LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

DRAFT FINAL
FEASIBILITY STUDY REPORT

FOR

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

PREPARED FOR

U.S. ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT

JOB No. 11-1530-0315
CONTRACT No. DACW41-92-D-9002
DELIVERY ORDER NO. 0015

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April 12, 1994

Mr. Richard Van Saun
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Kansas City District, Corps of Engineers
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Kansas City, MO 64106

Subject: **Draft Final Feasibility Study Report for Southwest Funston Landfill Fort Riley, Kansas Contract DACW41-92-D-9002, Delivery Order No. 0015 LEGS Project 11-1530-0315**

Dear Mr. Van Saun:

Law Environmental, Inc., is pleased to submit the Draft Final Feasibility Study Report for Southwest Funston Landfill, Fort Riley, Kansas. This report has been prepared using information presented in the Draft Final Remedial Investigation Report, and incorporates comment responses on the Draft Feasibility Study Report and discussions held February 17 and 18, 1994 on the Draft Feasibility Study.

The report distribution list is attached for your convenience. The Draft Feasibility Study Report Responses to Comments will be forwarded under separate cover.

If there are questions or comments concerning this submittal, please contact us at (404) 421-7008.

Sincerely,

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for Principal

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FORT RILEY, KANSAS

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DRAFT FINAL
FEASIBILITY STUDY REPORT

FOR

REMEDIAL INVESTIGATION/FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL

FORT RILEY MILITARY INSTALLATION
FORT RILEY, KANSAS

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12 April 1994

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY ES-1

1.0 INTRODUCTION 1-1

1.1 PURPOSE AND ORGANIZATION OF REPORT 1-1

1.2 BACKGROUND INFORMATION 1-3

1.2.1 Site Description 1-4
1.2.2 Site History 1-4
1.2.3 Site Characterization 1-15
1.2.4 Nature and Extent of Contamination 1-30
1.2.5 Fate and Transport 1-45
1.2.6 Baseline Risk Assessment 1-52
1.2.7 Conclusions 1-66

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES 2-1

2.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED (TBC) REQUIREMENTS 2-2

2.1.1 Chemical-Specific ARARs and TBC Requirements 2-2
2.1.2 Location-Specific ARARs and TBC Requirements 2-9
2.1.3 Action-Specific ARARs and TBC Requirements 2-11
2.1.4 Contaminant-Specific Remediation Goals 2-19

2.2 REMEDIAL ACTION OBJECTIVES 2-20

2.2.1 Soils 2-22
2.2.2 Groundwater 2-23
2.2.3 Surface Water and Sediment 2-24
2.2.4 Landfill Gas 2-24

2.3 EXTENT OF CONTAMINATION BASED ON REMEDIATION GOALS AND REMEDIAL ACTION OBJECTIVES 2-24

TABLE OF CONTENTS
(Continued)

Page

2.4 GENERAL RESPONSE ACTIONS 2-25

2.4.1 No Action 2-25
2.4.2 Institutional Controls 2-25
2.4.3 Containment Actions 2-26
2.4.4 Treatment Actions 2-26
2.4.5 Removal/Disposal Action 2-26

2.5 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS 2-26

2.5.1 Institutional Action Technologies 2-27
2.5.2 Containment Technologies 2-29
2.5.3 Removal/Disposal Technologies 2-35
2.5.4 Treatment Action Technologies 2-36

2.6 APPLICABLE TECHNOLOGY TYPES AND PROCESS OPTION TECHNOLOGIES 2-41

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES 3-1

3.1 ALTERNATIVE 1- NO ACTION 3-2

3.1.1 Description 3-2
3.1.2 Screening Evaluation 3-2

3.2 ALTERNATIVE 2 - INSTITUTIONAL CONTROLS AND RIVER BANK STABILIZATION 3-3

3.2.1 Description 3-3
3.2.2 Screening Evaluation 3-10

3.3 ALTERNATIVE 3 - NATIVE SOIL COVER 3-11

3.3.1 Description 3-11
3.3.2 Screening Evaluation 3-13

TABLE OF CONTENTS
(Continued)

Page

3.4 ALTERNATIVE 4 - SINGLE BARRIER COVER 3-14

3.4.1 Description 3-14
3.4.2 Screening Evaluation 3-18

3.5 ALTERNATIVE 5 - PHYSICAL CONTAINMENT OF GROUNDWATER 3-19

3.5.1 Description 3-19
3.5.2 Screening Evaluation 3-22

3.6 ALTERNATIVE 6 - HYDRAULIC CONTAINMENT OF GROUNDWATER 3-23

3.6.1 Description 3-23
3.6.2 Screening Evaluation 3-25

3.7 ALTERNATIVE 7 - GROUNDWATER EXTRACTION, TREATMENT AND DISCHARGE 3-28

3.7.1 Description 3-28
3.7.2 Screening Evaluation 3-31

3.8 SUMMARY OF SCREENING EVALUATION 3-32

4.0 DETAILED EVALUATION 4-1

4.1 EVALUATION CRITERIA 4-1

4.2 COST ESTIMATING 4-2

5.0 COMPARATIVE EVALUATION 5-1

5.1 EVALUATION SYSTEM FOR COMPARATIVE ANALYSIS 5-1

TABLE OF CONTENTS
(Continued)

Page

5.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT 5-3

5.3 COMPLIANCE WITH ARARs 5-3

5.4 LONG-TERM EFFECTIVENESS AND PERMANENCE 5-3

5.5 SHORT-TERM EFFECTIVENESS 5-4

5.6 REDUCTION OF MOBILITY, TOXICITY, AND VOLUME THROUGH TREATMENT 5-4

5.7 IMPLEMENTABILITY 5-4

5.8 COST 5-5

5.9 SUMMARY 5-5

6.0 REFERENCES 6-1

LIST OF APPENDICES

A REMEDIATION GOAL CALCULATIONS

B PUMPING WELL ANALYSES

C REFERENCES FOR DOCUMENTATION OF COSTS

LIST OF FIGURES

Figures		Page
1-1	Southwest Funston Landfill Location Map	1-2
1-2	General Site Map	1-5
1-3	Photographic Interpretation - Circa 1951	1-9
1-4	Photographic Interpretation - 1954	1-10
1-5	Photographic Interpretation - 1960	1-11
1-6	Photographic Interpretation - 1971	1-13
1-7	Photographic Interpretation - 1976	1-14
1-8	Cross Section Lines A-A' and B-B'	1-16
1-9	Drainage Features and Supply Well Locations	1-19
1-10	Cross Section A-A'	1-24
1-11	Cross Section B-B'	1-25
1-12	Water Table Contours	1-27
1-13	Groundwater Analytical Results - Baseline (July 1992) Investigation	1-34
1-14	Groundwater Analytical Results - First Quarter (November 1992)	1-35
1-15	Groundwater Analytical Results - Second Quarter (February 1993)	1-36
1-16	Groundwater Analytical Results - Third Quarter (May 1993)	1-37
1-17	Surface Water and Sediment Sampling Stations	1-40

LIST OF FIGURES
(Continued)

Figures		Page
2-1	Conceptual Cover Section Detail for Single Barrier Cover	2-31
2-2	Conceptual Cover Section Detail for Multi-Layer Cap	2-33
3-1	Toe Revetment Plan View	3-4
3-2	Toe Revetment Section A-A'	3-5
3-3	Toe Revetment Section B-B'	3-6
3-4	Location Plan - Potential Long-Term Monitoring Wells	3-9
3-5	Single Barrier Cover - Conceptual Cross-Section	3-15
3-6	Conceptual Surface Area Delineation - Single Barrier Cover	3-16
3-7	Alternative 5 - Physical Containment of Groundwater	3-20
3-8	Alternative 6 - Hydraulic Containment of Groundwater	3-24
3-9	Conceptual Layout for Treatment System - Alternative 6	3-26
3-10	Alternative 7 - Groundwater Extraction, Treatment and Discharge	3-29
3-11	Conceptual Layout for Treatment System - Alternative 7	3-30

LIST OF TABLES

Table		Page
1-1	Comparison of Historical Data to Current Kansas River Sediment Data	1-42
1-2	Exceedances of Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Requirements for Groundwater	1-44
1-3	Background Levels of Metals in Groundwater	1-46
1-4	Chemicals Detected in Private Irrigation Well	1-47
1-5	Exceedances of Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Requirements for Soils	1-48
1-6	Summary of Chemicals of Potential Concern	1-53
1-7	Regulatory and Guidance Criteria for Groundwater	1-56
1-8	Regulatory and Guidance Criteria for Surface Water	1-57
1-9	Comparison of Constituents Detected in Surface Soil Samples to RCRA Soil Action Levels	1-58
1-10	Endangered and Threatened Species (and Associated Habitats) Common to Fort Riley Area	1-64
2-1	Chemical- and Location-Specific Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) Requirements	2-3
2-2	Chemical-Specific ARARs	2-4
2-3	Location-Specific ARARs	2-5
2-4	Potential Chemical-Specific ARARs and TBCs for Groundwater	2-8
2-5	Action-Specific ARARs	2-13

LIST OF TABLES
(Continued)

Table		Page
2-6	Comparison of Maximum Detected Concentration in Groundwater and RCRA TCLP Level	2-14
2-7	Governing Remediation Goals for Groundwater	2-21
2-8	Groundwater Constituents Considered for Treatment	2-37
2-9	Screening of Technologies	2-43
3-1	HELP Model Average Annual Totals - Cover Design Evaluation	3-12
4-1	Evaluation of Threshold Criteria	4-3
4-2	Evaluation of Primary Criteria Detailed Analysis of Alternatives	4-7
4-3	Cost Projection for Alternative 2	4-10
4-4	Cost Projection for Alternative 3	4-11
4-5	Cost Projection for Alternative 4	4-12
4-6	Cost Projection for Alternative 6	4-13
4-7	Cost Projection for Alternative 7	4-15
4-8	Cost Projection Summary	4-17
5-1	Comparative Evaluation of Alternatives	5-2

LIST OF ACRONYMS AND ABBREVIATIONS

AEHA	Army Environmental Hygiene Agency
AKAL	Alternate Kansas Action Level
AKNL	Alternate Kansas Notification Level
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
AWQC	Ambient Water Quality Criteria
BCF	Bioconcentration Factor
BOD	Biological Oxygen Demand
CAA	Clean Air Act
CAL	Corrective Action Levels
CB	Cement-Bentonite
CEMRK	Corps of Engineers-Missouri River Division, Kansas City District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CLP	Contract Laboratory Program
CLOMR	Conditional Letter of Map Revision
cm/sec	centimeters per second
CSF	Carcinogenic Slope Factor
CWA	Clean Water Act
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEH	Directorate of Engineering and Housing
DNAPL	Dense, Non-aqueous phase liquid
DOD	Department of Defense

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

DOT	Department of Transportation
EE/CA	Engineering Evaluation/Cost Analysis
EM	Electromagnetic
ER-L	Effects Range - Low
ER-M	Effects Range - Median
°F	Degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FFA	Federal Facility Agreement
FS	Feasibility Study
ft	Feet
ft^2	Square feet
gpm	Gallons per minute
gpd	Gallons per day
HELP	Hydrologic Evaluation of Landfill Performance
HI	Hazard Index
HRS	Hazard Ranking System
IAG	Interagency Agreement
IRIS	Integrated Risk Information System
IRP	Installation Restoration Program
K	Hydraulic Conductivity
KAL	Kansas Action Level
KAR	Kansas Administrative Record
KDHE	Kansas Department of Health and Environment
KDWP	Kansas Department of Wildlife and Parks
KNL	Kansas Notification Level
kg	Kilogram

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

KGS	Kansas Geological Survey
Law	Law Environmental, Inc., Government Services Division
LDRs	Land Disposal Regulations
LEL	Lower Explosive Level
LENL	Law Environmental National Laboratory
LNAPL	Light, Non-aqueous Phase Liquid
m	Meter
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDL	Method Detection Limit
mg	Milligram
mg/kg	Milligrams per Kilogram
mg/L	Milligrams per Liter
n	Average Porosity in Percent
NAAQs	National Ambient Air Quality Standards
NCP	National Contingency Plan
ND	Not Detected (Above Method Detection Limits)
NESHAPS	National Emission Standards for Hazardous Air Pollutants
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List (Superfund List)
O & M	Operations and Maintenance
OSHA	Occupational Safety and Health Administration
OSWER	Officer of Solid Wastes and Emergency Response
PC	Plastic Concrete
PCBs	Polychlorinated biphenyls

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

ppb	Parts per billion
PPE	Personal Protective Equipment
ppm	Parts per million
PRC	Planning Research Corporation
PSF	Pesticide Storage Facility
PVC	Polyvinyl Chloride
PX	Post Exchange
QA/QC	Quality Assurance/Quality Control
RA	Remedial Action
RAO	Remedial Action Objective
RD	Remedial Design
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RG	Remedial Goal
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	Reasonable Maximum Exposure
RO	Reverse Osmosis
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act of 1986
SB	Soil-Bentonite
SCS	Soil Conservation Service
SFL	Southwest Funston Landfill
SM	Standard Method(s)
SMCL	Secondary Maximum Contaminant Level

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

TBC	To Be Considered
TKN	Total Kjehldal Nitrogen
TOC	Total Organic Carbon
TRPH	Total Recoverable Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
UCL	Upper Confidence Limit
μg/kg	Microgram Per Kilogram
μg/L	Microgram Per Liter
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USAETL	U.S. Army Engineer Topographic Laboratories
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UST	Underground Storage Tank
UV	Ultraviolet
VLDPE	Very Low-Density Polyethylene
VOC	Volatile Organic Compound
WWTP	Waste Water Treatment Plant
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

The United States Army Corps of Engineers, Missouri River Division, Kansas City District (CEMRK) contracted with Law Environmental Government Services (Law) to perform a Remedial Investigation/Feasibility Study (RI/FS) at the Southwest Funston Landfill (SFL), Fort Riley, Kansas. Pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Fort Riley was proposed for inclusion on the National Priority List (NPL) on July 14, 1989. Two sites at Fort Riley, the Pesticide Storage Facility and SFL, were combined by the U.S. Environmental Protection Agency (USEPA) as one site for Hazard Ranking System scoring purposes. Fort Riley, the USEPA, and the State of Kansas entered into a Federal Facility Agreement (FFA) effective June 28, 1991. Under Section IX.A., paragraph 2 of the Agreement, the SFL is specifically addressed as a potential contaminant source.

The SFL is one of several landfills at Fort Riley and is located in the southern portion of the Post, west of Camp Funston, near the north bank of the Kansas River. The landfill operated from the mid 1950s to 1981. It was closed in 1983 in accordance with a Kansas Department of Health and Environment (KDHE) approved closure plan. The SFL received various wastes which included typical municipal waste, spent solvents, waste oils, and waste mercury from broken instruments.

An Engineering Evaluation/Cost Analysis (EE/CA) was completed for SFL to assess the appropriateness of performing non-time-critical removal action construction activities along the Kansas River bank and on the landfill cover prior to the Record of Decision/Remedial Design/Remedial Action (ROD/RD/RA).

The public comment period for the EE/CA was August 17 to September 16, 1993. The Removal Action Memorandum was submitted to EPA and KDHE in December 1993. This memorandum specified improvements to be performed on the Kansas riverbank and the existing landfill cover. The riverbank improvements contract was awarded January 13, 1994, and is planned to be completed in spring 1994. The design of the cover improvements is also underway.

The Draft Final RI Report, submitted on November 1, 1993, provides the basis for the FS. The RI site characterization activities included:

- Surface features survey
- Surface geophysical survey
- Soil gas survey
- Installation of 20 monitoring wells and groundwater sampling
- Collection of soil samples from each of 8 deep well borings

- Collection of 7 surface water and 7 sediment samples
- Sampling of a private irrigation well
- Baseline and quarterly groundwater sampling
- X-Ray Fluorescence (XRF) screening of surface soils

The results of the RI site characterization indicate that some limited, sporadic, low-level volatile organic contamination is present in the site groundwater. Metals detected in the site groundwater were attributed to naturally occurring conditions. The surface soil investigation indicated that lead is present in the site cover soil and is also present at levels consistent with background conditions in the majority of samples analyzed. Some relatively low-level contamination was detected in subsurface soil. The surface water and sediment investigation indicated that there is no detected contamination that is attributable to the SFL. The hydrogeologic investigation concludes that groundwater movement at the site is controlled by the Kansas River and Threemile Creek which is immediately east of the landfill. On-site groundwater recharges the Kansas River at certain times.

Volatile organics were sporadically detected in the groundwater during the RI at concentrations greater than the maximum contaminant levels (MCLs). The baseline risk assessment (which is part of the RI) indicated potentially unacceptable risk if the on-site groundwater were ever to be used as a drinking water supply.

The purposes of the FS are to set remedial action objectives, screen technologies, develop remedial action alternatives, and evaluate how effectively each alternative satisfies the remedial action goals for the SFL and the goals of the National Contingency Plan. The technologies and alternatives for site remediation are evaluated based on their ability to protect human health and the environment, where practical and reasonable, within the applicable or relevant and appropriate requirements (ARARs).

In accordance with the National Contingency Plan, alternatives were developed in the FS to address the following remedial action objectives:

- Prevent ingestion and inhalation of groundwater with organic concentrations exceeding remediation goals (MCLs and risk-based calculations)

- Minimize human and ecological direct contact with landfill contents

Seven alternatives were identified to address the remedial action objectives. These were:

- Alternative 1 - No action
- Alternative 2 - Institutional controls, riverbank stabilization, and long-term groundwater monitoring
- Alternative 3 - Native soil cover
- Alternative 4 - Single barrier cover

- Alternative 5 - Physical containment of groundwater
- Alternative 6 - Hydraulic containment of groundwater
- Alternative 7 - Groundwater extraction and treatment

Alternatives 3 through 7 include the elements of Alternative 2. These alternatives were screened based on effectiveness, implementability, and cost. All were retained for detailed analysis except Alternative 5, which was screened out based on effectiveness.

The remaining alternatives were evaluated based on the following criteria:

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)
- Long-term effectiveness and permanence
- Short-term effectiveness
- Reduction in mobility, toxicity, and volume of waste through treatment
- Implementability
- Cost

Alternatives 3, 4, 6, and 7 were found to be responsive to overall protection of human health and the environment as well as compliance with ARARs.

1.0 INTRODUCTION

The United States Army Corps of Engineers, Missouri River Division, Kansas City District (CEMRK) contracted with Law Environmental Government Services (Law) to perform a Remedial Investigation/Feasibility Study (RI/FS) at the Southwest Funston Landfill (SFL), Fort Riley, Kansas (Figure 1-1). Pursuant to Section 105 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Fort Riley was proposed for inclusion on the National Priority List (NPL) on July 14, 1989. Two sites at Fort Riley, the Pesticide Storage Facility and SFL, were combined by the U.S. Environmental Protection Agency (USEPA) as one site. The USEPA reasoned that both contaminant sources potentially affect the same shallow aquifer and target populations. These two sites were finalized on the NPL on August 30, 1990, and were assigned a combined score of 33.79 on the Hazard Ranking System (HRS). An HRS of 28.5 is needed for inclusion on the NPL. The two sites are the subjects of separate RI/FS efforts.

Fort Riley, the USEPA, and the State of Kansas entered into a Federal Facility Agreement (FFA) effective June 28, 1991. Under Section IX.A., paragraph 2 of the Agreement, the SFL is specifically addressed as a potential contaminant source.

An Engineering Evaluation/Cost Analysis (EE/CA) report was completed for SFL (Law, 1993b) to assess the appropriateness of performing non-time-critical removal action construction activities along the Kansas River bank and on the landfill cover prior to the Record of Decision/Remedial Design/Remedial Action (ROD/RD/RA). The public comment period for the EE/CA was August 17 to September 16, 1993. Subsequently, the Removal Action Memorandum was signed, specifying improvements to be performed on the Kansas River bank and the existing landfill cover. The contract for construction of the riverbank improvements has been signed and implementation is planned for spring 1994. The cover improvements are under design.

For the purposes of this Feasibility Study (FS) and to be consistent with USEPA guidance, a No Action alternative was considered. However, it is anticipated that the cover improvements and bank stabilization activities identified in the EE/CA will be substantially completed prior to the ROD.

1.1 PURPOSE AND ORGANIZATION OF REPORT

The purposes of the FS are to set remedial action objectives, screen technologies, develop remedial action alternatives, and evaluate how effectively each alternative satisfies the remedial action goals for the SFL and the goals of the National Contingency Plan. The technologies and

FIGURE 1–1

SOUTHWEST FUNSTON LANDFILL LOCATION MAP

FORT RILEY, KANSAS

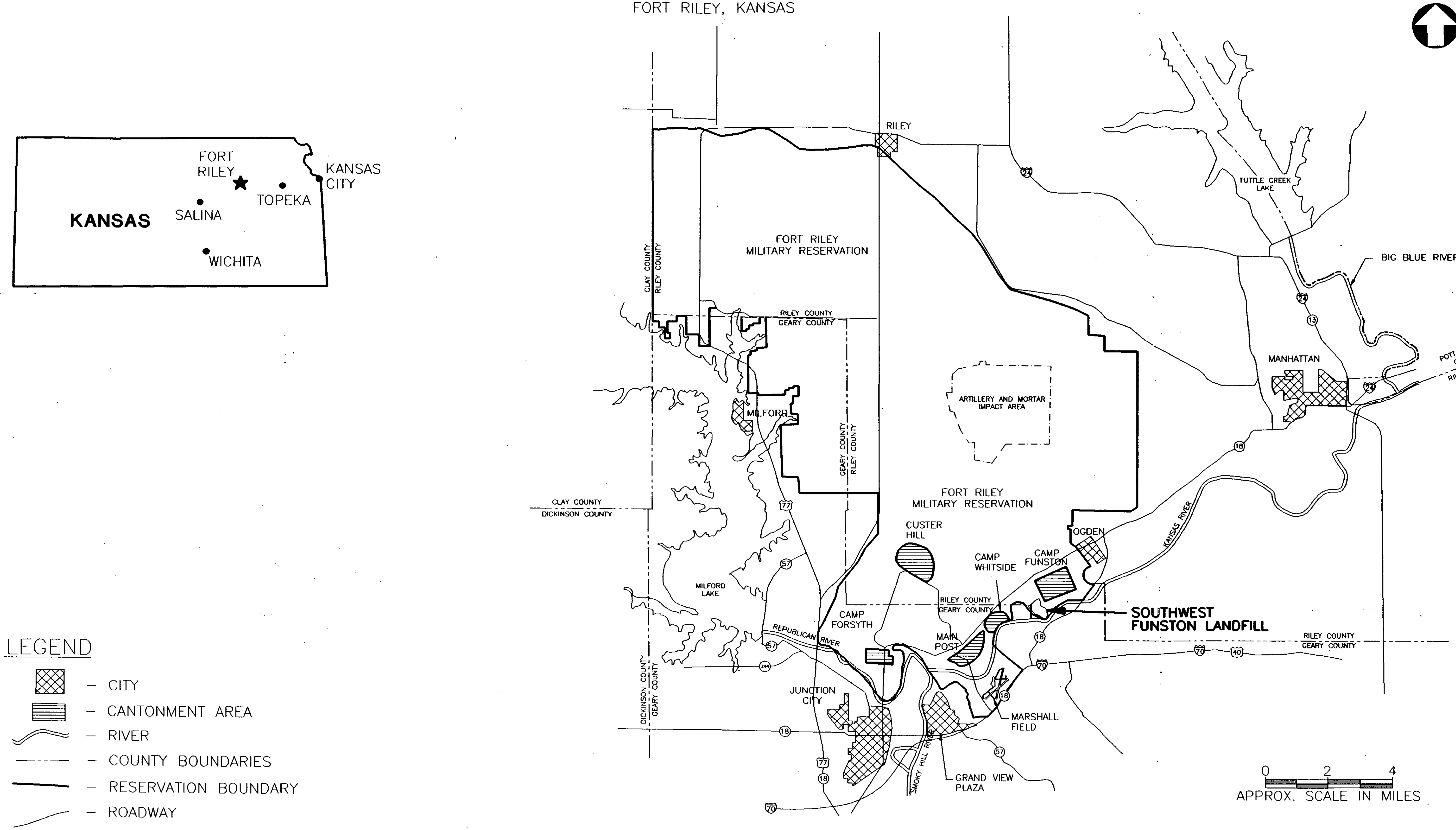

FIGURE 1–1
SFL LOCATION MAP

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GOVERNMENT SERVICES DIVISION

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alternatives for site remediation are evaluated based on their ability to protect human health and the environment, where practical and reasonable, within the applicable or relevant and appropriate requirements (ARARs).

The organization of this report is in accordance with the USEPA's Guidance on Conducting Remedial Investigations and Feasibility Studies Under CERCLA, OSWER Directive 9355.3-01, October 1988. The FS is divided into five sections. A brief description of these sections is as follows:

> Section 1.0 of this report presents a general overview and description of the SFL site and provides information on the nature and extent of contamination and a baseline risk assessment. The Draft Final Remedial Investigation for Southwest Funston Landfill (RI), dated November 1, 1993, with revisions dated April 1, 1994 (Law, 1993c), details the investigations conducted prior to and as part of the RI to determine if operating practices at the SFL have impacted the environment. Section 1.2 summarizes the site characterization information from the RI report.
>
> Section 2.0 presents potential ARARs and describes the remedial action objectives. The section identifies and screens response actions, technologies, and process options based on effectiveness, implementability, and cost. Technologies and process options retained following the screening process were used to develop alternatives.
>
> Section 3.0 develops remedial action alternatives to meet the remedial action objectives at the SFL site. The alternatives are screened based on effectiveness, implementability, and cost.
>
> Section 4.0 is a detailed analysis of the alternatives based on (1) overall protection of human health and environment, (2) compliance with ARARs, (3) long-term effectiveness and performance, (4) reduction in toxicity, mobility, and volume, (5) short-term effectiveness, (6) implementability, and (7) cost.
>
> Section 5.0 is a comparative analysis. In this section, each alternative is compared with the others based upon the seven criteria listed above.

1.2 BACKGROUND INFORMATION

This section summarizes the results of the Remedial Investigation (RI) conducted at the SFL site. The Draft Final RI Report (Law, 1993c) provides more detailed information and is the basis for the following summary.

1.2.1 Site Description

The Fort Riley Military Installation is situated along the north bank of the Kansas and Republican Rivers in Riley and Geary counties in north central Kansas (Figure 1-1), near the cities of Manhattan, Ogden, Junction City and Grandview Plaza, Kansas. The installation comprises about 101,000 acres and is located between two major surface water reservoirs: Tuttle Creek Lake completed in 1962 and Milford Lake completed in 1965.

The SFL is in the southern portion of Fort Riley, adjacent to the southwest corner of the Camp Funston cantonment area. The limits of the SFL (inferred from the magnetometer survey) extend from the north bank of the Kansas River north to near Well House Road, and east from the old Kansas River Channel to just west of Threemile Creek (Figure 1-2). The nearest surface-water impoundment to the SFL is Whitside Lake, an oxbow lake located about 0.5 miles northwest of the SFL site. This oxbow lake was part of the Kansas River channel prior to the 1951 flood which changed the course of the Kansas River. During flooding in 1993, floodwater passed through the lake following the course of the former channel. Sediment was deposited by the floodwater substantially reducing the size of the lake.

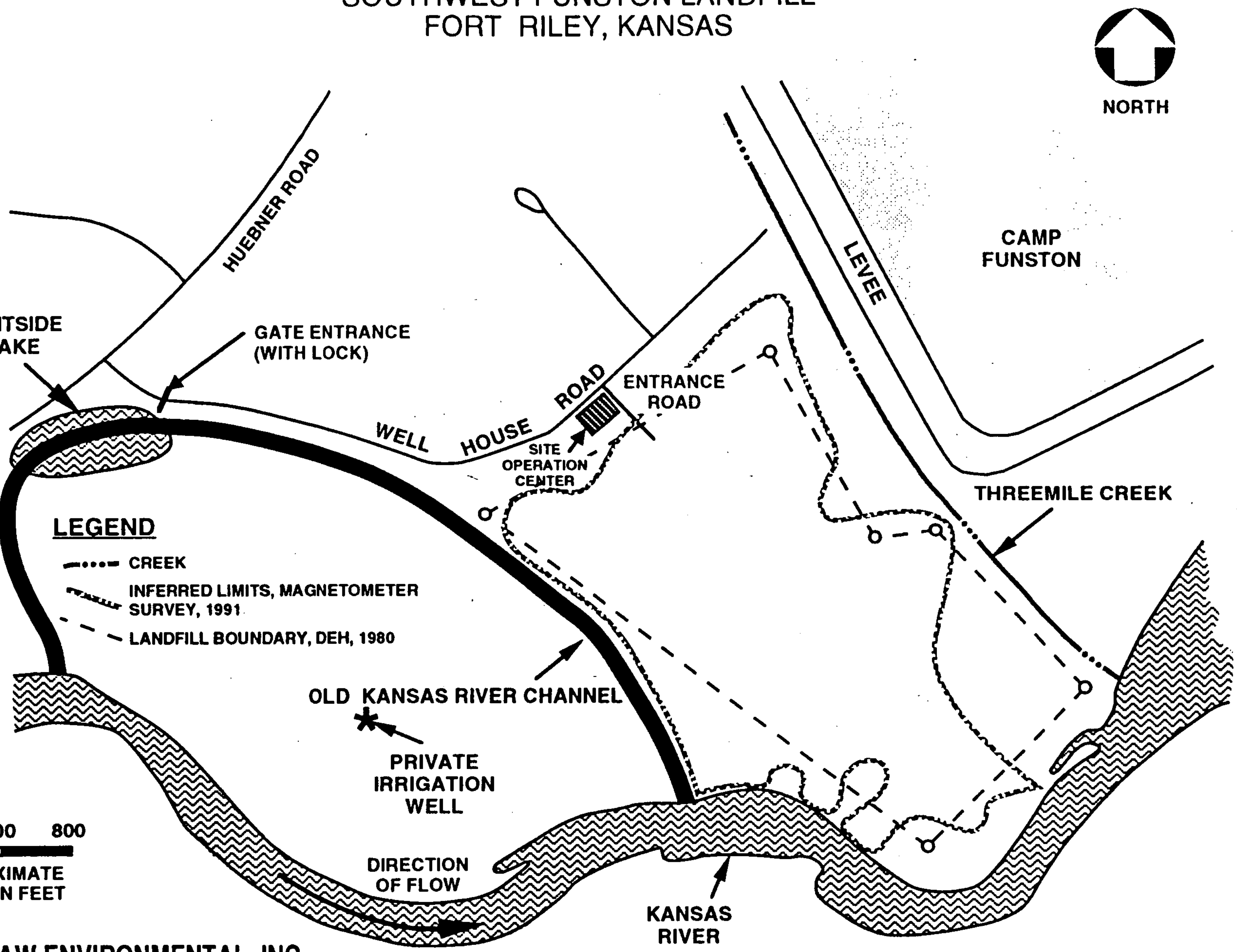
The landfill is presently covered with vegetation and displays little topographic relief compared to the surrounding land surface. In less than 2 percent of the total area, surface erosion is exhibited as rills and channels, resulting in partial removal of soil cover material. The landfill had about 2 feet (0.6 meter) of soil cover placed during 1983 closure activities. A portion of the soil was obtained from rifle ranges just north of the site.

During a site visit in March 1990, small amounts of scattered construction debris were observed on the surface of the landfill and along the banks of the Kansas River. Construction debris were also visible through the cover material. Depressions of up to 1.5 feet exist and are assumed to be the result of consolidation of the landfill contents at some of the former disposal trenches. Surface water has been observed in some of these depressions and no predominant drainage pathways exist at the site. Numerous holes, approximately 6 inches in diameter, presumably dug by small animals, have also been observed in and adjacent to the closed disposal trenches. See Section 1.2.3.5 for a more detailed description of surface conditions based on August 1992 visual survey.

1.2.2 Site History

Fort Riley was established in 1852 as a small outpost near the confluence of the Republican and Smokey Hill rivers. Since its inception, Fort Riley has continually served as a major center of military education and readiness, at times comprising a population of more than 20,000 military residents and civilian employees. The Fort Riley reservation has historically functioned both as a small municipality and light industrial complex. Solid waste disposal (landfilling), wastewater

FIGURE 1-2
GENERAL SITE MAP
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS



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treatment and discharge, facilities maintenance and construction, pesticide and herbicide usage, and electrical equipment installation, storage, and repair, are among the environmentally significant municipal activities at Fort Riley. Fort Riley's function as a military training, equipment supply, and maintenance center has historically required management and disposal of wastes associated with these activities.

1.2.2.1 Landfill History - The SFL operated from the mid-1950s until 1981 under a "grandfathered" Kansas Department of Health and the Environment (KDHE) permit (No. 370). A KDHE letter dated October 25, 1983 (see Appendix A of RI), states that the closure plan (F5-00157-1-J) was approved on August 9, 1982 (KDHE, 1983). No copy of an approved final report has been located, however, the KDHE letter referenced above also states that SFL was "... closed in an acceptable manner." The closure plan (see Appendix A of RI) included installation of six groundwater monitoring wells, topographic regrading, and the application of a continuous soil cover.

Most of the information regarding the sources and quantities of waste delivered to the SFL was obtained from two previous studies: (1) Installation Assessment Report [U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), 1984] and (2) Hazardous Waste Management Consultation [U.S. Army Environmental Hygiene Agency (AEHA), 1989].

Military operations and support activities at the installation which generated waste during the SFL period of operation include:

- Vehicle maintenance shops
- Vehicle wash racks
- Aircraft maintenance shop
- Print shop
- Furniture restoration shop
- Painting facilities
- Pathology, radiology, veterinary, and dental clinics
- Photography laboratories
- Oil analysis laboratory
- Pesticide/herbicide storage and preparation
- Laundry and dry cleaning facilities
- Former Fire Training Area
- Wastewater Treatment Plants
- Troop housing
- Family housing
- Administrative functions
- Commissary/Post Exchange (PX) stores
- Supply/Warehousing

Large volumes of typical municipal wastes such as domestic garbage and construction debris, and probably material normally found in waste streams of the various military and support activities were also disposed in the SFL. Most wastes generated and disposed on post were domestic refuse and sewage sludge from the wastewater treatment facilities. However, increasing mechanization of the Armed Forces caused an increase in the amount of petroleum products and solvents used and disposed in the landfill. According to the Installation Assessment Report, liquid wastes generally were not segregated in the landfill (USATHAMA, 1984). Spent solvents were mixed with waste oils and contaminated fuels and were disposed by dumping them into the SFL prior to about 1970. Also, solvent soaked rags and containers from the furniture stripping shop and print shop and paint stripping sludge and containers were disposed in the landfill.

The government inspector for the landfill closure project reported that materials existing on the surface of the SFL at the time of closure included: neatly stacked drums (no size estimate noted), scrap metal(s), and construction material debris. This communication further states that the "southwest side [is the] location of a lot of roofing/building materials - potentially containing asbestos."

Although wastes were not always segregated in the landfill, field observations and review of historical photographs suggest that material conducive to erosion control (such as construction debris and discarded heavy appliances) were segregated and placed along the bank of the Kansas River.

On occasion, material was burned in trenches, sometimes creating below grade fires (President, Harris Refuse Company, 1992). Additional information from the Section Chief, Environmental and Natural Resources Division, Directorate of Engineering and Housing (DEH) indicates trash and wood wastes were also burned in windrows (DEH, 1992d). The combustible waste consisted of building construction waste, tree stumps, trunks and limbs, wooden ammunition boxes, etc. These wastes/residue, once burned, were placed into trenches and covered with soil. Interviews did not provide information as to the frequency of these burnings.

Scrap metal that was brought to the SFL rather than the Defense Reutilization and Management Office (DRMO) [formerly Defense Property Disposal Office (DPDO)] was placed in a large pile (DEH, 1993f). The DPDO at times would conduct a spot sale of this scrap metal. The material not sold was placed in trenches and covered with soil. As stated above, the Installation Assessment Report indicates that waste oil was sold to a contractor after about 1970.

The President of Harris Refuse Company, Salina, Kansas, stated in a personal interview that during the first 15 years of operation, the SFL was managed by a private contractor. Both landfarming and trench disposal methods were used in the landfill during this time. Trenches were excavated approximately 16 feet below ground surface (President, Harris Refuse Company 1992). A preliminary report issued by the Army Environmental Hygiene Agency (AEHA), issued May 11, 1977, states:

> "Landfill contractor personnel reported that water [groundwater] occasionally seeps into the working trenches at a depth of about 20 feet when the river [Kansas] is high. To minimize production of leachate which could pollute the groundwater, trench depths should be reduced to 12 to 15 feet."

In 1970, Harris Refuse Company was under contract to manage and operate the SFL. Harris Refuse Company continued to manage the SFL until January 1981 (President, Harris Refuse Company, 1992). No specific data exists which record the waste types disposed in the landfill during this time. Trucks hauling "trash" were not weighed before or after dumping. All trucks belonging to Harris Refuse Company were assumed to be of a certain cubic yardage capacity. The weight was then estimated by multiplying the capacity by a conversion factor. The weight of non-contractor trucks was also estimated in this fashion. In addition, no documentation exists to identify or manifest the waste type according to the section chief, Environmental Division, DEH (DEH, 1993f).

Aerial photographs of the SFL site have been reviewed and indications of landfilling activities noted. An undated photograph, presumed to have been taken before the 1951 flood, shows the main channel of the Kansas River forming a bend which runs north to south along the western border of the present SFL (Figure 1-3). During the 1951 flood, the Kansas River formed a cut-off channel which isolated the bend (oxbow) from the main flow. The old channel has since filled with sediments and revegetated. Water bodies (oxbow lakes) were seen in the photograph (Figure 1-3) which may represent remnant channel locations from even earlier events. Linear features running both north-south and east-west are also prevalent. These features appear to be related to surface activities, such as mowing or grading. Four well houses for the abandoned Camp Funston supply wells can also be seen on pre-1951 photographs.

A December 1954 aerial photograph (flight altitude approximately 6,000 feet) showed numerous signs of surface activities, including roads, cleared areas, a building, and a water-filled pit possibly related to a sand pit operation (Figure 1-4). There is no indication that this apparent pit is related to any landfilling operations. Granular materials (sand and gravel) were present in the well log for closure well No. 2 which is located near this pit. The surface features north of Well House Road are presumed to be associated with tracked vehicle military training activities. No signs of landfilling related activities were seen in the 1954 photograph.

