1 Carcinogenic Effects

Adults--The average and reasonable maximum carcinogenic risks for future off-site residential adults are presented in Tables 6-20 and 6-21, respectively. The total cancer risk for average exposure was 3E-12. The reasonable maximum cancer risk for this scenario was 1E-11. These values are well within the Superfund site remediation risk range for carcinogens and suggest that future off-site contaminant migration is not likely to result in a significant increase in the number of cancers in off-site residential adults as a result of exposure conditions. Ingestion of methylene chloride contaminated groundwater is responsible for the majority of the pathway- and chemical-specific risk for both average and reasonable maximum exposure (91% and 88% for average and reasonable maximum exposure, respectively). Dermal contact with methylene chloride

Table 6-20

Average Cancer Risk for Off-Site Residential Adult - Future

Chemical	Ingestion of Groundwater	Inhalation while Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	2E-75	4E-85	6E-77	6E-80	1E-79	1E-78	6E-79	2E-75	<1
4,4'-DDE	8E-19	0E+00	1E-21	2E-24	3E-24	3E-20	2E-20	9E-19	<1
4,4'-DDT	2E-52	2E-61	2E-55	2E-58	3E-58	3E-53	2E-53	2E-52	<1
Methylene chloride	3E-12	1E-21	3E-13	0E+00	0E+00	5E-18	4E-18	3E-12	100
Total by pathway	3E-12	1E-21	3E-13	2E-24	3E-24	5E-18	4E-18		
% Contribution by pathway	91	<1	9	<1	<1	<1	<1		
Scenario Total								3E-12	

Table 6-21

Reasonable Maximum Cancer Risk for Off-Site Residential Adult - Future

Chemical	Ingestion of Groundwater	Inhalation while Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	1E-74	4E-84	4E-76	3E-79	6E-79	1E-77	7E-78	1E-74	<1
4,4'-DDE	4E-18	0E+00	8E-21	9E-24	2E-23	5E-19	3E-19	5E-18	<1
4,4'-DDT	8E-52	1E-60	2E-54	9E-58	2E-57	5E-52	2E-52	1E-51	<1
Methylene chloride	1E-11	1E-20	2E-12	0E+00	0E+00	8E-17	5E-17	1E-11	100
Total by pathway	1E-11	1E-20	2E-12	9E-24	2E-23	8E-17	5E-17		
% Contribution by pathway	88	<1	12	<1	<1	<1	<1		
Scenario Total								1E-11	

while showering accounts for virtually all of the remaining risk for both average and reasonable maximum exposure.

6.5.7.2 Noncarcinogenic Effects

Adults--Tables 6-22 and 6-23 characterize the average and reasonable maximum noncarcinogenic risk for future off-site adults, respectively. The total hazard index was 1E-2 for average exposure and 2E-2 for reasonable maximum exposure. Both values are below the Superfund site remediation goal of 1 for noncarcinogens. These hazard indices suggest that contaminant migration off-site is not likely to cause adverse noncarcinogenic health effects in off-site residential adults under future exposure conditions. Ingestion of contaminated groundwater contributed the majority of the pathway-specific risk for the average exposure scenario (71%). Ingestion of meat contributed most of the pathway-specific risk (47%) associated with reasonable maximum exposure. Zinc was responsible for the majority of the chemical-specific risk (99%).

Children--The average and reasonable maximum noncarcinogenic risk for children living off-site under future exposure conditions are presented in Tables 6-24 and 6-25, respectively. The hazard indices for the average and reasonable maximum exposure scenarios were 3E-2 and 6E-2, both of which are below the Superfund site remediation goal for noncarcinogens. These hazard indices suggest that contaminant migration off-site is not likely to cause adverse noncarcinogenic health effects in off-site residential children under future exposure conditions. Ingestion of contaminated groundwater contributed the majority of the pathway-specific risk (75%) for the average exposure scenario while ingestion of meat contributed most of the pathway-specific risk (43%) associated with reasonable maximum exposure. Again, zinc was responsible for the majority of the chemical-specific risk (99%).

Table 6-22

Average Non-Cancer Risk for Off-Site Residential Adult - Future

Chemical	Ingestion of Groundwater	Inhalation while Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	4E-71	0E+00	1E-72	1E-75	2E-75	2E-74	1E-74	4E-71	<1
2,4-D	9E-05	0E+00	1E-07	9E-09	2E-08	5E-09	3E-09	9E-05	<1
4,4'-DDT	7E-48	0E+00	1E-50	8E-54	1E-53	1E-48	9E-49	9E-48	<1
Endrin	6E-41	0E+00	8E-44	2E-46	3E-46	3E-42	8E-43	6E-41	<1
Methylene chloride	5E-08	7E-12	5E-09	0E+00	0E+00	9E-14	7E-14	6E-08	<1
Zinc	7E-03	0E+00	1E-05	7E-07	2E-06	3E-03	5E-04	1E-02	99
Total by pathway	7E-03	7E-12	1E-05	7E-07	2E-06	3E-03	5E-04		
% Contribution by pathway	71	<1	<1	<1	<1	24	5		
Scenario Total								1E-02	

Table 6-23

Reasonable Maximum Non-Cancer Risk for Off-Site Residential Adult - Future

Chemical	Ingestion of Groundwater	Inhalation of Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	6E-71	0E+00	2E-72	2E-75	4E-75	9E-74	4E-74	6E-71	<1
2,4-D	1E-04	0E+00	2E-07	1E-08	2E-08	2E-08	1E-08	1E-04	<1
4,4'-DDT	1E-47	0E+00	2E-50	1E-53	2E-53	6E-48	3E-48	2E-47	<1
Endrin	8E-41	0E+00	2E-43	3E-46	5E-46	1E-41	3E-42	9E-41	<1
Methylene chloride	7E-08	2E-11	1E-08	0E+00	0E+00	4E-13	3E-13	8E-08	<1
Zinc	1E-02	0E+00	2E-05	1E-06	3E-06	1E-02	2E-03	2E-02	99
Total by pathway	1E-02	2E-11	2E-05	1E-06	3E-06	1E-02	2E-03		
% Contribution by pathway	44	<1	<1	<1	<1	47	8		
Scenario Total								2E-02	