A March 1960 aerial photograph (flight altitude approximately 6,000 feet) displayed a developed road in the northern portion of the SFL site, leading to the southwest corner of the landfill and terminating at an area of activity possessing a single open trench (Figure 1-5). The signs of activity north and south of Well House Road previously described for the 1954 photograph were obscured by vegetation, indicating lack of usage. Also seen on the photograph are five northwest-southeast oriented excavation features. The sites of these excavations were visually inspected during a November 1991 reconnaissance and no visible evidence of landfilling activity was present at that time. Personal communications with DEH personnel suggest that these features may have been formed from local personnel excavating soil.

FIGURE 1-3

PHOTOGRAPHIC INTERPRETATION-CIRCA 1951

SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

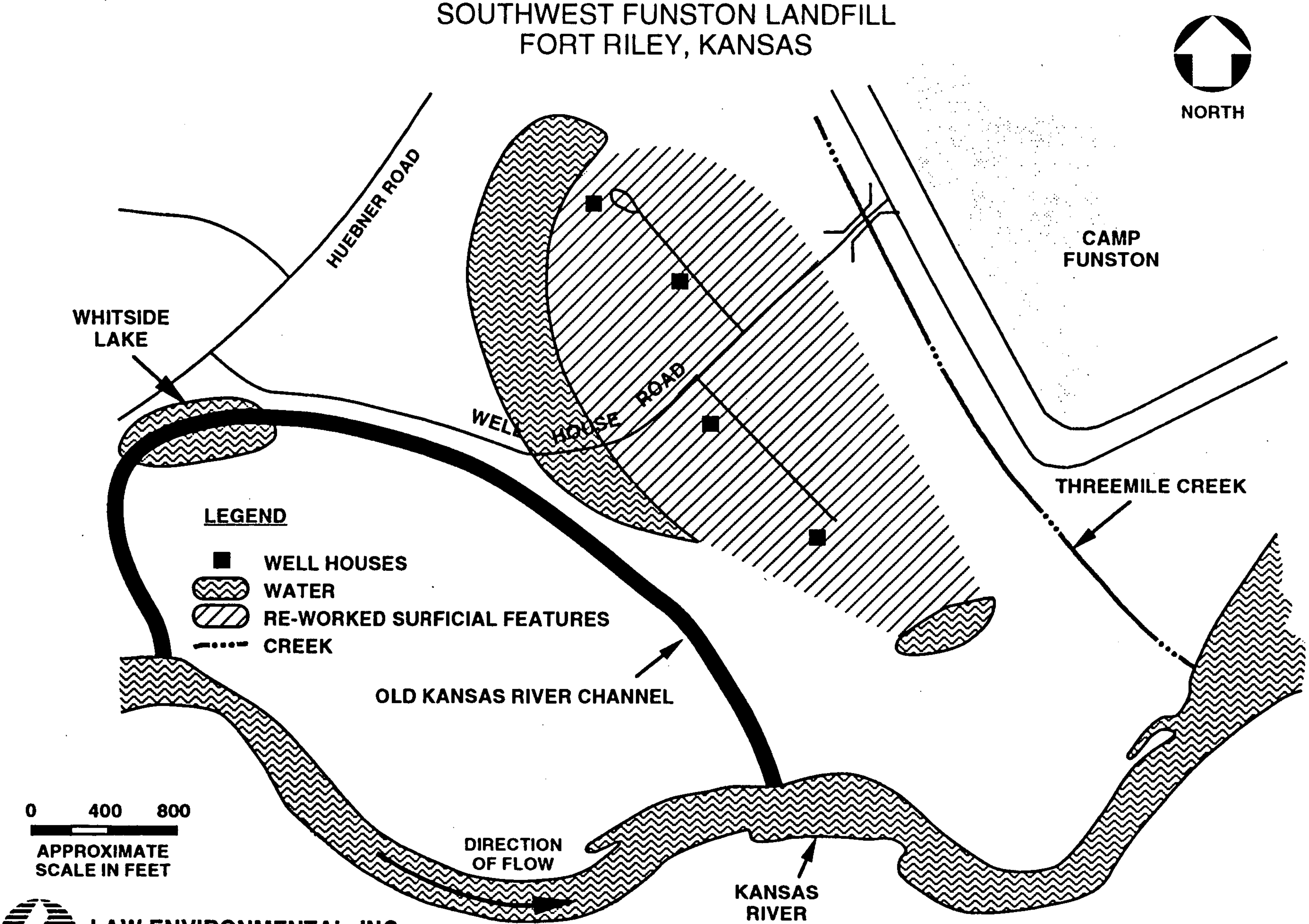

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FIGURE 1-4

PHOTOGRAPHIC INTERPRETATION-1954

SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

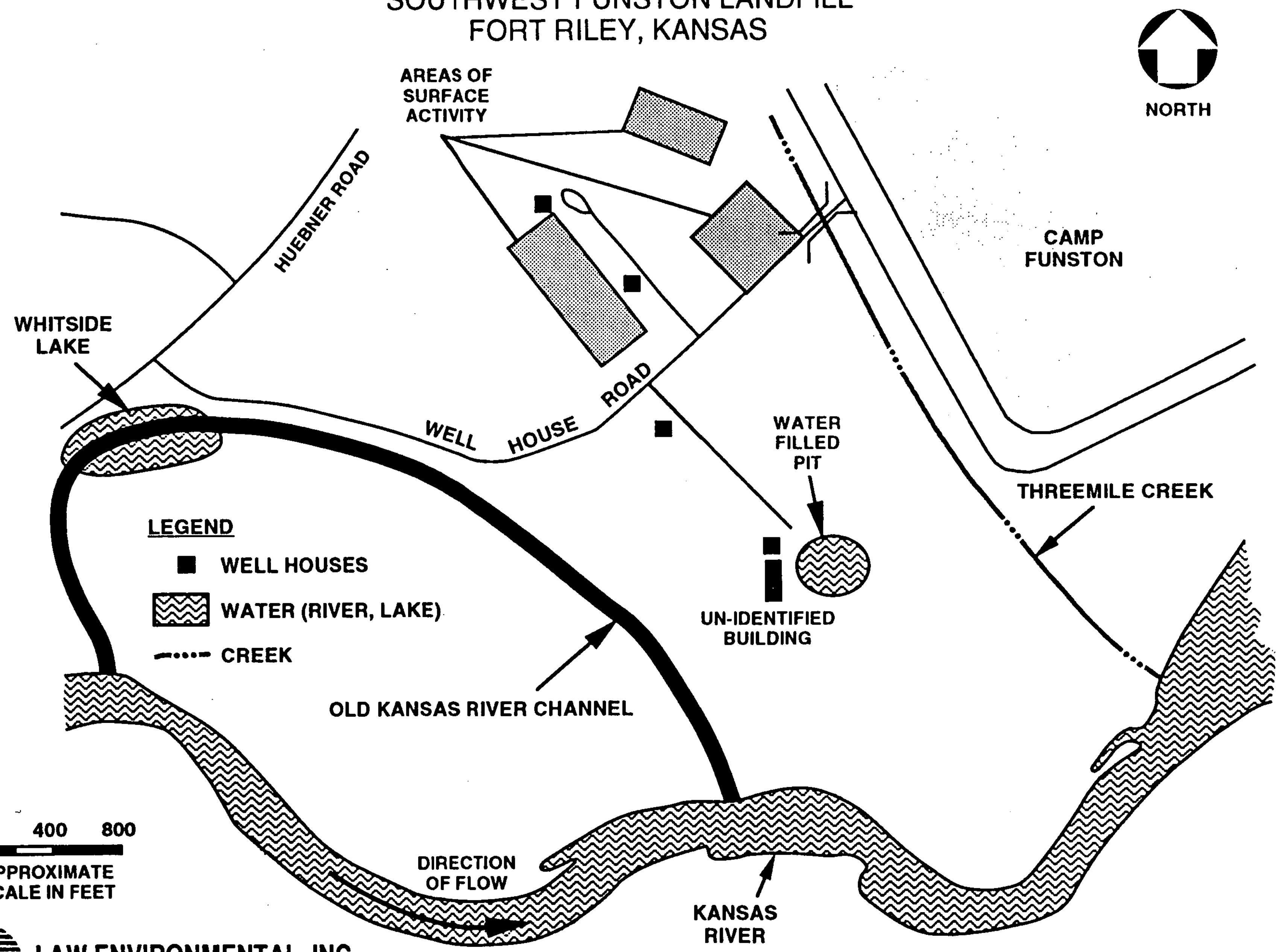

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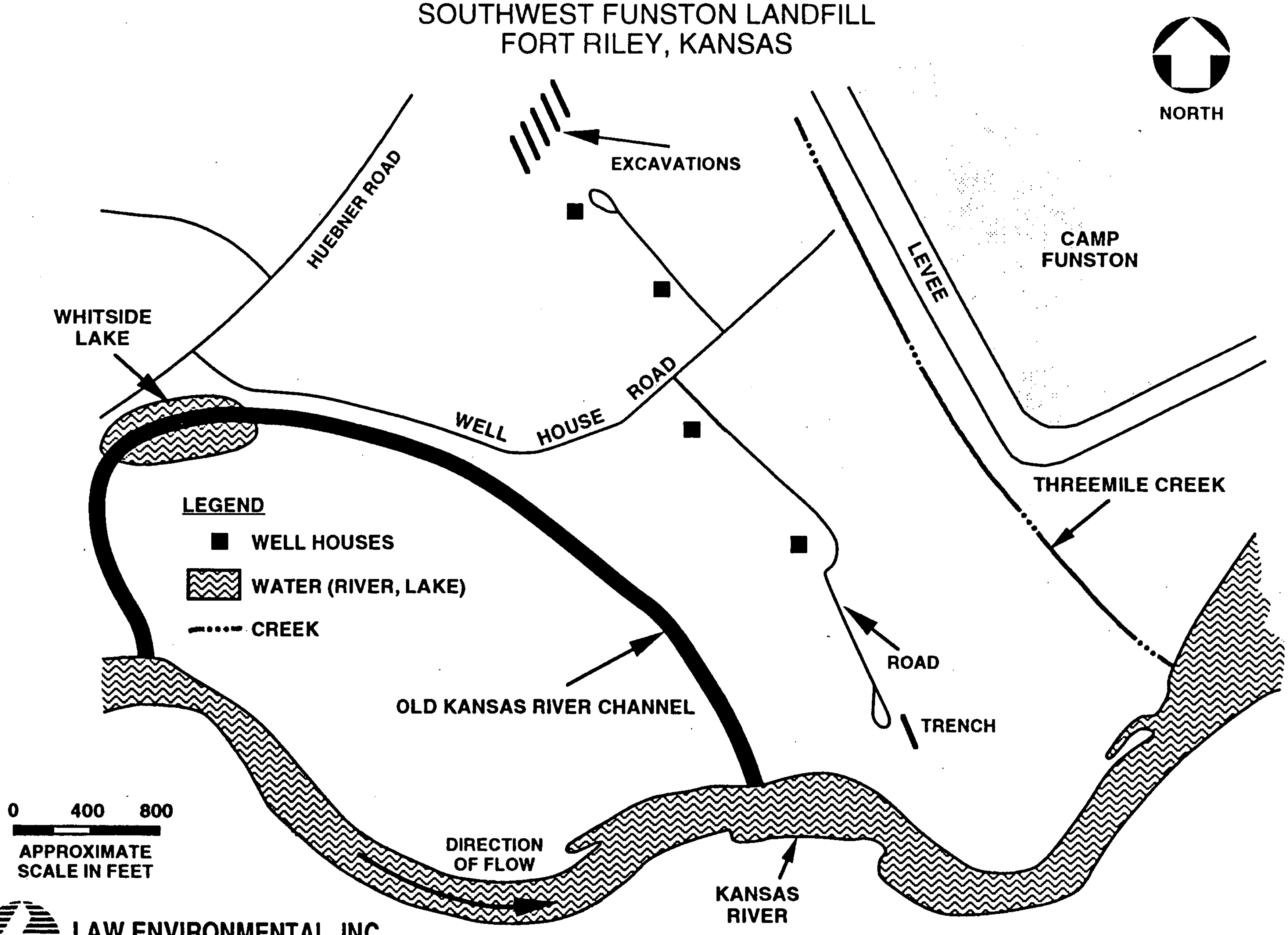
FIGURE 1-5

PHOTOGRAPHIC INTERPRETATION-1960

SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS



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Several trenches could be seen in a March 1971 aerial photograph (Figure 1-6). These trenches were located in the west-central to east-central portions of the landfill. Another trench could be seen near the southern border of the SFL adjacent to the river bank. Apparent debris piles were situated along the banks of the old channel near its confluence with the Kansas River. Fire training pits were observed adjacent to Well House Road at Threemile Creek. A building, identified as a gas chamber training building, was located north of the trenches in the west-central portion of the landfill. The Installation Assessment Report for Fort Riley does not specifically state that a gas chamber training building was located at the SFL, however, file drawings from the DEH (drawing no. 18-02-05, Dec. 1970) do identify a gas chamber building on the SFL as shown on Figure 1-6. The report mentions the use of o-chloro-benzylidene malononitrile (tear gas) in the gas chamber training areas. Existing documentation does not describe how often these training chambers were used nor the operating procedures. Typical gas chamber operating procedures encompass releasing tear gas in the building and having personnel enter the building wearing gas masks, remove the gas masks once in the building, and then leave the building after the eyes tear.

From a series of low altitude aerial photographs taken in February 1972, at least six open trenches were seen in an area adjacent to the river bank in the southwest portion of the landfill. According to documentation provided with the photographs and personal communications with a former Wastewater Treatment foreman, these trenches contained oil and grease. Several debris piles, generally less than 500 square feet in area, were scattered throughout the southern portion of the landfill.

A July 1976 aerial photograph (flight altitude approximately 6,000 feet) displayed large areas of barren ground indicating recent landfilling activity in the northwest corner of the SFL area and in an additional area extending in a band (approximately 200 feet wide) from the center of the landfill to the east boundary. The former Fire Training Area also displayed signs of surface activity (Figure 1-7).

1.2.2.2 Previous Investigations - Six monitoring wells were installed at the landfill in May 1983 as part of the July 1982 approved closure plan requirements for the SFL. Groundwater samples were periodically collected from these six monitoring wells between 1984 and 1990 (total of 11 sampling events). These results indicated detectable concentrations of arsenic, cadmium, copper, lead, nickel, and zinc, and high levels of iron in the monitoring wells. Arsenic concentrations ranged from 5.1 to 17 micrograms per liter (μg/L), lead from 13.7 to 25.1 μg/L, and iron from 55 to 14,900 μg/L. Petroleum hydrocarbons were found in all wells in 1984 in the range 2.62 to 11.9 μg/L.

From 1984 to 1986, the six closure monitoring wells were sampled once per year; from 1987 to 1990, the wells were sampled between one and three times per year, resulting in a total of 11 data points per well. Vinyl chloride was detected at a maximum of 53 μg/L in 1986.

FIGURE 1-6

PHOTOGRAPHIC INTERPRETATION-1971

SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

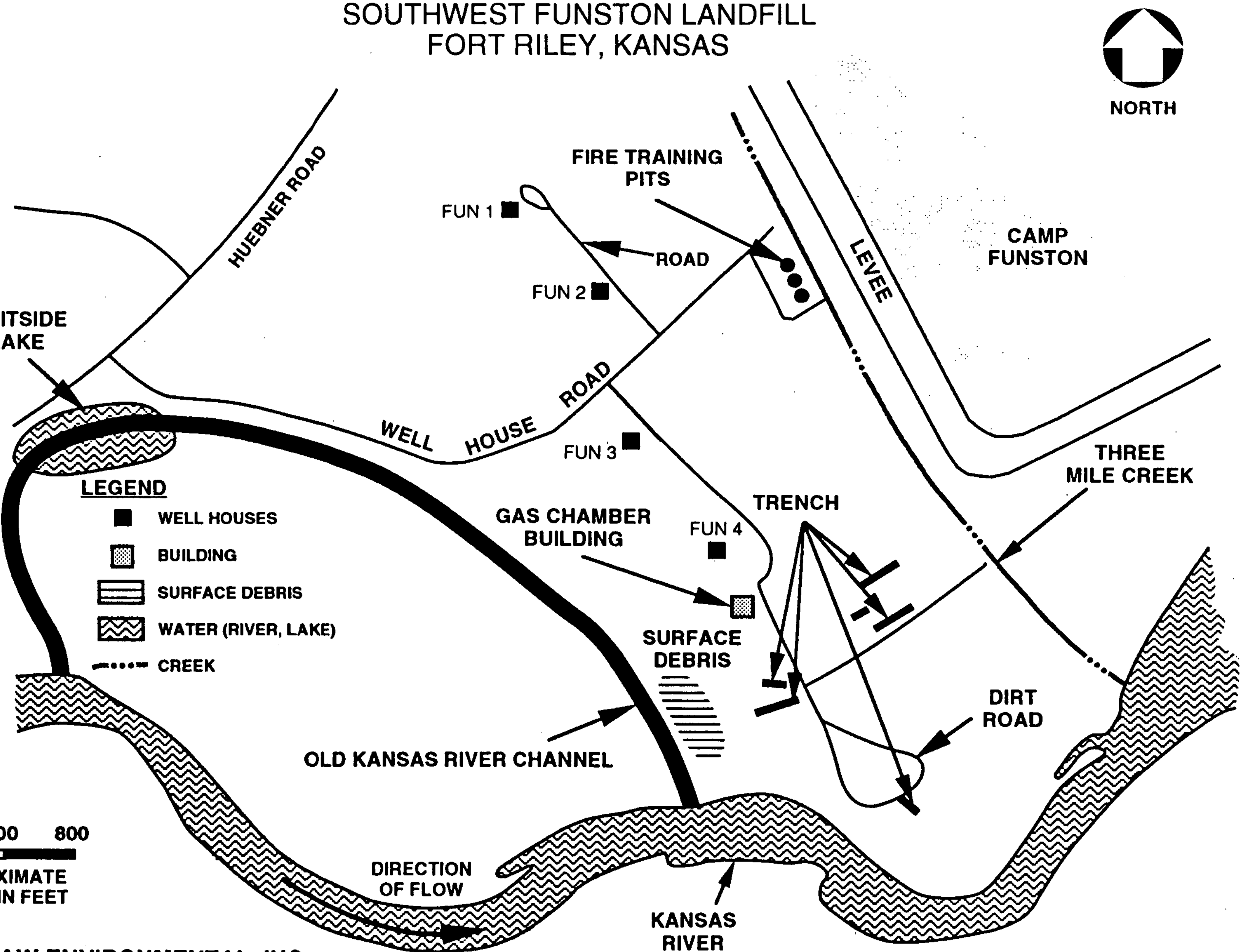

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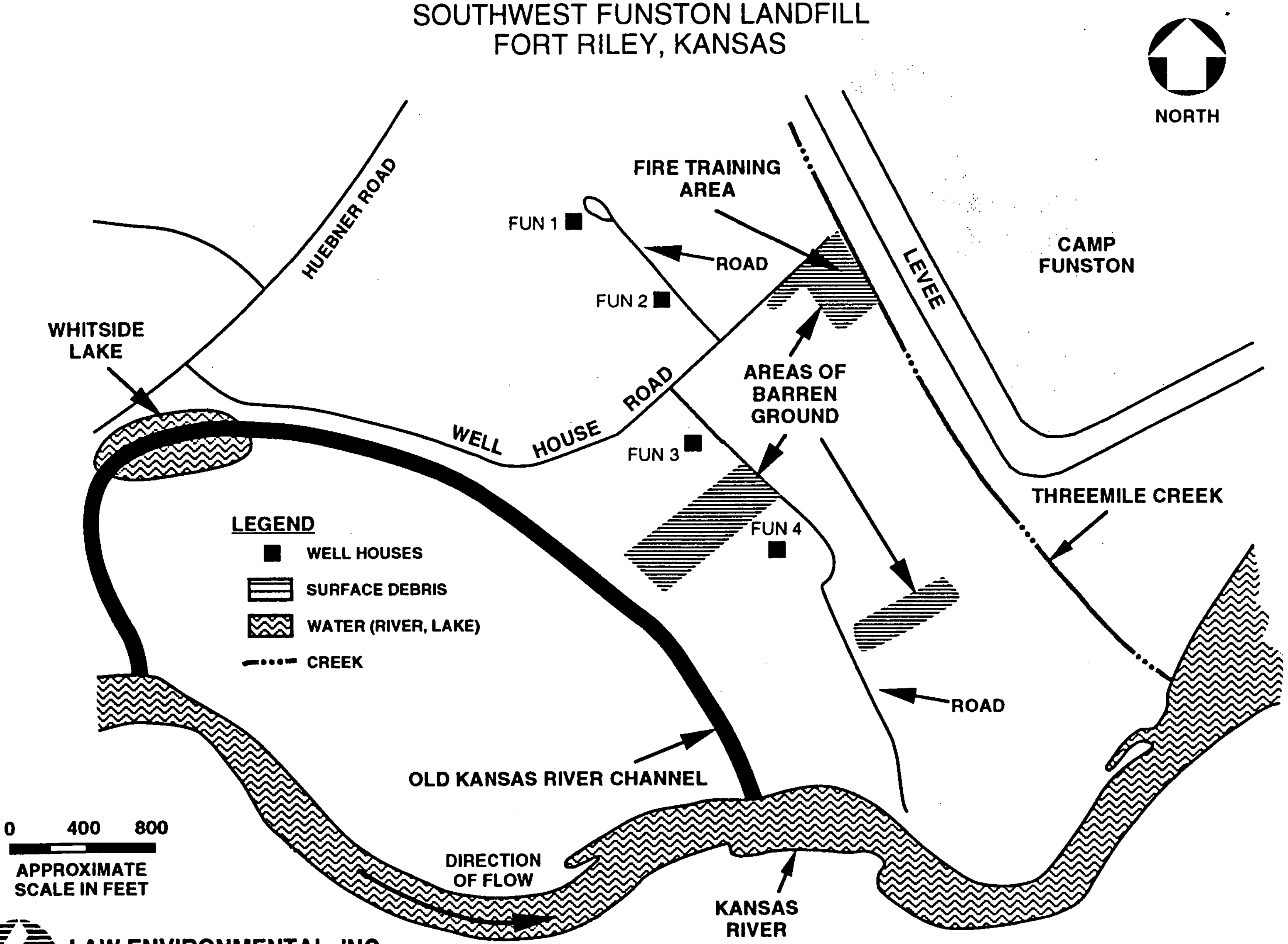
FIGURE 1-7

PHOTOGRAPHIC INTERPRETATION-1976

SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS



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Trichloroethene, dichloroethene, vinyl chloride, benzene, and ethylbenzene were detected in the initial testing performed in 1984 and in 1987. Dissolved and total iron were detected in concentrations above background. Arsenic and zinc were also detected in samples from the closure wells.

The comparability of the groundwater data from previous investigations with the RI data is limited. This is due in part to differences in monitoring well design and construction differences, sampling techniques and protocol, and differences in analytical methods.

Groundwater chemical data and hydrogeologic information are also available from the Ogden well field for the City of Ogden. Limited data are available for the abandoned Camp Funston supply wells located near the SFL.

1.2.3 Site Characterization

A remedial investigation was performed at the SFL site to characterize the site and accomplish objectives for selecting an appropriate remedial action. Field investigations at the SFL included:

- Surface features survey (November 1991)
- Surface geophysical survey (October and November 1991)
- Soil gas survey (October and November 1991)
- Installation of 20 monitoring wells (March to May 1992)
- Collection of soil samples from each of 8 deep well borings (March to May 1992)
- Collection of 7 surface water and 7 sediment samples (May 1992)
- Sampling of a private irrigation well (August 1991)
- Quarterly groundwater sampling (July 1992, November 1992, February 1993, and May 1993)
- X-ray fluorescence (XRF) screening of surface soils (July 1992)

The monitoring wells were installed in the alluvium at eight clustered locations as shown in Figure 1-8. These locations were selected in part based on soil gas field analytical data and geophysical survey data. Four of the eight locations (clusters 1, 3, 5, and 6) contain three wells: one shallow well screened above and below the water table; one intermediate well screened halfway between the water table and bedrock; and one deep well screened at the lower 10 feet of the alluvial aquifer. The other four locations (clusters 2, 4, 7, and 8) consist of a shallow well and a deep well. Location 4 was initially scheduled to have three wells in the cluster; however, due to the presence of relatively shallow bedrock, only two wells were installed.

A field survey of the physical, surficial site conditions was performed in August 1992 as part of the Engineering Evaluation/Cost Analysis for the removal action. The survey focused on the landfill surface and the adjacent Kansas River bank.

FIGURE 1-8
CROSS SECTION LINES A-A' AND B-B'
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

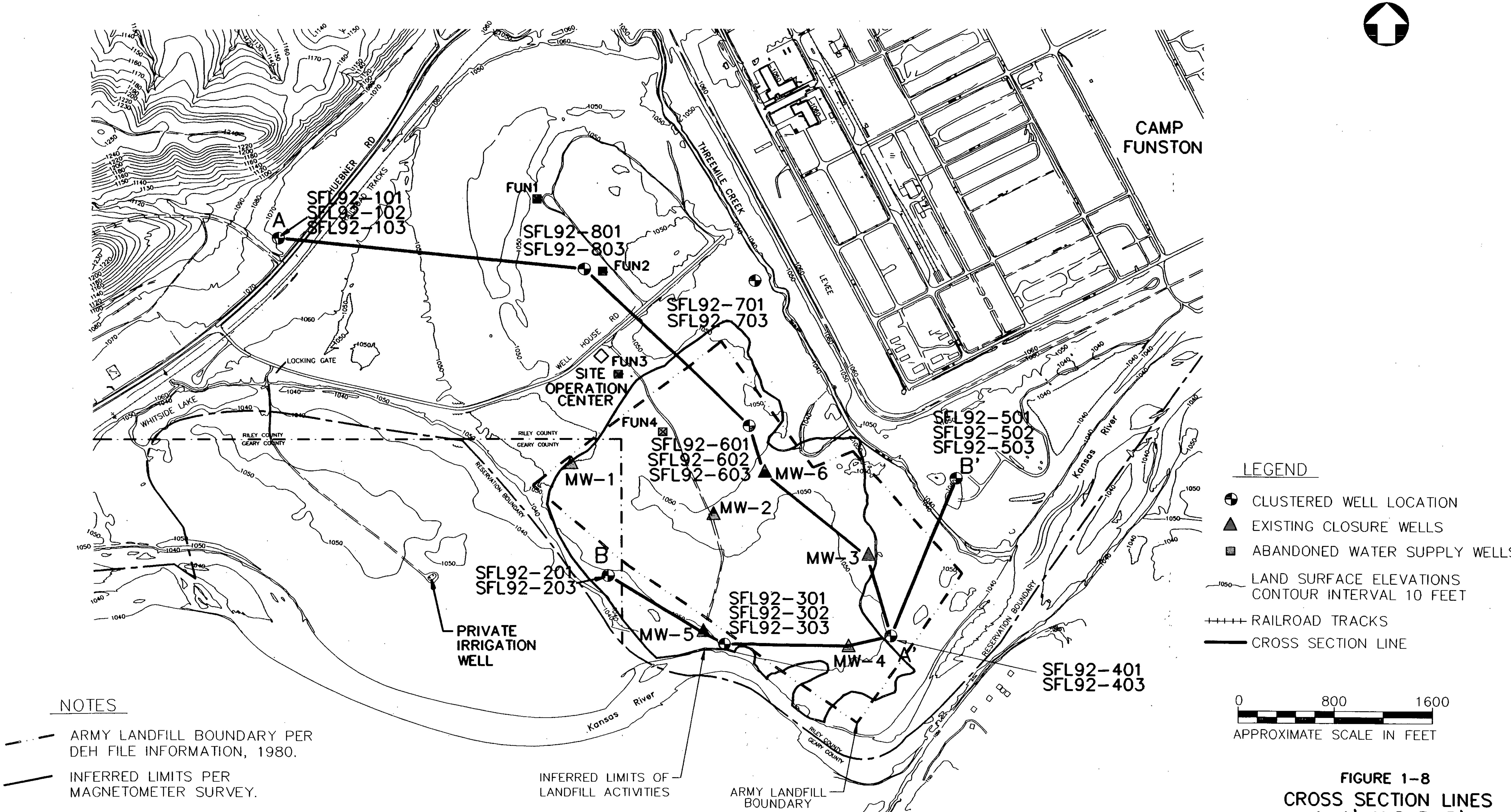

FIGURE 1-8
CROSS SECTION LINES A-A' AND B-B'

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The results of these site characterization field investigations are summarized below. In addition, an ecological risk assessment was performed for the site. The results of this assessment are summarized in Section 1.2.6.2.

1.2.3.1 Land Surface and Physiographic Features - Fort Riley lies within the Osage Plains section of the Central Lowlands physiographic province. The general topography around Fort Riley consists of plains incised by steep drainage features. The elevation within Fort Riley ranges from 1,025 to 1,356 feet above mean sea level (msl). Terrain on the installation varies among (1) narrow alluvial bottomlands and wide meander flood plains and associated terraces along the Republican and Kansas Rivers, (2) steep slopes and hilly relief, and (3) flat-lying or slightly dipping uplands.

The SFL is located in the alluvial bottomlands adjacent to the Kansas River and is relatively flat topographically with very little relief. The SFL is bounded by agricultural land to the west and Camp Funston to the east. The SFL site slopes very gently toward the east-southeast. Steep slopes exist along the banks of the Kansas River to the south and at the boundary of Threemile Creek to the east. The elevation of the closed landfill surface varies from about 1045 to 1052 feet msl.

1.2.3.2 Meteorology - Based upon average monthly climatological data collected at the Marshall Airfield weather station near Fort Riley, the area experiences a temperate climate with a mean temperature of 80 degrees Fahrenheit (°F) in July and a mean temperature of 27°F in January.

Prevailing wind direction varies from south to southwest during the period of April to January and from a northerly direction during the months of February and March. Mean wind speed is fairly constant at 8 miles per hour with a normal maximum of 12 miles per hour.

Average annual precipitation near Fort Riley is approximately 35 inches. Approximately 70 percent of annual precipitation occurs from April through September. Twenty-four-hour event totals can exceed 3.5 inches from April through October during thunderstorm periods. June and July experience the highest incidence of thunderstorms per month. Lake evaporation is approximately 50 inches per year. Fort Riley is in a subhumid climatic region which would produce evapotranspiration rates approximately equal to the rainfall amount (USGS, 1993a).

1.2.3.3 Surface Water Hydrology - Rainfall-runoff patterns on the Fort Riley installation are influenced primarily by overland flow to ditches, concrete-lined channels, impoundments, and area streams and rivers. The major rivers in the vicinity of the site are the Republican, Smoky

Hill, and Kansas rivers. The Smoky Hill River joins the Republican River to form the headwaters of the Kansas River approximately 5 miles upstream of the SFL (Figure 1-9). The Kansas River flows easterly, just south of the SFL site, and eventually drains into the Missouri River at Kansas City.

Before the construction of Milford Dam (1965), major flooding of three- to five-day durations occurred approximately every 8 to 10 years. Historical records indicate that the SFL site and adjacent Camp Funston experienced repeated surface flooding in 1951. The levee between the SFL and Camp Funston was raised in response to the 1951 floods. According to the Federal Emergency Management Agency (FEMA) flood insurance rate map dated January 1982, the entire SFL area is within the 100-year flood elevation of 1061.3 feet msl. The reported 50-year flood elevation is 1052.6 feet msl, which is above the SFL ground surface (FEMA, 1982).

The annual discharge data and mean daily values for the Smoky Hill and the Republican rivers indicate the Smoky Hill contributes about 65 percent of the flow in the Kansas River near Fort Riley. Milford Dam releases, which represent the largest fraction of total flow at the Republican River gage, contribute about 30 percent of the flow in the Kansas River. The remaining five percent is attributed to the watershed area of the Kansas River between the confluence of the Smoky Hill and Republican River and the Kansas River gage station at Fort Riley.

Based on annual peak gage height and discharge values at the Kansas River gage between 1964 and 1992, the Kansas River exhibits highest water stages between March through October. The lowest river stages usually occur between November and February.

Threemile Creek is adjacent to the east side of the SFL. Without augmentation, this stream would likely have only seasonal flow but the addition of approximately 1,500,000 gallons per day of wastewater treatment plant effluent about three miles upstream into a tributary (Forsyth Creek) of Threemile Creek puts this creek in the perennial class (USATHAMA, 1984). The confluence of Forsyth Creek and Threemile Creek is located just north of Huebner Road. It is unknown how much discharge enters Threemile Creek or how much of the initial effluent discharge is lost through seepage and evapotranspiration along Forsyth Creek.

The soil type and thickness of the streambed as well as discharge characteristics of Threemile Creek along its reach near the SFL are unknown. As presented in the Draft Final Remedial Investigation Report, Threemile Creek is thought to be a hydraulic boundary condition for groundwater flow in the alluvial aquifer system, functioning either as a line source of recharge or discharge depending on the location and on the stage of the Kansas River and Threemile Creek relative to the local groundwater system. The basis for this presentation is an analysis of stream bed elevations, groundwater elevations measured in monitoring wells, water surface elevations, and the assumption that streambed materials and the porous media of the alluvial aquifer are directly connected hydraulically.

FIGURE 1-9
DRAINAGE FEATURES AND SUPPLY WELL LOCATIONS
FORT RILEY, KANSAS

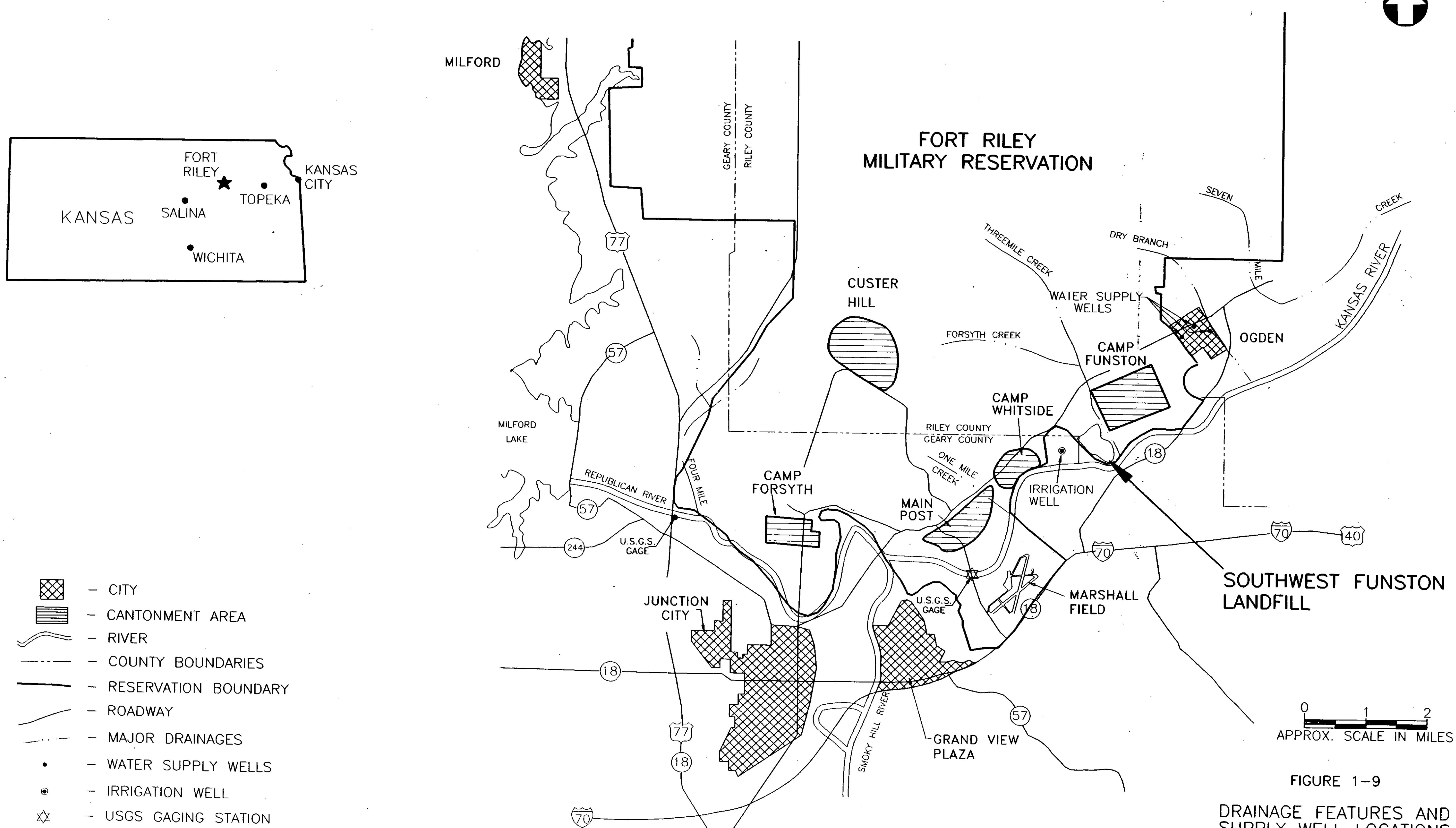

FIGURE 1-9

DRAINAGE FEATURES AND SUPPLY WELL LOCATIONS

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Surface water impoundments at or near Fort Riley include two man-made reservoirs, several oxbow lakes, and many ponds. Tuttle Creek Reservoir, northeast of Fort Riley, is fed by the Blue River. The Blue River drains into the Kansas River downstream of the SFL. Milford Reservoir, west of Fort Riley and upstream of the SFL site, is fed by the Republican River.

The nearest impoundment to the SFL is Whitside Lake, an oxbow lake located about a half mile northwest of the site. This lake was formed as a result of the 1951 flood and had a surface area of about 8 acres. The lake was dry prior to 1992 due to several years of drought. Higher than normal precipitation in 1992 refilled the lake. Floodwater passed through the lake in 1993 following the former (pre-1951 flood event) river course. Sediment was deposited leaving much of the lake silted in after the floodwater receded. No direct drainage from the SFL site into Whitside Lake was observed during the field investigation. The agricultural field adjacent to Whitside Lake and west of the SFL was left covered in sand and silt following the flooding. The irrigation well located in this field is not currently accessible.