Table 6-24

Average Non-Cancer Risk for Off-Site Residential Child - Future

Chemical	Ingestion of Groundwater	Inhalation of Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	1E-70	0E+00	4E-72	6E-75	1E-74	5E-74	6E-74	1E-70	<1
2,4-D	3E-04	0E+00	4E-07	4E-08	7E-08	1E-08	1E-08	3E-04	<1
4,4'-DDT	2E-47	0E+00	4E-50	4E-53	7E-53	3E-48	4E-48	3E-47	<1
Endrin	2E-40	0E+00	3E-43	9E-46	2E-45	8E-42	4E-42	2E-40	<1
Methylene chloride	2E-07	2E-11	2E-08	0E+00	0E+00	2E-13	3E-13	2E-07	<1
Zinc	2E-02	0E+00	4E-05	3E-06	1E-05	6E-03	2E-03	3E-02	99
Total by pathway	2E-02	2E-11	4E-05	3E-06	1E-05	6E-03	2E-03		
% Contribution by pathway	75	<1	<1	<1	<1	18	7		
Scenario Total								3E-02	

Table 6-25

Reasonable Maximum Non-Cancer Risk for Off-Site Residential Child - Future

Chemical	Ingestion of Groundwater	Inhalation while Showering	Dermal Contact While Showering	Ingestion of Fruits	Ingestion of Vegetables	Ingestion of Meat	Ingestion of Milk	Total	Percent Contribution
gamma-BHC	1E-70	0E+00	4E-72	9E-75	2E-74	2E-73	2E-73	1E-70	<1
2,4-D	3E-04	0E+00	4E-07	6E-08	1E-07	5E-08	5E-08	3E-04	<1
4,4'-DDT	2E-47	0E+00	4E-50	6E-53	1E-52	1E-47	2E-47	5E-47	<1
Endrin	2E-40	0E+00	3E-43	1E-45	2E-45	3E-41	1E-41	2E-40	<1
Methylene chloride	2E-07	2E-11	2E-08	0E+00	0E+00	9E-13	1E-12	2E-07	<1
Zinc	2E-02	0E+00	4E-05	5E-06	2E-05	3E-02	9E-03	6E-02	99
Total by pathway	2E-02	2E-11	4E-05	5E-06	2E-05	3E-02	9E-03		
% Contribution by pathway	42	<1	<1	<1	<1	43	15		
Scenario Total								6E-02	

6.5.8 Risk Characterization for the Future On-Site Worker Exposure Scenario

This scenario addresses pathways of exposure considered to be complete for an on-site worker at some time in the future. It was assumed that on-site contamination will not increase. However, CAFB is an expanding base and it is possible that land use at the site will change significantly in the future. The future on-site worker scenario assumes exposure to site-related contaminants via three pathways: 1) inhalation of contaminants in the air (volatilized chemicals or fugitive dust generation); 2) incidental ingestion of contaminated soil; and 3) dermal contact with contaminated soil.

Noncarcinogenic and carcinogenic effects were evaluated with both average and reasonable maximum exposure parameters. Noncarcinogenic effects were evaluated assuming both chronic (25 years) and subchronic (7 years) exposures. Carcinogenic effects were evaluated only for the chronic exposure scenario.

6.5.8.1 Carcinogenic Effects

Tables 6-26 and 6-27 show the carcinogenic risk resulting from average and reasonable maximum on-site worker exposure, respectively. For average exposure, the risk value was 1E-5. The risk value associated with reasonable maximum on-site worker exposure was also 2E-5. Dermal contact with aldrin contaminated soil accounts for the majority of the chemical- and pathway-specific risk. These risk values do not exceed the Superfund site remediation goal of 10^4 (1 in 10,000) for carcinogens and suggest that carcinogenic effects are not likely to occur as a result of this exposure scenario.

6.5.8.2 Noncarcinogenic Effects

Tables 6-28 and 6-29 illustrate the noncarcinogenic risks resulting from average and reasonable maximum on-site worker chronic exposure scenarios, respectively. Tables 6-30 and 6-31 summarize the noncarcinogenic risks associated with

Table 6-26

Average Cancer Risk for On-Site Worker - Future

Chemical	Inhalation of Ambient Air	Ingestion of Soil	Dermal Contact with Soil	Total	Percent Contribution
Aldrin	1E-15	1E-06	1E-05	1E-05	90
beta-BHC	1E-16	1E-07	1E-06	1E-06	9
gamma-BHC	7E-18	1E-10	1E-09	1E-09	<1
4,4'-DDD	0E+00	8E-11	8E-10	9E-10	<1
4,4'-DDE	0E+00	6E-11	6E-10	7E-10	<1
4,4'-DDT	3E-17	1E-09	1E-08	1E-08	<1
Methylene chloride	9E-14	2E-11	2E-10	2E-10	<1
Total by pathway	9E-14	1E-06	1E-05		
% Contribution by pathway	<1	9	91		
Scenario Total				1E-05	

Table 6-27

Reasonable Maximum Cancer Risk for On-Site Worker - Future

Chemical	Inhalation of Ambient Air	Ingestion of Soil	Dermal Contact with Soil	Total	Percent Contribution
Aldrin	3E-15	5E-06	1E-05	2E-05	90
beta-BHC	2E-16	5E-07	1E-06	2E-06	9
gamma-BHC	1E-17	4E-10	1E-09	1E-09	<1
4,4'-DDD	0E+00	3E-10	8E-10	1E-09	<1
4,4'-DDE	0E+00	2E-10	6E-10	8E-10	<1
4,4'-DDT	7E-17	4E-09	1E-08	1E-08	<1
Methylene chloride	2E-13	7E-11	2E-10	2E-10	<1
Total by pathway	2E-13	6E-06	1E-05		
% Contribution by pathway	<1	29	71		
Scenario Total				2E-05	

Table 6-28

Average Non-Cancer Risk for On-Site Worker - Future (Chronic)

Chemical	Inhalation of Ambient Air	Ingestion of Soil	Dermal Contact with Soil	Total	Percent Contribution
Acetone	0E+00	6E-07	6E-06	7E-06	<1
Aldrin	0E+00	7E-03	7E-02	8E-02	61
gamma-BHC	0E+00	7E-07	7E-06	8E-06	<1
4,4'-DDT	0E+00	2E-05	2E-04	2E-04	<1
2,4-D	0E+00	1E-06	1E-05	1E-05	<1
Diesel	0E+00	6E-04	6E-03	7E-03	5
Endrin	0E+00	7E-07	7E-06	8E-06	<1
Methylene chloride	2E-04	1E-07	1E-06	2E-04	<1
4-Methyl-2-pentanone	1E-07	3E-08	3E-07	4E-07	<1
MCPP	0E+00	4E-03	4E-02	4E-02	33
Toluene	6E-05	2E-08	2E-07	6E-05	<1
2,4,5-T	0E+00	4E-08	4E-07	4E-07	<1
Xylenes	0E+00	7E-10	7E-09	8E-09	<1
Zinc	0E+00	6E-05	6E-05	1E-04	<1
Total by pathway	3E-04	1E-02	1E-01		
% Contribution by pathway	<1	9	91		
Scenario Total				1E-01	

Table 6-29

Reasonable Maximum Non-Cancer Risk for On-Site Worker - Future (Chronic)

Chemical	Inhalation of Ambient Air	Ingestion of Soil	Dermal Contact with Soil	Total	Percent Contribution
Acetone	0E+00	2E-06	6E-06	8E-06	<1
Aldrin	0E+00	3E-02	7E-02	1E-01	61
gamma-BHC	0E+00	3E-06	7E-06	1E-05	<1
4,4'-DDT	0E+00	7E-05	2E-04	2E-04	<1
2,4-D	0E+00	4E-06	1E-05	1E-05	<1
Diesel	0E+00	2E-03	6E-03	8E-03	5
Endrin	0E+00	3E-06	7E-06	1E-05	<1
Methylene chloride	3E-04	4E-07	1E-06	3E-04	<1
4-Methyl-2-pentanone	2E-07	1E-07	3E-07	6E-07	<1
MCPP	0E+00	2E-02	4E-02	6E-02	33
Toluene	1E-04	7E-08	2E-07	1E-04	<1
2,4,5-T	0E+00	2E-07	4E-07	6E-07	<1
Xylenes	0E+00	3E-09	7E-09	1E-08	<1
Zinc	0E+00	3E-04	6E-05	3E-04	<1
Total by pathway	4E-04	5E-02	1E-01		
% Contribution by pathway	<1	29	71		
Scenario Total				1E-01	

Table 6-30

Average Non-Cancer Risk for On-Site Worker - Future (Subchronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	5E-03	5E-03	94
4-Methyl-2-pentanone	3E-07	3E-07	<1
Toluene	3E-04	3E-04	6
Total by pathway	5E-03		
% Contribution by pathway	100		
Scenario Total		5E-03	

Table 6-31

Reasonable Maximum Non-Cancer Risk for On-Site Worker - Future (Subchronic)

Chemical	Inhalation of Ambient Air	Total	Percent Contribution
Methylene chloride	9E-03	9E-03	94
4-Methyl-2-pentanone	5E-07	5E-07	<1
Toluene	6E-04	6E-04	6
Total by pathway	1E-02		
% Contribution by pathway	100		
Scenario Total		1E-02	

average and reasonable maximum on-site worker subchronic exposure scenarios. The hazard indices for average chronic and subchronic exposure scenarios were 1E-01 and 5E-03, respectively and are below the Superfund site remediation goal for noncarcinogens. Dermal contact with contaminated soil was responsible for 91% of the average pathway-specific risk associated with chronic exposure. Aldrin accounted for 61% of the average chemical-specific risk. Inhalation of methylene chloride accounted for the majority of the average chemical- and pathway-specific risk associated with subchronic exposure of workers to site-related chemicals. The hazard indices for reasonable maximum chronic and subchronic exposures were 1E-01 and 1E-02, respectively and are below the Superfund site remediation goal for noncarcinogenic substances. Dermal contact with contaminated soil was responsible for 71% of the reasonable maximum pathway-specific risk associated with chronic exposure. Aldrin accounted for 61% of the reasonable maximum chemical-specific risk. Inhalation of methylene chloride accounted for the majority of the reasonable maximum chemical- and pathway-specific risk associated with subchronic exposure of workers to site-related chemicals.

6.5.9 Major Factors Driving Risks

The results of this baseline risk assessment should not be interpreted as a characterization of absolute risk. The hazard index estimates discussed below highlight potential sources of risk at the site and support a no-action decision. Tables 6-32 and 6-33 identify the key chemicals and exposure pathways that drive the carcinogenic and noncarcinogenic risk, respectively. Discussions of the magnitude and nature of risks that potentially exist at Landfill No. 4 and the major uncertainties affecting the risk estimates are presented below.