During periods of heavy precipitation, localized ponding of the SFL site occurs as observed during the field investigation. No significant, predominant drainage features or patterns exist at the site due to the flat-lying topography. Based on field observations, surface water runoff during excessive precipitation drains generally to the east-southeast toward Threemile Creek and the Kansas River through minor depressions.

1.2.3.4 Site Geophysics - Geophysical surveys using electromagnetic (EM) and magnetometer instrumentation were conducted during the field investigations. The magnetometer surveys consisted of a perimeter profile and several radial profiles to locate subsurface metallic features within the area. The EM survey consisted of perimeter profiles around the area south of Well House Road.

The extent of subsurface metallic debris was interpreted from the geophysical data and this area was also inferred to generally be the limits of landfill activity (See Figure 1-8). The interpreted metallic debris area may also be the result of grading activities which reportedly occurred following cessation of landfilling and which may have resulted in near-surface metallic debris in areas not previously used for landfilling. A continuous perimeter of metallic anomalies was not detected during the geophysical survey and therefore, the boundary of metallic debris is somewhat interpretive.

Anomalous areas detected by the EM survey generally coincided with the anomalous areas detected by the magnetometer survey. An exception was noted in the southeast corner of the landfill where a EM anomaly was observed and a magnetic anomaly was not. The data at this location indicate the presence of electrically conductive materials other than metallic debris (e.g., deposition of a non-metallic material or a clayey zone).

Additional random placement of materials is believed to have occurred within the wooded area east of the landfill and west of Threemile Creek, outside of the inferred area of landfill activity. During a SFL wetlands survey performed by the USACE in March 1993, evidence of previous disturbances within this wooded area were noted (USACE, 1993). It is thought that localized spot burial of waste within this area may have occurred, but these events are not documented or positively identified using the available, historical aerial photographs (see Section 1.2.2.2). The previous disturbances could also have been due to previous military tank training activities. The predominant coverage of trees and vegetation in this area indicate that the recovery from the previous disturbances is well underway.

1.2.3.5 Site Surface Conditions - The landfill is covered with grass, with areas of other leafy vegetation (weeds, sunflowers, and saplings), and displays little relief compared to the surrounding land surface. Surface erosion in some areas has resulted in the development of rills and channels and has resulted in partial loss of soil cover material. These rills and channels run parallel with site drainage and are therefore expected to be due to surface water runoff rather than settlement. The surface erosion features were observed on less than 2 percent of the landfill surface (estimated). Most of the erosion was observed near the corrugated metal culvert on the east central border of the landfill.

Depressions one to two feet deep were observed at several locations due to common and widespread settlement in areas suspected of being the former disposal trenches. An estimated 20 to 30 percent of the landfill surface has observable settlement and does not drain well. During periods of wet weather, localized ponding of water was observed in the depressions with no predominant drainage pathway existing at the site. An estimated 5 percent of the landfill held ponded water. There were also numerous burrows (three to six inches in diameter) throughout the landfill, most likely due to burrowing by small animals.

Some scattered debris, consisting of rusted oil and coffee cans, old aluminum soft drink cans, wood debris, wire, cable, and concrete debris, was observed on the surface of the landfill. Based on visual observation it is expected that this material is due to surface dumping and subsequent grading activities rather than exposure of the previously buried landfill contents. Less than an estimated 3 percent of the landfill had evidence of surface dumping or exposed debris. Not all areas of the landfill were accessible or visible during the August 1992 visit due to the presence of tall weeds and thick undergrowth. Based on observations made during groundwater monitoring in September 1993, a thin veneer of sediment (up to 8 inches thick in spots) was deposited in places on the landfill following the 1993 flood event.

Along the Kansas River bank, there is a limited amount (along approximately 20 percent of the length of the SFL area bank) of bank protection at the landfill, consisting of construction rubble (e.g., rock, bricks, concrete and other material) protruding from the bank of the landfill. It is suspected that the construction rubble was placed or dumped with the intention of protecting the bank from the Kansas River. The rubble is not in an established continuous pattern, but randomly covered part or all of the bank in certain areas. Two weeks prior to the August 1992 site visit, a significant release of water (15,700 cubic feet per second at the Fort Riley Gauge on August 13, 1992) from the Milford Dam upstream caused the water to rise in the river. The river elevation rose to an estimated elevation of 1044 MSL, which is three to four feet below the top of the bank. This increased discharge caused a noticeable minor erosion and slope failure in some localized areas along the SFL. At the time of the site visit, the water elevation was estimated at ten feet below the top of the bank. In general, sloughing and localized slope failure was observed in areas without slope protection. In the one area, materials such as steel cable, steel fencing and an occasional drum were seen protruding from the bank. Slope stability issues and erosion were generally more pronounced on the west and southwest reach of the riverbank. Natural deposition of river sediments was occurring in areas toward the eastern portion of the site.

1.2.3.6 Regional Geology - Fort Riley is situated in three distinct geological-topographical areas (USAETL, 1977). The first is the uplands area, consisting of flat-lying to gently northwesterly dipping limestones and shales. The uplands area generally is covered by various shale units which overlie the escarpment-forming limestones. Small streams have dissected these thick shale units and eroded much of the area into a rolling plateau. Local topographic relief (the change in land-surface elevation within a specified area) ranges from 164 to 240 feet in the uplands area. The second geological-topographical area is the steep to hilly country. It is composed of alternating limestones and shales, which extend from the uplands down to the third area known as the alluvial bottomlands. The third geological-topographical area is the alluvial bottomlands which consist of deposits from the Republican and Kansas Rivers. Relief in this area ranges from 25 to 60 feet.

1.2.3.7 Local Geology - Deep monitoring well borings at the eight clustered monitoring well locations and closure well boring logs were used to characterize the unconsolidated material within the study area. Grain size distribution and Atterberg Limits tests were conducted for selected soil samples to confirm the field descriptions of the unconsolidated material. Each of the deep monitoring well borings were sampled continuously to the top of bedrock. Depth to the shale/limestone bedrock (Council Grove Group) ranged from 34 to 67 feet below ground surface. The variable depth to bedrock is probably due to preferential weathering/erosional processes, including those from past fluvial (river) systems.

Two cross sections have been developed for the SFL site to illustrate the relationships of the geologic units encountered throughout the study area. The cross section locations are shown in Figure 1-8. Cross section A to A' is a northwest to southeast cross section which shows the interpreted stratigraphic relationships between wells SFL92-103, SFL92-803, SFL92-603, MW-

6, MW-3 and SFL92-403 (Figure 1-10). Cross section B to B' is a west to east cross section which shows the interpreted stratigraphic relationships between wells SFL92-203, MW-5, SFL92-303, MW-4, SFL92-403 and SFL92-503 (Figure 1-11).

Both cross sections show a general coarsening downward sequence of alluvial material. Silt to silty sand occurs in the upper 10 to 20 feet underlain by approximately 10 to 20 feet of a fine to medium grain sand which overlies about 15 to 40 feet of coarse grain sand, gravel and cobbles. This unconsolidated (alluvial) material is underlain with variably weathered shaley limestone. Discontinuous clay lenses, ranging up to 10 feet thick, occur in about one-half of the borings. An exception to this general pattern is about a 25-foot thick clay deposit that occurs at closure well MW-4.

1.2.3.8 Regional Hydrogeology - The Fort Riley Military Reserve area covers a portion of the watershed for the Republican River, Milford Lake Reservoir, and the Kansas River. The area is characterized by poorly developed karst topography in interbedded limestones and shales (KGS, 1968). The term "karst" refers to topographic and lithologic characteristics associated with carbonate dissolution by groundwater. The bedrock is overlain by residual soil, alluvium, and loess.

The alluvial deposits are capable of yielding more than 1,000 gallons per minute (gpm) from a single well. This alluvial aquifer is recharged through direct infiltration of rain and by seepage from limestone and shales and the adjacent rivers. Water levels in the Fort Riley Main Post water supply wells screening the alluvial deposits generally range from 15 to 25 feet below land surface.

The primary source of drinking water for Fort Riley, Junction City, the Riley County Rural Water district, and Ogden, is the valley fill alluvium (alluvial aquifer) of the Republican and Kansas rivers. Junction City and Fort Riley's water supply wells are within the Republican River floodplain and are five miles upstream of the SFL sites. Ogden's water supply wells are located within the Kansas River floodplain, approximately 2.6 miles downstream of the site (USGS, 1982).

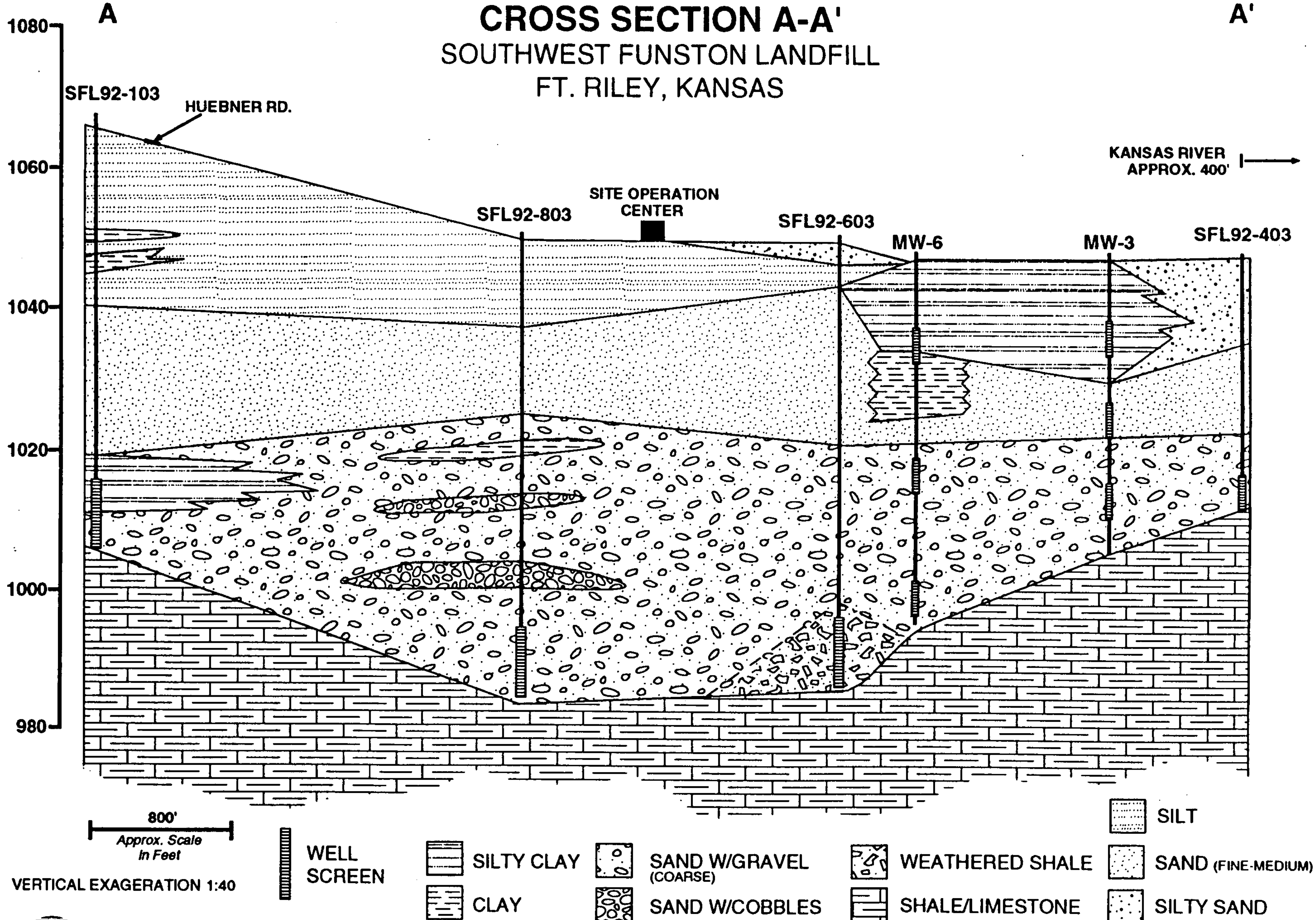
1.2.3.9 Site Hydrogeology - The SFL site is located entirely within the Kansas River alluvium. During seasonal periods of high river stage, the alluvial aquifer receives recharge from the Kansas River. Site-specific hydrogeologic conditions were investigated by obtaining data from six existing closure wells, installing 20 new monitoring wells, and performing in-situ hydraulic conductivity tests. The following discussion summarizes the hydrogeological information gathered from this investigation.

FIGURE 1-10

CROSS SECTION A-A'

SOUTHWEST FUNSTON LANDFILL

FT. RILEY, KANSAS



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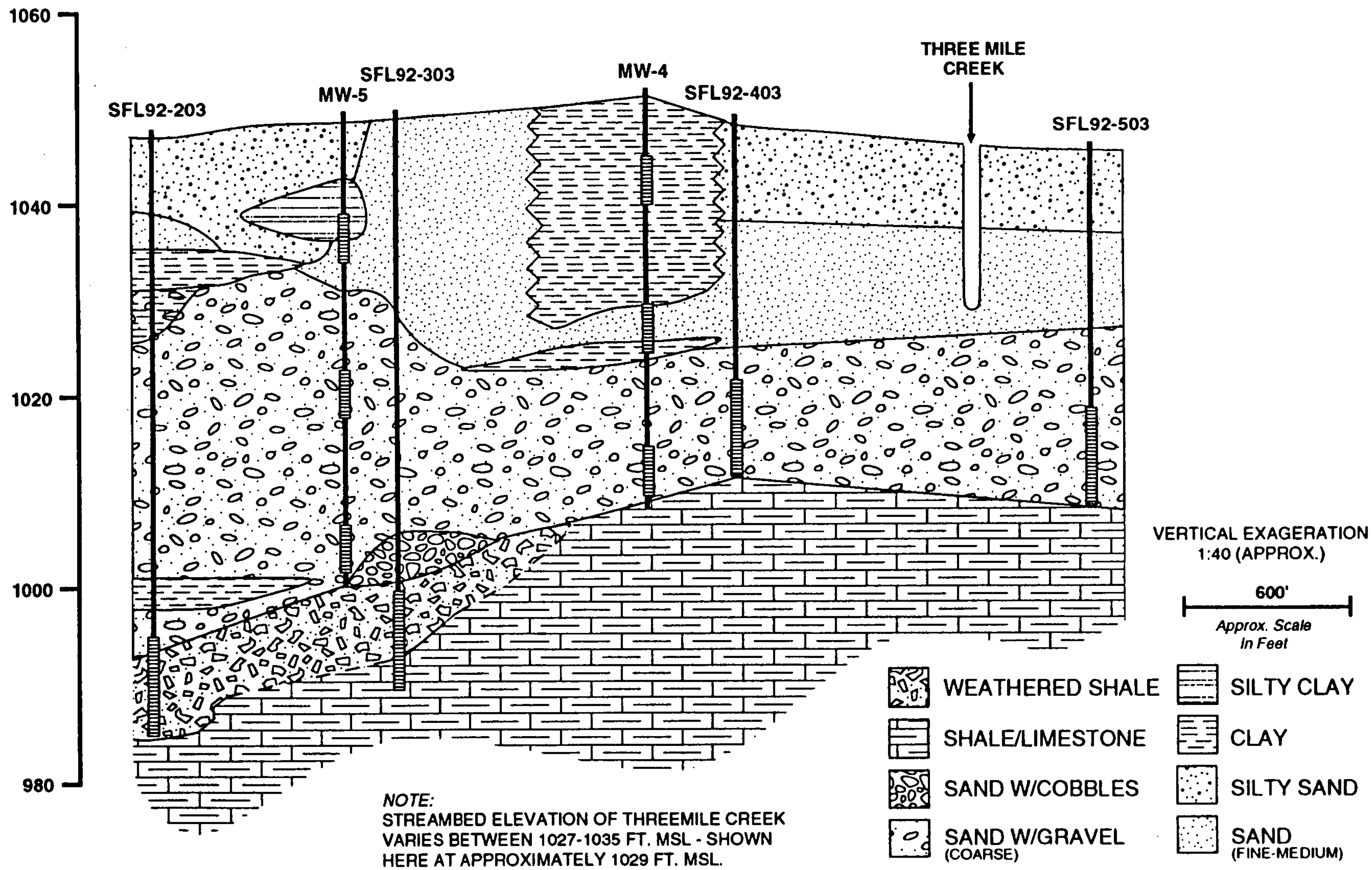
1530.75

FIGURE 1-11

CROSS SECTION B-B'

SOUTHWEST FUNSTON LANDFILL
FT. RILEY, KANSAS



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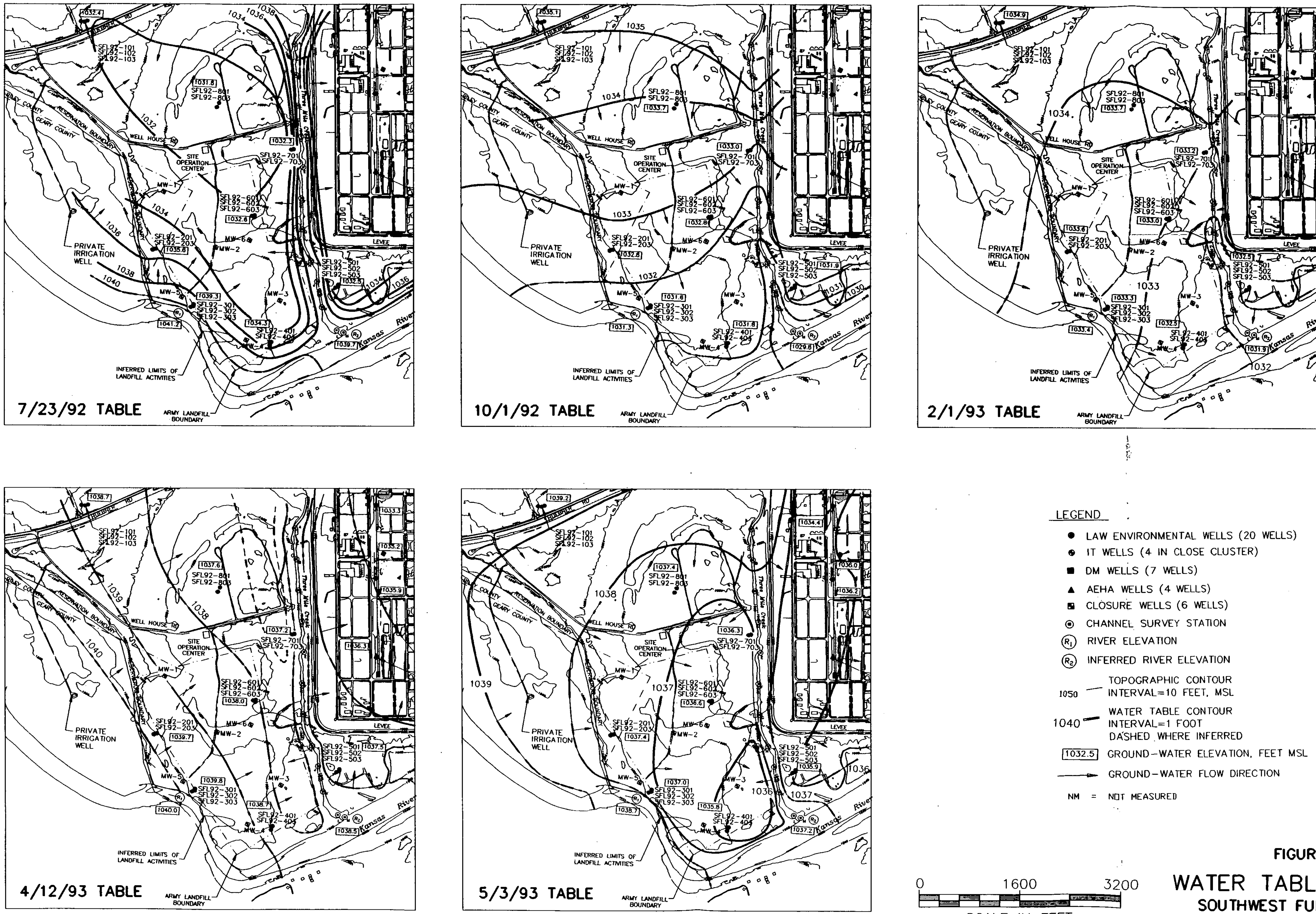
Increases in groundwater levels at the SFL can be caused by infiltration from precipitation (both regionally and at the landfill) and/or influx from the Kansas River and Threemile Creek. The RI report presents Threemile Creek as a hydraulic boundary condition for groundwater flow in the shallow aquifer system, functioning as a line source of either recharge or discharge, depending on the location and on the stage of the Kansas River and Threemile Creek relative to the local groundwater table. The basis for this presentation is an analysis of stream bed elevations, groundwater elevations measured in monitoring wells, and water surface elevations. Potentiometric surface maps for the first five RI measurement events are presented in Figure 1-12.

The hydraulic conductivity of the alluvial materials is assumed to range from 10 to 500 feet/day. The hydraulic conductivity value of 10 feet/day is based on the analysis of slug-in and slug-out field test procedures performed on each of the 20 newly installed monitoring wells at the SFL. The hydraulic conductivity value of 500 feet/day is based on interpretation of specific capacity data available for Funston supply wells FUN1, 2, 3 and 4 (Latta, 1949). The Funston wells are abandoned water supply wells that are located near the SFL and were operated from the 1940s to the late 1970s. Based on these data, the range of 10 to 500 feet/day is assumed to represent the likely range of hydraulic conductivity at the SFL site.

Water level data show that water levels in all the SFL wells can vary significantly. Groundwater levels in the wells can be influenced both by precipitation and changes in the stages of Threemile Creek and the Kansas River. Flow direction is from regions of higher elevation to lower elevation. The direction of groundwater flow varies in response to fluctuating surface-water stages relative to groundwater levels. On an average, long-term basis, the direction of groundwater flow will be toward the southeast with discharge from the groundwater system to the surface water system. For certain periods of time, conditions will reverse in response to variations in river stage, and flow will be from the surface-water system to the groundwater system. Therefore, depending on these time-varying conditions, the direction of groundwater flow in the SFL area varies in response to flow reversals near the Kansas River and Threemile Creek.

Under conditions of long stable stages in the Kansas River and Threemile Creek, transitory flow under Threemile Creek may occur. However, precipitation events, regular releases to the Kansas River and its tributaries from upstream reservoirs, and wastewater discharges to the Threemile Creek drainage basin result in persistently fluctuating stages, with flow both toward the river and away from the river. It is highly likely that any such flow under Threemile Creek would subsequently be toward the Kansas River and would not continue for a substantial distance parallel to the Kansas River toward Ogden.

Although groundwater flow directions at the SFL site vary, the net groundwater flow direction will be toward the Kansas River on a long-term basis. To estimate the net flow condition across the SFL site, estimates of average groundwater elevation and average river stage were determined from available data and a net gradient across the site was calculated. Across the



LEGEND

- ● LAW ENVIRONMENTAL WELLS (20 WELLS)
- IT WELLS (4 IN CLOSE CLUSTER)
- ■ DM WELLS (7 WELLS)
- ▲ AEHA WELLS (4 WELLS)
- CLOSURE WELLS (6 WELLS)
- ◎ CHANNEL SURVEY STATION
- (R1) RIVER ELEVATION
- (R2) INFERRED RIVER ELEVATION
- 1050 TOPOGRAPHIC CONTOUR INTERVAL=10 FEET, MSL
- 1040 WATER TABLE CONTOUR INTERVAL=1 FOOT DASHED WHERE INFERRED
- [1032.5] GROUND-WATER ELEVATION, FEET MSL
- GROUND-WATER FLOW DIRECTION
- NM = NOT MEASURED

0 1600 3200

SCALE IN FEET

FIGURE 1-12

WATER TABLE CONTOURS

SOUTHWEST FUNSTON LANDFILL

FORT RILEY, KANSAS

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

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SFL site, these estimated average elevations result in an estimated average gradient of 0.0005 feet/foot. Based on hydraulic conductivity values of 10 and 500 feet/day and an assumed effective porosity of the alluvial soils of 0.30, the velocity of net groundwater flow across the SFL site to the river may range from 0.02 to 0.83 feet/day.

1.2.3.10 Leachate Generation Mechanisms - Under current conditions, there are three significant mechanisms which interact to result in water contacting wastes in the landfill and potentially resulting in leachate production. The three mechanisms are:

- Infiltration through the landfill cap
- River influx to the landfill during high water conditions
- Increases in the regional water table elevation which result in groundwater being above the bottom of the landfill

These three mechanisms were projected as separate influences to provide a general understanding of the impact of potential remedial actions at the landfill. It is understood that these mechanisms inter-relate and all three contribute to water table fluctuation at the landfill. However, in order to evaluate the potential impacts of various remedial actions, it was necessary to use existing information, conceptual models and simplistic assumptions to project the relative influence of each mechanism. For the purpose of this report, the mechanisms are defined as follows:

- Infiltration Through the Landfill Cap - The contribution of water to the aquifer underlying the SFL which results from rainfall infiltration through the landfill cover.

- River Influx - The contribution of water to the aquifer underlying the SFL which results from Kansas River inflow to the SFL directly along the SFL/Kansas River boundary.

- Regional Water Table Fluctuations - All other mechanisms, except the two described above, which impact groundwater elevations at the landfill. This would include infiltration outside the boundaries of the SFL, regional influence of surface water bodies (including the Kansas River) and influences of the bedrock aquifer.

Rainfall Infiltration/Volume Estimates - The Hydrologic Evaluation of Landfill Performance (HELP) model was used in evaluating percolation through the landfill surface soil (Section 3.6.2.4 of the RI). Based on the HELP model simulations, the average infiltration rate of moisture passing through the surface soil and potentially coming in contact with the underlying landfill contents is estimated to be 2 to 3 inches per year (50,000 to 80,000 gallons per acre per year). This equals approximately 800,000 to 1,300,000 cubic feet per year over the estimated 120-acre landfill. The average infiltration rate was modeled using the historical average annual rainfall reported for Marshall Air Field of about 35 inches.

Additional HELP modelling was performed by CEMRK using porosity and hydraulic conductivity data derived from laboratory analyses of existing SFL soils. This additional modelling indicated that, assuming a condition of "poor" for the existing vegetative cover, infiltration through the landfill is 2.59 inches per acre per year. The results of this most recent study are consistent with the information provided in the RI.

River Influx/Volume Estimates - During periods of elevated river levels, the Kansas River and Threemile Creek are believed to recharge the aquifer along the boundary of the SFL. Fluctuations of the local water table within the SFL area due to influx of the Kansas River along the boundary of the landfill are expected to cause groundwater to periodically come in contact with landfill wastes.

The observed site conditions were used to predict the typical seasonal variations of groundwater elevations expected at the site due to precipitation (Section 3.6.2.5 of the RI). Historical Kansas River stream gage records were used to determine the annual average high water elevation and duration in the Kansas River. These site observations, available historical data for rainfall, and Kansas River gage heights were used to estimate the average annual influx volume into the SFL from the Kansas River and Threemile Creek. Influx estimates range from 60,000 to 3,000,000 cubic feet per year. These values are roughly equivalent to 0.1 to 7 inches per year (about 4,000 to 200,000 gallons per acre per year) over the estimated 120 acre landfill area.

Regional Water Table Fluctuations - Historical average information on seasonal fluctuations of the groundwater elevations within the SFL do not exist; however, an evaluation of the impact of regional water table fluctuations on the volume of water in contact with the fill material was made using the information collected during the RI (Section 3.6.2.6 of the RI). There is uncertainty in this approach because on-site data during the five groundwater measurement events may not reflect long-term historical averages.

During the July 1992 to May 1993 period, at least 15,000,000 (approximate cubic feet) of water potentially contacted the fill material. This water would be due to all three of the mechanisms discussed above. Comparing this total to the "typical" average values for infiltration through the SFL cover (800,000 to 1,300,000 ft^3/year) and range of river influx values (60,000 to 3,000,000 ft^3/year) indicates that a significant portion of the total water in contact with the fill (from at least 72 to 92 percent) is due to regional water table fluctuations.

The average estimated annual infiltration volume through the landfill cover is being compared to the regional water table observed during an unusually wet year for the Kansas area, which will overestimate the regional water table effects used in the comparison of these two mechanisms which both influence groundwater levels at the SFL. However, the comparison shows that the regional water table and the hydraulic boundary created by the fluctuating water table near the Kansas River will have a more significant influence on SFL water levels than infiltration through the landfill surface.

1.2.4 Nature and Extent of Contamination

According to historical information, groundwater chemistry results, and waste generation data obtained during the RI, the SFL is a source of contamination in the groundwater. Types of materials disposed at SFL which are potential sources of contamination include wastes generated by the following activities:

- Motor vehicle maintenance shops (metal-laden waste oils, spent degreasing solvents [such as petroleum naphtha], tetrachloroethene, carbon tetrachloride and antifreeze [ethylene glycol]).

- Vehicle wash racks (liquid wastes similar to, but more dilute than the oils and solvents generated by vehicle maintenance; sedimentation basin and oil-water separator sludges).

- Dried sludges from the four Wastewater Treatment Plants (WWTPs) on the installation.

- Print shop wastes (primarily rags soaked with ink and tetrachloroethene).

- Furniture repair shop wastes (including solvent/paint sludge, acetone, tetrachloroethene and cellulose nitrate).

- Paint-related wastes typically associated with Fort Riley painting facilities (including paint sludge, acetone [solvent], cellulose acetate [thinner], cellulose acetate butyrate [thinner], and paint booth air filters).

- Oil Analysis Laboratory wastes (trichloroethane and trichlorotrifluoroethane have been used as solvents in the various analyses).

- Autoclaved biological waste.

- Waste mercury from accidental spills and instrument breakage.

- Pesticide Storage Facility wastes (used storage containers, unsalvageable equipment, and contaminated rags).

- Former Dry Cleaning Facility wastes (including Stoddard [naphtha] solvent, tetrachloroethene, and paper/carbon filters removed from solvent distilling machines).

Other potential sources of contamination in the area, in addition to wastes disposed in the SFL, include the following:

- The area north of Well House Road at the SFL which was identified as possibly containing several small areas of subsurface metallic debris. There was an indication of localized activity (trenching and grading) in the 1951, 1954, and 1960 aerial photographs.

- The former Fire Training Area, northeast of the SFL proper, which was identified as a potential source of contamination due to the use of fuels and possible use of solvents to ignite materials used in training fire fighters.

- The farmland southwest of the SFL, identified as another potential source of contaminants due to the use of herbicides, pesticides, and fertilizers.

- The Camp Funston area which includes equipment maintenance areas in the western portion of Camp Funston for both the Kansas National Guard and the 89th Army Reserve Command. The area also has a history of rail yard operations, including petroleum product loading, unloading and storage. In addition, at least 28 underground storage tanks (USTs), some of which were reported to have leaked, have been removed from Camp Funston in the past four years.

- The WWTPs located upstream of the SFL, which may be potential sources of contaminants to surface water and sediment in the vicinity of SFL.

The results of the field sampling program are summarized below. Media sampled included soil gas, groundwater, surface and subsurface soils, surface water, and sediments. The soil gas and surface soil samples were analyzed on site using a mobile laboratory. Groundwater, soil, surface water, and sediment samples were sent to an off-site analytical laboratory for the following analyses:

- Volatile organics
- Semi-volatile organics
- Chlorinated pesticides/Polychlorinated Biphenyls (PCBs)
- Metals (total and dissolved)
- Organophosphorus pesticides
- Explosives

- Herbicides
- Selected inorganic analytes
- Total recoverable petroleum hydrocarbons (TRPH)

1.2.4.1 Soil Gas Results - The results of the soil gas survey were used to identify areas of potential contamination for the placement of monitoring wells. Monitoring well cluster 2 (SFL92-201 and SFL92-203) was located along the western boundary of SFL where soil gas data indicated that diesel fuel and chlorinated compounds were present. Monitoring well cluster 3 (SFL92-301, SFL92-302, and SFL92-303) was located near the southwestern border of the landfill where soil gas samples exhibited volatiles and chlorinated compounds (tetrachloroethene, trichloroethene and 1,1,1-trichloroethane).

Monitoring well cluster 4 (SFL92-401 and SFL92-403) was located near the southeast boundary of the SFL where soil gas samples exhibited volatiles in an area where the geophysical results indicated EM anomalies. Monitoring well cluster 6 (SFL92-601, SFL92-602, and SFL92-603) was located near the northern edge of the landfill in an area where soil gas samples exhibited volatiles and fuel-related compounds.

Soil gas samples were also collected in the area where fire training activities took place; the soil gas results contained no measurable levels of fuel-related compounds. However, to the south of this area, one soil gas sample contained 1,1,1-trichloroethane; this sample was collected in an area where the geophysical survey exhibited an EM anomaly. Monitoring well cluster 7 (SFL92-701 and SFL92-703) was located in the area of this EM anomaly and soil gas sample.

1.2.4.2 Groundwater Results - Twenty monitoring wells were installed during 1992 at eight cluster locations. Four of the eight locations (1, 3, 5, and 6) contained clusters of one shallow, one intermediate, and one deep well. The 100 cluster wells were used to establish background concentrations. The 500 cluster well data were not included as part of the SFL because the cluster is east of Threemile Creek. The four remaining locations (2, 4, 7, and 8) consisted of one shallow and one deep well. The monitoring well sampling events upon which this FS is based occurred in July 1992, November 1992, February 1993, and May 1993 (the baseline, first, second, and third quarters, respectively). A summary of the fourth quarter groundwater data is presented at the end of this section for completeness, although it has not been used for the purpose of the FS.

Baseline (July 1992) Groundwater Analysis Results - Both organic and inorganic constituents were detected in the groundwater samples collected during the baseline sampling event at the SFL during the RI. During baseline sampling of the monitoring wells at the SFL, groundwater flow was away from Threemile Creek and the Kansas River. The only organic compounds detected during the baseline sampling at SFL were volatile organic compounds (VOCs). Figure 1-13 provides well locations with corresponding positive organic analytical results and inorganic results which exceeded drinking water standards (Maximum Contaminant Levels [MCLs]). The complete analytical results are provided and discussed in the Draft Final RI Report (Law, 1993c).

First Quarter (November 1992) Groundwater Analysis Results - Organic and inorganic constituents were both detected in the groundwater samples collected during the first quarter sampling event. During this sampling event, groundwater flow direction was towards Threemile Creek and the Kansas River. The flow direction indicates that Threemile Creek is acting as a discharge area for the groundwater. The only organic compounds detected during the first quarter sampling at SFL were petroleum hydrocarbons and VOCs. Figure 1-14 provides well locations with corresponding positive organic analytical results and inorganic results which exceeded MCLs.

Second Quarter (February 1993) Groundwater Analysis Results - Detectable concentrations of organic and inorganic constituents were present in the groundwater samples collected during the second quarter (February 1993) sampling event at SFL. The groundwater gradient during this sampling event was east-southeast toward the Kansas River and Threemile Creek. The direction of groundwater flow indicates that Threemile Creek is acting as a discharge area for groundwater contaminant migration. The only organic compounds detected during the second quarter sampling event at SFL were VOCs. Figure 1-15 provides well locations with corresponding positive organic results and inorganic results greater than MCLs.

Third Quarter (May 1993) Groundwater Analysis Results - As with the previous sampling events, both organic and inorganic constituents were detected in the groundwater samples collected during the third quarter (May 1993) sampling event at the SFL. The groundwater gradient during this sampling event was directed to the center portion of the SFL, indicating Threemile Creek was acting as a recharge source. The only organic compounds detected during the third quarter sampling event at SFL were petroleum hydrocarbons and VOCs. Figure 1-16 provides well locations with corresponding positive organic analytical results and inorganic results which exceed MCLs.

Fourth Quarter (September 1993) Groundwater Analysis Results - As with the previous sampling events, both organic and inorganic constituents were detected in the groundwater samples collected during the fourth quarter (September 1993) sampling event at the SFL. The groundwater gradient during this sampling event was to the east, toward Threemile Creek, indicating that Threemile Creek was active as a discharge area for the groundwater. The only organic compounds detected during the fourth quarter sampling event were VOCs. Organic compounds detected at concentrations greater than background were arsenic, barium, cadmium, chromium, and lead, with cadmium and lead detected slightly above their MCLs.

FIGURE 1-13

GROUND-WATER ANALYTICAL RESULTS*
BASELINE (JULY 1992) INVESTIGATION
SOUTHWEST FUNSTON LANDFILL

FORT RILEY, KANSAS

NOTE

*THIS INCLUDES ALL POSITIVE ORGANIC RESULTS AND METALS RESULTS WHICH EXCEED FEDERAL MCLS.