6.5.9.1 Carcinogenic Effects

None of the estimated cancer risks for the various exposure scenarios exceed the Superfund site remediation goal of cancer risk range of 1E-4 (1 in 10,000) to

Table 6-32

Identification of Key Chemicals and Exposure Pathways that Drive the Carcinogenic Risk Assessment

Scenario	Total Scenario Risk	Chemicals that Contribute Chemical-Specific Risk (% Contribution)		Exposure Pathways that Contribute Pathway-Specific Risk (% Contribution)	
Off-Site Residential (Present)					
- Adult, Average	1E-09	Aldrin	(81)	Ingestion of vegetables	(47)
- Adult, Reasonable Maximum	1E-08	Aldrin	(86)	Ingestion of vegetables	(34)
On-Site Worker (Present)					
- Adult, Average	2E-14	Methylene chloride	(98)	Inhalation of ambient air	(100)
- Adult, Reasonable Maximum	7E-14	Methylene chloride	(98)	Inhalation of ambient air	(100)
Off-Site Residential (Future)					
- Adult, Average	3E-12	Methylene chloride	(100)	Ingestion of groundwater	(91)
- Adult, Reasonable Maximum	1E-11	Methylene chloride	(100)	Ingestion of groundwater	(88)
On-Site Worker (Future)					
- Adult, Average	1E-05	Aldrin	(90)	Dermal contact with soil	(91)
- Adult, Reasonable Maximum	2E-05	Aldrin	(90)	Dermal contact with soil	(71)

Table 6-33

Identification of Key Chemicals and Exposure Pathways that Drive the Non-Carcinogenic Risk Assessment

Scenario	Total Scenario Risk	Chemicals that Contribute Chemical-Specific Risk (% Contribution)		Exposure Pathways that Contribute Pathway-Specific Risk (% Contribution)	
Off-Site Residential (Present)					
- Adult, Average	2E-03	Zinc	(64)	Inhalation of ambient air	(35)
- Adult, Reasonable Maximum	5E-03	Zinc	(83)	Ingestion of meat	(47)
- Child, Average	7E-03	Zinc	(86)	Ingestion of vegetables	(41)
- Child, Reasonable Maximum	1E-02	Zinc	(93)	Ingestion of meat	(36)
On-Site Worker (Present)					
- Adult, Average					
Chronic	5E-05	Methylene chloride	(74)	Inhalation of ambient air	(100)
Subchronic	1E-03	Methylene chloride	(93)	Inhalation of ambient air	(100)
- Adult, Reasonable Maximum					
Chronic	2E-04	Methylene chloride	(75)	Inhalation of ambient air	(100)
Subchronic	4E-03	Methylene chloride	(95)	Inhalation of ambient air	(100)
Off-Site Residential (Future)					
- Adult, Average	1E-02	Zinc	(99)	Ingestion of groundwater	(71)
- Adult, Reasonable Maximum	2E-02	Zinc	(99)	Ingestion of meat	(47)
- Child, Average	3E-02	Zinc	(99)	Ingestion of groundwater	(75)
- Child, Reasonable Maximum	6E-02	Zinc	(99)	Ingestion of meat	(43)

Table 6-33

(Continued)

Scenario	Total Scenario Risk	Chemicals that Contribute Chemical-Specific Risk (% Contribution)		Exposure Pathways that Contribute Pathway-Specific Risk (% Contribution)	
On-Site Worker (Future)					
- Adult, Average					
Chronic	1E-01	Aldrin	(61)	Dermal contact with soil	(91)
Subchronic	5E-03	Methylene chloride	(94)	Inhalation of ambient air	(100)
- Adult, Reasonable Maximum					
Chronic	1E-01	Aldrin	(61)	Dermal contact with soil	(71)
Subchronic	1E-02	Methylene chloride	(94)	Inhalation of ambient air	(100)

1E-6 (1 in 1,000,000). None of the chemicals or exposure pathways contribute a chemical-specific or pathway-specific risk greater than or equal to 1 in 10,000. This indicates that significant increases in the number of cancers are unlikely to occur in potentially exposed populations as a result of contaminants originating from Landfill No. 4. However, the calculated risk values for the future on-site worker scenario (2E-05) are within the Superfund site remediation risk range goal. Ingestion of vegetables and meat contaminated with aldrin drives the present off-site residential carcinogenic risk. Inhalation of volatilized methylene chloride drives the present on-site worker carcinogenic risk, while dermal contact with aldrin contaminated soil drives the future on-site worker carcinogenic risk. Ingestion of methylene chloride contaminated groundwater drives the future off-site residential carcinogenic risk. However, it should be noted that the field investigation at Landfill No. 4 was conducted to determine whether contaminant migration has occurred at the site. Therefore, the risk assessment is based on projected contaminant migration from the site and not on contaminants (or concentrations) found within the landfill itself.

6.5.9.2 Noncarcinogenic Effects

All of the estimated noncarcinogenic hazard indices for the various exposure scenarios were below the Superfund site remediation goal of 1.0 for noncarcinogens. This indicates that adverse noncarcinogenic human health effects are unlikely to occur as a result of exposure to contaminants originating from Landfill No. 4. Again, it should be noted that the risk assessment for Landfill No. 4 was conducted based on projected contaminant migration from the site and not for contaminant concentrations found within the confines of the landfill itself.

6.5.9.3 Nature of Potential Risks at Landfill No. 4

Ingestion of aldrin drives the present off-site residential carcinogenic risk. No studies were located regarding cancer in humans after oral exposure to aldrin or its

toxic metabolite, dieldrin. A few epidemiological studies have examined cancer mortality in workers employed in the manufacture of these pesticides. However, it is not expected that ingestion would contribute significantly as a source of exposure since manufacturing practices limit such exposures. Several rodent bioassays report a positive carcinogenic response (hepatocellular carcinoma and hepatomas) following ingestion of aldrin and/or dieldrin. In addition to producing an increase in the incidence of hepatocellular carcinomas in mice, dieldrin has also been reported to significantly decrease the time to tumor development in rodents. A significant increase in follicular cell adenoma and carcinoma of the thyroid has also been observed in rodents following oral exposure to aldrin. The lowest dose reported to produce a tumorigenic response (Cancer Effect Level, CEL) in laboratory animals are 0.33 and 1.5 mg/kg-day for hepatocellular carcinoma and carcinoma of the thyroid, respectively. It is not known whether similar effects would be observed in humans exposed (orally) to aldrin and/or dieldrin. However, concentrations of aldrin or dieldrin ingested in the form of meats and vegetables resulting from contamination at Landfill No. 4 are likely to be much lower than these concentrations. Therefore, it can be safely assumed that off-site residents will not experience a significant increase in cancer incidence as a result of aldrin contamination at Landfill No. 4.

Methylene chloride drives the present on-site worker and the future off-site residential carcinogenic risks as well as the present and future (subchronic) on-site worker noncarcinogenic risks. The ingestion pathway drives the future off-site residential carcinogenic risks while the inhalation pathway drives other scenario risks. The toxic effects of methylene chloride are varied in nature. High levels of methylene chloride in air (above 500 ppm) can irritate the eyes, nose, and throat. Methylene chloride at this level can also affect the central nervous system, causing effects such as sluggishness, irritability, light headedness, nausea, and headaches. Some effects have been noted at concentrations as low as 300 ppm. However, these symptoms usually disappear soon after discontinuation of exposure. Results from animal studies suggest that frequent or lengthy exposures to methylene chloride may cause changes in the liver and kidney.

However, based on studies of exposed workers, it appears unlikely that methylene chloride will cause serious liver or kidney damage in humans unless exposure is very high. No liver or kidney damage in humans exposed to 30 and 125 ppm (104 to 435 mg/m^3) methylene chloride in the workplace for up to 30 years or 140 to 475 ppm for at least three months has been reported. The maximum hourly estimated methylene chloride concentration (0.05 $\mu g/m^3$) at Landfill No. 4 was far below this concentration. Therefore, it can be safely assumed that on-site workers and off-site residents will not likely experience adverse health effects as a result of exposure to methylene chloride originating from the site.

Chronic oral exposure to methylene chloride via drinking water has resulted in hepatic changes and histopathological alterations, decreased body weight gain, and biochemical changes in the blood of rats. Some laboratory animals exposed to high concentrations of methylene chloride throughout their lifetime develop cancer. Methylene chloride has not been shown to cause cancer in humans exposed at occupational levels. However, based on animal studies, it should be treated as a potential human carcinogen.

Ingestion of zinc contaminated foods drives both the present and future off-site residential noncarcinogenic risks. Zinc is an essential dietary nutrient but health can be adversely affected if excessive amounts of zinc are consumed. Zinc toxicosis may manifest as stomach or digestive problems. Zinc can also interfere with immune function and the body's ability to use other essential nutrients such as iron and copper. The levels of zinc that produce health effects are usually much higher than the Recommended Dietary Allowances (RDA) of 15 mg/day for males and 12 mg/day for women (ATSDR *Toxicological Profile for Zinc*, 1989). However, the concentrations of zinc ingested in the form of foods resulting from contamination at Landfill No. 4 are likely to be much lower than the RDA for zinc and, therefore, are not likely to result in adverse human health effects.

Dermal contact with aldrin contaminated soil drives the future (chronic) on-site worker noncarcinogenic and carcinogenic risks. No key studies of dermal exposure of humans to aldrin were located in the available literature. However, dermal LD_{50}s of 98 mg/kg and 1,250 mg/kg were reported for rats and rabbits, respectively. Available epidemiological studies on aldrin and dieldrin are considered to be inadequate to establish a clear assessment of the relationship between these compounds and the risk of cancer in humans. Furthermore, no data describing the carcinogenic effects in animals following exclusively dermal exposure were found in the available literature. However, as discussed previously, several rodent bioassays report a positive carcinogenic response following ingestion of aldrin or dieldrin (ATSDR *Toxicological Profile for Aldrin/Dieldrin*, 1991).

6.5.10 Uncertainties Associated with Risk Characterization

Risk characterization results are not actual representation of risk but rather conditional estimates of risk which should be interpreted in light of the considerable number of assumptions required to quantify exposure, intake and dose-response. Uncertainties associated with identification of chemicals of potential concern, exposure assessment, and toxicity assessment all contribute to the level of confidence that can be placed on the risk characterization results. The uncertainties associated with these steps are discussed in previous sections of the report and are summarized in this section to facilitate interpretation of the risk characterization.

6.5.10.1 Identification of Contaminants of Potential Concern

Uncertainties associated with identification of chemicals of potential concern are discussed in detail in Section 6.2.9 (Data Limitations/Data Gaps) and include:

- Limitations of the analytical methods in detection of chemicals in the sampled soil below the instrument detection limit;
- Use of estimated values below the detection limit and values close to detection limits;
- Use of potentially false negatives; and
- The generally small number of samples and locations used to evaluate background concentrations of inorganic chemicals.

6.5.10.2 Exposure Assessment

Sources of uncertainty associated with the exposure assessment are discussed in Section 6.3.8. The primary sources of uncertainty that can limit the accuracy of the assessment are:

- Analytical data used to estimate release rates to the environment;
- The ability of fate and transport models to realistically simulate the behavior of chemicals in the environment; and
- The accuracy of exposure assumptions in representing the degree and magnitude of exposure.

6.5.10.3 Toxicity Assessment

Sources of uncertainty associated with the toxicity assessment are discussed in detail in Section 6.4.5. The major source of uncertainty is attributed to the lack of verified toxicity values for several chemicals and includes:

- The lack of inhalation RfCs for acetone, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, aldrin, dichloroprop, MCPP, β-BHC, and δ-BHC, γ-BHC, 2,4,5-T, endrin, heptachlor epoxide, 2-hexanone, xylenes, and zinc;

- Low to medium confidence ratings for USEPA-verified toxicity values;
- The use of oral RfDs and slope factors for dermal exposure;
- The lack of verified inhalation slope factors for many of the contaminants evaluated; and
- Inability to evaluate the possible synergistic or antagonistic effects of the mixture of chemicals detected at the site.