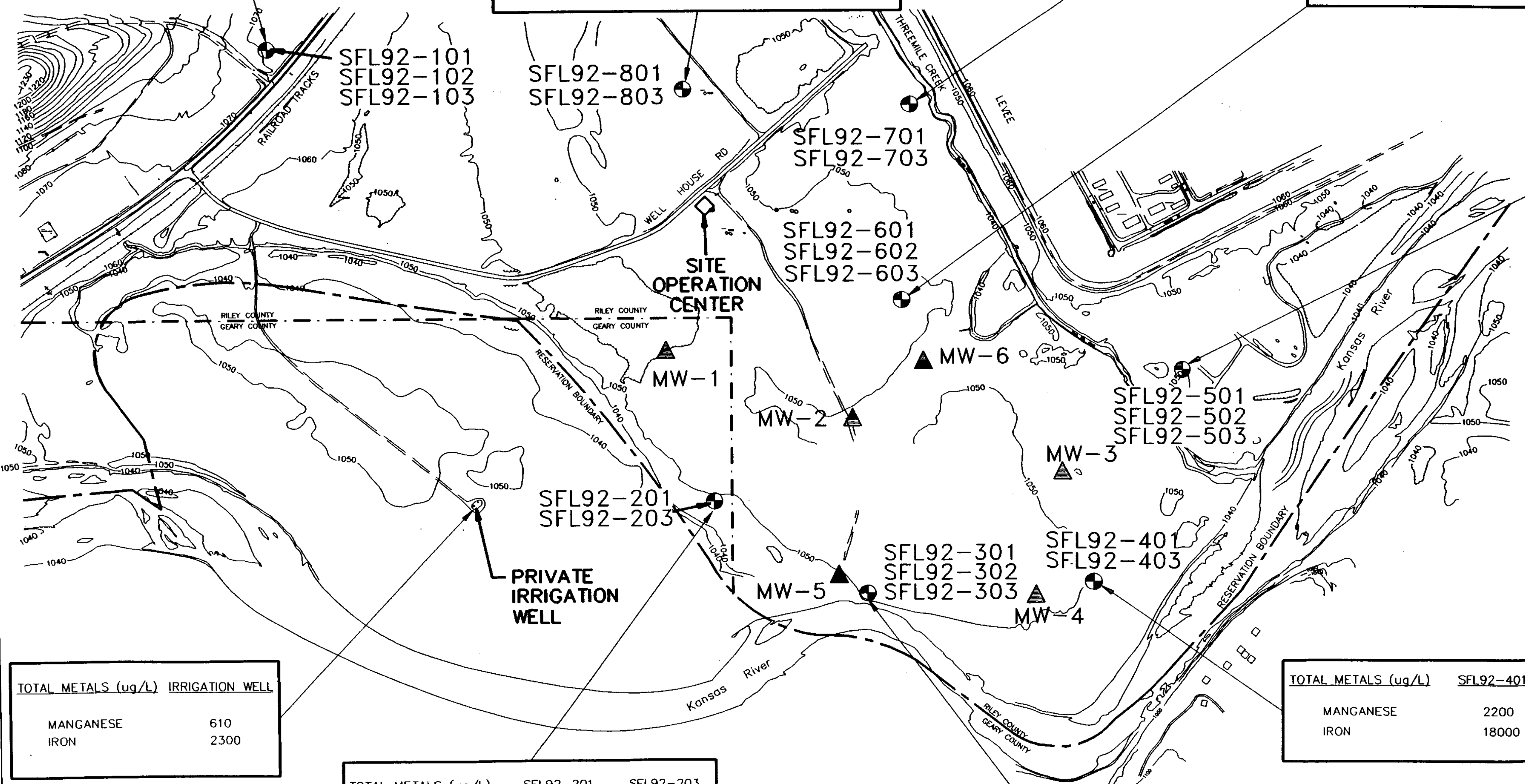
VOLATILE ORGANICS (ug/L)	SFL92-101	SFL92-102	SFL92-103
METHYLENE CHLORIDE	21 (T)	18 (T)	16 (T)
TOTAL METALS (ug/L)			
ALUMINUM	ND	460	120
IRON	1700	550	110
MANGANESE	1000	320	290

VOLATILE ORGANICS (ug/L)	SFL92-801	SFL92-803
1,1,2,2 TETRACHLOROETHANE	15	12
1,1,2 TRICHLOROETHANE	8.8	--
1,2 DICHLOROPROPANE	4.1	3.6
2-HEXANONE	22	18
BENZENE	2.4	--
BROMOFORM	8.0	6.4
CHLORODIBROMOMETHANE	5.2	--
METHYLENE CHLORIDE	8.4 (T)	12 (T)
METHYL ISOBUTYL KETONE	22	19
STYRENE	3.1	--
XYLENES	--	6.3
CIS-1,3-DICHLOROPROPENE	5.9	5.4
TOTAL METALS (ug/L)		
MANGANESE	430	1200
IRON	2700	230

VOLATILE ORGANICS (ug/L)	SFL92-701	SFL92-703
METHYLENE CHLORIDE	6.3	ND
TOTAL METALS (ug/L)		
MANGANESE	560	960
IRON	3100	2700

VOLATILE ORGANICS (ug/L)	SFL92-601	SFL92-602	SFL92-603
BENZENE	8.9	ND	ND
VINYL CHLORIDE	18	ND	ND
TOTAL METALS (ug/L)			
MANGANESE	2500	1700	1500
IRON	35000	20000	5800

VOLATILE ORGANICS (ug/L)	SFL92-501	SFL92-502	SFL92-503
1,1,1,2 TETRACHLOROETHANE	5.2	ND	6.0
1,1,2,2 TETRACHLOROETHANE	ND	ND	6.3
1,2,3 TRICHLOROPROPANE	30	ND	34
1,2 DIBROMOETHANE	21	ND	24
ETHYL METHACRYLATE	22	ND	24
METHACRYLONITRILE	29	ND	30
METHYL CHLORIDE	11	ND	11
METHYLENE BROMIDE	19	ND	22
METHYLENE CHLORIDE	ND	6.2 (T)	ND
PENTACHLOROETHANE	12	ND	13
TRICHLOROFLUOROMETHANE	5.2	ND	5.2
VINYL CHLORIDE	14	ND	ND
XYLENES	8.4	ND	9.1
TRANS-1,2-DICHLOROETHENE	8.7	7.9	ND
TRANS-1,4-DICHLORO-2-BUTENE	18	ND	20
TOTAL METALS (ug/L)			
MANGANESE	1900	NA	1800
IRON	12000	NA	10000



LEGEND

- CLUSTERED WELL LOCATION
- EXISTING CLOSURE WELLS
- CONTOUR INTERVAL (10 ft)
- RAILROAD TRACKS
- NA - NOT ANALYSED
- ND - NOT DETECTED
- T - SAMPLE RESULTS ARE LESS THAN 10 TIMES AMOUNT IN TRIP BLANK.

TOTAL METALS (ug/L)	IRRIGATION WELL
MANGANESE	610
IRON	2300

TOTAL METALS (ug/L)	SFL92-201	SFL92-203
MANGANESE	1600	1500
IRON	17000	4400

TOTAL METALS (ug/L)	SFL92-301	SFL92-302	SFL92-303
MANGANESE	410	440	1100
IRON	2200	2700	3000

TOTAL METALS (ug/L)	SFL92-401	SFL92-403
MANGANESE	2200	2400
IRON	18000	17000

0 800 1600

APPROXIMATE SCALE IN FEET

FIGURE 1-13

GROUND-WATER ANALYTICAL RESULTS (JULY '92)

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FIGURE 1-14

GROUND-WATER ANALYTICAL RESULTS*
FIRST QUARTER (NOVEMBER 1992)
SOUTHWEST FUNSTON LANDFILL

FORT RILEY, KANSAS

TOTAL METALS (ug/L)	SFL92-101	SFL92-102	SFL92-103
ALUMINUM	ND	230	ND
MANGANESE	880	250	220
IRON	500	320	260
TRPH (mg/L)	ND	ND	3.9

TOTAL METALS (ug/L)	SFL92-801	SFL92-803
MANGANESE	450	1400
IRON	2700	160

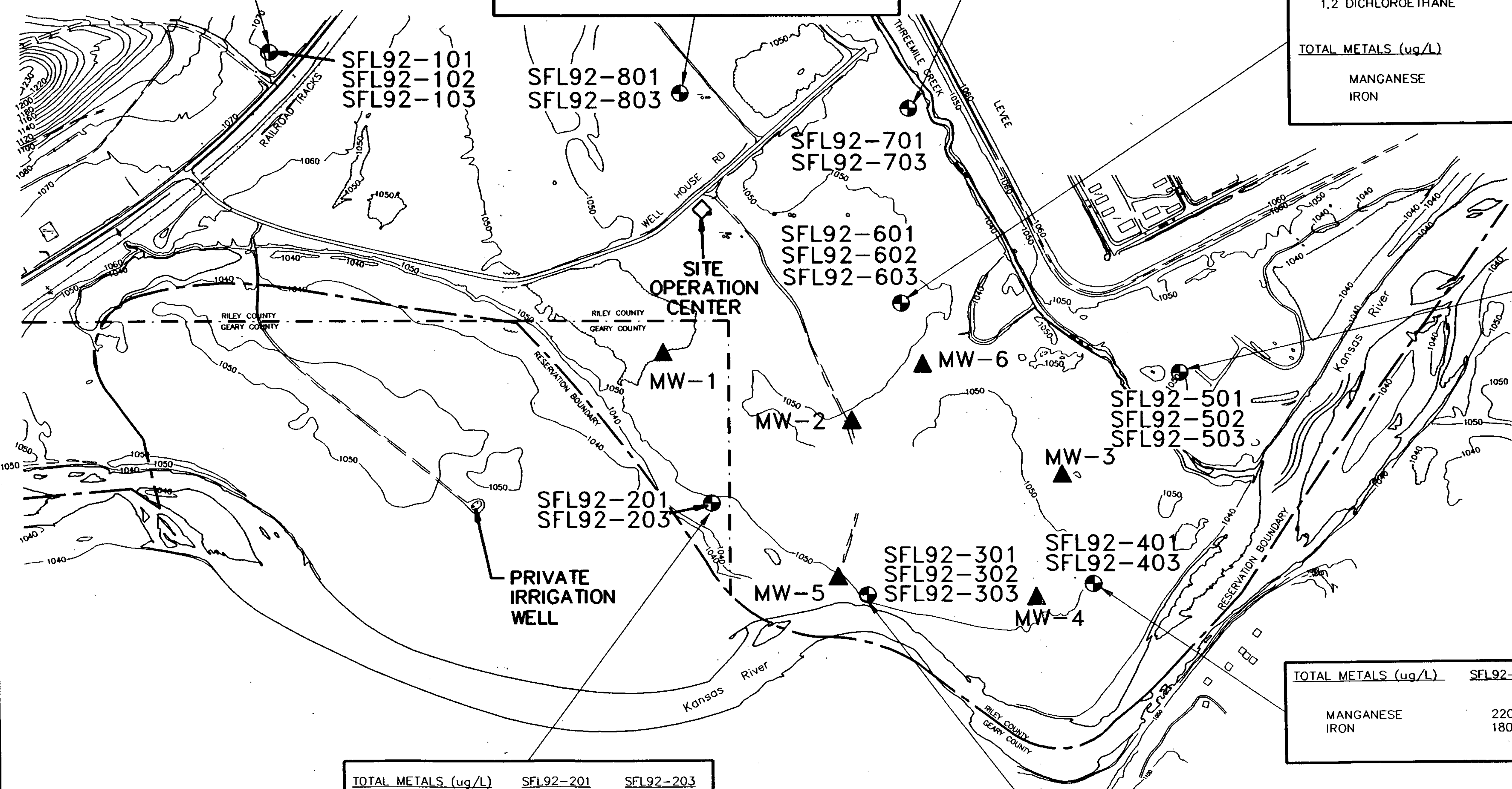
TOTAL METALS (ug/L)	SFL92-701	SFL92-703
ALUMINUM	ND	250
ANTIMONY	ND	31
MANGANESE	500	1200
IRON	1400	2200

NOTE

*THIS INCLUDES ALL POSITIVE ORGANIC RESULTS AND METALS RESULTS WHICH EXCEED FEDERAL MCLS.

VOLATILE ORGANIC (ug/L)	SFL92-601	SFL92-602	SFL92-603
BENZENE	5.0	4.9	ND
1,2 DICHLOROETHANE	16	ND	ND
TOTAL METALS (ug/L)			
MANGANESE	2100	2100	1900
IRON	28000	24000	7900

VOLATILE ORGANIC (ug/L)	SFL92-501	SFL92-502	SFL92-503
1,2 DICHLOROETHANE	6.8	8.1	ND
TRPH (mg/L)	2.3	3.1	2.0
TOTAL METALS (ug/L)			
MANGANESE	1900	2100	1900
IRON	11000	11000	12000



LEGEND

- CLUSTERED WELL LOCATION
- EXISTING CLOSURE WELLS
- CONTOUR INTERVAL (10 ft)
- RAILROAD TRACKS
- ND - NOT DETECTED

TOTAL METALS (ug/L)	SFL92-401	SFL92-403
MANGANESE	2200	2400
IRON	18000	18000

TOTAL METALS (ug/L)	SFL92-201	SFL92-203
ALUMINUM	ND	350
MANGANESE	2000	1500
IRON	19000	5900
TRPH (mg/L)	ND	3.5

TOTAL METALS (ug/L)	SFL92-301	SFL92-302	SFL92-303
MANGANESE	660	1200	1300
IRON	63	7700	3600
TRPH (mg/L)	2.2	14	ND

0 800 1600

APPROXIMATE SCALE IN FEET

FIGURE 1-14

GROUND-WATER ANALYTICAL RESULTS (NOV. '92)

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

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FIGURE 1-15

GROUND-WATER ANALYTICAL RESULTS*
SECOND QUARTER (FEBRUARY 1993)
SOUTHWEST FUNSTON LANDFILL

FORT RILEY, KANSAS

VOLATILE ORGANICS (ug/L)	SFL92-101	SFL92-102	SFL92-103
METHYLENE CHLORIDE	15	ND	18
TOTAL METALS (ug/L)			
MANGANESE	810	170	120
IRON	590	ND	90

VOLATILE ORGANICS (ug/L)	SFL92-801	SFL92-803
METHYLENE CHLORIDE	13	11
TOTAL METALS (ug/L)		
ANTIMONY	ND	23
MANGANESE	410	1200
IRON	2700	55

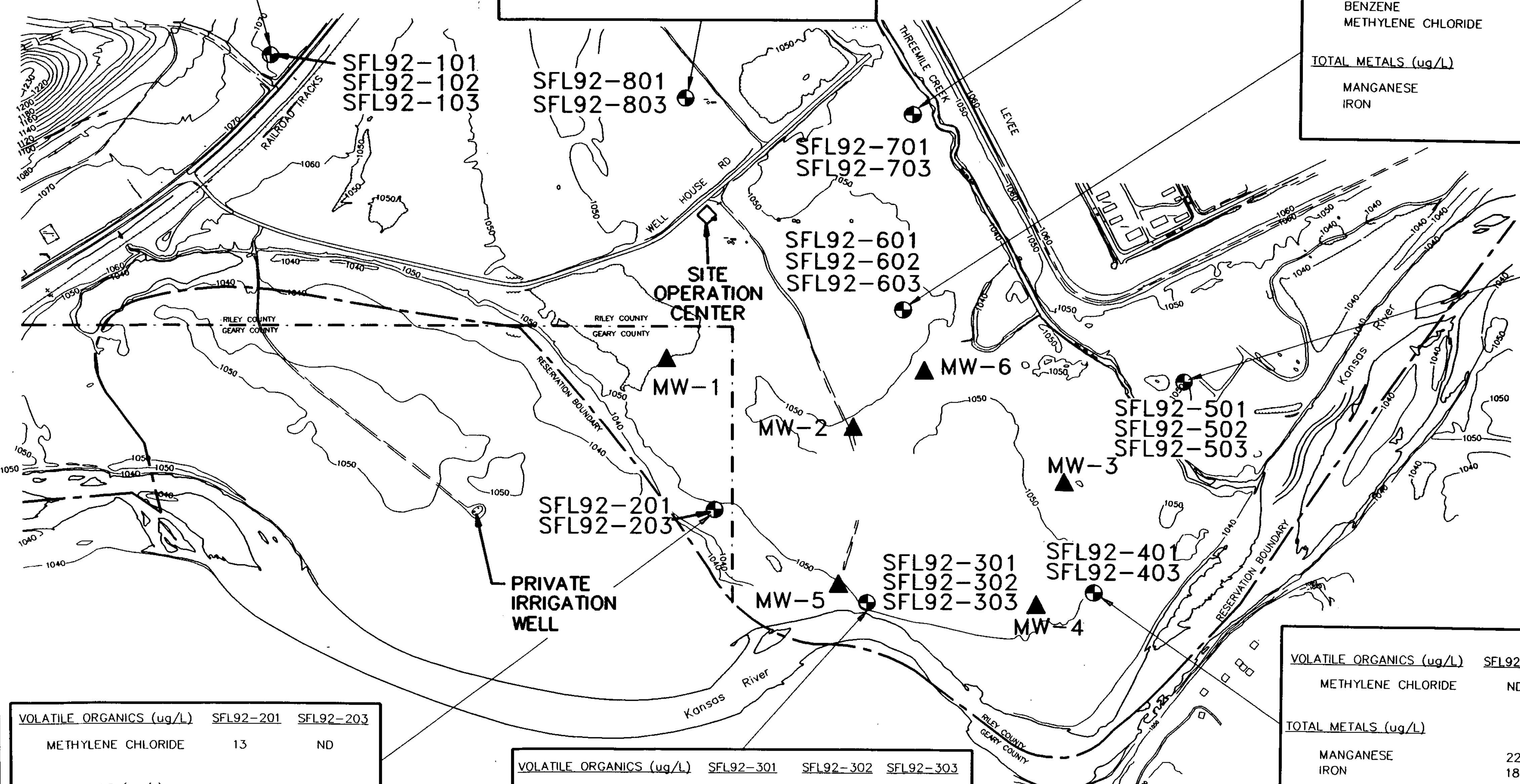
VOLATILE ORGANICS (ug/L)	SFL92-701	SFL92-703
METHYLENE CHLORIDE	11	ND
TOTAL METALS (ug/L)		
MANGANESE	560	1300
IRON	3000	2300

NOTE

*THIS INCLUDES ALL POSITIVE ORGANIC RESULTS AND METALS RESULTS WHICH EXCEED FEDERAL MCLS.

VOLATILE ORGANICS (ug/L)	SFL92-601	SFL92-602	SFL92-603
BENZENE	1.6	1.5	ND
METHYLENE CHLORIDE	ND	ND	13
TOTAL METALS (ug/L)			
MANGANESE	2100	2300	2000
IRON	32000	27000	8500

VOLATILE ORGANICS (ug/L)	SFL92-501	SFL92-502	SFL92-503
METHLENE CHLORIDE	ND	13	10
TRANS-1,2-DICHLOROETHENE	5.3	4.0	ND
TOTAL METALS (ug/L)			
MANGANESE	1800	2000	1900
IRON	11000	9800	12000



LEGEND

- CLUSTERED WELL LOCATION
- EXISTING CLOSURE WELLS
- 1050 CONTOUR INTERVAL (10 ft)
- +++++ RAILROAD TRACKS
- ND - NOT DETECTED

VOLATILE ORGANICS (ug/L)	SFL92-201	SFL92-203
METHYLENE CHLORIDE	13	ND
TOTAL METALS (ug/L)		
MANGANESE	2700	1400
IRON	16000	5300

VOLATILE ORGANICS (ug/L)	SFL92-301	SFL92-302	SFL92-303
METHYLENE CHLORIDE	ND	ND	11
TOTAL METALS (ug/L)			
MANGANESE	1200	1300	1400
IRON	2000	9300	3800

VOLATILE ORGANICS (ug/L)	SFL92-401	SFL92-403
METHYLENE CHLORIDE	ND	10
TOTAL METALS (ug/L)		
MANGANESE	2200	2300
IRON	18000	18000

0 800 1600
APPROXIMATE SCALE IN FEET

FIGURE 1-15
GROUND-WATER ANALYTICAL RESULTS (FEB. '93)

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FIGURE 1-16

GROUND-WATER ANALYTICAL RESULTS*
THIRD QUARTER (MAY 1993)
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

VOLATILE ORGANICS (ug/L)	SFL92-101	SFL92-102	SFL92-103
METHYLENE CHLORIDE	10 (T)	ND	10 (T)
TOTAL METALS (ug/L)			
MANGANESE	810	58	38
IRON	1800	190	ND

TOTAL METALS (ug/L)	SFL92-801	SFL92-803
MANGANESE	340	1300
IRON	2500	ND

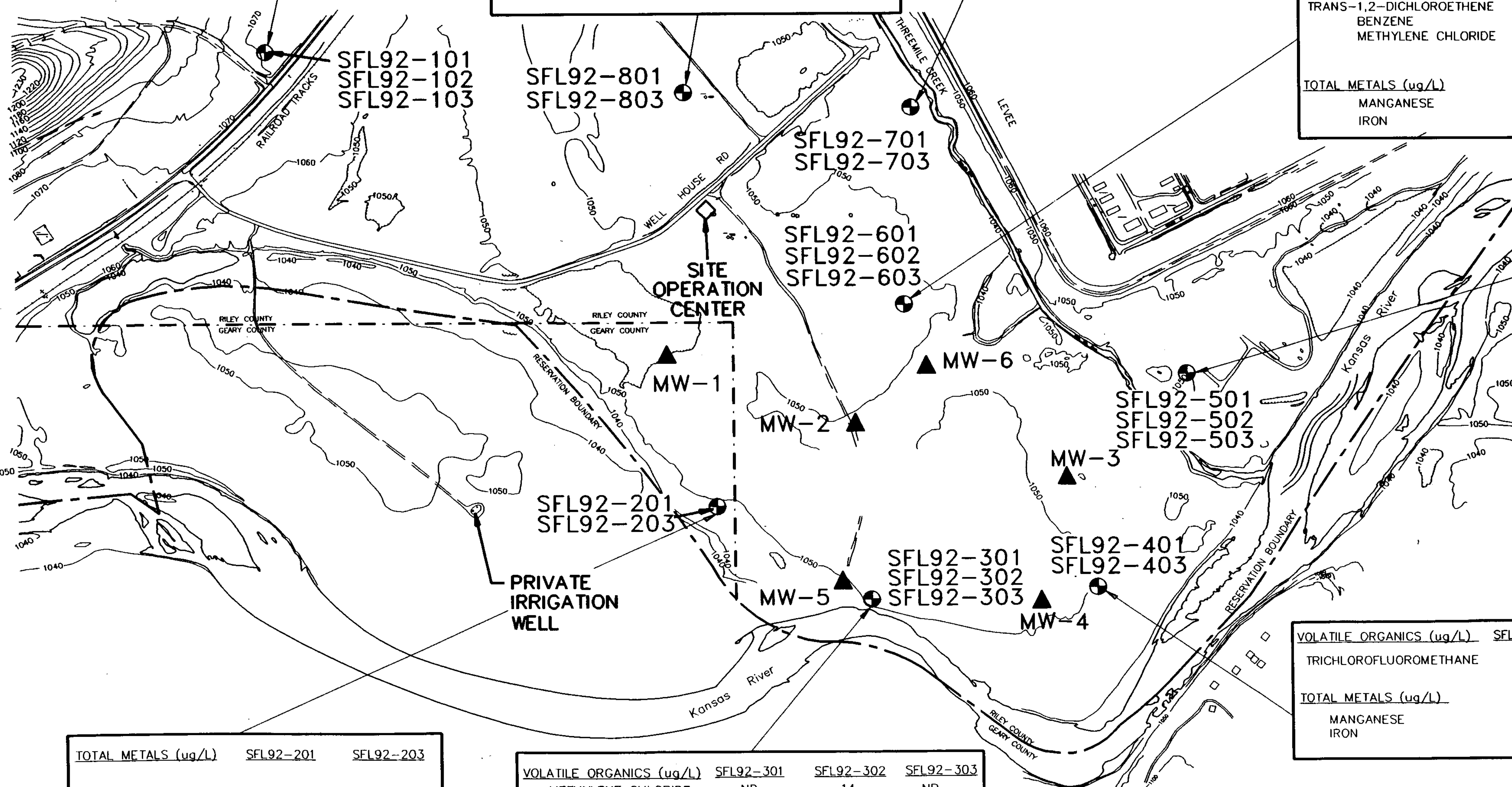
VOLATILE ORGANICS (ug/L)	SFL92-701	SFL92-703
TRICHLOROETHENE	4.3	ND
TOTAL METALS (ug/L)		
MANGANESE	710	1400
IRON	4600	2400

NOTE

*THIS INCLUDES ALL POSITIVE ORGANIC RESULTS AND METALS RESULTS WHICH EXCEED FEDERAL MCLS.

VOLATILE ORGANICS (ug/L)	SFL92-601	SFL92-602	SFL92-603
1,1-DICHLOROETHANE	3.0	ND	ND
TRANS-1,2-DICHLOROETHENE	6.2	ND	ND
BENZENE	14	ND	ND
METHYLENE CHLORIDE	ND	11 (T)	ND
TOTAL METALS (ug/L)			
MANGANESE	2200	2200	2000
IRON	36000	23000	8200

VOLATILE ORGANICS (ug/L)	SFL92-501	SFL92-502	SFL92-503
TRANS-1,2- DICHLOROETHENE	3.5	ND	ND
METHYLENE CHLORIDE	ND	ND	12 (T)
TOTAL METALS (ug/L)			
MANGANESE	1700	1900	2000
IRON	9400	11000	14000



LEGEND

- CLUSTERED WELL LOCATION
- EXISTING CLOSURE WELLS
- CONTOUR INTERVAL (10 ft)
- RAILROAD TRACKS
- ND - NOT DETECTED
- T - SAMPLE RESULTS ARE LESS THAN 10 TIMES AMOUNT IN TRIP BLANK.

TOTAL METALS (ug/L)	SFL92-201	SFL92-203
MANGANESE	1600	1400
IRON	11000	4700

VOLATILE ORGANICS (ug/L)	SFL92-301	SFL92-302	SFL92-303
METHYLENE CHLORIDE	ND	14	ND
TRPH (mg/L)	ND	ND	0.74
TOTAL METALS (ug/L)			
MANGANESE	650	670	1100
IRON	1300	4200	3000

VOLATILE ORGANICS (ug/L)	SFL92-401	SFL92-403
TRICHLOROFLUOROMETHANE	2.1	ND
TOTAL METALS (ug/L)		
MANGANESE	2100	2300
IRON	17000	18000

0 800 1600
APPROXIMATE SCALE IN FEET

FIGURE 1-16
GROUND-WATER ANALYTICAL RESULTS (MAY '93)

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1.2.4.3 Soil Sampling Results - Surface soil samples were collected at a depth of 0 to 6 inches and analyzed on site using X-Ray Fluorescence (XRF). The sample locations were selected using a randomly based grid. The sampling points were approximately 100 feet apart. The surface soil investigation was focused on the cover material of the landfill because of the suspected contaminants (lead, copper, and zinc) from small arms bullets; approximately 60 percent of the cover material was reportedly excavated from the berm of a rifle range just north of SFL. Surface soils were analyzed for lead, copper, and zinc by XRF. The highest XRF results were verified by splitting field samples for analysis by a Contract Laboratory Program (CLP) laboratory. Concentrations of lead in surface soils ranged from 26 to 440 mg/kg with five sample results exceeding the maximum detected background concentration of 230 mg/kg. The highest concentrations of lead were detected in the eastern portion of the landfill. Only three samples produced results greater than the method detection limit (MDL) of 100 mg/kg for zinc, and two samples contained detectable copper.

Subsurface soil samples were collected from the eight deep monitoring well boring locations (See Figure 1-16). The samples characterize subsurface soils at the periphery of the site to determine if there have been releases from the landfill. Three soil samples were selected from each boring for laboratory analysis. One sample was collected at the water table, and one was collected just above the soil/bedrock interface. The remaining soil samples were selected from the intermediate zone. Plastic and metal debris was encountered at 16 feet in boring SFLSB201.

Several VOCs were detected in subsurface soils including methylene chloride, methyl chloride, and carbon disulfide. Because these compounds were detected only once, at concentrations below the RCRA Corrective Action Levels (CALs), and were not detected in the corresponding groundwater samples, the presence of these compounds is probably not significant.

Pesticide and PCB compounds detected included 4,4'-DDE (a metabolite of DDT) and Aroclor-1248 (a PCB mixture). The 4,4'-DDE was detected at a concentration of 55 μg/kg and Aroclor-1248 at 250 μg/kg. Both were detected in soil sample SFLSB201, which was collected from a depth of 16 to 20 feet. Plastic and metal debris were encountered in this sample. The Aroclor-1248 was detected in the sample but not in the duplicate of this sample. This is most likely due to the heterogeneous nature of the soil.

Semi-volatile organic compounds detected include bis(2-ethylhexyl)phthalate and butyl benzyl phthalate. Bis(2-ethylhexyl)phthalate was detected in both upgradient and downgradient soil samples. Bis(2-ethylhexyl)phthalate is a common contaminant associated with latex gloves which are used both in the field and laboratory. However, the presence of this compound may also be associated with landfill activities, such as the disposal of plastics. Butyl benzyl phthalate was detected once in the duplicate sample SFLSB2011.

A TRPH analysis was performed on each soil sample. Hydrocarbons were detected in most samples, including samples from the upgradient, background well cluster, at levels less than 100 mg/kg. These positive detections may indicate the possibility of false positives due to sample matrix. The only soil sample exceeding the background levels of TRPH were sample SB201 (16-20') and its duplicate SB2011 with 380 and 470 mg/kg, respectively.

Many metals are naturally occurring in soil. To evaluate the impact of the SFL to the soil, a comparison must be made between metal concentrations upgradient and downgradient of the site. A number of metals were detected in downgradient samples at concentrations greater than the upgradient concentrations. However, only beryllium and thallium concentrations in the soil samples analyzed exceeded CALs in both upgradient and downgradient soils. No other metal CALs were exceeded.

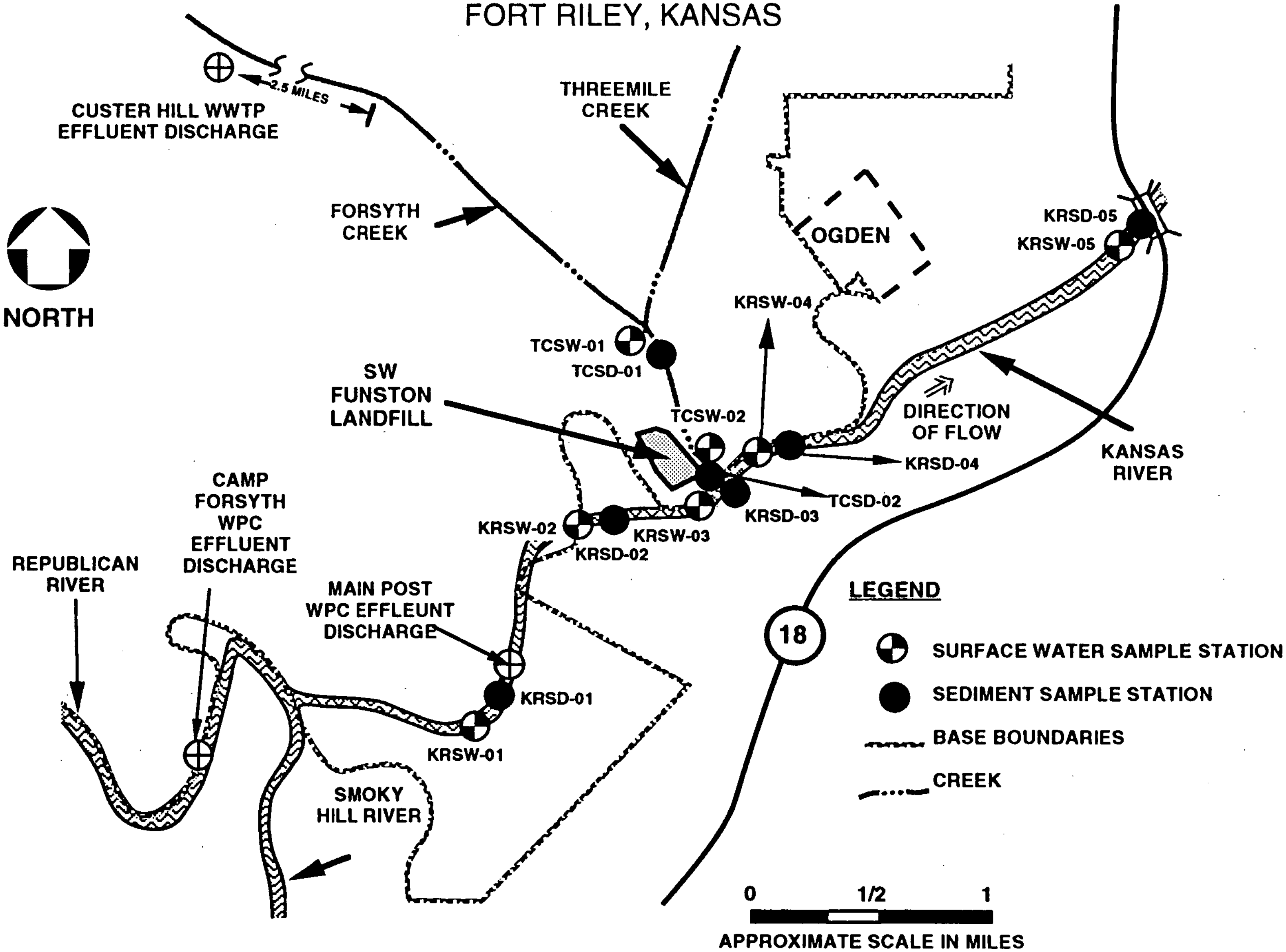
1.2.4.4 Surface Water Results - Surface water samples were collected in May of 1992. The objective of the surface water sampling was to determine if contamination from the SFL has impacted the water quality of the Kansas River and Threemile Creek. A total of seven locations were selected. To assess possible contamination adjacent to the SFL, three sampling locations were chosen. In addition, three sampling locations were selected to provide background or ambient conditions along the Kansas River and Threemile Creek. Also, an additional sampling location was selected to provide downstream conditions. Surface water and sediment sampling locations are shown in Figure 1-17.

Analytical results indicate metals and inorganic constituents present in the surface water collected. Results of the organic analyses performed indicated no measurable level of contamination of the surface waters sampled in the vicinity of the SFL except methylene chloride. Methylene chloride was detected at consistent concentrations in upstream and downstream samples indicating that the landfill did not contribute to the concentration of this compound. Although methylene chloride is a common laboratory contaminant, its presence cannot be confirmed to be due to laboratory contamination because the associated laboratory method blank did not contain this compound.

Many metals are naturally occurring in surface water. Arsenic, aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium were detected in all surface water samples. The variances in the results from downstream samples compared to the upstream samples were less than 25 percent which may be the result of the analytical uncertainty inherent in the analytical method. The variances were, therefore, considered insignificant, indicating that the landfill is not measurably impacting the surface water.

Surface water samples are routinely collected and analyzed from the Republican and Smokey Hill Rivers upstream of the SFL by KDHE. The historical data were accessed through the USEPA STORET database. The historical results for arsenic and manganese values are consistent with the results of this investigation. The aluminum concentrations detected during this investigation were slightly higher than those detected historically.

FIGURE 1-17
SURFACE WATER AND SEDIMENT SAMPLING STATIONS
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS



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1.2.4.5 Sediment Results - Sediment samples were collected in May of 1992 immediately after the associated surface water sample. Analytical results indicate petroleum hydrocarbons, metals, and other inorganic constituents present in the sediment samples collected. Due to the fact that this was a single sampling event and sediment deposition is not uniform, the results of this investigation can only indicate what SFL's contribution to sediment contamination may be.

Results of the organic analyses performed indicated no measurable level of organic contamination of the sediments sampled in the vicinity of the SFL (with the exception of TRPH and methylene chloride). Methylene chloride and TRPH were detected at consistent concentrations in samples from both upstream and downstream locations indicating that the landfill did not contribute to the concentration of these compounds.

Many metals are naturally occurring in sediment. Arsenic was detected in all sediment samples collected, upstream and downstream. Barium, calcium, iron, sodium, and vanadium were detected at comparable levels in the upstream and downstream sediment samples from the Kansas River, indicating that the SFL is not contributing to the concentration of the metals. Lead, aluminum, manganese, magnesium, potassium, and zinc were detected in all sediment samples analyzed. The concentrations of these metals are consistent upstream and downstream of the SFL; however, significant increases in concentrations were noted in the sample collected farthest downstream of the landfill. The increase may indicate a potential impact on sediment quality from a source downstream of the landfill, between sampling stations KRSD-04 and KRSD-05, or the increase may be attributable to natural variability.

Concentrations of all analyzed metals, except calcium, silver, and zinc, detected in samples from Threemile Creek were higher than Kansas River values. Both samples upstream and downstream of the SFL contained the metals at consistent concentrations indicating no influence from the landfill. The elevated concentrations of metals in Threemile Creek may be attributable to other waste sources or natural conditions upstream of the SFL.

Sediment samples were collected from the Republican and Smokey Hill Rivers upstream of the SFL from 1976 through 1978. The results of the current investigation were compared to the historical data (see Table 1-1). All metals concentrations were within the range of values detected historically.

1.2.4.6 Summary and Interpretation of Nature and Extent of Contamination - This section summarizes the nature and extent of contamination at the SFL. Included are discussions of the analytical results of groundwater, surface and subsurface soils, surface water, and sediments.

Groundwater - Organics were detected at the landfill in monitoring wells SFL92-601 and SFL92-602 and at monitoring wells SFL92-501, SFL92-502, and SFL92-503 during the baseline sampling event and the first three quarterly sampling events. Wells SFL92-601 and SFL92-602

TABLE 1-1

COMPARISON OF HISTORICAL DATA TO CURRENT KANSAS RIVER SEDIMENT DATA
Southwest Funston Landfill
Fort Riley, Kansas

Constituent	EH (1976-1978)	Law 1992
Arsenic, mg/kg	NA	0.7 - 1.2
Cadmium, mg/kg	< QL	< 1.0
Chromium, mg/kg	29.7	2.2 - 2.3
Copper, mg/kg	1.4 - 5	< 1.0 - 1.3
Iron, mg/kg	1900 - 17000	1700 - 3700
Lead, mg/kg	4 - 14.3	1.1 - 2.1
Manganese, mg/kg	92 - 200	34 - 130
Zinc, mg/kg	11 - 143	4.0 - 10

NA - Not Available
QL - Quantitation Limit Not Provided
EH - Kansas Department of Health & Environment, Environmental Health Laboratories

are in a downgradient position relative to groundwater flow at the SFL during all sampling events. Organics were also detected in the baseline samples at monitoring well cluster 8 (SFL92-801 and SFL92-803) but not in the subsequent quarterly sampling events. Organics were detected at SFL92-401 and SFL92-701 during the third quarter sampling event only. The presence of low levels of contaminants in the baseline event only at wells SFL92-801 and SFL92-803 may have been due to processes within the unsaturated zone in response to the antecedent rainfall, which may have mobilized contaminants in the capillary fringe/water table zone or the direction of groundwater flow due to elevated Kansas River levels. The contaminants detected in SFL92-801 and SFL92-803 may be the result of the localized dumping in this area or migration from the SFL. The presence of significantly lower levels or absence of volatiles in the clusters 6 and 7, which are between 5 and 8, indicate that the contaminants detected at the 5 and 8 clusters are possibly unrelated and localized.