The most significant uncertainties associated with risk characterization are the limitations of analytical methods and fate and transport models in addition to the lack of verifiable toxicity values. The majority of the tasks performed during risk assessment utilize conservative assumptions which tend to result in overestimation of risk (use of estimated values below instrument RLs, exposure assumptions which tend to be conservative, etc.). However, the limitations associated with analytical methods and the lack of EPA-verified toxicity values for some chemicals could result in underestimation of risks. Alternately, many of the uncertainties associated with risk assessment have the potential to either over or underestimate the risk associated with exposure.

6.6 Environmental Evaluation

This section presents a qualitative evaluation of potential adverse impacts of contamination from Landfill No. 4 on critical habitats and endangered species in the area. A description of the site and the nature and extent of the contaminants of concern were presented earlier in this report. Information for this qualitative evaluation was adapted from a ecological risk assessment of CAFB prepared by Woodward-Clyde and Consultants (Woodward-Clyde, 1992).

6.6.1 Local Ecology

CAFB and surrounding areas are part of the High Plains grasslands. Much of the natural grassland ecology has been disrupted by agricultural practices. Small trees and large shrubs are located around riparian areas and playa lakes. The areas surrounding CAFB are used for crops and livestock. Common agriculture crops grown in the area include wheat, sorghum, and alfalfa.

Landfill No. 4 is vegetated with a variety of grasses. The area is not maintained in any manner and the grass is tall. Agricultural land lies east and south of the landfill. A playa lake is located approximately 1,000 feet to the south and the base ordinance area is situated 800 feet west of Landfill No. 4.

6.6.2 Threatened and Endangered Species

Table 6-34 lists threatened and endangered species and species of high federal concern historically inhabiting areas within CAFB and surrounding Curry County. The Baird's sparrow and the ferruginous hawk are known to occur in this area. However, both birds are infrequent visitors in the area. The Baird's sparrow may be found in the area from early August and departs by November. The ferruginous hawk may occasionally feed on CAFB, but does not reside there because of lack of suitable nesting habitat.

6.6.3 Other Species

Small amphibians and reptiles are known to occupy areas in and around CAFB. The pocket gopher and the deer mouse are two common small mammals found at CAFB. Both animals inhabit areas covered with small shrubs and grasses similar to those found at Landfill No. 4. Pheasant, quail, and migratory waterfowl feed on waste grains in the fields near the landfill. Waterfowl, mostly dabbler ducks, utilize the playa

Table 6-34

Federal- and State-Protected Animals Potentially Occurring in the Vicinity of CAFB (Curry County), New Mexico

Common Name	Scientific Name	Federal Status	State Status
Birds			
Baird's sparrow	*Ammodramus bairdii*		Endangered (group 2)
Bald eagle	*Haliaeetus leucocephalus*	Endangered	Endangered (group 2)
Peregrine falcon	*Falco perigrinus*	Endangered	Endangered (group 1)
Long-billed curlew	*Numenius americnus*		Endangered (group 2)
Western snowy plover	*Charadrius aleandrus nivosis*		Endangered (group 2)
Mammals			
Black-footed ferret	*Mustela nigripes*	Endangered	Possibly Extinct
Swift fox	*Vulpes velox*		Endangered (group 2)
Reptiles			
Texas horned lizard	*Phrynosoma cornutum*		Endangered (group 2)

Endangered (group 1): Species whose prospects of survival or recruitment within the state are in jeopardy.
Endangered (group 2): Species whose prospects of survival or recruitment within the state are likely to become jeopardized in the foreseeable future.

Possibly Extinct: Potentially no longer in existence in the state.
Source: Woodward-Clyde, 1992.

lake as a resting and feeding area during migration. The primary predators in the area are several species of raptors. Mated pairs of Mississippi kite, recently removed from New Mexico's protected species list, have been spotted on the base defending territory near the golf course. Occasionally, a big game animal such as the longhorn antelope has been spotted in the vicinity.

6.6.4 Selection of Indicator Species

Animals that inhabit Landfill No. 4 and utilize nearby areas such as the Playa Lake are potentially exposed to chemicals originating from Landfill No. 4. It is not possible to assess effects on all species potentially impacted by exposure to chemicals of concern at Landfill No. 4. Ducks have been chosen as the indicator species to represent potential impacts of chemicals at the landfill on wildlife in the area. Dabbler ducks, which include gadwalls, mallards, pintails, shovelers and widgeons, make up the majority of wildlife found at CAFB. The ducks are not usually found at Landfill No. 4; however, they spend a majority of their time resting at the nearby playa lake and feeding in the adjacent grain fields.

6.6.5 Qualitative Risk Assessment for Potential Exposure to Wildlife

Potential exposure of ducks to contaminants originating at Landfill No. 4 is via surface water flowing downgradient to the nearby playa lake. Mean annual precipitation for the area is 15 inches with a low monthly average of 0.4 inches during the winter months. Contaminants of concern were detected in the surface soil. Therefore, movement of chemicals towards the playa lake via runoff is possible. However, due to low annual precipitation, few chemicals are likely to be carried from the landfill to the lake.

Ducks typically begin migrating through the Clovis area by late October and reach their highest numbers by mid-November. The majority of the ducks have

continued southward migration by the time the lakes are frozen which is usually in the beginning of January. During mild winters, ducks can remain in the vicinity until mid-March. The average amount of time ducks spend in the area is between 1.5 to 3 months.

Considering the low precipitation and the amount of time the ducks are found in the area, the level of exposure is likely to be low.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Field activities were completed in 1992 to collect soil samples from Landfill No. 4 at CAFB. The soil samples were analyzed for various chemical parameters to provide information concerning possible contamination from the landfill. Chemical analysis results were verified through extensive QA/QC measures, including a 10% CLP data validation effort. The review indicated that the chemical data are acceptable and defensible. Data show that quality control mechanisms were effective in ensuring measurement data reliability within expected limits of sampling and analytical error.

A baseline risk assessment was performed in accordance with EPA guidance documents using the chemical results from the soil samples and the knowledge of CAFB personnel. The risk assessment indicates that, based on current knowledge, there is little likelihood that adverse human health effects will occur as a result of exposure to contaminants originating at the site. Migration of contaminants to the groundwater was shown to be insignificant. In addition, the qualitative evaluation of potential adverse impacts of contaminants originating at Landfill No. 4 on critical habitats and endangered species in the area indicates that deleterious effects from the site contaminants are unlikely. Therefore, the results of the risk assessment indicate that, based on existing data and conservative assumptions, the risk to human health and the environment are acceptable.

No further action is recommended. The risk assessment has demonstrated that the risk to groundwater is insignificant; therefore, groundwater monitoring is not necessary for the site. Additionally, the drilling of borings to groundwater or the installation of wells creates the potential of introducing contaminants (via a new, direct pathway or by carrying contaminated soil down with the drilling tools or well materials) into the aquifer. For this reason, drilling to groundwater under or adjacent to the landfill is not recommended. This investigation addressed the 20- to 60-foot depth

interval. The vertical extent of organics in the soil has not been delineated beyond this interval. However, the risk assessment has demonstrated that the risks from deep soil contamination are insignificant. Only TICs (tentatively identified compounds), potential laboratory contaminants and trace amounts of pesticides have been identified in the soil below the base of the landfill. The identification and quantitation of TICs is highly uncertain and is likely to be inaccurate (Section 6.2.6). Potential laboratory contamination (e.g., TRPH, diesel) is discussed in Sections 5.3, 6.2.2 and the Quality Control Summary Report (QCSR). The pesticide residuals may result from the activities associated with the adjacent agricultural production. Upon completion of the RFI, Cannon AFB will submit a Class III permit modification for Landfill No. 4.

8.0 REFERENCES

1. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Aldrin/Dieldrin. (Draft). February, 1991.

2. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Alpha-, Beta-, Gamma-, Delta-Hexachlorocyclohexane. December, 1989.

3. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for p,p'-DDT, -DDE, -DDD. December, 1989.

4. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Methylene Chloride. (Draft), February, 1992.

5. Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Toluene. December, 1989.

6. Agricultural Science Station, 1988. Pan Evaporation data and precipitation data, average monthly rates.

7. American Conference of Governmental Industrial Hygienists (ACGIH), Documentation of the Threshold/limit Values and Biological Exposure Indices, Fifth Edition, p. 402, 1986.

8. Andelman, J.B. et.al (1989). "Exposure to Volatile Organics from Indoor Uses of Water." In: Proceedings of Symposium on Total Exposure Methodology: A New Horizon. Las Vegas, Nevada, November 27-30.

9. Base, C.F. III, R.D. Sharp, A.L. Sjoreen, and R.W. Shore. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture. Oak Ridge National Laboratory, ORNL 5786, DE 85000287. September, 1984.

10. Berkstresser, C.F., Jr. and Mourant, W.A. Groundwater Resources and Geology of Quay County, New Mexico. New Mexico Bureau of Mines and Minerals Resources Groundwater Report, v. 9. 1996.

11. Bouwer, H., and R.C. Rice. A Slug Test for Determining hydraulic Conductivity of Unconfined Aquifers With Completely or Partially Penetrating Wells. Water Resources Research, 12 (1976), 423-28.

12. Clement Associates, Inc., 1988. Multipathway Health Risk Assessment Input Parameters Guidance Document. Prepared for the South Coast Air Quality Management District, El Monte, CA, June.

13. CH2M Hill, 1983. Installation Restoration Program Records Search for Cannon AFB, Clovis, New Mexico.

14. Dean, J.H., Murray, M.J., and Ward, E.C., 1991. Toxic Responses of the Immune System in: M.O. Amdur, J.D. Doull, and G.D. Klassen (Eds.) Casarett and Doull's Toxicology: The Basic Science of Poisons, fourth edition, Macmillan Publishing Co., New York, N.Y., pp.282-333.

15. Frye, J.C., Glass, H.D., Leonard, A.B. and Coleman, D.D., 1974. Caliche and Clay Mineral Zonation of Ogallala Formation in Central - Eastern New Mexico. New Mexico Bureau of Mines and Minerals Resources Circular 144.

16. Frye, J.C. and Leonard, A.B., 1972. Structure of Ogallala Formation in East Central New Mexico. New Mexico Bureau of Mines and Minerals Resources, Target Exploration Report No. E/6.

17. Glass, H.G., Frye, J.C. and Leonard, A.B., 1973. Clay Minerals in East - Central New Mexico. New Mexico Bureau of Mines and Minerals Resources, Circular 139.

18. Gordon, T. and Amdur, M.O., 1991. Principles of Toxicology in: Klaassen, C.D., Amdur, M.O., and Doull, J. (eds) Casarett and Doull's Toxicology: The Basic Science of Poisons, fourth edition. Macmillan Publishing Co., New York, N.Y., pp.383-406.

19. Gordon, T., and Amdur, M.O., "Responses of the Respiratory System to Toxic Agents." In: Casarett and Doull's Toxicology: The Basis Science of Poisons. M.O. Amdure, J. Doull, and C.D. Klaassen, eds. Pergamon Press. New York, 1991, pp. 383-406.