Regarding the detection of volatile organic compounds in SFL wells, in general, their presence in the 500 Series wells indicates that groundwater flow beneath Threemile Creek may occur. That is, the source of these compounds may be located in the landfill. However, a review of historical operations and activities at Camp Funston (see Section 4.4 of the RI) indicates that a number of potential sources exist (or have existed) at Camp Funston. Currently, there is not enough information to positively correlate organic contaminants in the 500 Series wells (and/or their sources) with solely SFL or Camp Funston.

Methylene chloride (not associated with method blank contamination) was sporadically detected in all well clusters. However, most of the methylene chloride hits were associated with trip blank contamination.

Table 1-2 summarizes the constituents which exceeded ARARs for groundwater. The MCLs were exceeded for vinyl chloride, 1,1,2-trichloroethane, and cis-1,3-dichloropropene in the groundwater samples in clusters 5 and 8. The MCLs were exceeded for vinyl chloride and benzene at cluster 6.

Although metals were detected in the groundwater at the site, the only Safe Drinking Water Act (SDWA) standards exceeded were Secondary MCLs for manganese, iron, and aluminum. Secondary MCLs are regulations that control parameters in drinking water which primarily affect aesthetic qualities of the water, such as taste, color, and odor. These metals were also detected at levels above Secondary MCLs in samples from the Fort Riley and City of Ogden drinking water wells, both upgradient and downgradient from SFL, indicating that the observed metal concentrations are natural for this area. Even though certain metal concentrations exceeded those found in background wells, their concentrations are within the regional ranges for the Kansas River alluvium (USGS, 1975; Fader, 1974). Groundwater concentrations of iron and manganese in wells screened in the Kansas River alluvium in Riley and Geary counties have historically been shown to range from 160 to 4,300 μg/L and 200 to 2,000μg/L, respectively. Iron and manganese concentrations have been shown as high as 30,000 μg/L and 2,800 μg/L, respectively, in alluvial wells in Wyandotte County (Fader, 1974).

TABLE 1-2

EXCEEDANCES OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO BE CONSIDERED (TBC) REQUIREMENTS FOR GROUNDWATER*

Southwest Funston Landfill

Fort Riley, Kansas

PARAMETER	SAMPLE NO.	SAMPLE CONC'N (μg/L)	FEDERAL MCL[(a)] (μg/L)	KAL[(b)] (μg/L)	KNL[(c)] (μg/L)
Vinyl Chloride	SFL92-501 SFL92-601	14 18	2	2	0.2
1,2-Dichloroethane	SFL92-501, 502, 601	6.8-16	5	5	0.5
1,1,2,2-Tetrachloroethane	SFL92-503, 801, 803	6.3-15	---	1.7	0.17
Benzene	SFL92-601	14	5	5	0.005
1,1,2-Trichloroethane	SFL92-801	8.8	5	6.1	0.61
cis-1,3-Dichloropropene	SFL92-801 SFL92-803	5.9 5.4	---	2	0.2
Antimony	SFL92-703, 303	26-31	6	143	---
Beryllium	SFL92-101, 102, 103, 201, 202, 203, 303, 401, 403, 501, 503, 504, 601, 602, 603, 701, 703, 801, 803, IRRWELL	1.0-4	4**	0.13	---
Manganese	ALL	320-2700	50[(d)]	50	---
Aluminum	SFL92-102, 103 203, 302, 303, 602, 703, 803	110-460	50-200[(d)]	5000	---
Iron	SFL92-101, 102, 201, 202, 203, 301, 302, 303, 401, 403, 501, 503, 504, 601, 602, 603, 701, 703, 801, IRRWELL	550-35000	300[(d)]	300	---

* - Effective January 17, 1994
** - Based on baseline, first, second, and third quarter sample analyses
(a) - Maximum Contaminant Level (40 CFR 141 Subpart B)
(b) - Kansas Action Level
(c) - Kansas Notification Level
(d) - Secondary MCL

Other background data were also considered in the groundwater chemical evaluation. Data from the Fort Riley and Ogden well fields are provided in Table 1-3. Recent unpublished data for the City of Ogden and wells in Riley and Geary County are also presented in Table 1-3. Finally, the chemical data collected for the private irrigation well west of the site are presented in Table 1-4. These data also support the conclusion that the metals levels in excess of the secondary MCLs are naturally occurring.

Surface and Subsurface Soil - The landfill surface soils were analyzed for lead, copper, and zinc by XRF. Metals were the only constituents expected in the landfill cover because an estimated 60 percent of this soil originated from a berm at the rifle range. The results of the XRF surface soil analysis indicate the presence of lead in isolated locations throughout the central eastern portion of the landfill at concentrations consistent with background in the majority of the samples analyzed. The XRF is a field procedure and provides semi-quantitative data because of limited quality control. Scattered tracks and debris were also noted on about 3 percent of the landfill surface. Based on visual observation, this material appears to be due to surface dumping rather than exposure of the previously buried landfill contents.

The purpose of the subsurface soil investigation was to determine if there were releases from the landfill. The results characterize subsurface soils at the periphery of the landfill to accomplish that objective. The chemical results of the subsurface soil analysis indicate the isolated presence of volatile organics, a pesticide degradation product (DDE), Aroclor-1248, and phthalates. The volatile, pesticide, and phthalate concentrations are below all RCRA CALs. The Aroclor-1248 concentration exceeded the CAL in monitoring well boring SFL92-201 (Table 1-5) in one soil sample at a 16-foot depth but was not detected in the sample duplicate. Various metals were detected in the soil samples upgradient and downgradient of the site. Only beryllium and thallium concentrations in the soil samples analyzed exceeded CALs in samples from both upgradient and downgradient locations. Petroleum hydrocarbons (as TRPH) were detected in samples taken from locations upgradient and downgradient of the site.

Surface Water and Sediments - The surface water and sediment results indicate that the SFL is not contributing organic contaminants to the Kansas River. Methylene chloride was detected but concentrations were similar upstream to downstream indicating no landfill contribution. The results of the groundwater samples collected from the monitoring wells located beside the river confirm this. The methylene chloride detections may be attributable to laboratory contamination. Metals were detected in both upstream and downstream samples at similar concentrations.

1.2.5 Fate and Transport

There are a number of transport pathways for migration of constituents at the SFL site. The Kansas River and Threemile Creek affect the movement of constituents from the landfill by influencing the elevation of the groundwater table and the direction and velocity of groundwater

TABLE 1-3

BACKGROUND LEVELS OF METALS IN GROUNDWATER
Southwest Funston Landfill
Fort Riley, Kansas

PARAMETER	RANGE OF DETECTIONS (μg/L)		
	FORT RILEY WATER WELLS[1]	OGDEN WATER WELLS[2]	U.S.G.S. WATER WELLS[3]
Aluminum	60 - 70	ND - 60	NA
Antimony	NA	ND - 10	NA
Arsenic	2.0 - 3.0	1 - 10	ND - 30
Barium	181 - 321	80 - 200	100 - 570
Beryllium	NA	ND - 3	NA
Calcium	85600 - 87300	14700 - 197000	NA
Cobalt	NA	ND	NA
Copper	NA	ND - 980	1 - 70
Iron	32 - 114	14 - 380	NA
Lead	NA	ND - 20	ND - 38
Magnesium	19800 - 20800	21600 - 37000	NA
Manganese	51 - 197	7 - 250	ND - 3700
Potassium	600 - 9140	3420 - 7200	NA
Selenium	NA	ND - 10	ND - 9
Silver	NA	ND - 5	ND - 10
Sodium	35700 - 36600	20000 - 66900	NA
Vanadium	NA	ND - 4	NA
Zinc	11 - 266	4 - 59	NA
Source(s)	DOD 1987 DOD 1987b	KHEL 1991 KHEL 1991b USGS 1993b	USGS 1993b

1 From Fort Riley drinking water wells in the alluvium. This includes the main cantonment area.
2 From Ogden water wells installed in the alluvium.
3 From wells located north of the Kansas River, Township 12 south, Range 6 east, Geary and Riley Counties, Kansas.

NA - Not available
ND - Not detected

TABLE 1-4

CHEMICALS DETECTED IN PRIVATE IRRIGATION WELL
Southwest Funston Landfill
Fort Riley, Kansas

PARAMETER	SAMPLE CONCENTRATION
TOTAL METALS:	
Aluminum	BDL
Arsenic	0.0083
Barium	0.16
Beryllium	0.0014
Calcium	67
Iron	2.3
Magnesium	9.8
Manganese	0.61
Potassium	6.5
Selenium	0.0011
Sodium	140
Zinc	0.013 JB
WET CHEMICAL INORGANICS:	
Bicarbonate	362
Chloride	38.2
Nitrate	12.5
Sulfate	93.4

All concentrations are in mg/L (ppm).

JB Sample concentration is estimated; constituent associated with blanks.
BDL Below detection limit

2537.54

TABLE 1-5

EXCEEDANCES OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO BE CONSIDERED (TBC) REQUIREMENTS FOR SOILS

Southwest Funston Landfill

Fort Riley, Kansas

PARAMETER	SAMPLE	SAMPLE CONC'N (mg/kg)	RCRA CAL[a] (mg/kg)
Aroclor-1248	SFLSB-201	0.25	0.09
Beryllium	SFLSB-102	0.5	
	SFLSB-201	1	0.2
	SFLSB-203	0.6	
	SFLSB-303	1.6	
	SFLSB-403	0.5	
	SFLSB-502	0.4	
	SFLSB-503	0.3	
	SFLSB-703	2.3	
	SFLSB-803	0.5	
Thallium	SFLSB-101	15	
	SFLSB-203	21	7
	SFLSB-602	17	

[a] – RCRA Corrective Action Levels – Federal Register, Vol 55, No. 145, 27 July 1990. Pages 30798–30884. Corrective Action for Solid Waste Managements Facilities, Proposed Rule

flow. Seasonal variations in precipitation may also affect the elevation of the groundwater table. Other transport processes of importance include the infiltration/percolation of rain water through the landfill cover and surface water runoff across the landfill surface. Based on available elevation data and on inference, Threemile Creek and the Kansas River alternate between areas of recharge or discharge to the shallow aquifer system under the SFL. Constituents carried in the groundwater and surface water runoff are eventually discharged to these surface water bodies. Therefore, off-site migration may occur by transport in the creek or river. However, the Kansas River and Threemile Creek do not appear to be impacted by the landfill, based on the absence of site-related constituents above background concentrations. Under certain circumstances, intermittent groundwater flow under Threemile Creek toward the Camp Funston area may also occur, with subsequent discharge to the Kansas River.

1.2.5.1 Soil - In general, the inorganic constituents detected at the site are expected to persist in the soil. Though absorbed to soil particles, these constituents may be transported from the site via surface-water runoff. Surface runoff may mobilize constituents present in the cover material of the landfill, but it should not affect the underlying waste or soil.

Some inorganic constituents, however, may exhibit a moderate tendency to leach from the soil and be transported in a dissolved state. These more leachable constituents (e.g., arsenic, cadmium, and chromium) may be transported into deeper soils, surface water, and groundwater.

The VOCs detected in soil samples at the site are less persistent in soil and will be more mobile than the inorganic constituents. That is, they will tend to partition into other media, such as air, surface water, and groundwater. Once in surface water, they will typically volatilize into the air.

1.2.5.2 Groundwater - Based on available site data, both dissolved species and species adsorbed to particulates or colloids are transported in groundwater at the SFL site. The VOCs are transported primarily as dissolved species, given their relatively high solubilities and low partition coefficients. Based on the calculated retardation factors (Law, 1993c), most of these volatile compounds should travel at approximately the same velocity as the groundwater. Despite the seasonal variations in groundwater flow direction at this site, the groundwater from the surficial aquifer will eventually discharge to either Threemile Creek or the Kansas River. This is an important fate process for the VOCs because they will volatilize relatively rapidly if they are discharged to surface water. Because of the possibility of intermittent groundwater flow under Threemile Creek, potential groundwater movement from SFL toward Camp Funston cannot be precluded.

The metal species may be transported as both dissolved and adsorbed species depending on the conditions of the surrounding environment. Metals transported in the alluvial aquifer may also eventually discharge to Threemile Creek and the Kansas River. Discharge to surface water is significant to the fate of the metals because the physical and chemical properties of groundwater and surface water may be quite different, and release to the surface water system may alter the partitioning of metals between the dissolved, adsorbed, and solid phases.

Because there are no human or ecological receptors on site who are exposed to the constituents detected in the groundwater, it is of interest to determine how long it would take a particular constituent to migrate off site. Since groundwater from beneath the landfill is interpreted to discharge to Threemile Creek and the Kansas River, these two surface water bodies represent the nearest off-site exposure point. Assuming intermittent groundwater flow under Threemile Creek, Camp Funston might also be an off-site exposure point. Based on interpretation of available data, there is no evidence suggesting significant transport from the SFL area to Camp Funston, but the possibility cannot be precluded. Although the groundwater flow direction and velocity vary at the SFL site, "net" groundwater flow velocities ranging from 0.02 feet/day to 0.83 feet/day were calculated based on estimated average groundwater and river elevations and on a hydraulic conductivity range of 10 feet/day to 500 feet/day (Draft Final RI). The distance from the center of the landfill in a southeasterly direction to the Kansas River is approximately 2000 feet. Based on these values, it would take approximately 7 years to 274 years for a constituent in the center of the landfill to migrate in a southeasterly direction to the Kansas River. This time estimate does not account for periodic flow reversals. Constituents which were detected in groundwater samples collected from wells which are closer to the river could potentially reach the creek or river in a shorter amount of time. For instance, wells SFL92-301, SFL92-302, and SFL92-303 are located approximately 200 feet from the river (in a southeast direction). Therefore, it would take about 6 months to 27 years for a constituent detected at this location to migrate to the river.

The travel time estimates are approximations because changes in groundwater flow direction will likely increase the residence time and decrease the concentration (by the effects of dilution) of a constituent within the landfill area. Additionally, effects of dispersion, retardation, and degradation were not considered in the calculation. Dispersion has the effect of decreasing the time required for a constituent to migrate a given distance, while retardation tends to increase the constituents residence time. Degradation has the effect of decreasing the concentration of a constituent over time.

1.2.5.3 Surface Water/Sediment - Contamination of nearby surface water bodies may occur via surface water runoff or groundwater discharge. Surface water runoff may potentially transport constituents present in the surface soils. Runoff flows generally in a southeastward direction towards Threemile Creek and the Kansas River. As discussed above, groundwater beneath the SFL also discharges into Threemile Creek and the Kansas River.

Metals were the only constituents detected in surface water and sediment samples collected from the Kansas River and Threemile Creek. However, the concentrations detected in the downstream samples were not significantly higher than those detected in the upstream samples. These comparisons suggest that the metals present at the landfill are relatively immobile.

It is unknown whether VOCs detected in groundwater samples at the SFL have discharged to the adjacent surface water bodies. No VOCs were detected in the Kansas River or Threemile Creek, but detection of volatile species in surface water is unlikely given their low vapor pressures (i.e., high potential to volatilize).

Since no semi-volatile organic compounds were detected in the surface water or sediments, it is likely that they are relatively immobile, or migrating at a slow rate. Of the four semi-volatile compounds detected in soil samples, only bis(2-ethylhexyl)phthalate was detected throughout the vertical extent of the aquifer. The absence of this constituent from surface water and sediment samples suggests that it has not migrated off site.

1.2.5.4 Summary of Fate and Transport - In summary, the dominant fate and transport processes of importance at the SFL include:

- Three mechanisms which may potentially generate leachate and contribute to groundwater contamination. These mechanisms are infiltration of rainwater through waste and soils, river influx directly along the landfill boundary, and regional water table fluctuations. They occur in areas of known landfill activities and areas where suspected dumping may have occurred (e.g., near wells SFL92-801 and SFL92-803).

- Groundwater movement toward the river, and any episodic, high river-stage event that temporarily reverses groundwater flow away from the river along portions of the southern (and possibly eastern) boundary of the landfill. Because of the possibility of intermittent groundwater flow under Threemile Creek, potential groundwater movement from SFL toward Camp Funston cannot be precluded.

Surface water runoff across the landfill cover soils to the east-southeast constitutes a minor pathway.

The VOCs detected on site range from non-persistent to highly persistent in the natural environment. The potential discharge of groundwater into Threemile Creek and the Kansas River would substantially decrease the persistence of VOCs because these constituents volatilize quickly from surface waters.

Based on analytical data and apparent site conditions, it appears that low levels of constituents may be leached from soil or waste via infiltration associated with rainfall events, due to river influx and because of seasonal water table elevations. Although there is a net flow of groundwater to the river and creek, and possibly under the creek, given the low levels of constituents apparently leached from the SFL media it appears that groundwater constituents are significantly degraded or diluted by the time they reach the landfill boundaries.

1.2.6 Baseline Risk Assessment

This section summarizes the results of the baseline risk assessment for the SFL at Fort Riley. The baseline risk assessment includes a human health evaluation and an environmental evaluation of the SFL site, which are based on the results of the baseline and quarterly sampling episodes conducted from July, 1992 to May, 1993.

1.2.6.1 Human Health Evaluation - A risk assessment approach, consistent with that presented in the USEPA's "Risk Assessment Guidance for Superfund" (USEPA, 1989b), was used to evaluate potential impacts to human health as a result of existing contamination at the SFL. The objective of the baseline human health evaluation is to estimate the effects of the existing conditions on the exposed and potentially exposed populations if no action is taken to remediate conditions at the site. The results are used to determine whether further study and/or remedial actions are necessary.

Chemicals of Potential Concern - The chemicals of potential concern identified in the soil, surface water, groundwater, and sediments sampled at the site are identified in Table 1-6. These chemicals were selected for evaluation in the baseline risk assessment based on the following criteria, in accordance with federal guidance (USEPA, 1989b):

- Comparison of chemical concentrations with naturally occurring levels
- Evaluation of measured concentrations and frequency of detection at the site
- Evaluation of essential nutrients
- Comparison of chemical concentrations with levels detected in associated blank samples
- Evaluation of data qualifiers
- Evaluation of toxicity and use of a concentration-toxicity screen
- Physical and chemical characteristics related to environmental mobility and persistence

Exposure Assessment - A potential exists for constituents in the soil, sediments, surface water, and groundwater at the SFL to reach human target populations through several exposure routes.

TABLE 1–6

SUMMARY OF CHEMICALS OF POTENTIAL CONCERN
Southwest Funston Landfill
Fort Riley, Kansas

	Concentration				
Chemical	Groundwater	Soil Borings	Sediments **	Surface Water **	Surface Soils
Aluminum	0.11 – 0.35*	370 – 21000*	8200*	1.3*	3200 – 5900*
Antimony	0.022 – 0.031	BDL	BDL	BDL	5.1 – 5.8
Arsenic	0.002 – 0.045	0.5 – 7.2*	2.1	0.0044	1.5 – 3.1
Barium	0.068 – 2.0	17 – 760*	150*	0.17	60 – 170
Benzene	0.0015 – 0.014	BDL	BDL	BDL	BDL
Beryllium	0.001 – 0.004	0.2 – 2.3*	0.2*	BDL	0.29 – 0.67
Cadmium	0.004 – 0.005	<0.06 – 0.06*	1.6*	BDL	0.53 – 2.1
Cobalt	0.008 – 0.012*	1.6 – 7.8*	6.2*	BDL	BDL
Copper	0.004 – 0.015*	0.8 – 13*	6.2*	BDL	12 – 110
1,2–Dichloroethane	0.016 – 0.016	BDL	BDL	BDL	BDL
cis–1,3–Dichloropropene	0.0054 – 0.0059	BDL	BDL	BDL	BDL
Lead	BDL	0.9 – 16*	5.9*	BDL	10 – 160
Manganese	0.34 – 2.70	9.2 – 740*	200JL*	0.15	88 – 220
Mercury	BDL	BDL	BDL	BDL	<0.11 – 1.8
Methylene Chloride	0.0062 JB – 0.032 B2*	0.0079 JB* – 0.078 JB*	0.016JB*	0.011JB*	NA
Silver	0.003 – 0.008*	1.3 – 1.5*	BDL	BDL	<0.68 – 3.2
1,1,2,2–Tetrachloroethane	0.0063 – 0.015	BDL	BDL	BDL	BDL
Thallium	0.0017 – 0.0017	17 – 21*	BDL	BDL	<0.23 – 0.26
1,1,2–Trichloroethane	0.0088 – 0.0088	BDL	BDL	BDL	BDL
TRPH	BDL	10 – 470*	BDL	BDL	BDL
Vanadium	0.009 – 0.025	1.7 – 41*	22*	BDL	11 – 18
Vinyl Chloride	0.018 – 0.018*	BDL	BDL	BDL	BDL
Zinc	0.004JB – 0.013*	3.5 – 73*	30*	0.035*	27J – 250J

Note: All concentrations are in ppm (mg/kg or mg/L) and includes baseline, first, second, and third quarter sample analyses

BDL Below Detection Limit. Not selected as a chemical of potential concern for this media.
NA Not analyzed.
JL Sample concentration is estimated due to poor precision and is biased low.
JR Sample concentration is estimated; constituent is associated with rinsate.
JBR Sample concentration is estimated; constituent is associated with rinsate and blanks.

* Not selected as a chemical of concern in this medium.

JB Sample concentration is estimated; constituent associated with blanks.
JE Sample concentration is estimated due to poor precision.
M2 Sample concentration is biased low due to matrix spike recovery caused by the matrix spike effect.
B1 Sample results are less than five times the amount detected in the blank – Result is estimated.
B2 Sample results are less than ten times the amount detected in the blank – Result is estimated.
J Sample concentration is estimated.
** The value is from the sample collected from Threemile Creek.

Eighteen potential exposure pathways were quantified in this assessment, including six current exposure pathways and twelve future pathways. The pathways quantified include:

Current Land Uses - Occupational Scenarios (exposures that may occur during work on utility lines located adjacent to Threemile Creek)

1. Dermal contact with surface water
2. Dermal contact with sediments
3. Incidental ingestion of sediments

Current Land Uses - Trespassing Hunter Scenarios (exposures that may occur as a result of present-day hunters trespassing on the SFL)

4. Incidental ingestion of soil
5. Inhalation of fugitive dust
6. Dermal contact with soil

Future Land Uses - Occupational Scenarios (exposures that may be experienced by future maintenance/groundskeeping employees at the SFL)

7. Dermal contact with surface water
8. Dermal contact with sediments
9. Incidental ingestion of sediments
10. Incidental ingestion of soil
11. Inhalation of fugitive dust
12. Dermal contact with soil

Future Land Uses - Recreational Hunter Scenarios (exposures that may occur as a result of future hunters at the SFL)

13. Incidental ingestion of soil
14. Inhalation of fugitive dust
15. Dermal contact with soil

Future Land Uses - Groundwater Scenario (exposures that may occur from hypothetical future residents using groundwater from the water-bearing zone beneath the site)

16. Ingestion of drinking water
17. Inhalation of volatiles during bathing and household water use
18. Dermal contact while showering

As described in the risk assessment, intake variables and exposure point concentrations were selected so that the combination of variables results in an estimate of reasonable maximum exposure (RME). The RME is defined as the maximum exposure that is reasonably expected to occur at a site. The RME scenarios considered in the risk assessment were:

- Current - a utility worker who also hunts on or near the SFL

- Future - a grounds maintenance worker who lives near the SFL, uses the area for hunting, and uses the groundwater from the most contaminated well for general household purposes.

The chemical concentrations used to estimate exposure were the 95 percent upper confidence limits on the mean or the maximum detected concentration (whichever was smaller).

Toxicity Assessment - The toxicity assessment is an integral part of the preliminary risk evaluation process. First, a comparison of site concentrations to regulatory requirements, standards, and criteria is made. State and federal regulations, rules, guidelines, and criteria are compared to site concentrations in a sampled media. This comparison serves as a qualitative guide and points out media which may be serving as potential sources of risk.

The National Primary Drinking Water Regulations established by the USEPA provide MCLs and Maximum Contaminant Level Goals (MCLGs) for a number of constituents. By definition, the MCLGs equal to zero are non-enforceable health goals, while the MCLs are the enforceable standards which must be set as close to the MCLGs as feasible. Secondary MCLs are non-enforceable guidelines set for aesthetic reasons such as taste, color, and odor of water. Non-zero MCLGs are also considered ARARs for groundwater. Applicable state and federal MCLs for the chemicals of potential concern are provided in Table 1-7.

In addition to MCLs, the State of Kansas has developed Kansas Action Levels (KALs), Kansas Notification Levels (KNLs), Alternate Kansas Action Levels (AKALs), and Alternate Kansas Notification Levels (AKNLs). The KNL or AKNL is used to constitute administrative confirmation that groundwater contamination exists. The KAL or AKAL is applied to represent the level at which long-term exposure to contaminant concentrations is unacceptable.

The USEPA has developed Ambient Water Quality Criteria (AWQC) for constituents in surface waters. The AWQC for the protection of aquatic organisms are derived based on two criteria: (1) acute criterion representing the maximum concentrations permissible at any time, and (2) chronic criterion representing the maximum permissible concentration averaged over a 24-hour time period. The State of Kansas incorporates the federal AWQC for the protection of aquatic life as the State Water Quality Standards by reference (KAR, 1987). Table 1-8 presents the AWQC for the constituents detected in the site's surface water.

Currently under CERCLA regulations, no guidelines exist for allowable soil concentrations. In the proposed RCRA Subpart S regulations (Federal Register, 1990), Corrective Action Levels (CALs) have been developed which are health-based criteria serving as an indication of whether a corrective measure is required. The calculation of CALs incorporates risk levels of 10^{-6} for Class A and B carcinogens, 10^{-3} for Class C carcinogens, and a hazard index of 1 for systemic toxicants. The concentrations of constituents detected in the site's surface soil samples are compared to the proposed RCRA CALs in Table 1-9.

TABLE 1-7

REGULATORY AND GUIDANCE CRITERIA FOR GROUNDWATER
Southwest Funston Landfill
Fort Riley, Kansas

Parameter	Exposure * Point Concentration [A] (mg/L)	Maximum * Detected Concentration (mg/L)	Federal Maximum Contaminant Level [B] (mg/L)	Federal Maximum Contaminant Level Goal [B] (mg/L)	Kansas Maximum Contaminant Level [C] (mg/L)	Kansas Action Level [D] (mg/L)	Kansas Notification Level [D] (mg/L)	Alternate Kansas Action Level [D] (mg/L)	Alternate Kansas Notification Level [D] (mg/L)
Antimony	0.012	0.031	0.006 F	0.006 F	--	0.143	--	--	--
Arsenic	0.019	0.045	0.05	0	0.05	0.05	--	--	--
Barium	0.569	2.0	2 E	2 E	1	1	--	--	--
Benzene	0.0014	0.014	0.005	0	--	0.005	0.0005	--	--
Beryllium	0.0021	0.004	0.004 F	0.004 F	--	0.00013	--	--	--
Cadmium	0.0026	0.005	0.005	0.005	0.01	0.005	--	--	--
1,2-Dichloroethane	0.0028	0.016	0.005	0	--	0.005	0.0005	--	--
cis-1,3-Dichloropropene	0.0017	0.0059	--	--	--	0.002	0.0002	--	--
Manganese	1.748	2.7	0.05 S	0.2 F	--	0.05	--	--	--
1,1,2,2-Tetrachloroethane	0.003	0.015	--	--	--	0.0017	0.00017	--	--
Thallium	0.0017	0.0017	0.002	0.0005	--	0.013	--	--	--
1,1,2-Trichloroethane	0.0027	0.088	0.005	0.003	--	0.0061	0.00061	--	--
Vinyl Chloride	0.0054	0.018	0.002	0	--	0.002	0.0002	--	--

Boxed values indicate exceedence of regulatory or guidance criteria

S – Secondary MCL

P – Proposed MCL/MCLG

T – Value is for total chromium.

TT – Treatment technology – Action Level is value stated.

A – The 95% UCL (or maximum detected concentration if 95 % UCL > maximum concentration) of concentrations detected in ground water samples.

B – Maximum Contaminant Levels and Maximum Contaminant Level Goals (40 CFR 141 Subpart B)

C – Kansas Drinking Water Rules (KAR 28.15), last amended 1 May, 1988.

D – KDHE Memorandum, dated 5 December, 1988; Revised Groundwater Contaminant Cleanup Target Concentraions for Aluminum and Selenium.

E – National Public Drinking Water Rules for 38 Inorganic and Synthetic Organic Chemicals (January, 1991), Phase II Fact Sheet.

F – Drinking Water Regulations and Health Advisories, USEPA Office of Water, December 1992.

-- No guidance value available

* – Based on baseline, first, second, and third quarter sample analyses

TABLE 1–8

REGULATORY AND GUIDANCE CRITERIA FOR SURFACE WATER
Southwest Funston Landfill
Fort Riley, Kansas

Parameter	Maximum Concentration Detected (mg/L) Threemile Creek	FEDERAL AMBIENT WATER QUALITY CRITERIA (mg/L)** For the Protection of Aquatic Life: Acute	Chronic	For the Protection of Human Health: (consumption of) Water & Fish	Fish only	KANSAS STATE WATER QUALITY STANDARDS*** [C] For the Protection of Aquatic Life: (mg/L)
Aluminum	BB	--	--	--	--	--
Arsenic, pentavalent	0.0044 [T]	0.85 [A]	0.048 [A]	0.0022 [B]	0.0175 [B]	--
Arsenic, trivalent	0.0044 [T]	0.36	0.19	0.0022 [B]	0.0175 [B]	--
Barium	0.17	--	--	1	--	--
Manganese	0.15	--	--	0.05	0.1	--
Methylene Chloride	ND	--	--	--	--	--

Boxes indicate an exceedence of regulatory or guidance criteria
A – Insufficient data to develop criteria. Value presented is lowest observed effect level.
B – Human health criteria for carcinogens reported for three risk levels. Value presented in this table is the 10^{-6} risk level.
BB – Below background.
C – The State of Kansas has incorporated the Federal AWQC for the protection of aquatic life as the State Water Quality Standards by reference.
T – Valence of metal was not established; concentration listed in table is for total metal(s).
Sources: **Quality Criteria for Water – 1986. EPA 440/5–86.001, 1 May, 1987.
***Kansas Water Quality Standards (KAR 28.16.28), 1 May, 1987.

TABLE 1–9

COMPARISON OF CONSTITUENTS DETECTED IN SURFACE SOIL SAMPLES TO RCRA SOIL ACTION LEVELS
Southwest Funston Landfill
Fort Riley, Kansas

Parameter	Exposure Point Concentration[a] (Surface Soils) (mg/kg)	RCRA Corrective Action Level[b] (mg/kg)
Aluminum	5900	30*
Antimony	5.8	30
Arsenic	3.1	80
Barium	170	4000
Beryllium	0.67	0.2
Cadmium	2.1	40
Chromium	16	400[c]
Copper	110	--
Lead	160	500–1000[d]
Manganese	220	--
Mercury	1.8	200
Silver	3.2	200
Thallium	0.26	7[e]
Vanadium	18	--
Zinc	250	--

Boxes indicate an exceedance of regulatory or guidance criteria.

-- No available soil action level

* Value is for aluminum phosphide.

a The maximum of detected concentrations in ths site samples.

b RCRA Action Levels – Federal Register, Vol. 55, No. 145, 27 July 1990. Pages 30798–30884. Corrective Action for Solid Waste Managements Facilities, Proposed Rule.

c Value is for hexavalent chromium.

d Interim Guidance on Establishing Soil Lead Cleanup Levels at Superfund Sites. Memorandum from H. Longest and B. Diamond to EPA Regions. OSWER Directive No. 9355.4–02. September 7, 1989.

e Value is for thallium acetate.

In addition to comparing detected concentrations to potential ARARs, quantitative reference values describing the toxicity of the constituents of concern were evaluated. Toxicity values such as Reference Dose or Reference Concentration (RfD/RfC) and Carcinogen Slope Factor (CSF) are based primarily on human and animal studies with supporting evidence from pharmacokinetics, mutagenicity, and chemical structure studies. The toxicity values used in the risk assessment were obtained from the USEPA's Integrated Risk Information System (IRIS) database.

Risk Characterization - The results of the Baseline Risk Assessment at SFL indicate that there may be a concern for potential risk to human health, based on some of the exposure scenarios evaluated.

A hazard index greater than 1.0 was calculated for the following receptors and exposure pathways. As shown below, even if the total risks are adjusted by subtracting risks associated with background metal concentrations, the resulting "site-specific" risks are still greater than the standard point of departure [Hazard Index (HI) = 1.0].

Receptor	Exposure Pathway - Medium	Total HI	Site-Specific HI*
Off-Site Residential			
Future Adult	Ingestion of groundwater	26	16
Future Child	Ingestion of groundwater	54	29

As stated earlier, estimation of risks due to groundwater exposures is likely to be overestimated, in part because the exposure point concentrations used to evaluate potential risk were not modeled to the nearest exposure point. The uncertainties associated with the risks estimated for these exposure pathways are discussed in more detail in the uncertainties section of this summary. While concentrations of arsenic and beryllium contribute to the calculated unacceptable risk (total and site-specific), the detected concentrations did not exceed federal MCLs.

Cancer risk estimates were calculated for two receptors that exceed the NCP risk range of 1×10^{-6} to 1×10^{-4}, as follows:

Receptor	Exposure Pathway - Medium	Total Cancer Risk	Site-Specific Cancer Risk*
Off-Site Residential			
Future Adult	Ingestion of groundwater	1×10^{-3}	5×10^{-4}
Future Adult	Inhalation of VOCs from groundwater	3×10^{-4}	3×10^{-4}

*Site-specific risk accounts for the risk due to background

As stated earlier, these estimated risks are based on conservative exposure assumptions and, therefore, may be overestimated. The uncertainties associated with the risks calculated are discussed in more detail at the end of this section. It is important to note that when the risks due to background concentrations of metals are accounted for, the estimated carcinogenic risks remain above the NCP range of 1 x 10^{-4} to 1 x 10^{-6}.

Uncertainties - The following, based on assumptions made and existing data gaps, identify and attempt to characterize the uncertainties associated with the Baseline Risk Assessment results:

- Toxicity values are not available for several constituents of concern, and therefore, the risk due to these constituents was not quantified. Thus, the overall noncarcinogenic and carcinogenic risks calculated for a particular pathway of interest at the site may be underestimated.

- Chemical-specific absorption factors are not currently available to convert dermal intakes into dermal absorbed doses for constituents detected in soil and sediment media. The use of these factors, if they were indeed available, in calculating risks due to dermal exposures to soil and sediment may have resulted in significantly reduced risk estimations via these pathways.

- In accordance with USEPA Region VII guidance (USEPA, 1992a), when calculating risks due to dermal exposures, oral toxicity values were not adjusted by oral absorption rates. The default dermal absorbance factor used in Region VII is 100 percent; the constituents are assumed to be completely absorbed through the skin. Thus, the bioavailability of a constituent via dermal exposure is assumed to be equal to that received from an oral dose. This assessment process tends to overestimate risks associated with dermal exposures and may, in particular, greatly overestimate dermal risks due to constituents that are non-lipid soluble (i.e., metals).

- The exposure scenario assuming a sustained, long-term use of contaminated groundwater may not be reasonable based on the limited and sporadic detection of contaminants in the groundwater.

- The assumption of the exclusive use of the groundwater beneath the site for a future potable water source is unlikely because a public supply of potable water is readily available nearby. Zoning laws prohibit construction in a 100-year floodplain, so residential development (and associated private well installation) is precluded on the SFL site. However, because the aquifer beneath the site is classified as a usable aquifer by the State of Kansas, a potable water use scenario is presented.

- The adequacy of the XRF data for evaluating the exposure potential to surface soil constituents is questionable. These data were generated for use in determining metals concentrations in the landfill cover; the samples were not analyzed for organic compounds. Thus, if organic compounds exist in the surface soils in toxic concentrations, the risk due to exposure of surface soils may be underestimated. However, since the results of the CLP analysis for the highest "hits" from the XRF screening were used in the risk assessment, the results are biased high in terms of characterizing surficial soil concentrations across the entire landfill. This will result in a conservative approach for determining risk which will overestimate the potential risks.

- In evaluating risks due to chromium exposure, all chromium detected on site was assumed to be trivalent chromium (the less toxic species). Calculations for the site, based on redox potential, show that trivalent chromium is the predominant chromium species on site (See Appendix Mg of the RI [LAW, 1993c]).

- The noncarcinogenic and carcinogenic risks calculated for future exposures to groundwater are based on the concentrations of constituents detected at the site. Constituent concentrations were not modeled to the nearest potential exposure point (i.e., the nearest potable water well), because further study is needed before an accurate and justifiable modeling effort can be made. Modeled concentrations at an off-site exposure point would most likely be less than the concentrations detected in site samples. Therefore, the risks estimated for future groundwater pathways in the risk assessment may be overestimated.

- In accordance with USEPA Region VII guidance (USEPA, 1992b), metals with maximum detected concentrations greater than the site-specific maximum background concentration in a given medium were identified as chemicals of concern, provided they "passed" the concentration-toxicity screen. Therefore, metals that have been identified as chemicals of concern using USEPA Regional VII guidance may be, in fact, within the range of naturally-occurring background and may not be attributable to the site.

- In evaluating risks from future exposures to site media, the assumption was made that future constituent concentrations will remain the same as current concentrations. Dilution, decay, degradation, and attenuation of constituents occurs naturally over time, and site contaminants would thus present a reduced risk in future scenarios.

This risk assessment should not be viewed as an absolute quantitative measure of the risk to public health presented by site-specific contaminants. The assumptions and inherent uncertainties in the risk assessment process do not allow this level of confidence. This risk assessment provides a conservative indication of the potential for risk due to exposure to site-specific chemicals and should help guide the management of the site to reduce that potential risks to acceptable levels.

Conclusions of the Human Health Evaluation

- The SFL site lies entirely within the 100- and 500-year floodplain of the Kansas River. Therefore, the only receptors expected to be on or adjacent to the site are occupational and recreational receptors. The risks to these receptors (utility workers, grounds maintenance workers, and recreational hunters) are within the acceptable range for both noncarcinogenic and carcinogenic compounds.