20. Hawley, G.G. The Condensed Chemical Dictionary. Van Nostrand Reinhold Company, New York, New York, 1981.

21. Hewitt, W.R.; Brown, E.M.; and Plaa, G.L. (1983). Relationship between carbon skeleton length of ketonic solvents and potentiation of chloroform-induced hepatotoxicity in rats. Toxicol. Lett. 16:297-3-4, 1983.

22. Integrated Risk Information Service (IRIS), 1992. U.S. Environmental Protection Agency. Search dated September, 1992.

23. Kearney, A.T., 1987. Preliminary Review/VSI Report, RCRA Facility Assessment. Cannon Air Force Base. U.S. Environmental Protection Agency, Region VI by A.T. Kearney, Inc., Chicago, Illinois.

24. Lee Wan and Associates, Inc., 1990. RCRA Facility Investigation Work Plan, Cannon AFB, New Mexico.

25. Luckey, R.R., E.D., Gutentag and J.B. Weeks, 1981. Water-level and Saturated Thickness Changes, Pre-development to 1980, in the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming: Hydrologic Investigation Atlas HA-652, U.S. Geological Survey.

26. McCarty, P.L., Reinhard, M., and Rittman, B.E. (1981). "Trace Organics in Groundwater", Env. Science Technol., 15:1, 40-51.

27. Pao, E.M., et al., 1982. Food Commonly Eaten by Individuals: Amount Per Day and Per Eating Occasion. Home Economics Research Report Number 44, U.S. Department of Agriculture, Washington, D.C., March.

28. Radian Corporation, July 1992. RCRA Facility Invesigation Air Force Base Landfill No. 4 SWMU No. 104, Houston, Texas, July 1992.

29. Radian Corporation. Installation Restoration Program Phase II - Confirmation/Quantification Stage I, Final Report for Cannon AFB, New Mexico, Volume I.

30. Radian Corporation, 1992. Remedial Investigation (RI) Report Investigation, Study and Recommendation for 29 Waste Sites, Holloman Air Force Base, New Mexico, Volume I Draft Final.

31. Radian Corporation, July 1992. Quality Assurance Project Plan Cannon Air Force Base Landfill No. 4 Solid Waste Management Unit No. 104 Houston, Texas, July 1992.

32. Radian Corporation, December 1992. Quality Control Summary Report (QCSR) Cannon Air Force Base Landfill No. 4 Solid Waste Management Unit No. 104. Austin, Texas, December 1992.

33. Radian Corporation, July 1992. Site Safety and Health Plan Extent of Contamination Cannon Air Force Base Landfill No. 4, SWMU No. 4, Houston, Texas, July 1992.

34. Reeves, C.C., Jr., 1970. Drainage Pattern Analyses, Southern High Plans, West Texas and Eastern New Mexico in Ogallala Aquifer - A Symposium: Richard B. Mattox and William D. Miller, eds., Texas Tech University Special Report Number 39, International Center for Arid and Semi-arid Land Studies.

35. Sims, R.C., Sims, J.L., and Hansen, S.G. (1991). "Soil Transport and Fate Database, Version 2.0", Department of Civil and Environmental Engineering, Utah State University, Logan, Utah.

36. Soil Conservation Service. Curry County Soils Survey, Series No. 4, 1953.

37. Theis, C.V., 1936. Possible Effects of Groundwater on the Ogallala Formation of Llano Estacado. Washington Academy of Science Journal, v. 26.

38. Thomas, J.A., 1991. Principles of Toxicology in: Klaassen, C.D., Amdur, M.O., and Doull, J. (eds) Casarett and Doull's Toxicology: The Basic Science of Poisons, fourth edition. Macmillan Publishing Co., New York, N.Y., pp.484-520.

39. Travis, C.C. and A.O. Arms, 1988. "Bioconcentration of Organics in Beef, Milk, and Vegetation." Environmental Science and Technology 22(3):271-274.

40. U.S. Environmental Protection Agency (USEPA, 1989a). Risk Assessment Guidance for Superfund, Volume 1: Human Health Evaluation Manual, Part A. USEPA/5-40/1-89/002, December, 1989.

41. U.S. Environmental Protection Agency (USEPA, 1989b). Exposure Factors Handbook. USEPA/600/8-89/043, July, 1989.

42. U.S. Environmental Protection Agency (USEPA, 1992). Health Effects Assessment Summary Tables (HEAST). Annual FY-1992. Office of Research and Development. OERR-9200.6-303 (92-2). October, 1992.

43. U.S. Environmental Protection Agency (USEPA, 1990). Interim Methods for Development of Inhalation Reference Concentrations. External Review Draft. USEPA/60-0/8-90/066A, September.

44. U.S. Environmental Protection Agency (USEPA, 1991). "Standard Default Exposure Factors." Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Supplemental Guidance. March 25, 1991.

45. U.S. Environmental Protection Agency (NTP, 1986). National Toxicology Program Memorandum from the Offices of Research and Development; Environmental Criteria and Assessment.

46. U.S. Environmental Protection Agency (USEPA, 1984). Health Effects Assessment for Toluene. USEPA/540/1-86/033, September.

47. Weeks, J.B. and Gutentag, E.D., 1981. Bedrock Geology, Altitude of Base and 1980 Saturated Thickness of the High Plains Aquifer in Parts of Colorado,Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas and Wyoming: Hydrologic Investigation Atlas, HA-648, U.S. Geological Survey.

48. Woodward-Clyde Consultants. Remedial Investigation Report For 18 Solid Waste Management Units Cannon Air Force Base Clovis, New Mexico. Omaha, Nebraska, May 1992.

49. Interview with Mr. Sid Rollinson, Cannon AFB Water Plant, November 1992.

50. Telephone conversation with Mr. Rick Crow of the Base Natural Resources Environmental Group, Cannon Air Force Base, New Mexico, 8 and 13 October, 1992.

51. Telephone conversation with Mr. Bruce Herricks of the County Agricultural Extension Services, Curry County, New Mexico, 27 October 1992.