- Future residential development of the site is not considered in this risk assessment. However, because the State of Kansas considers all aquifers to be a potential future potable water source, the potential risks to future residential users of this groundwater were estimated. A hazard index greater than one was calculated for future residential adults (HI = 16) and children (HI = 29) using the groundwater as a source of drinking water. Arsenic, antimony, and manganese are the major contributors to this risk. Arsenic concentrations detected in the groundwater were all at levels below the maximum contaminant level (MCL) of 0.05 mg/L. Manganese concentrations were consistent with historical levels of manganese in alluvial wells throughout the Kansas River valley. Antimony was only detected once in two of the four groundwater sampling events, in different wells. Therefore, it is questionable whether antimony is a widespread, site-related constituent.

- Risks due to the carcinogenic compounds are also calculated as part of the human health evaluation. The acceptable cancer risk range of 1×10^{-6} to 1×10^{-4} is exceeded for future residential adults using the groundwater beneath the SFL as a potable water source (cancer risk = 5×10^{-4}). The constituents contributing most to this risk estimate are vinyl chloride, 1,1,2,2-tetrachloroethane, arsenic, and beryllium. Neither arsenic nor beryllium were detected at concentrations greater than their MCLs. However, several organics including vinyl chloride, 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, benzene, 1,1,2-trichloroethane, and cis-1,3-dichloropropane were infrequently detected at concentrations greater than their MCLs or KALs.

- It should be noted that the estimate of risk for the groundwater pathways is very conservative, as it is based on the assumption that all of the drinking water ingested in a given day comes from the contaminated source. In addition, the reduction of constituent concentrations through attenuation are not accounted for in the assessment. Since a public water supply of potable water is already available in the area, and since it is highly improbable that the SFL site will be developed for residential use or be developed as a residential water supply field in the future, the calculated risks due to the consumption of on-site groundwater are likely to be overestimations.

1.2.6.2 Ecological Risk Assessment - The Ecological Risk Assessment for the SFL was conducted in accordance with the guidance provided in the "Risk Assessment Guidance for Superfund, Vol. II - Environmental Evaluation Manual" (USEPA, 1989b). The objectives of the environmental assessment are to:

1. Determine the uses of nearby natural resources (land, air, water, and biota);
2. Identify potential environmental impacts
3. Assess the significance of any environmental impacts

In this ecological risk assessment, potential receptors present in the vicinity of the SFL and the potential pathways by which these receptors might be exposed to chemicals of concern present in surface soils, surface water, and sediments were evaluated.

Terrestrial Vegetation - Fort Riley is within the Flint Hills region of the Central Plains. The ecological region is known as a tall grass prairie. Terrestrial systems associated with the SFL and surrounding area consisted of two major habitat types: grassland/prairie habitats and riverain habitats. The grassland/prairie habitats include various grass species including:

- Switchgrass (*Panicum virginatum*)
- Indian grass (*Sorgastrum nutans*)
- Thistle (*Canduus hataus*)
- Johnson grass (*Sorghum halepense*)
- Sunflower (*Helianthus* sp.)

Vegetation typically noted in riverine and densely vegetated drainage habitats in the Fort Riley area include cottonwood (*Populus deltoides*), sycamore (*Platanus occidentalis*), box elder (*Acer negundo*), and hackberry (*Celtis occidentalis*) as canopy cover and dominated by redbud (*Cercis canadensis*), dogwood (*Cornus* sp.), greenbrier (*Smilax* sp.), poison ivy (*Rhus radicans*), Virginia creeper (*Parthenocissus quinquefolia*), and seedling overstory species.

The SFL site consists primarily of cleared areas, vegetated by grasses and other herbaceous vegetation intermixed with non-vegetated areas. Wooded areas are scattered throughout the site, and parts of the site can be classified as riparian woodland and bottomland.

Terrestrial Wildlife - The animal community frequenting the general area of the site includes many species of birds (dove, starling, pigeon, duck, pheasant, quail, wild turkey, and songbirds), insects, small mammals (bats, snakes, skunks, raccoons, possums, rabbits, squirrels, and other rodents), and larger mammals (deer, and bobcat). The areas around and downgradient of the SFL may provide suitable habitats for most of the above species. A variety of animals inhabiting areas adjacent to the landfill may pass through the area during hunting/foraging activities. Habitats suitable for the above species include grasslands and the riverine woodlands. Herbivores and prairie dwellers which will utilize the grasslands include rabbits, rodents, snakes, and skunks while squirrels will predominantly utilize the cottonwoods and oaks of the woodland habitat. All other species mentioned above will utilize both habitats for foraging and normal daily activities at the SFL.

Endangered Species - A recent survey conducted by the U.S. Fish and Wildlife Service (USFWS, 1992) provided much of the necessary background information regarding the potential for threatened and endangered species on site. Nine federally listed threatened and endangered species along with twelve federal Category 2 candidate species and an additional six state-listed threatened species could potentially occur on Fort Riley (USFWS, 1992; KDWP, 1993; IRP, 1992). Category 2 candidate species are those which the U.S. Fish and Wildlife Service is seeking additional information regarding their biological status to determine if listing of these species is warranted. A listing of the threatened and endangered species known to occur in the Fort Riley area, along with their typical habitats, is provided in Table 1-10.

Aquatic Species - Threemile Creek provides a limited aquatic habitat. The creek averages approximately 15 feet in width and a water depth of 3 feet. The creek is partly to mostly shaded and most of the shoreline supports vegetation. Stream-banks are relatively unstable and stream sediments throughout much of the creek consists primarily of silt, mud/muck, sand, and organic material. Benthic macroinvertebrates were observed at each station on Threemile Creek. Although no *in-situ* water quality monitoring was conducted, it was apparent that Threemile Creek supports aquatic life, including shiner, minnow, and sunfish varieties of fish.

Summary - Currently, there is no available guidance that describes criteria for classifying risks to ecological receptors. Therefore, ecological risk assessors typically conduct the risk characterization portion of an ecological risk assessment using professional judgement (USEPA, 1989b). During the site walkover during September 1992, the aquatic system and the surrounding terrestrial ecosystems were observed. This walkover included a day-long reconnaissance of the SFL site and adjacent land areas within a five-mile radius. Near optimal conditions, i.e., growing season, for observing the terrestrial ecosystems were present.

Based on the site walkover and a comparison of detected constituent concentrations to ARARs, no negative impacts (chronic or acute) on flora and fauna are readily apparent at this time. Body burden and reproductive effects are examples of chronic effects. Acute effects result in death. Terrestrial and aquatic life in the area of Threemile Creek may potentially suffer negative impacts from constituents currently detected in on-site sediment and surface water, which may in turn impact surface water and sediment downstream. Terrestrial and riparian communities periodically using this stream for a water source or habitat may be negatively impacted by constituent concentrations in surface waters and sediments. Based on the flow rate within the Kansas River, downstream surface water impacts are expected to be minimal.

TABLE 1-10

ENDANGERED AND THREATENED SPECIES
(AND ASSOCIATED HABITATS) COMMON TO FORT RILEY AREA
Southwest Funston Landfill
Fort Riley, Kansas

SPECIES	HABITAT
Piping Plover (FT, ST)	Open unvegetated beach or sandbar
Least Tern (FE, SE)	Sparsely vegetated sandbars in a wide channel with good visibility
Bald Eagle (FE, SE)	Near water bodies (rivers, lakes, etc.) utilizing riparian forest; recorded sitings
Peregrine Falcon (FE, SE)	Large river or waterfowl management areas, cropland, meadows and prairies, river bottoms, marshes, and lakes. Siting by Natural Resource personnel near Manhattan Airport
Whooping Crane (FE, SE)	Wetland, riverine base sandbars, shallow water, slow river flow
Eskimo Curlew (FE, SE)	Wet meadows, fields, pastures, drier parts of salt and brackish marshes
Western Prairie Fringed Orchid (FT)	Tallgrass prairie and sedge meadow (fire adapted)
Prairie Mole Cricket* #	Tallgrass prairie, ungrazed or unmowed native tallgrass with silt-sandy loam soils
Regal Fritillary Butterfly* #	Prairie meadows (wet), moist tallgrass prairie, virgin grassland where violets act as host plants
Sturgeon Chub* (ST)	Areas of shallow strong currents and gravel bottoms, turbulent areas where shallow water flows across sandbars
Texas Horned Lizard*	Dry-flat areas with sandy, loamy, or rocky surfaces with little vegetation
Loggerhead Shrike* # (FT)	Grassland or shrubby fields with scattered woody vegetation for perching and nesting
Long-billed Curlew	Great Plains grasslands, marshes, mud flats, sandbars
White-faced Ibis* (ST)	Small ponds with stands of cattail or bulrush
Western Snowy Plover* (ST)	Unvegetated riverine
Eastern Spotted Skunk* (ST)	Open level cultivated farmland, upland sites with preference for fallen logs and brushpiles
Eastern Hognose Snake (ST)	Suitable habitat present along river, undated reported sitings
Topeka Shiner* (ST)	Turbulent areas in rivers where shallow water flows across sand bars
American Burying Beetle # (FE, SE)	Tallgrass prairie, ungrazed or unmowed native tallgrass with silt-sandy loam soils
Black Tern*	Wetland areas
Henslow's Sparrow* #	Native grassland with few trees
Hairy False Mallow* #	Rocky outcrops and dry areas in prairies

Sources: Fort Riley, 1992; Kansas Threatened and Endangered Species Listing (10/15/92).
Underlined species are known to occur on Fort Riley.
* Candidate species for federal endangerment listing.
\# Species with suitable habitat at the SFL site.
FE - Federally endangered SE - State endangered
FT - Federally threatened ST - State threatened

1.2.7 Conclusions

In general, it appears that site-related constituents are not being transported off-site to a great extent. Inorganic constituents were detected in soils (as expected) and, to a lesser extent, in groundwater. VOCs were also detected sporadically in soil and groundwater.

Volatile organics were infrequently detected at concentrations greater than the Maximum Contaminant Levels and the risk assessment indicated potentially unacceptable risks if the groundwater were to be used as a potable water supply. In accordance with NCP, it was determined that alternatives to address the low levels of volatile organics in the shallow, alluvial aquifer at Southwest Funston Landfill may be appropriate for the FS.

Remedial actions to address the metals in the groundwater at the landfill are not warranted because 1) none of the metals which contribute to the unacceptable risk estimates, except antimony, are present at concentrations which exceed primary Maximum Contaminant Levels, and 2) the levels of iron and manganese detected, which exceed secondary Maximum Contaminant Levels, are consistent with historical data for naturally-occurring metals in the alluvial groundwater of the Kansas River valley. Antimony was only detected once in two of the four groundwater sampling events in different monitoring well clusters (i.e., detected in less than five percent of the samples). Therefore, it is questionable whether antimony is a widespread, site-related constituent that warrants remediation. Continued monitoring to confirm the presence or absence of antimony in the groundwater may be warranted.

The surface water and sediment results indicate that the SFL is not contributing any organic contaminants to the Kansas River or Threemile Creek. Metals were detected in both upstream and downstream samples at comparable levels which are consistent with historical data for the Kansas River. Therefore, the SFL does not appear to be impacting the Kansas River or Threemile Creek.

Various metals were detected in soil samples upgradient and downgradient of the site. Only beryllium and thallium concentrations in subsurface soil samples exceeded the proposed RCRA Corrective Action Levels; these constituents were present in both upgradient and downgradient samples at comparable levels and thus do not appear to be site-related.

Sections 1.2.4.6 and 1.2.5.4 summarize and conclude on the nature and extent of contamination and the fate and transport, respectively.

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section of the Feasibility Study (FS) addresses three main areas: (1) identification of applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) requirements; (2) development of preliminary remediation goals (RG) and remedial action objectives; and (3) identification and screening of potentially applicable technologies.

The technology identification and screening process represents the first step in the development and evaluation of remedial alternatives for the SFL. Media-specific technologies and process options determined applicable to the SFL are combined into remedial alternatives which address the remedial action objectives. The approach utilized in developing this section of the FS was to identify additional potentially applicable general response actions beyond the removal action planned to be implemented and then develop subcategories of general response actions called remedial technologies. The general response actions are those broad category actions which potentially satisfy the remedial action objectives presented in Section 2.2. General response actions include no-action, institutional controls, containment, treatment, removal and disposal. The remedial technology type refers to the general category of remedial technologies, (i.e., capping) where as process options refer to a specific technology (i.e., clay or asphalt cap) within each technology type. After the remedial technologies have been developed, then specific process options are identified and screened. During screening, any one of the general response actions, remedial technologies, or process options can be omitted from further analysis based on effectiveness, implementability, or cost.

Effectiveness is based upon how proven and reliable the process option is with respect to the site-specific media and constituents of concern. Effectiveness also considers potential impacts to human health and the environment that may result from the implementation of the process option.

Implementability addresses the ability to install and operate a technology or process option considering site-specific characteristics. Implementability also considers the ability to obtain regulatory approval for a technology being considered. Those technologies that are ineffective or unworkable considering regulatory issues, site-specific and contaminant-specific conditions are eliminated from further consideration.

Costs are evaluated based upon relative capital and operation and maintenance cost (O&M) in comparison with the other process options presented for a specific technology type. Costs are listed as high, medium, or low. The cost evaluation is based upon engineering judgement. Initial opinions of cost for comparison between alternatives are presented in the detailed analysis of alternatives (Section 4.0).

2.1 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED (TBC) REQUIREMENTS

Superfund remedial response actions must address the requirements of the environmental laws which are determined to be "applicable" or "relevant and appropriate." The identification of the ARARs is done on a site-specific basis, and involves the comparison of a number of factors, including the types of hazardous substances present (chemical-specific), the types of remedial actions considered (action-specific), and the physical nature of the site (location-specific), to the statutory or regulatory requirements of the relevant environmental laws.

A requirement under CERCLA is that environmental laws may either be "applicable" or "relevant and appropriate," but not both. Therefore, the identification of site-specific ARARs involves a two-part analysis: first, a determination whether a given requirement is applicable, and second, if it is not applicable, a determination whether it is both relevant and appropriate. Applicable requirements are those standards, requirements, criteria, or limitations promulgated under Federal or State law that specifically address a hazardous substance, contaminant, remedial action, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those standards, requirements, criteria, or limitations promulgated under Federal or State law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site (USEPA, 1988a).

In addition to the ARARs, TBCs are also identified during the process of determining remedial response objectives. The TBCs are non-promulgated advisories or guidance issued by state or federal government that are not legally binding and do not have the status of potential ARARs. The TBCs are used, however, in conjunction with site risk assessment, to aid in the determination of cleanup levels necessary to protect human health and the environment. Examples of TBCs include health advisories, reference doses (RfDs), guidance policy documents developed to implement regulations, and calculated risk-based remediation goals.

A discussion of each type of ARAR or TBC, specific examples of each, and the relevance of these specific examples to the SFL project are presented below. Chemical- and location-specific ARARs and TBCs are summarized in Table 2-1. In addition, the regulation involved, applicable action and administrative requirements for chemical- and location-specific ARARs are summarized in Tables 2-2 and 2-3, respectively.

2.1.1 Chemical-Specific ARARs and TBC Requirements

Chemical-specific ARARs are usually health- or risk-based numerical action values or methodologies which, when applied to site-specific conditions, result in the establishment of

TABLE 2-1

CHEMICAL- AND LOCATION-SPECIFIC
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
AND TO BE CONSIDERED (TBC) REQUIREMENTS
Southwest Funston Landfill
Fort Riley, Kansas

TYPE OF ARAR	ARARs	TBC REQUIREMENTS
Chemical-Specific	Maximum Contaminant Levels (MCLs) (40 CFR 141 Subpart B)	Proposed Subpart S
	Maximum Contaminant Level Goals (MCLGs) (40 CFR 141 Subpart F)	
	Alternate Cleanup Levels (40 CFR 264.94)	
	Kansas Drinking Water Rules (KAR 28.15)	
	Ambient Water Quality Criteria (40 CFR 131)	Kansas Notification Levels (KNLs)
		Kansas Action Levels (KALs)
		Risk-Based Remediation Goals
Location-Specific	Flood Plain Management Executive Order 11988 (16 USC 661 et. seq., 40 CFR 6.302, Appendix A)	None Identified
	Endangered Species Act of 1973 (16 USC 1531-1544)	
	Fish and Wildlife Coordination Act Requirements (33 CFR 320-330; 40 CFR 6.302)	
	Surface Water Use Designations (KAR 28.16.28d)	
	Designation of Critical Water Quality Management Areas (KAR 28.16.70)	
	Clean Water Act Section 404 Permitting Requirements (3 U.S.C. 1341, 33 CFR 320 through 330, 40 CFR 230)	
	Clean Water Act Section 401 Water Quality Certification (33 U.S.C. 1341)	
	National Historic Preservation Act (16 U.S.C. 469; 36 CFR 65 and 36 CFR 800)	

TABLE 2-2

CHEMICAL-SPECIFIC ARARs
Southwest Funston Landfill
Fort Riley, Kansas

REGULATION	RELEVANT ACTION	SUBSTANTIVE REQUIREMENT
40 CFR 141: Subpart B National Primary Drinking Water Regulations	Water treatment	Sets maximum contaminant levels (MCLs) for public water systems (defined as at least 15 service connections or serving at least 25 persons). The MCLs for site-related constituents are shown in Table 2-4.
40 CFR 141: Subpart F National Primary Drinking Water Regulations	Water Treatment	Provides health-based, non-enforceable goals (MCLGs) for drinking water. MCLGs set above zero are relevant and appropriate per the NCP. The available MCLGs for the site-related constituents are shown in Table 2-4.
40 CFR 264.94(b) Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities	Water treatment	Alternate concentration limits that may be established by EPA's Regional Administrator on consideration of human health and environmental effects.
KAR 28.15 Kansas Drinking Water Rules	Water treatment	Sets maximum contaminant levels (MCLs) for public water supply systems (defined as at least 10 service connections or regular service of at least 25 individuals daily at least 60 days per year). The Kansas MCLs for site-related constituents are shown in Table 2-4.

TABLE 2-3

LOCATION-SPECIFIC ARARS
Southwest Funston Landfill
Fort Riley, Kansas

REGULATION	APPLICABLE ACTION	SUBSTANTIVE REQUIREMENT
16 U.S.C. 661 et. seq. Flood Plain Management	Excavation, Filling	Technical evaluation of the effects of the remediation on the floodplain, including a hydraulic study of the floodplain and possible mitigation plans, in order to obtain a Conditional Letter of Map Revision (CLOMR) from the FEMA.
16 U.S.C. 1531-1544 Endangered Species Act of 1973	Excavation, Material Handling	Determination of presence/absence of endangered or threatened species and actions to protect and preserve any such species or associated habitat.
33 CFR 320-330; 40 CFR 6.302 Fish and Wildlife Coordination Act	Excavation, Filling, Material Handling	Protection of fish and wildlife resources potentially affected by the remedial actions.
KAR 28.16.28d Surface Water Use Designations	Excavation, Grading	Protection of surface water quality such that current "non-contact recreational" and "consumptive recreational" designations can be maintained.
KAR 28.16.70 Designation of Critical Water Quality Management Areas	Excavation, Grading	Management of watershed to the extent that the following are not caused: damages to resources of the State; public nuisance or health hazards; destruction of fishery habitat; excessive deposition of sediments on river bottoms; additional risk to threatened or endangered fish or wildlife; violation of water quality standards.

TABLE 2-3

LOCATION-SPECIFIC ARARS
Southwest Funston Landfill
Fort Riley, Kansas

REGULATION	APPLICABLE ACTION	SUBSTANTIVE REQUIREMENT
3 U.S.C. 1341; 33 CFR 320-330; 40 CFR 230 Clean Water Act Section 404 Permitting Requirements	Excavation, Grading, Bank Stabilization	Selection of the least environmentally damaging alternative when a discharge of material to the aquatic environment is involved, and actions to be taken to minimize potential adverse effects.
33 U.S.C. 1341 Clean Water Act Section 401 Water Quality Certification	Bank Stabilization	None beyond KAR 28.16.28d and KAR 28.16.70.
16 U.S.C. 469; 36 CFR 65 and 36 CFR 800 National Historic Preservation Act	Excavation, Grading, Material Handling	Protection and recovery of significant artifacts and preservation of the buildings and grounds of Fort Riley.

numerical action values. These values establish the acceptable concentrations of constituents for a particular exposure pathway. The principal contaminants of concern at this site, which were detected in groundwater samples, are benzene, 1,2-dichloroethane, 1,1,2-trichloroethane, cis-1,3-dichloropropene, 1,1,2,2-tetrachloroethane, and vinyl chloride. The chemical-specific ARARs and TBCs for drinking water are presented below.

Drinking Water - The National Primary Drinking Water Regulations (NPDWR) established by the USEPA provide Maximum Contaminant Levels (MCLs) and Maximum Contaminant Level Goals (MCLGs) for a number of constituents (40 CFR 141 Subpart B). By NPDWR definition, the MCLGs are non-enforceable health goals, while the MCLs are the enforceable standards that must be set as close to the MCLGs as feasible. The MCLs combine health effects data on specific chemicals with other concerns, such as analytical detection limits, treatment technology, and economic impact. Federal MCLs apply to "public water systems," defined as systems which provide piped water for human consumption with at least 15 service connections or serving at least 25 persons.

MCLs are not applicable to the site because the groundwater is not directly provided to a public water system. In accordance with the NCP, non-zero MCLGs are relevant and appropriate requirements for the site since the site groundwater could potentially be used for future groundwater use. MCLs are relevant and appropriate for a constituent that has a MCLG set at zero or where its MCLG is otherwise not appropriate (i.e., MCLG set below the practical quantitation limit). The MCLs and MCLGs for four constituents of concern present in the groundwater are shown in Table 2-4.

The State of Kansas has developed Kansas Action Levels (KALs) and Kansas Notification Levels (KNLs) for constituents in groundwater. The KALs present the level above which long-term exposure to contaminant concentrations is unacceptable and apply to fresh and usable water aquifers in the state. KNLs are levels at which the public must be notified that contaminants are in the water supply. The KALs and KNLs for constituents of concern in groundwater are presented in Table 2-2 as groundwater TBCs. Discussions with the Kansas Department of Health and the Environment indicate that the State of Kansas has failed to meet the federally mandated deadline for completing revisions to the drinking water regulations and health advisories (KDHE, 1992). Therefore, by default, the state is required to enforce the federally-established MCLs.

Surface Water - As required by Section 304 of the CWA, the USEPA is required to develop and publish criteria, based on scientific knowledge, to be utilized by states in developing water quality standards. The federal Ambient Water Quality Criteria (AWQC; 40 CFR 131) establish water quality criteria for the protection of aquatic organisms and/or human health. These ARARs establish the basis for discharge criteria into the Kansas River and are considered relevant and appropriate to groundwater remediation alternatives which include discharge to surface water features.

TABLE 2-4

POTENTIAL CHEMICAL-SPECIFIC ARARs AND TBCs FOR GROUNDWATER
Southwest Funston Landfill
Fort Riley, Kansas

Parameter	Exposure* Point Concentration [a] (mg/L)	Maximum* Detected Concentration (mg/L)	Federal Maximum Contaminant Level [b] (mg/L)	Federal Maximum Contaminant Level Goal [b] (mg/L)	Kansas Maximum Contaminant Level [c] (mg/L)	Kansas Action Level [d] (mg/L)	Risk-Based Remediation Goals[e] (mg/L)
Benzene	0.0014	0.014	0.005	--	--	0.005	--
1,2-Dichloroethane	0.0028	0.016	0.005	--	--	0.005	--
cis-1,3-Dichloropropene	0.0017	0.0059	--	--	--	0.002	0.0028
1,1,2,2-Tetrachloroethane	0.003	0.015	--	--	--	0.0017	0.00042
1,1,2-Trichloroethane	0.0027	0.088	0.005	0.003	--	0.0061	--
Vinyl Chloride	0.0054	0.018	0.002	--	--	0.002	--

ARAR or TBC which is exceeded by maximum detected concentration

a – The 95% UCL of concentrations detected in ground water samples.
b – Maximum Contaminant Levels and Maximum Contaminant Level Goals (40 CFR 141 Subparts B and F)
c – Kansas Drinking Water Rules (KAR 28.15), last amended 1 May, 1988.
d – KDHE Memorandum, dated 5 December, 1988; Revised Groundwater Contaminant Cleanup Target Concentrations for Aluminum and Selenium.
e – Risk-based Remediation Goals listed if no federal MCL is available. Remediation Goals for other constituents based on MCLs. Remediation goals based on carcinogenic risk are presented using 10^{-5} target risk level.
-- No value available
* Based on baseline, first, second, and third quarter sample analyses

Source: Drinking Water Regulations and Health Advisories, USEPA Office of Water, May 1993.

Risk-Based Remediation Goals

Site-specific risk-based remediation goals for groundwater were calculated for the SFL and should be considered as TBCs. These risk-based action levels consider the actual and future potential exposure routes at the site, including ingestion, inhalation and dermal contact with affected groundwater. The risk-based remediation goals are provided in Table 2-4.

2.1.2 Location-Specific ARARs and TBC Requirements

Location-specific ARARs are regulations which are applicable to any actions conducted at the site because of its location. Location-specific ARARs are summarized and explained below. There were no location-specific TBCs associated with this project.

Flood Plain Management, Executive Order 11988, 16 USC 661 et seq, 40 CFR 6.302, Appendix A

Executive Order 11988, Floodplain Management, regulates direct and indirect development of a flood plain to avoid adverse effects due to flooding. Since the SFL is located within the 50-year floodplain, these regulations are applicable to the project. Prior to excavation or filling within the 100-year floodplain, the Army may be required to obtain a Conditional Letter of Map Revision (CLOMR), which is issued by the Federal Emergency Management Agency (FEMA). In order to obtain the CLOMR allowing filling, the Army is required to submit to FEMA the results of a technical evaluation of the effects of the proposed remedial actions on the floodplain in the vicinity of the SFL. This information is likely to consist of a hydraulic study of the existing flood plain, and the proposed flood plain following the site grading effort. Flood elevation effects (increases) caused by the site excavation/filling are evaluated. If the filling causes an increase in the flood elevations at the site, mitigative measures may be considered necessary as a condition of the CLOMR. Localized flood plain elevation increases may be allowed in some cases if the Army can obtain agreements with all potentially affected property owners.

Endangered Species Act of 1973 (16 USC 1531-1544)

These regulations protect or conserve endangered or threatened species. Fort Riley falls within an area that eight federally endangered species and thirteen additional candidate species for the federal endangerment listing are likely to inhabit. Of the 21 total species, two federally endangered species are also present in the Fort Riley area. Confirmed sightings along the river corridor include the bald eagle and the eastern hognose snake, and these sightings make this ARAR applicable to this project. Thus, the potential impacts of any proposed remedial actions on threatened and endangered species habitats in the vicinity of the SFL must be considered.

Fish and Wildlife Protection (16 USC 661-666c, 16 USC 2901 et seq, 33 CFR 320-330; 40 CFR 6.302)

The Fish and Wildlife Coordination Act requires Federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose, to take action to protect the fish and wildlife resources which may be affected by the action. The Fish and Wildlife Service and the appropriate State agency shall be consulted to ascertain the means and measures necessary to mitigate, prevent and compensate for project-related losses of wildlife resources and means to enhance the resources. These regulations are relevant and appropriate to this site because several different species of animals have been identified at Fort Riley, including the American burying beetle, the Texas horned lizard, the loggerhead shrike, and the regal fritillary butterfly, which may be adversely impacted by proposed remedial actions at the SFL.

Surface Water Use Designations (KAR 28.16.28d)

These regulations provide criteria for approved uses of certain types of waters. Surface waters located at the SFL site exist principally in isolated small areas of localized ponding and within Threemile Creek. The Kansas River is classified for "non-contact recreational use" and "consumptive recreational use" in the area. In addition, the Kansas River is also designated as an expected aquatic life region. This ARAR is applicable because site excavation and grading activities may impact water quality in Threemile Creek and the Kansas River.

Designation of Critical Water Quality Management Areas (KAR 28, 16.70)

These regulations provide criteria for the management of watersheds, such as the Kansas River, or portions of watersheds to be designated as critical water quality management areas because of pollutant sources which cause or may reasonably be expected to cause: damages to resources of the State; public nuisance or health hazards; destruction of fishery habitat; excessive deposition of sediments on river bottoms; additional risk to threatened or endangered fish or wildlife; or violation of water quality standards. Provisions of this ARAR protective of fish habitat maintenance and control of sediment deposition in the water are applicable to remedial activities at the SFL site because site excavation and grading activities may impact water quality in Threemile Creek or the Kansas River.

CWA - Section 404 Permitting Requirements (3 U.S.C. 1341, 33 CFR 320 through 330, 40 CFR 230)

Section 404 of the Clean Water Act regulates the discharge of dredged or fill material into waters of the U.S., including wetlands. It is the nation's primary wetlands protection mechanism. Regulatory authority is vested with the USACE with oversight by USEPA. Regulations governing the Section 404 program are contained in 33 CFR 320 through 330 and 40 CFR 230. The 404(b)1 Guidelines (the Guidelines) contained within 40 CFR 230 mandate the selection of the least environmentally damaging practicable alternative when a discharge of material to the aquatic environment is involved. The Guidelines also include actions that should be taken to minimize adverse effects to the aquatic environment. While no special aquatic sites, as defined by the Guidelines, will be impacted by the proposed remedial actions at SFL, there may be deposition of fill material associated with additional bank stabilization or remedial activities. Therefore, Section 404 and its associated regulations are applicable to this project.

CWA - Section 401 Water Quality Certification (33 U.S.C. 1341)

Section 401 of the Clean Water Act (the Act) requires that, for bank stabilization, the discharge complies with the applicable provision of Section 301, 302, 303, 306, and 307 of the Act and any other appropriate requirements of State law, such as state water quality criteria. Since proposed remedial activities include placement of rock during bank stabilization, this ARAR is applicable. However, no additional requirement should be imposed by this ARAR beyond those discussed in Surface Water Use Designations (KAR 28.16.28d) and Designating Critical Water Quality Management Areas (KAR 28.16,70).

National Historic Preservation Act (16 U.S.C. 469)

These regulations were enacted to protect and preserve significant artifacts and historic properties. The historical and archaeological significance of Ft. Riley, in addition to its inclusion on the National Register of Historic Places, make this ARAR applicable to this project. As a result, impacts to the buildings and grounds of Ft. Riley, and the potential destruction of artifacts at the site, must be considered as part of the proposed remedial actions.

A cultural resources survey of areas adjacent to the landfill site (north and east sides) was performed in August 1993 in conjunction with the proposed removal action. (The landfill area was not surveyed due to obvious surface disturbance.) The survey encountered no shallow (upper 1.5 meter) cultural resources, but did not rule out deeply buried resources.

Non-Applicable Location-Specific ARARs

The Protection of Wetlands regulations (Executive Order 11990) do not apply because, based on a Corps of Engineers wetlands delineation survey, there are no identified wetlands that could be impacted by site activities (USACE, 1993). Therefore, these regulations are not applicable to this project.

2.1.3 Action-Specific ARARs and TBC Requirements

Action-specific ARARs are technology-based or activity-based requirements or limitations on the proposed remedial actions at a site. By definition, action-specific ARARs are dependent on the proposed remedial actions at a site. Possible action-specific ARARs and TBCs are presented in Table 2-5 and are described below. Also discussed below are the means by which these ARARs and TBCs relate to the proposed actions.

In developing action-specific ARARs and TBCs for this project, the following assumptions were made:

1. Soil, sediment, groundwater, and surface water will only be hazardous by characteristic, if any are hazardous at all. This is discussed further under 40 CFR 261 (page 2-16).

2. The isolated hit of PCBs (as Aroclor 1260) was only detected in a single, subsurface soil sample, at a level exceeding Toxic Substances Control Act (TSCA) action levels. Because this compound was not detected in the duplicate of this sample, its presence at this site is questionable, and the regulations concerning disposal of PCBs (TSCA) are not considered.

3. Based on the data presented in the Draft Final RI Report for SFL, it is expected that the groundwater does not contain any compound in sufficient concentration to classify it as a characteristic hazardous waste under RCRA (see Table 2-6).

Potential remedial actions at this site include:

- Repair of the existing cover to provide a native soil cover
- Installation of a rock revetment for river bank stabilization
- Installation of a single barrier cover over the landfill
- Installation of a multi-layer cover over the landfill
- Installation of a slurry wall around the outside of the landfill
- Groundwater containment, extraction, treatment, and disposal

General ARARs for All On-Site Activities

The Occupational Safety and Health Administration (OSHA) regulations concerning employee exposure to hazardous substances or materials (29 CFR 1910.1000) and the OSHA Standards for Hazardous Waste Operations and Emergency Response (29 CFR 1910.120) will apply to on-site actions taken at the SFL site. Both of these regulations are applicable to the SFL site because of the requirements each provides which specifically regulates actions involving hazardous waste operations or any actions that present the possibility of employee exposure to hazardous substances.

TABLE 2-5

ACTION - SPECIFIC ARARs

SOUTHWEST FUNSTON LANDFILL - FORT RILEY, KANSAS

	OSHA - EMPLOYEE EXPOSURE (29 CFR 1910.1000)	OSHA - STANDARDS FOR HAZARDOUS WASTE OPERATIONS AND EMERGENCY RESPONSE (29 CFR 1910.120)	KANSAS SOLID WASTE MANAGEMENT REGULATIONS (KAR 28.29 PART II)	KANSAS HAZARDOUS WASTE MANAGEMENT REGULATIONS (KAR 28.31)	NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS) (40 CFR 50)	NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (40 CFR 61)	KANSAS AMBIENT AIR QUALITY STANDARDS AND AIR POLLUTION CONTROL REGULATIONS (KAR 28.19)	STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE (40 CFR 262 SUBPART A)	STANDARDS FOR IDENTIFICATION OF HAZARDOUS WASTE (40 CFR 261)	STANDARDS APPLICABLE TO TRANSPORTERS OF HAZARDOUS WASTE (40 CFR 263)	STANDARDS APPLICABLE TO GENERATORS OF HAZARDOUS WASTE (40 CFR 262 SUBPART B, C, D)	DOT HAZARDOUS WASTE TRANSPORTATION REGULATIONS (49 CFR 107)	LAND DISPOSAL RESTRICTIONS (40 CFR 268)	NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (40 CFR 122)	GENERAL PRETREATMENT REGULATIONS FOR EXISTING & NEW SOURCE OF POLLUTION FOR POTWS (40 CFR 401 AND 403)	WATER POLLUTION CONTROL REGULATIONS (KAR 28.16)	UNDERGROUND INJECTION CONTROL DIAGRAM (40 CFR 144 - KAR 28.46)	FEDERAL FACILITY COMPLIANCE ACT
INSTITUTIONAL CONTROLS AND MONITORING	●	●	●	●				●	●	●	●	●	●					
LANDFILL COVER	●	●	●		●	●	●											
SLURRY WALL	●	●	●		●	●	●											
ROCK REVETMENT	●	●	●															
GROUNDWATER EXTRACTION	●	●	●	●				●	●	●	●	●	●					
GROUNDWATER TREATMENT:																		
AIR STRIPPING	●	●	●	●		●	●	●	●	●	●	●	●					
COAGULATION/FLOCCULATION/ SEDIMENTATION	●	●	●	●				●	●	●	●	●	●					
AEROBIC BIOLOGICAL TREATMENT	●	●	●	●				●	●	●	●	●	●		●			
NITRIFICATION/DENITRIFICATION	●	●	●	●				●	●	●	●	●	●		●			
GROUNDWATER DISCHARGE:																		
SURFACE WATER	●	●	●											●		●		
WWTP	●	●	●												●			●
UNDERGROUND INJECTION													●				●	

● ARAR

MPAA

TABLE 2-6

COMPARISON OF MAXIMUM DETECTED CONCENTRATION IN GROUNDWATER AND RCRA TCLP LEVEL
Southwest Funston Landfill
Fort Riley, Kansas

PARAMETER[a]	MAXIMUM * DETECTED CONCENTRATION (mg/L)	RCRA TCLP LEVEL[b] (mg/L)
Benzene	0.014	0.5
1,2-Dichloroethane	0.016	0.5
cis-1,3-Dichloropropene	0.0059	--
1,1,2,2-Tetrachloroethane	0.015	--
1,1,2-Trichloroethane	0.088	--
Vinyl Chloride	0.018	0.2

a - Parameters listed are site-related constituents of concern
b - (40 CFR 261 Subpart C)
-- No value available
* Based on baseline, first, second, and third quarter sample analyses

2537.54

Kansas Solid Waste Management Regulations (KAR 28.29 Part II)

The Kansas state regulations for solid waste management (KAR 28.29 Part II) provide state regulations for solid waste management. These regulations are appropriate to the SFL site because solid waste was disposed at the SFL site and because the landfill closed, leaving solid waste in place, but contained. There are no identified substantive requirements within these regulations regarding closed facilities.

Kansas Hazardous Waste Management Regulations (KAR 28.31)

These regulations will apply to a groundwater extraction action if drill cuttings generated during well installation are characteristically hazardous wastes, and, if so classified, the cuttings are removed from the site. In accordance with CERCLA, the drill cuttings, if generated within the landfill, could be left in the landfill without constituting disposal. The same situation could occur for soil excavated during the construction of a slurry wall if the soil has a hazardous characteristic. These standards will also apply to groundwater treatment actions if the sludge generated as a consequence of these actions is a characteristically hazardous waste.

National Ambient Air Quality Standards (NAAQs; CAA 40 CFR Part 50)

These are federal standards that define the levels of air quality which are necessary to protect public health. These ARARs are applicable to proposed capping actions and for slurry wall installation because the grading and excavation activities associated with these actions may generate elevated levels of airborne particulate matter, the concentrations of which are specifically regulated by the NAAQs.

National Emission Standards for Hazardous Air Pollutants (NESHAPs; CAA 40 CFR Part 61)

These are federal standards that provide national emissions standards for listed hazardous air pollutants. Among the currently listed pollutants is vinyl chloride, one of the contaminants of concern in groundwater at this site. These regulations are applicable to landfill cover alternatives and to the air stripping groundwater treatment action for the following reasons. Vinyl chloride is a constituent of concern in groundwater at this site and may be released to the atmosphere during the air stripping process. Soils removed during installation of a slurry wall or regrading of the site may also generate volatile emissions and particulates addressed by the regulations.

Kansas Ambient Air Quality Standards and Air Pollution Control Regulations (KAR 28.19)

These are State of Kansas regulations that provide state emission standards for listed hazardous air pollutants and also provide state air quality standards to protect the public health. Among the currently listed contaminants are vinyl chloride and total particulate matter. These regulations are applicable to the landfill cover alternatives and to air stripping groundwater treatment action. Grading activities associated with capping may generate elevated levels of airborne particulate matter, the concentrations of which are specifically addressed under these regulations. In addition, vinyl chloride is a contaminant of concern in groundwater at this site and may be released during the air stripping groundwater treatment action.

Criteria for Municipal Solid Waste Landfills (40 CFR 258)

These regulations are not applicable because the landfill was closed prior to promulgation of the regulations. However, the closure criteria are relevant to an alternative involving repair of the existing cover or other cover improvements. Since the SFL does not have a liner system, the pertinent requirement from the closure criteria of 40 CFR 258 (also referred to as RCRA Subtitle D) is to construct a cover that is a minimum of 18 inches thick and has a maximum hydraulic conductivity 1 x 10^{-5} cm/sec or a cover design which achieves an equivalent reduction in infiltration.

The infiltration reduction requirement is applicable to existing MSWLFs that were open prior to the promulgation date (October 9, 1991) and were still in operation after that date. The requirement for these facilities was selected as a compromise between protection of groundwater resources and the financial burden of new closure requirements imposed on operators of these existing landfills. An infiltration reduction requirement was selected that is not strictly protective of groundwater so that numerous existing MSWLFs would not close before the promulgation date to avoid new, expensive closure requirements.

The infiltration reduction requirement of Subtitle D is considered to be relevant and appropriate for the SFL.

RCRA - Standards for Identification of Hazardous Waste (40 CFR 261)

These regulations establish the standards for identification of hazardous wastes. The regulation is applicable only for solid wastes. For this site, potential solid wastes that might be generated during remedial action are extracted groundwater, excavated soil, drill cuttings, and sludge generated from a groundwater treatment process. If excavated soil or drill cuttings were generated within the landfill, they would qualify as solid waste only if they were taken outside the landfill; this is consistent with the CERCLA definition of "land disposal". Solid wastes can be identified as hazardous based on characteristics or based on being a listed waste.

40 CFR 261 was promulgated on May 19, 1980. The SFL stopped receiving wastes in 1981, but there is no documentation identifying or manifesting waste types received at the SFL (DEH, 1993f). Since there is no affirmative evidence of hazardous waste being disposed of at the SFL, this regulation is not applicable.

An Installation Assessment Report (USATHAMA, 1984) suggests that waste mercury and spent solvents were disposed at the SFL (no indication of time frame). These two wastes could potentially be similar to presently regulated hazardous wastes. The Installation Assessment Report presents the findings of a facility-wide investigation that consisted of reviewing pertinent records and interviewing Fort Riley personnel. The source(s) of information that were specific to the SFL are not discussed in the report. The nature and quantities of the waste mercury and spent solvents are not known. The concentrations of the toxic constituents in the wastes are unknown and the matrix of the waste (as it was actually received at the SFL) is also not known. Therefore, there is a lack of evidence that these reported waste streams were sufficiently similar to presently regulated, listed wastes to demonstrate relevance and appropriateness. Additionally, investigations to date have not found evidence of concentrated sources within the landfill, therefore the disposed materials (as they exist today) are not expected to be similar to listed wastes.

These regulations could be applicable to the groundwater extraction action because they would be used to determine if the extracted groundwater was a characteristically hazardous waste. It would also be applicable if characteristically hazardous drilling cuttings or sludge from groundwater treatment were to be disposed off the site. It would also apply to groundwater treatment actions that would generate sludge. The standards would be applied to discern whether the sludge generated as a consequence of the groundwater remediation is a characteristically hazardous waste.

<u>RCRA - Standards Applicable to Generators of Hazardous Waste (40 CFR 262 Subpart A)</u>

These regulations define general requirements applicable to hazardous waste generators. These regulations would be applicable to a groundwater extraction action if drill cuttings generated during well installation were characteristically hazardous waste and were to be disposed off the site. In accordance with CERCLA, drill cuttings from the landfill could be kept within the landfill without constituting disposal. These standards would also be applicable if groundwater treatment actions were to generate sludge that was characteristically hazardous waste and was to be disposed off the site.

<u>RCRA - Standards Applicable to Transporters of Hazardous Waste (40 CFR 263)</u>

These regulations provide federal requirements for transportation of hazardous waste, specifically identifying the applicability of these regulations to transporters, describing the manifesting system, and providing guidelines for discharge cleanup while in transit. These standards would be applicable only if characteristically hazardous waste, such as drill cuttings, were generated and then disposed off the site. Off-site disposal would trigger the manifesting system requirements. These standards would also be applicable to groundwater treatment actions if the sludge generated by remedial action was a characteristically hazardous waste and was disposed off the site.

<u>Standards Applicable to Generators of Hazardous Waste (40 CFR 262 Subparts B, C, and D)</u>

These federal standards regulate the manifesting, pre-transport, recordkeeping, and reporting requirements for hazardous wastes. These standards would be applicable to the groundwater extraction action if characteristically hazardous waste, such as drill cuttings, were generated and disposed off the site. These standards would also apply to groundwater treatment actions if the sludge generated was a characteristically hazardous waste and was disposed off the site.

DOT Rules for the Transportation of Hazardous Materials (49 CFR 107)

These rules regulate the transportation of hazardous waste by roadway, rail, air, and water. These regulations would be applicable to a groundwater extraction action if characteristically hazardous waste, such as drill cuttings or sludge, was generated during remediation and then disposed off the site.

RCRA - Land Disposal Restrictions (LDRs; 40 CFR 268)

These regulations establish treatment standards to which hazardous wastes must be treated before they can be land disposed; these regulations also establish the circumstances under which an otherwise prohibited waste may continue to be land disposed. These regulations would be applicable to a groundwater extraction action if characteristically hazardous waste, such as drill cuttings, was generated during remediation and disposed off site. If characteristically hazardous sludge were generated from the treatment process, LDRs would apply whether the sludge was disposed on or off the site; in either event, the LDRs must be considered prior to disposal.

CWA - National Pollutant Discharge Elimination System (NPDES) Requirements (33 USC 1251 et seq., 40 CFR 122)

The National Pollutant Discharge Elimination System (NPDES) regulations pertain to the discharge of pollutants into the waters of the United States. NPDES discharge requirements would be applicable if pumped groundwater was discharged from a groundwater treatment system to Threemile Creek or the Kansas River. NPDES requirements for storm-water runoff on construction sites are also applicable to reconstruction or repair of the cover or any other construction activity involving the disturbance of 5 or more acres.

An engineer with the State of Kansas, Department of Health and Environment, Bureau of Water, has stated that if an alternative involving discharge of wastewater to a surface water body is selected, Fort Riley would be required to submit information fulfilling the reporting requirements of a completed permit application, Form 1 - General Information (available from USEPA's Permit Division Consolidated Permits Program) to the State of Kansas Bureau of Water at least 180 days prior to discharge startup. Since remedial actions at the SFL are regulated under CERCLA, a permit is not required; however, the Army must comply with substantive requirements of a permit. Modification of an existing permit to include SFL discharges may also be an option, since the Department of the Army currently has a "Kansas Water Pollution Control Permit and Authorization to Discharge Under NPDES" (Kansas Permit No. F-KS97-P001 and Federal Permit No. KS-0029505).

Relative to the effluent quality requirements, Kansas Statute 65-165, "Permit for Discharge of Sewage; Recordation; Revocation or Modification, Notice; New Permit" states:

> "...whenever it is the secretary's opinion that the general interests of the public health would be served thereby, or that the discharge of such sewage would not detract from the quality of the waters of the state for their beneficial uses for domestic or public water supply, agricultural needs, industrial needs, recreational needs or other beneficial use and that such discharge meets or will meet all applicable state water quality standards and applicable federal water quality and effluent standards under the provisions of the federal water pollution control act and the amendments thereto as in effect on January 1, 1984, the secretary of health and environment shall issue a permit..."

According to the engineer contacted at KDHE, water quality of the receiving water (Threemile Creek or the Kansas River) may be considered background water quality. From this initial discussion, it appears that discharges to Threemile Creek or the Kansas River could be allowed by KDHE if the concentrations of metals in the effluent do not exceed background stream levels; however, KDHE review of the design information would be necessary before effluent concentration levels and approvals could be assured.

Water Pollution Control Regulations (KAR 28.16)

These regulations are State of Kansas regulations that limit the amount of pollutants that can be discharged into state waterways. It would be applicable to a surface water discharge action if treated groundwater were discharged to the Kansas River, a State of Kansas waterway. These regulations provide concentrations of pollutants below which discharge to the Kansas River is permitted.

2.1.4 Contaminant-Specific Remediation Goals

Contaminant-specific remediation goals (RGs) are concentrations for individual contaminants of concern for specific medium and land use combinations. RGs are designed to be protective of human health and the environment and comply with ARARs. At the SFL site, the RGs have been set equal to non-zero MCLGs or MCLs, if they exist. When non-zero MCLGs or MCLs were not available for a particular contaminant, risk-based RG concentrations have been calculated. These calculated RGs are criteria that are "to be considered" (TBC) for remediation of the site. The contaminant-specific RGs developed and/or calculated for the SFL site are designed to protect human health. (Fourth quarter groundwater data was not included in the risk assessment. However, examination of this data indicates that it would not affect the results or conclusions of the risk assessment or, therefore, the calculation of RGs.)

2.1.4.1 Exposure Pathways - As indicated in the baseline risk assessment, the unacceptable risks posed by the SFL site were associated with potential future exposures to volatile organics in on-site groundwater via ingestion (adults only) and inhalation (adults and children). Therefore, contaminant-specific RGs were only developed for pathways related to groundwater exposures. Though dermal contact with the groundwater was not associated with unacceptable risk, it has been included as a potential exposure route when calculating risk-based RGs (in order to be conservative). As indicated in Tables A-1 through A-4 in Appendix A, the inclusion of this exposure has a minor effect on RGs.

2.1.4.2 Determination of Contaminant-Specific Remediation Goals - There is a non-zero MCLG set for 1,1,2-trichloroethane and the MCLG is the RG for this constituent. MCLs exist for three other volatile contaminants of concern in the groundwater (benzene; 1,2-dichloroethane; and vinyl chloride). Therefore, the RGs assigned to these three contaminants are their MCLs. However, MCLs do not exist for the two remaining volatile contaminants of concern in the groundwater (cis-1,3-dichloropropene and 1,1,2,2-tetrachloroethane). Therefore, risk-based RGs have been calculated for these two contaminants of concern using the methodology described in the following paragraphs. A summary of the governing contaminant-specific remediation goals is presented in Table 2-7.

The risk-based remediation goals for the SFL site were calculated following methodology presented in USEPA guidance (USEPA, 1991a). This methodology involves estimating exposures for the scenarios of interest at the site. Exposures to contaminants of concern are estimated using exposure variables that describe the potential receptors, such as exposure frequency and duration, body weight, and intake rate. The exposure variable values used for calculating RGs for the SFL site are consistent with the values recommended by the USEPA (USEPA, 1989a) and used in the baseline risk assessment for the site (Law, 1993a).

The RG calculation is also dependent on target risks and contaminant-specific toxicity values. The target risks used for the RG calculations for the SFL site are 1×10^{-5} for carcinogens and 1.0 for non-carcinogens. The carcinogenic target risk is in the middle of the carcinogenic risk range considered acceptable by the USEPA (1×10^{-4} to 1×10^{-6}), while 1.0 is the standard point-of-departure used by the USEPA for non-carcinogens. Finally, the contaminant-specific toxicity values used in the RG calculations were obtained from the USEPA's Integrated Risk Information System database. The derivation of the risk-based RG equation and the calculation of the risk-based RGs are provided in Appendix A.

2.2 REMEDIAL ACTION OBJECTIVES

The primary remedial goal at the site is to protect human health and the environment. Remedial action objectives are media-specific goals developed to achieve this protection. The objectives

TABLE 2-7

GOVERNING REMEDIATION GOALS FOR GROUNDWATER [a]
Southwest Funston Landfill
Fort Riley, Kansas

ANALYTE	REMEDIATION GOAL	MAXIMUM DETECTION CONCENTRATION	95% UCL[f]	DETECTION FREQUENCY [d]	EXCEEDANCE FREQUENCY [e]
Benzene	5 [b]	14	1.4	7/56	2/56
1,2-Dichloroethane	5 [b]	16	2.8	3/56	3/56
cis-1,3-Dichloropropene	2.8 [c]	5.9	1.7	2/56	2/56
1,1,2,2-Tetrachloroethane	0.42 [c]	15	3	2/56	2/56
1,1,2-Trichloroethane	3 [g]	8.8	2.7	1/56	1/56
Vinyl Chloride	2 [b]	18	5.4	2/56	2/56

Note: All units are μg/L.
a The governing remediation goals are MCLs (if they exist); otherwise risk-based remediation goals are presented.
b Remediation goal is based on MCL (Drinking Water Regulations and Health Advisories, US EPA, Office of Water, May 1993).
c Remediation goal is based on a carcinogenic target risk of 10^{-5}.
d The detection (and exceedance) frequencies include Well Cluster 5 (which was omitted from the risk assessment).
e The frequency of detections exceeding the remediation goal.
f Upper confidence level
g Remediation Goal is based on MCLG

presented here were developed considering the information in the Draft Final RI Report (Law, 1993a). Remedial action objectives are discussed in this section for each medium at the site.

2.2.1 Soils

The risk assessment indicates no exposure route for subsurface soils and, therefore, no unacceptable risk. Furthermore, the risk assessment indicates a carcinogenic risk of 3×10^{-6} due to direct contact with the surface soil. This risk is above the 1×10^{-6} point of departure but within the acceptable risk range defined by the NCP. There are two uncertainties associated with this calculation. First, the calculation was based on the highest "hits" from the XRF screening for surface soil which may bias high the calculated risk. Second, the characterization of the surface soil focused only on the three metals listed above. The presence of the other constituents of concern in the surface soil is not known. However, the landfill surface soil was borrowed material for the final cover and was placed after the landfill contents had been disposed. Surface soil sampling focused on lead, copper, and zinc because a portion of the soil was borrowed from a rifle range. The presence of other constituents of concern are not anticipated. The ecological risk assessment, based on the same site data, indicates that risk to exposure of the surface soils to ecological receptors is low.

The calculated risk is based on the characteristics of the surficial cover soil. The risk of direct contact with the trash and debris that is exposed in limited areas has not been quantified. Based on the risk assessment conclusions and the associated uncertainties, the following RAO is considered:

- Minimize human and ecological direct contact with landfill contents.

Stormwater infiltration is identified as one, but not the only, potential mechanism for generating leachate in the landfill contents and transporting constituents of concern to the groundwater. The existing cover material has settled in places allowing stormwater to pond. This ponded water provides a hydraulic head for vertical migration of infiltration. The cover also has scattered burrow holes, settlement cracks, and a small number of eroded rills that provide potential conduits for downward movement of stormwater. For these reasons, the following RAO is considered:

- Reduce the potential for leachate generation by reducing stormwater ponding and infiltration (i.e., facilitating evapotranspiration) as practical.

The Kansas River bank has evidence of erosion, sloughing, and localized slope failures due to the river action. Historical movement of the river has also been noted. Currently, bulky solid waste (placed to control erosion) is exposed in places along the riverbank. Without stabilization of the bank, there is the potential for continued sloughing and erosion of the river bank until landfill contents were exposed that could present an unacceptable risk to humans or the environment. For this reason, the following RAO is considered:

- Stabilize the Kansas River bank slope adjacent to the SFL to control movement of the channel into the landfill and to prevent exposure and erosion of the landfill contents.

2.2.2 Groundwater

Remedial action objectives were established for groundwater by comparing the site data to remediation goals (RGs) for the constituents of concern. The constituents of concern are those compounds that contribute to an unacceptable risk (based on the baseline risk assessment) or exceed their non-zero MCLG or MCL. The MCL is the governing RG for most constituents; one constituent has a non-zero MCLG. For those without a MCL or non-zero MCLG, the risk-based RG is considered.

The only inorganic constituent exceeding its MCL is antimony. It was detected three times in 56 total metals samples; once in well SFL92-703 during the first quarterly sampling event and once each in wells SFL92-801 and SFL92-803 during the second quarterly sampling event. The data indicate that the presence of antimony at levels exceeding the MCL is limited. Furthermore, antimony has been detected in the Ogden drinking water wells at levels exceeding the MCL. Published EPA data (USEPA, 1990) indicate that the typical range of antimony found in naturally occurring Kansas soils is 2 to 10 ppm. This information suggests that the antimony observed in the SFL groundwater may be due to background or natural conditions. Manganese, iron, and aluminum were detected at levels exceeding their secondary MCLs. However, comparison of on-site data to both upgradient and published regional data indicates that on-site data are comparable to background levels. Furthermore, secondary MCLs are set for constituents that have objectionable aesthetic properties; they are not pertinent to the protection of human health and the environment. For these reasons, no remedial action objectives are established for inorganics in groundwater.

The six organic constituents of concern are benzene, 1,2-dichloroethane, cis-1,3-dichloropropene, 1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, and vinyl chloride. As shown in Table 2-4, the maximum detected concentration of each constituent exceeds the respective MCL except for cis-1,3-dichloropropene and 1,1,2,2-tetrachloroethane which do not have MCLs. The maximum detected levels for these two compounds exceed their calculated risk-based RGs. The maximum detected concentration of 1,1,2-trichloroethane also exceeds its non-zero MCLG.

As shown in Table 2-4, the frequency of detection and RG exceedance frequency is low for all six compounds. Benzene is the only constituent that has been detected consistently over time in the same monitoring well. Furthermore, the 95 percent UCL for each constituent is less than the respective RG except for 1,1,2,2-tetrachloroethane and vinyl chloride.

The RAO for groundwater is summarized below:

- Prevent ingestion, inhalation and dermal contact with groundwater with organic concentrations exceeding the RGs.

2.2.3 Surface Water and Sediment

The surface water and sediment results indicate that the SFL is not contributing any organic contaminants to the Kansas River or Threemile Creek. Metals were detected in both upstream and downstream samples at comparable levels which are consistent with historical data for the Kansas River. Therefore, the SFL does not appear to be impacting the Kansas River or Threemile Creek and no remedial action objectives are established for surface water and sediment.

2.2.4 Landfill Gas

Landfill gas was not sampled at the SFL, however, health and safety monitoring was performed during drilling to detect the presence of combustible gases. An explosimeter was used during drilling to monitor the atmosphere around the borehole. The monitor was set with an alarm to sound if combustible gases were detected exceeding 5 percent of the lower explosion level (LEL). This condition was not observed during drilling. Additionally, no evidence of distressed plants or excessive landfill odors (which are indicative of landfill gas) was observed during site visits and field sampling efforts.

The main concern with landfill gases is collection in subterranean structures such as manholes and basements, creating a hazard of explosion or suffocation due to the displacement of oxygen. There are limited buried utilities within close proximity to the SFL site, and the nearest structure, where gases might accumulate, is about 2,000 feet from the SFL and across Threemile Creek. The creek protects Camp Funston from the lateral migration of landfill gas, if it occurs, because such gas would escape to the atmosphere through the bank of the creek. Based on this discussion, no RAOs are identified for landfill gas.

2.3 EXTENT OF CONTAMINATION BASED ON REMEDIATION GOALS AND REMEDIAL ACTION OBJECTIVES

Considering the RGs and chemical data from the RI, the extent of groundwater contamination appears to be limited. No consistent spatial patterns were discernible from the RI data and the limits of a plume cannot be defined with the available data. Attempts to define the limits of a volatile organics plume are complicated by the groundwater gradient reversals which have been observed during the sampling events. Furthermore, many of the groundwater constituents that were detected in a particular monitoring well for a given sampling event were not detected in the previous or subsequent sampling events. The variability of sporadic low level detections of organic constituents in groundwater does not indicate a definable plume of contamination. Therefore, estimation of the volume of contaminated groundwater is inappropriate and the volume of groundwater to be addressed by the remedial action objectives is unknown. Section 3.3 of USEPA guidance "Conducting RI/FS for CERCLA Municipal Landfill Sites" indicates it is typically impractical to complete a detailed characterization of landfill contents, and therefore, estimation of the volume of contaminated media in the landfill was not completed.

2.4 GENERAL RESPONSE ACTIONS

Five general response actions have been identified to categorize the potential remedial actions for the SFL: (1) No Additional Action; (2) Institutional; (3) Containment; (4) Treatment; and (5) Removal/Disposal. These general response actions were developed based upon the Remedial Action Objectives. The various remedial technologies associated with the general response actions are discussed in Section 2.6. Although each of the response actions are presented individually, most of the remedial alternatives presented in Section 4.0 include a combination of response actions.

2.4.1 No Action

This is considered a baseline for comparing the other actions.

2.4.2 Institutional Controls

This general response category includes controls which prevent or limit access to the site and restrict current or future uses of the area or continue to evaluate existing concentrations. Examples of institutional controls include fencing, warning signs, master plan restrictions, utility easement and access restrictions, on-site work procedures and groundwater monitoring.

2.4.3 Containment Actions

Containment is the use of barriers to control routes of exposure and contaminant migration. Containment response actions do not treat or reduce toxicity or volume of contamination. Containment actions generally refer to a surficial cover, or a vertical wall, such as a slurry wall.

2.4.4 Treatment Actions

Treatment actions refer to the use of chemical, physical, thermal, or biological treatment methods to reduce or eliminate the toxicity, mobility, or volume of contamination. Treatment technologies typically alter the characteristics of the contaminants by changing the chemical structure or isolating or destroying the contaminant. Typically, a single treatment method is not capable of treating all potential constituents of concern, i.e., volatile organics, semi-volatile, and metals, and a combination of technologies are utilized to achieve clean-up standards.

2.4.5 Removal/Disposal Action

The removal/disposal action includes the collection of groundwater, soils, or other media and placing these media in a secure location. For groundwater, disposal typically constitutes discharge to a receiving stream or POTW and this action often requires treatment prior to discharge. The USEPA RI/FS guidance for municipal solid waste landfills (USEPA, 1991a) states that excavation (removal) of soils and landfill contents are typically limited to "hot spots". Removal/disposal is practical when efforts are focused on areas that pose the prominent threat at a site. The data collected does not indicate any localized areas that present a prominent threat at the site. Therefore, removal/disposal of contaminated soils is eliminated from further consideration.

2.5 IDENTIFICATION AND SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS

The potentially applicable remedial technology types and process options were identified based primarily upon effectiveness considering the site characteristics and the remedial action objectives. Remedial technology types refer to the general categories of technologies while the process options refer to the specific remedial technologies within the technology category. As an example, capping is a technology type while a native soil cover, single barrier cover, and multi-layer cover are process options under capping.

The identified technologies were evaluated and screened utilizing the following evaluation criteria:

- Effectiveness
- Implementability
- General Cost (high, medium, low)

For the implementability/feasibility evaluations, site location, accessibility, site conditions, and the developmental stage of the selected technology (i.e, bench scale, pilot scale, or full scale) and the technologies effectiveness for the constituents of concern are considered.

2.5.1 Institutional Action Technologies

Three institutional technologies (groundwater monitoring, land use controls, and access controls) have been identified that are potentially applicable to the site. The identified technologies are discussed below.

2.5.1.1 Groundwater Monitoring - Groundwater monitoring could be used to monitor on-site groundwater. Long-term groundwater monitoring would be similar to the groundwater sampling activities of the RI except the analyte list would be limited to the constituents of concern. A groundwater monitoring program may use and maintain the existing monitoring wells installed for the RI/FS and/or any additional wells installed. The requirements for post-closure monitoring of solid waste landfills (40 CFR 258) could be a model for developing a modified site-specific plan.

The five-year site review program in accordance with CERCLA is specified in the Interagency Agreement (IAG), and groundwater monitoring would be reviewed as part of this five-year assessment. Therefore, groundwater monitoring is retained for alternatives development.

2.5.1.2 Land Use Controls - Since the site is part of a military installation, there is an existing mechanism in-place for controlling use at the site. In accordance with military regulations, all proposed site development and similar activities must be subjected to a military review process to assure that proposed activity is consistent with the facility-wide master plan. Part of the review process includes review and comment by DEH. Fort Riley has the authority to adopt site-specific restrictions and requirements, and enforce them through this review process.

Optional land use controls that could be implemented by the Army include:

- Restrictions or prohibitions on site development and on-site activities (controls are currently in place).
- Conditional access to existing utilities.
- Restrictions or prohibitions on future utility easements.
- Prohibition on groundwater use.

These options are described below.

Site Development Restrictions

Fort Riley could establish rules that the site is to remain unimproved or establish guidelines that define acceptable development. The facility master plan currently identifies the property as a landfill. Acceptable development could be restricting structures that involve excavation for foundation work, effectively limiting construction to slab-on-grade structures. These controls may prevent future exposure to landfill contents and are, therefore, retained for alternatives development.

Utility Restrictions

Fort Riley could establish rules restricting future access or easements across the site for utilities. The only existing buried utility at the site is an abandoned 12-inch water line. Fort Riley could prohibit on-site access for removal of this line. Alternately, Fort Riley could establish worker health and safety requirements, including the use of personal protective equipment, for removal activities on the line. Utility restrictions may prevent future exposure to landfill contents. Therefore, they are retained for alternatives development.

Groundwater Use Restrictions

Fort Riley could prohibit the use of groundwater at the site. These restrictions could prevent future exposure to contaminated groundwater and are, therefore, retained for alternatives development.

2.5.1.3 Access Controls - Access controls include perimeter fencing, gates, and warning signs. There is currently a gate along North Well House Road restricting vehicular access to the site. The removal action cover will effectively cover any exposed landfill contents and should control exposure to hunters or other site visitors. A fence and signs could also be used to control temporary and unauthorized site access. Since the removal action cover is planned, fences and signs are screened from further consideration.

2.5.2 Containment Technologies

Four applicable containment technology types were identified for this site: surface controls, capping, in-situ vertical walls, and river bank stabilization technologies. Surface controls and capping technologies address the remedial action objectives for soil and the vertical walls address groundwater remedial action objectives.

The four technologies are discussed in the following sections.

2.5.2.1 Surface Control Process Options - Surface control process options include:

- Diversion and collection of stormwater
- Grading
- Surface vegetation

Surface controls address some of the remedial action objectives for soils. However, they are eliminated from further evaluation because the existing cover, once repaired, will exceed the effectiveness of the identified surface control technologies. Surface run-on does not occur at the site. Therefore, diversion of stormwater is not needed. The existing cover is vegetated to control erosion. Furthermore, grading to promote surface runoff is integral to the capping technologies under consideration and most of the covers require vegetation. Therefore, they are a necessary part of the capping technologies but are not retained as "stand-alone" technologies.

Consideration of a flood control diversion berm is not warranted at the SFL to limit landfill surface erosion during major flood events. At near bank full conditions, the average channel velocity of the Kansas River at Southwest Funston Landfill is estimated to be 4.85 feet per second, using the rating curve for the local gaging station. The velocity at the water surface on the bank is estimated to be 2.90 feet per second, based on U.S. Army Corps of Engineers, Engineer Manual EM 1110-2-1601, Hydraulic Design of Flood Control Channels. As soon as the river overtops the bank, velocities will drop considerably below 2.90 feet per second because the channel cross sectional area becomes larger and the flow is no longer directed to follow the bend in the river. Those velocities will be considerably below 5 feet per second which is typically taken to be the threshold limit for erosion of grass covered soils. Therefore, erosion of the landfill cover will be minimal during a 100-year flood. Furthermore, following the estimated 50-year flood which occurred during June 1993 and inundated the SFL landfill surface, a visual inspection of the post-flood landfill surface was made by the USACE, Kansas City District. Based on this inspection, it was concluded that no significant erosion of the landfill surface had occurred and, in some areas, sediment deposition was noted. Therefore, a flood control berm has been eliminated from further consideration.

2.5.2.2 Capping Process Options - The potentially applicable capping process options for this site are as follows:

- Native soil cover
- Single Barrier Cover
- Geosynthetics
- Multi-layer Cover
- Hard cap (asphalt or concrete)

The capping options presented will meet the remedial action objectives of providing cover over the waste and reducing stormwater ponding. Each capping option will also reduce infiltration to meet or exceed the minimum requirements of the RAO (repair existing cover). The relative effectiveness of each option in reducing infiltration beyond the minimum requirements of the RAO is discussed below and is used in screening the options.

Native Soil Cover

A native soil cover is the placement of local soils over the landfill contents. This cover would prevent the exposure of the landfill contents but would not provide a hydraulic barrier to infiltration. The existing SFL cover (once settlement is repaired to control stormwater ponding, cracks, and erosion are repaired) is a native soil cover. As part of the preliminary design evaluation, the USACE has sampled the existing cover and determined the thickness to be approximately 2 feet (where undamaged).

Single Barrier Cover

A single barrier cover is an earthen cover that includes a hydraulic barrier (see Figure 2-1) to inhibit the downward movement of infiltration. The hydraulic barrier can be constructed of compacted clay. Industry standard is to construct a 2-foot thick clay layer with an in-situ hydraulic conductivity of not more than 1×10^{-7} cm/sec. If adequate clay is not available at a site, bentonite can be mixed with the available soils to achieve the desired low-permeability characteristics. Alternately,a geosynthetic barrier (see below) can be used in lieu of clay or soil-bentonite mixture. The hydraulic barrier layer must be protected from the elements and therefore, soil must be placed over the barrier layer. The climatic conditions at Fort Riley, as in many places, are such that a drainage layer would be required above the compacted clay layer to avoid the saturation of the overlying protective soil.

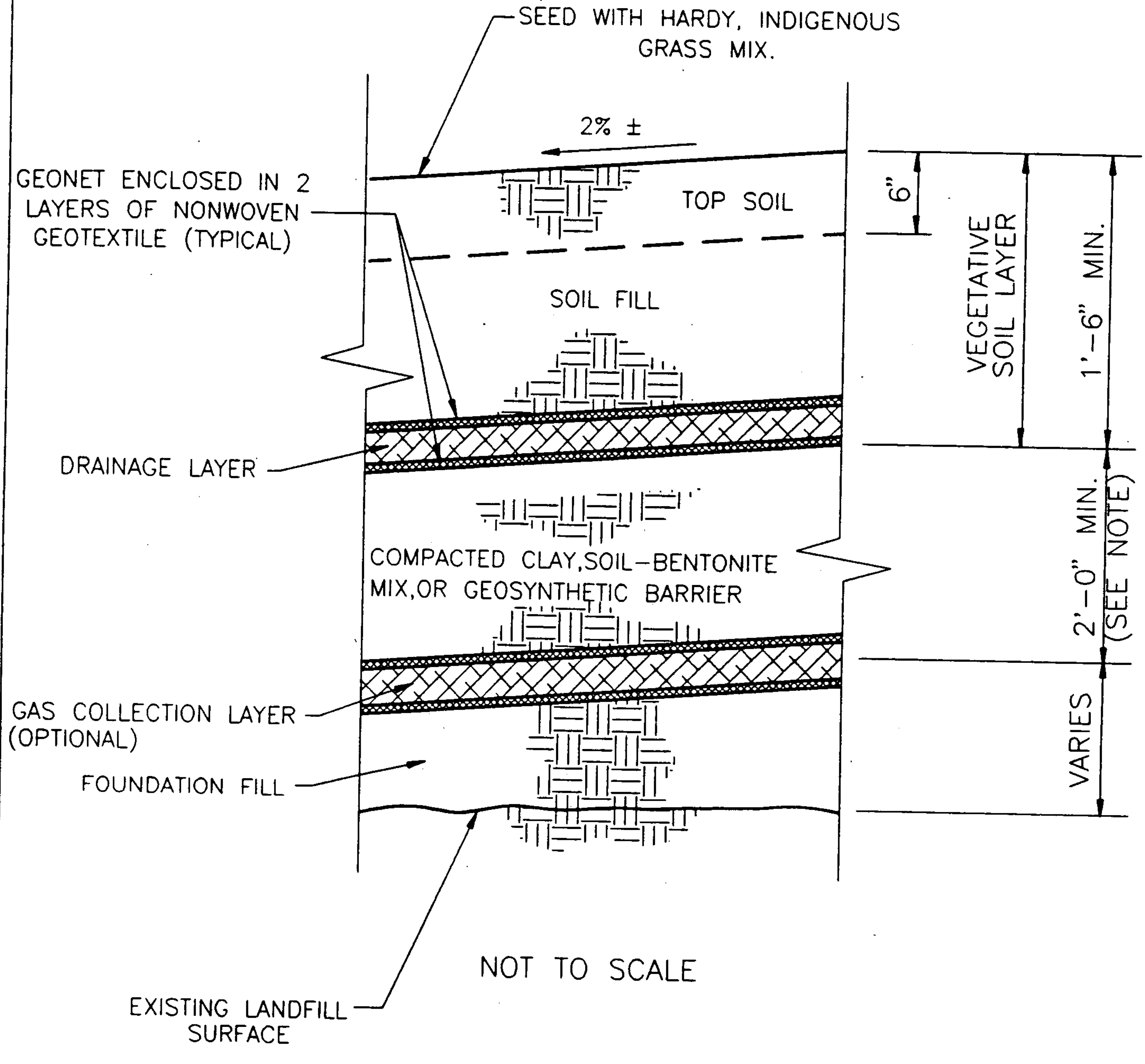
The hydraulic barrier would impede the downward movement of infiltration causing a hydraulic head to develop above the barrier. The drainage layer would wick infiltration laterally to the edge of the cover or other release point and reduce the hydraulic head on the barrier. An adequate design and quality-controlled construction of a cover could assure that infiltration through the barrier would be reduced to a small fraction of the infiltration without the barrier.

FIGURE 2-1

CONCEPTUAL COVER SECTION DETAIL

FOR SINGLE BARRIER COVER

FORT RILEY, KANSAS



NOT TO SCALE

NOTE: 2'-0" DIMENSION DOES NOT APPLY IF A GEOSYNTHETIC BARRIER IS USED

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Geosynthetics

Covers can be constructed using geosynthetic barriers for controlling infiltration. Geosynthetic barriers include elastomeric membranes of PVC, polyethylene, or hypalon. There are products consisting of bentonite flakes enclosed in geotextile blankets or adhered to the underside of a membrane and products consisting of a geotextile coated with an asphaltic emulsion. The various products will create an effective barriers when designed, constructed, and maintained properly. A common consideration with these products is that they must be protected from penetration and from the elements. A geosynthetic barrier is typically placed over a protective bedding material and covered with a similar material. Geosynthetics are not typically used by themselves in a cap system and are not considered as a stand alone option. Geosynthetics are an integral part of the single-barrier and multi-layer cap options.

Multi-layer Cover

A multi-layer cover is, for the most part, similar to a single barrier cover except that the hydraulic barrier is constructed with compacted clay overlain with a geosynthetic barrier, commonly referred to as a composite barrier (see Figure 2-2). A compacted clay layer, by itself, is not truly impervious but allows a small flow rate of water through as long as the clay is saturated. A geosynthetic barrier is, for practical purposes, impervious to liquid transmissions except at punctures, holes, and leaking seams in the barrier. Geosynthetic barriers are difficult to construct without having breaches in the barriers. These breeches can transmit significant flows of infiltrating water unless the underlying material has a relatively low permeability. Either component of the composite barrier would, by itself, significantly reduce infiltration to a small fraction of that which would be expected without a barrier. In combination, the composite barrier would further reduce the infiltration but it is questionable whether this small, additional reduction in infiltration would be significant.

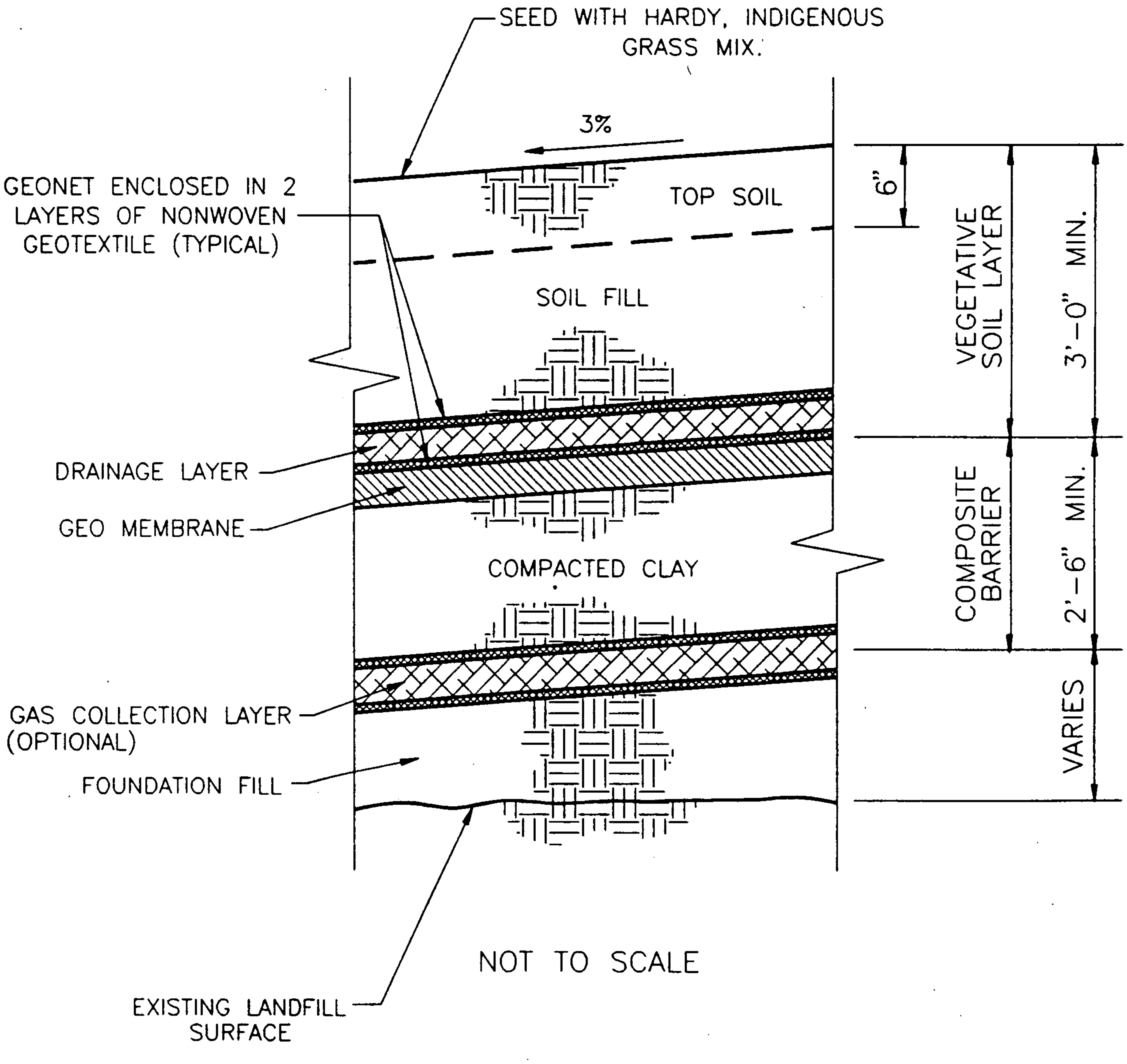
Infiltration is one of three potential leachate generation mechanisms (see Section 1.2.3.9) and a hydraulic barrier would only address infiltration. For this reason, the small additional reduction in infiltration provided by the multi-layer cover versus the single barrier cover would be anticipated to have an insignificant impact on the potential generation of leachate, and subsequently on the groundwater quality. Therefore, the multi-layer cover is screened from further evaluation. Furthermore, the RI/FS guidance for MSWLFs states that a native soil cover or a single barrier cover is appropriate in situations where groundwater contamination is limited, a portion of the landfill contents is below the water table (and lowering the water table is impractical), or the groundwater is not being used for drinking water. These are the conditions at the SFL. Also, the guidance states that multi-layer covers are used where RCRA listed or characteristic hazardous wastes or wastes sufficiently similar to listed wastes have been disposed. These wastes are not known to have been disposed at the SFL.

FIGURE 2-2

CONCEPTUAL COVER SECTION DETAIL

FOR MULTI-LAYER CAP

FORT RILEY, KANSAS



NOT TO SCALE

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Hard Cap

A hard cap is typically constructed of concrete or asphaltic pavement and the construction method is similar. When adequately maintained, a hard cap provides a barrier to stormwater infiltration that is superior to the clay cap described above. However, cracking can occur as with any pavement application and the cracks provide an pathway for water to penetrate the cap and routine crack repair is critical to the cap's integrity. Based on the existing topography, it appears that differential settlement has occurred over the landfill surface and future settlement is possible. The multi-layer cap described above will provide a barrier to infiltration as effective as a hard cap, but the multi-layer cap can withstand more settlement without jeopardizing its integrity than the hard cap. For this reason, the hard cap is screened from further evaluation.

2.5.2.3 Vertical Barrier - This technology would consist of construction of a cut-off wall around the entire perimeter of the SFL, which would limit the potential migration of contamination from the landfill in the groundwater. The cut-off wall could consist of either a slurry wall, a plastic concrete (PC) wall, a grouted sheet-pile wall, or some combination of the above.

Slurry walls are constructed by excavation of vertical trenches and using a bentonite/water slurry to support the side of the excavation. The slurry is then displaced by backfill material consisting of soil-bentonite (SB) or cement-bentonite (CB). The SB walls generally have a lower permeability than CB walls, and require a relatively level surface area for construction. The CB walls have a higher shear strength and resistance to compressibility, and can be constructed in panels rather than in a continuous trench.

A plastic concrete (PC) wall is constructed in panels, with trenches excavated in sections which are stabilized by a bentonite slurry, which is removed prior to installation of a specially designed PC mix. The higher strength of the concrete permits a thinner cross section and it can be used in dense soils and soft rock, with construction in sections that may be subsequently connected by constructing linking panels.

A grouted sheet-pile wall is constructed by driving conventional or specially designed steel sheet-piles to the bedrock layer and then grouting the joints to prevent groundwater migration through the wall. The sheet-pile wall is much more expensive than the slurry wall or plastic concrete wall, but could be constructed in closer proximity to the river bank or the landfill perimeter.

At the SFL site, bedrock is found at depths of approximately 35 to 65 feet, with an estimated average depth of about 55 feet. The cut-off wall would be approximately 9100 feet long in order to encompass the landfill area.

Hydraulic characteristics of the bedrock at the SFL site have not been determined. However, because the bedrock is known to be composed of shale and limestone, penetration into bedrock by the cut-off wall will likely be required.

Based on the subsurface and surface conditions at the site, and because no interference from roadways or utilities is anticipated, which would require a higher shear strength, the less expensive soil-bentonite slurry wall is retained for the cut-off wall around the perimeter of the landfill. In areas adjacent to the Kansas River or Threemile Creek, the installation of an SB wall may be inhibited by the excessive infiltration of river water. Sections of grouted sheet pile wall can be installed and tied into a slurry wall in areas where the SB wall cannot be implemented. Therefore, the sheet pile wall technology is also retained.

2.5.2.4 Riverbank Stabilization - The EE/CA evaluated riverbank stabilization alternatives and selected rock revetment as part of the removal action. Since the remedial action objectives for soil are the same as the EE/CA objectives, the EE/CA evaluation of rock revetment is adequate and appropriate for the FS. The one evaluation criterion not in the EE/CA was long-term effectiveness. As with all of the riverbank stabilization alternatives considered, the long-term effectiveness is dependent on adequate maintenance. Long-term maintenance requirements for rock revetment are anticipated to be similar to the requirements for any of the surface armor type technologies considered in the EE/CA (rubble, rip rap, sand bags). Other EE/CA technologies such as structural walls, gabions, and grout blankets may potentially have less long-term maintenance requirements. However, if these systems fail, substantial repair or replacement can be anticipated. The advantage of rock revetment is that it is self healing, e.g., once undercut, rock revetment will shift and fill in the void to avoid further undercutting or erosion. Repair of rock revetment is also straightforward since it typically involves placement with conventional construction equipment. The EE/CA contains a more complete discussion of riverbank stabilization alternatives.

2.5.3 Removal/Disposal Technologies

Aboveground containment is not considered applicable for this site for the following reasons. According to the NCP, USEPA expects to use containment for waste that poses a relatively low long-term threat or where treatment is impractical (40 CFR 300.430(a)(1)). USEPA's RI/FS Guidance For Municipal Solid Waste Landfills (USEPA, 1991b) states that excavation and disposal of landfill contents is typically limited to "hot spots." The scope of the RI focused on soils outside the identified limits of the landfill (except for the SFL92-200 well series) to characterize releases that might identify the presence of "hot spots" in the SFL. Since significant releases were not detected, excavation and disposal or treatment is eliminated from further analysis as a remedial technology.

Table 2-9 summarizes the initial screening of the removal and disposal technologies for groundwater. Collection of groundwater via recovery wells is a viable process option and is further discussed in Alternatives 6 and 7. Recovery trenches are not feasible to place in the landfill due to potential unknown characteristics of the landfill. Recovery trenches will not be considered for further evaluation for the collection of groundwater.

Discharge of groundwater directly to surface water through an NPDES discharge is a viable process option, considering the potential range of recovery flow (250 to 1,000 gpm). Discharge via a WWTP is not viable considering the flow. The main post WWTP can only accept approximately 20 gpm. A WWTP discharge will not be considered for the development of alternatives. Discharge of groundwater via reinjection is not feasible for SFL. Reinjection of groundwater into the landfill would require treatment of the groundwater which would exceed its economical use. Groundwater reinjection would also result in the potential extraction and migration of constituents in the landfill to the groundwater. Reinjection will not be retained for the development of alternatives.

The only removal/disposal technologies retained are recovery wells for groundwater extraction and NPDES discharge for disposal. Alternatives 6 and 7 will require that both of these technologies be implemented after treatment of the groundwater.

2.5.4 Treatment Action Technologies

The general treatment technologies which have been considered for remediation of the groundwater include biological, physical/chemical, and thermal technologies. Using treatment technologies, the groundwater at the site will be treated for low concentrations of organic constituents (benzene and vinyl chloride). Table 2-8 identifies the concentrations of the constituents of concern detected in groundwater at the site. In general, it is assumed that the quality of the groundwater which enters a treatment system will be similar to the quality represented on Table 2-8. As discussed in Section 2.2.3, inorganic constituents in the groundwater are generally present at levels comparable to background and/or below the MCLs. As discussed in Section 2.2, based on conversations with the State of Kansas Department of Health and Environment, it is assumed that it will not be necessary to treat groundwater to below background conditions of the receiving body of water (Threemile Creek) for metals. The treatment of metals will only be addressed as necessary to prevent operational concerns with any treatment system selected for organic treatment.

Typically, a combination of treatment options are utilized to achieve remedial action objectives. Overall, treatment process options are screened for their effectiveness at remediating the groundwater; ease of implementation of the treatment process option; and the overall cost of the process option in comparison with other treatment options. The initial screening of these treatment action technologies for groundwater was summarized on Table 2-8 and is discussed below.

TABLE 2-8

GROUNDWATER CONSTITUENTS CONSIDERED FOR TREATMENT
Southwest Funston Landfill
Ft. Riley, Kansas

PARAMETER	CONCENTRATION RANGE (mg/L)
TOTAL METALS:	
Calcium*	44-330
Iron*	0.055-36
VOLATILE ORGANICS:	
1,2-Dichloroethane	0.016
1,1,2,2-Tetrachloroethane	0.0063-0.015
1,1,2-Trichloroethane	0.0088-0.0088
Benzene	0.0015-0.014
Vinyl Chloride	0.018
cis-1,3-Dichloropropene	0.0054-0.0059

* Constituents considered for operational design of the treatment system

2.5.4.1 Biological Treatment Technologies Screened for Groundwater - The biological treatment options screened for treatment of groundwater include:

- Activated Sludge
- In-Situ Bioremediation

These treatments are discussed below.

Activated Sludge

With activated sludge treatment, nutrients are added to the contaminated groundwater and indigenous microbes or cultured microbes biodegrade the contaminants. In the first step of the activated sludge process, the contaminated water is mixed and aerated with the existing biological sludge (microorganisms). Organics which come in contact with the microorganisms are utilized as food and oxidized to carbon dioxide and water. After the aeration step, clarification is utilized to remove the suspended organisms and the treated water is discharged. The sludge is either returned to the aeration step to support growth or washed from the system.

In-Situ Bioremediation

With in-situ bioremediation, supplemental nutrients are added to the contaminated groundwater and indigenous microbes or cultured microbes biodegrade the contaminants. This process requires the utilization of extraction and reinjection wells.

Available data indicated limited organic constituents present in the groundwater (< 1 ppm total). Biological processes are typically not efficient at these low organic concentrations due to a lack of food mass. Food would need to be added to support biological degradation. Additionally, biological degradation processes are inhibited by metals and halogenated organics which are present in the groundwater; therefore, biological treatment (activated sludge or in-situ) was not considered effective for organic treatment at the site. At this time, other treatment options such as carbon adsorption and air stripping are expected to be more effective and require less capital and operational cost at the low organic loading. Therefore, biological treatment technologies will not be considered for further evaluation for groundwater treatment.

2.5.4.2 Physical/Chemical Treatment Screening for Groundwater - The physical/chemical treatments screened for treatment of groundwater are:

- Steam Stripping
- Sedimentation
- Filtration
- Coagulation/Flocculation
- Reverse Osmosis
- Neutralization
- Precipitation
- Oxidation/Reduction
- UV Oxidation
- Air Stripping
- Carbon Adsorption

These treatment options are discussed below.

Steam Stripping

Steam stripping uses steam to extract organic constituents from a liquid. This process may be performed through direct contact in a packed tower similar to an air stripping unit or through indirect contact in a multiple pass heat exchanger. In comparison to the other treatment types and process options for organic latent groundwater, the process is energy intensive and is not considered cost effective. Steam stripping is not considered a process option for further evaluation due to high energy requirements compared to other options.

UV Oxidation

UV oxidation treatment systems generally combine ultraviolet (UV) light with ozone and hydrogen peroxide to produce highly reactive hydroxyl radicals. The hydroxyl radicals react with and break down VOCs in the groundwater. UV oxidation, although highly effective, requires a high recycle rate of groundwater to achieve complete destruction of organics. Inorganics tend to oxidize and foul the UV light causing operational concerns. UV oxidation is not retained as a process option due to the high capital cost and potentially high operation and maintenance cost for organics removal.

Reverse Osmosis

Reverse osmosis is a system which separates contaminants from a liquid through the use of semi-permeable membranes. Reverse osmosis (RO) is primarily utilized for treating liquid wastewater containing high metallic salt and for water purification. Additionally, organics may attack the RO membrane causing fouling and resulting in higher maintenance costs. RO is not considered for remediation at this site since other treatment options are considered more suitable and economical for treatment of the groundwater.

Sedimentation

Sedimentation is a solids removal technique used to remove settleable solids from water. In this process, solids are allowed to settle by gravity into a tank, lagoon, etc. This process effectively removes suspended solids such as sand, sediment, etc. and insoluble metals from the water. Sedimentation is typically used in conjunction with other processes to provide solids removal prior to treatment for organics removal.

Filtration

Filtration is a solids removal technique in which water is passed through a filter media to remove suspended solids and insoluble metals (after chemical treatment) from the water. Filtration is typically used in conjunction with other processes to provide solids removal prior to treatment to remove organics.

Coagulation/Flocculation

Coagulation/flocculation involves the addition of a coagulating reagent to coagulate small, unsettleable particles suspended in a liquid medium. The addition of the flocculating agents to the liquid is typically followed by rapid mixing to disperse the agent through the liquid and then slow and gentle mixing to allow for contact between small particles and agglomeration into larger particles. Coagulation/flocculation typically requires other process options such as neutralization, sedimentation, and filtration to remove suspended solids.

Carbon Adsorption

Activated carbon adsorption is primarily used to remove trace organic compounds from aqueous or gaseous waste streams. In this process, the dissolved contaminants adsorb to the carbon particles and stay adsorbed while the treated liquid is released. It is proven effective in removing certain organic compounds and a few inorganic compounds from liquids.

Air Stripping

Air stripping is a process option in which the contaminated liquid and air are fed through either a packed tower or low profile stripper design and dissolved molecules from the contaminated liquid are transferred into an air stream. Residuals from the process include a contaminated off-gas and a treated water. The contaminated off-gas can be treated through air pollution control equipment if required. This method is effective in removing volatile organic compounds. Air stripping can also be associated with carbon adsorption where the carbon adsorption is used for polishing.

Neutralization

Neutralization is the addition of either an acid or an alkali for the controlling of pH. Typically, sulfuric acid, sodium hydroxide or calcium hydroxide are used to control pH. For the treatment of heavy metals in the groundwater, neutralization is typically utilized with coagulation/ flocculation, chemical precipitation, and sedimentation.

Chemical Precipitation

Chemical precipitation involves utilizing a chemical reaction to convert a soluble substance into an insoluble form. This can be accomplished by the addition of precipitating agents or by changing the actual composition of the solvent so that the solubility of the dissolved substance is decreased. The insoluble precipitate is thus removed by filtering or coagulation/flocculation and sedimentation from the water. The two most widely used precipitating agents are hydroxide and sulfide compounds. Sulfides have some advantage over hydroxides due to their lower solubilities, but sulfides also require additional health and safety consideration. These technologies are effective at handling metal contamination and could be applicable in conjunction with technologies that are better suited for removing organics.

Oxidation/Reduction

Chemical oxidation/reduction involves creating a reaction which will increase the oxidation state of one reactant and at the same time decrease another reactants oxidation state. The process is primarily used to reduce and precipitate metals for removal from a liquid phase. In oxidation/reduction, the presence of a wide range of contaminants may complicate the process and produce unwanted side effects. Also, aqueous wastes with high organic concentrations may require the use of large volumes of oxidation/reduction agents and may make the process too costly relative to other treatment techniques.

For solids and heavy metals removal from the groundwater, oxidation/reduction, sedimentation, filtration, coagulation/flocculation, neutralization, and precipitation are viable process options. For treatment of organics in the groundwater, carbon adsorption and air stripping are viable process options and will be further evaluated in Sections 3 and 4.

2.5.4.3 Thermal Treatment Technologies Screening for Groundwater - The thermal treatment technology screened for treatment of groundwater includes only incineration.

With thermal treatment, high temperatures are used to destroy or detoxify the hazardous constituents of combustible wastes. Various types of incinerators may be used to destroy the organics in other liquids. Liquids can also be blended with other solid waste for disposal by incineration. Incineration reduces the volume of waste material. Incineration is very energy intensive, and the off-gas generated from the incineration process may require treatment. Permits for incineration are difficult to obtain, thus significantly impacting the implementability of incineration at a facility. At this site, in comparison with other treatment technologies, incineration is not considered a practical or cost effective treatment for groundwater due to the high operating costs and difficulty in achieving community and regulatory acceptance.

2.6 APPLICABLE TECHNOLOGY TYPES AND PROCESS OPTION TECHNOLOGIES

Table 2-8 summarizes the general response actions, technology types, and process options considered, as well as the screening comments. Based upon the screening information, the following remedial technology types and process options are considered for further evaluation:

General Response Action	Technology Type	Process Option
Institutional Actions	Groundwater Monitoring	
	Land Use Controls	Site Development Restrictions
	Land Use Controls	Utility Restrictions
	Land Use Controls	Groundwater Use Restrictions

Containment	Capping	Native Soil Cover
	Capping	Single Barrier Cover
	Vertical Wall	Slurry Wall
	Riverbank Stabilization	Rock Revetment
Treatment	Physical/Chemical	Sedimentation
		Filtration
		Coagulation/Flocculation
		Neutralization
		Precipitation
		Oxidation/Reduction
		Air Stripping
		Carbon Absorption
Removal	Groundwater Extraction	Recovery Wells
Disposal	Groundwater Discharge	Discharge to POTW
	Groundwater Discharge	Surface Water Discharge

TABLE 2-9

SCREENING OF TECHNOLOGIES
Southwest Funston Landfill
Fort Riley, Kansas

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING CRITERIA		
				EFFECTIVENESS	RELATIVE COST	IMPLEMENTABILITY
No Additional Action	None	None	No action at site beyond removal action. Includes only O&M.	Groundwater Remedial Action Objective (RAO) is currently met because groundwater is not used. May not assure long-term compliance with groundwater RAO.	No additional capital cost beyond removal action. Low O&M cost.	Being implemented. Removal action is currently under design.
Institutional Controls	Groundwater Monitoring	None	Long-term groundwater monitoring using existing monitoring wells.	Groundwater RAO is currently met because groundwater is not used. Monitoring will detect degradation of groundwater quality, if it occurs.	Low capital cost. High monitoring and maintenance cost.	Can be readily implemented. Some monitoring wells are in place.
	Land Use Controls	Site Development Restrictions	Facility regulations enforced by Fort Riley restricting development of site.	Effective if adequately enforced. Existing regulations already restrict certain types of development because site is in floodplain.	Low capital cost. No O&M costs.	Can be readily implemented.
		Utility Restrictions	Facility regulations enforced by Fort Riley restricting access and easement to future utilities	Effective at controlling utility worker exposure to landfill contents, if adequately enforced.	Low to medium capital cost. No O&M costs.	Can be readily implemented.
		Groundwater Use Restrictions	Facility regulations enforced by Fort Riley restricting future use of groundwater on site.	Effective at controlling future use of groundwater. Groundwater is not currently used and a potable water system serves the area.	Low capital cost. No O&M costs.	Can be readily implemented.
	Access Controls	Signs & Fencing	Construct a perimeter fence around the landfill and install warning signs.	Effective at controlling potential exposure to landfill contents by controlling unauthorized access. Removal action cap effectively controls this exposure route.	High capital cost. Low O&M cost.	Readily implemented.
Containment	Surface Controls	Grading	Improve surface topography to promote stormwater runoff. Used with all capping technologies except hard cap.	Effective at reducing ponded water after a storm event. Expected to reduce infiltration rate by eliminating ponded surface water and decreasing detention time of surface water. No impact of regional groundwater levels or river influx.	Low to medium capital cost. Medium O & M costs.	Readily implemented. Required volume of borrow soil is probably available adjacent to site.
		Revegetation	Improve or replace existing vegetation to promote evapotranspiration and reduce soil erosion. Used with all capping technologies except hard cap.	Will not significantly improve existing conditions by itself. Effective when used in conjunction with other containment technologies. No impact on regional groundwater levels or river influx.	Low capital cost. Medium O & M costs.	Readily implemented.
		Diversion/ Collection	Regrade area around landfill to divert off-site surface runoff around the landfill.	Will not be effective because off-site drainage north of landfill does not drain onto landfill.	Low capital cost. Low O & M cost.	Readily implemented but will not be effective, so not retained.

TABLE 2-9

SCREENING OF TECHNOLOGIES
Southwest Funston Landfill
Fort Riley, Kansas

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING CRITERIA		
				EFFECTIVENESS	RELATIVE COST	IMPLEMENTABILITY
Containment (continued)	Capping (Landfill Cover)	Hard Cap	Place asphalt or concrete hard cover over landfill surface which has been graded to remove depressions.	Future settlement will cause cracking and reduce the cap effectiveness in reducing infiltration.	High capital cost. High O & M cost.	Could be implemented, but requires frequent maintenance to repair and maintain integrity. Not retained.
		Geosynthetics	Use geosynthetic membranes to form a barrier to infiltration. Use soil below and above the membrane to establish a slope and protect the membrane. Install landfill gas collection and vegetate the surface.	Membrane will form adequate barrier to infiltration but not as effectively as a single barrier or multi-layer cover; a subsurface drainage layer is critical to infiltration reduction. Minimal reduction in regional groundwater levels. No effect on river influx.	Medium to high capital cost. Medium O&M cost.	Can be readily implemented. Quality control during construction is critical to performance of membrane. Raising the grade may impact the floodplain. Not retained.
		Native Soil Cover	Provide about 2 feet of native soil to cover waste and promote runoff. Vegetate to control erosion. This technology is similar to the existing cover, once necessary repairs are made.	Will maintain cover over landfill contents. Will reduce infiltration by minimizing stormwater ponding and repairing cracks and erosional rills on the existing cover. No significant reduction in regional groundwater levels. No effect on river influx.	Low to medium capital cost. Medium O&M cost.	Readily implementable. Suitable fill soil should be available adjacent to the site. Future settlement may require maintenance to repair future depressions.
		Single Barrier Cover	Construct a cover consisting of a hydraulic barrier (using clay, soil-bentonite mix, or geosynthetic), a subsurface drainage layer, and vegetative surface layer. Provide a two percent slope to promote drainage. Also, provide a gas collection system.	Will maintain cover over the landfill contents. Will reduce infiltration through the cover by providing a hydraulic barrier to downward movement of water and promoting lateral drainage with the subsurface drainage layer. Resulting infiltration from this cover is a small fraction of the anticipated infiltration from the native soil cover. Minimal impact to other leachate generation mechanisms. Two percent grade provides protection from ponding due to settlement of landfill.	High capital cost, Medium O&M cost.	Ease of implementation depends on availability of local clay source. Can be readily implemented. Local clay soil source may not be readily available. Quality control of geosynthetic membrane construction, if selected, is critical to performance of hydraulic barrier. Raising the existing grade may impact the floodplain.
		Multi-Layer Cover	Construct a Multi-Layer Cap including a subsurface drainage layer, composite liner of geosynthetic membrane, 2 feet of clay with 1 x 10^{-7} cm/sec hydraulic conductivity, and a vegetative surface layer. Implement grading to provide 3 percent slope to the edge of the cap. Vegetate surface. Provide gas collection system.	Will maintain cover over the landfill contents. Infiltration reduction is similar to single barrier cover. The additional reduction in infiltration of this cover (due to the composite barrier) versus the single barrier cover is minor. Minimal reduction of regional groundwater levels. No effect on river influx. Three percent grade provides effective long-term protection from ponding caused by future settlement.	High capital cost. Medium O & M costs.	Implementation more difficult than other listed capping technologies. Large volumes of soil and clay needed for construction may not be locally available. A drainage layer, and gas collection system can be implemented but add to construction complexity. Raising the existing grade may impact the floodplain. Not retained.

TABLE 2-9

SCREENING OF TECHNOLOGIES
Southwest Funston Landfill
Fort Riley, Kansas

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING CRITERIA		
				EFFECTIVENESS	RELATIVE COST	IMPLEMENTABILITY
Containment (continued)	Vertical Barrier	Soil-Bentonite (SB) Slurry Wall	Construct a soil bentonite slurry wall encompassing the SFL keying into the top of shale at the base of the alluvium.	Can effectively reduce groundwater flow if wall is properly keyed into bedrock. SB walls typically are less permeable than CB or plastic concrete (PC) walls.	High capital cost. Low O&M cost.	Depth to rock is approximately 55 feet. Slurry walls can be constructed at this depth; therefore retained. Soil bentonite walls are easier to construct than PC walls. Can be implemented at SFL, considering work space and topography.
		Cement-Bentonite (CB) Slurry Wall	Construct a cement-bentonite slurry wall encompassing the SFL keying into the top of shale at the base of the alluvium.	Typically an order of magnitude more permeable than SB walls. CB walls have higher strength than SB walls.	High capital cost. Low O&M cost.	Same implementability concerns as SB wall. CB walls are not retained, because they are more permeable and more expensive than SB walls, and the additional structural strength they provide is not required at the SFL.
		Grouted Sheet Pile Wall	Construct sheet pile wall by driving steel sheet piling to bedrock and grouting joints to limit groundwater flow.	Can effectively reduce groundwater flow if joints are sealed properly. Obtaining a low permeability connection with bedrock may be difficult and should be investigated during design.	High capital cost. Low O&M cost.	Implementation may be difficult adjacent to the Kansas River if debris is encountered. Can be implemented. Retained as an alternative to SB wall adjacent to the Kansas River and Threemile Creek, if excessive infiltration complicates SB wall installation.
		Plastic Concrete (PC) Wall	Construct a plastic concrete (PC) wall that is assembled from precast or cast-in-place panels. Trenches are excavated in sections. As construction proceeds, sections are sealed by a bentonite slurry. The special high-strength plastic concrete allows thinner wall sections than CB or SB walls, which can support structural loads such as highways.	Can effectively reduce groundwater lateral flows if joints are constructed properly and wall bottom is sealed into a low permeability layer. Hydraulic conductivity is usually higher than SB walls. Can support structural loads.	High capital cost. Low O&M cost.	Can be implemented and is generally used when a limited work space prevents construction of SB walls, and in steep terrain where leveling of work area is impractical. Not retained because these conditions do not exist at the SFL.
	Riverbank Stabilization/ Soils, Landfill Contents	Rock Revetment Bank Stabilization	Placement by dumping of graded quarry run stone along toe of the bank and as a blanket on the bank to stabilize the bank. Slope shaping not required. This will be implemented in Spring 1994 as a removal action.	Effectively provides long-term bank stability when installed properly. Provides additional buffer between landfill and river bank. Proven technology under more severe conditions in Missouri River.	Medium capital cost. Low O & M expected.	Will be implemented as a removal action in Spring 1994. Suitable rock fill is available. Can be maintained and extended readily by placing additional rock. Retained as final remedial technology.
Removal	Groundwater Extraction	Recovery Wells	Groundwater is collected via recovery wells.	Effective for the collection of groundwater in an alluvial aquifer with high hydraulic conductivity, which exists at the SFL.	Low capital cost. Low O&M cost.	Easily implemented.
		Recovery Trenches	Groundwater is collected via recovery trenches.	Effective for the collection of groundwater from aquifers with low hydraulic conductivity. Construction is complicated and more expensive with greater depths.	Moderate capital cost. Moderate O&M cost.	Easily implemented at shallow depths, less than 25 feet. More expensive than using recovery wells at the SFL. Therefore not retained.

TABLE 2-9

SCREENING OF TECHNOLOGIES
Southwest Funston Landfill
Fort Riley, Kansas

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING CRITERIA		
				EFFECTIVENESS	RELATIVE COST	IMPLEMENTABILITY
Treatment of Groundwater	Physical/Chemical Treatment	Steam Stripping	Steam is used to extract volatile organics from liquid. The process may be performed in a packed tower or in a multiple pass heat exchanger.	Effective at treating volatile organics, phenols, ketones and phthalates; does not treat metals.	High capital cost. High O&M cost.	Energy requirements are primary limitation and may make process too difficult to implement; off gas may require treatment.
		Sedimentation	Settleable solids settle by gravity into a tank, etc.	Effective in removing suspended solids and insoluble metals. Not effective in the removal of organics.	Low capital cost. Moderate O&M cost.	Easily implemented. Typically utilized in conjunction with other process options.
		Filtration	Suspended solids are passed through a filter media.	Effective in removing suspended solids and insoluble metals. Not effective in the removal of organics.	Low capital cost. Low O&M cost.	Easily implemented. Typically utilized in conjunction with other process options.
		Coagulation/ Flocculation	Reagents are added to liquid waste to coagulate suspended particles and facilitate separation.	Effective in removing suspended particles and certain metals; would be combined with other process options to provide complete liquid treatment.	Low capital cost. Moderate O&M cost.	Relatively easy to implement; requires sludge treatment process.
		Neutralization	Acid or caustic is added to media to alter pH.	Effective as final treatment process or as a pretreatment process; suited primarily for inorganic waste; may form chemical complexes; may precipitate heavy metals and result in significant quantities of sludge.	Low capital cost. Moderate O&M cost.	Relatively easy to implement; may require sludge treatment process.
		Precipitation	Alteration of chemical equilibrium to reduce solubility of constituents.	Effective in removing the metals of concern from the groundwater; organic compounds may interfere with precipitation.	Low capital cost. Moderate O&M cost.	Relatively easy to implement; additional equipment may be required; sludge dewatering and treatment and disposal required.
		Oxidation/Reduction	Chemical form of the contaminants is changed to a less toxic form via an oxidation or reduction reaction.	Effective in treating most organics and metals; presence of a wide range of contaminants may complicate process and produce unwanted side effects.	Low capital cost. Moderate O&M cost (high O&M with numerous contaminants).	Relatively easy to implement; additional equipment may be required; sludge dewatering and treatment and disposal may be required.
		UV Oxidation	Ultraviolet light is combined with ozone and hydrogen peroxide to produce highly reactive hydroxyl radicals. The hydroxyl radicals react with and break down volatile organics in the liquid.	Effective for treating volatile organics, phenols, aromatics, and polynuclear compounds. High suspended solids or iron content may interfere with system operation.	High capital cost. High O&M cost.	Relatively easy to implement; may require frequent cleaning of lamps due to iron in groundwater.

TABLE 2-9

SCREENING OF TECHNOLOGIES
Southwest Funston Landfill
Fort Riley, Kansas

GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	PROCESS OPTION	DESCRIPTION	SCREENING CRITERIA		
				EFFECTIVENESS	RELATIVE COST	IMPLEMENTABILITY
Treatment of Groundwater (continued)	Physical/Chemical Treatment (continued)	Reverse Osmosis	Contaminants are separated from a liquid via use of semi-permeable membranes.	Effective for the treatment of concentrated metal streams. Will require pretreatment for the removal of solids.	Moderate capital cost. High O&M cost.	Relatively easy to implement; will need to treat more concentrated waste stream.
		Air Stripping	Contaminated water is aerated in a packed column or low-profile air stripper to transfer volatile organics from liquid phase to air.	Effective in removing certain organic compounds.	Moderate capital cost. Moderate O&M cost.	Relatively easy to implement. May require carbon treatment on air stream. Periodic cleaning of trays required.
		Carbon Adsorption	Contaminated water is passed through a bed of activated carbon.	Effective in removing low concentrations of certain organic and inorganic constituents.	Low capital cost. Moderate O&M cost.	Easily implemented. Typically utilized in conjunction with other process options, especially as a polishing step.
	Biological Treatment	In-Situ Bioremediation	Supplemental nutrients are added to the contaminated liquid and indigenous microbes or cultured microbes biodegrade the contaminants.	Effective in removing nonhalogenated organics, including gasoline and fuel oil, hydrocarbon solvents, alcohols, etc.; process is generally inhibited by presence of halogenated organics, elevated metals, chlorides, acids, or caustics.	Low capital cost. Moderate O&M cost.	Dependent upon the biodegradability of constituents; groundwater monitoring program required; metals can inhibit effectiveness; contact mechanisms must be understood; treatability tests needed.
		Activated Sludge	Supplemental nutrients are added to the contaminated liquid and indigenous microbes or cultured microbes biodegrade the contaminants.	Effective in removing organic constituents; presence of halogenated organics, elevated metals, chlorides, acids, or caustics could inhibit process.	Moderate capital cost. High O&M cost.	Dependent upon the biodegradability of constituents in groundwater. Elevated metal concentrations can present operational concerns.
	Thermal Treatment	Incineration	High temperatures are used to destroy or detoxify the hazardous constituents of combustible wastes.	Limited effectiveness. Water is not readily combustible and typically not treated in this method.	High capital cost. High O&M cost.	Can be implemented; not practical.
Disposal	Groundwater Discharge	Surface Water	Groundwater is discharged to the Kansas River or Threemile Creek.	Effective if effluent meets limits established for discharge. Can be utilized for higher flow rates than the POTW option.	Moderate capital cost. Moderate O&M cost.	May require additional groundwater treatment to achieve discharge criteria. Can be implemented.
		Discharge to POTW	Groundwater is discharged to the sanitary sewer main west along Heubner Road to Main Post Plant.	Effective if effluent meets criteria for discharge. Current conditions would limit flow to approximately 20 gpm.	Moderate capital cost. Low O&M cost.	May require treatment prior to discharge. Can be implemented if flow rate does not exceed hydraulic capacity of treatment plant (20 gpm available).
		Groundwater Reinjection	Groundwater is discharged back into the aquifer via a reinjection trench or reinjection well.	Can be an effective method of groundwater disposal assuming groundwater quality reinjection standards can be met.	Moderate capital cost. Moderate O&M cost.	Difficult to implement. May result in additional leaching of otherwise stationary constituents. May form precipitates in the aquifer, and plug reinjection trench.

3.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

The process options retained for alternative development from Section 2.0 were combined into alternatives that address the remedial action objectives and provide a range of treatment and containment combinations. Screening of the alternatives was then performed based on the following criteria:

- Effectiveness
- Implementability
- Cost

The evaluation of effectiveness for each alternative considers:

- Overall protection of human health and the environment.
- Reduction in mobility, toxicity, and volume through treatment.
- Short-term impacts (construction and implementation phase).
- Long-term impacts (after remedial action is complete).

The evaluation of implementability considers technical and administrative feasibility. Technical feasibility addresses whether the alternative can be constructed, operated reliably, and maintained. The administrative feasibility refers to the ability to obtain regulatory approval and the availability of services and equipment necessary to implement the alternative.

The cost evaluation considers capital and operation and maintenance costs. For alternatives screening relative costs are assessed based on the other alternatives in terms of low, medium, and high. Estimated opinions of costs are more fully developed for the alternatives retained for detailed analysis in Section 4.0.

The removal action riverbank stabilization project contract was awarded on January 13, 1994 and construction is scheduled for Spring 1994. The design of the removal action cover is in progress. The bank stabilization project should be substantially complete during the public comment period on the FS.

The alternatives presented in this section include:

- Alternative 1 - No action
- Alternative 2 - Institutional controls and river bank stabilization
- Alternative 3 - Native soil cover
- Alternative 4 - Single barrier cover
- Alternative 5 - Physical containment of groundwater
- Alternative 6 - Hydraulic containment of groundwater
- Alternative 7 - Groundwater extraction and treatment

3.1 ALTERNATIVE 1- NO ACTION

3.1.1 Description

The no action alternative is one in which no actions are taken to prevent contaminants from leaving the site, to limit the use of the site, or to prevent exposure to contamination at the site. The natural processes that impact the landfill and the groundwater are considered in the evaluation of this alternative. This alternative has the same associated risk to human health and the environment as those identified in the baseline risk assessment. The no action alternative is presented as a baseline for comparison of the other alternatives.

3.1.2 Screening Evaluation

At the present time, there is no adverse exposure to human populations caused by the SFL. Because the site is situated in the flood plain, potential human exposure scenarios include infrequent visits by individuals such as maintenance workers and hunters. There is no unacceptable risk associated with these scenarios. The baseline risk assessment also evaluates the potential, future on-site groundwater user. This scenario indicates unacceptable risk due to exposure to the groundwater. The no action alternative is not effective in mitigating this potential, future exposure scenario. Adverse impacts on ecological receptors were not apparent in the baseline risk assessment.

The baseline risk assessment did not consider exposure scenarios where the landfill contents become exposed at the ground surface. Given the condition of the adjacent Kansas River bank, it is plausible that landfill contents could be exposed in the future and that could result in an unacceptable risk to human health and the environment. The no action alternative is not effective in addressing this potential scenario.

Off-site migration of groundwater contaminants is limited because the predominant migration route of on-site groundwater is discharge to the surface water features. Since the contaminants of concern are VOCs and the fate of VOCs in surface water is relatively rapid volatilization, the release of VOCs to the surface is not believed to have an adverse impact on the Kansas River or Threemile Creek. Though Threemile Creek is believed to be a groundwater boundary most of the time, groundwater migration under Threemile Creek may occur under certain hydrogeologic conditions. Groundwater monitoring conducted for the RI did not indicate a continuous groundwater contaminant plume migrating from the site. With only a few exceptions, detections of the constituents of concern were isolated both spatially and over time. The fate of the VOCs in the groundwater due to natural processes of attenuation and degradation are discussed in general in the RI. It is believed that these natural processes have a beneficial impact on the groundwater and the relatively limited groundwater contamination that was observed in the RI may be partially attributed to these natural processes. The no action alternative does not monitor future groundwater conditions.

Implementability - There are no implementability considerations in the no action alternative.

Cost - There are no costs associated with the no action alternative.

3.2 ALTERNATIVE 2 - INSTITUTIONAL CONTROLS AND RIVER BANK STABILIZATION

3.2.1 Description

This alternative includes stabilizing the Kansas River bank (being implemented in Spring 1994 as a removal action) and implementing in the Fort Riley facility master plan the following site-specific regulations:

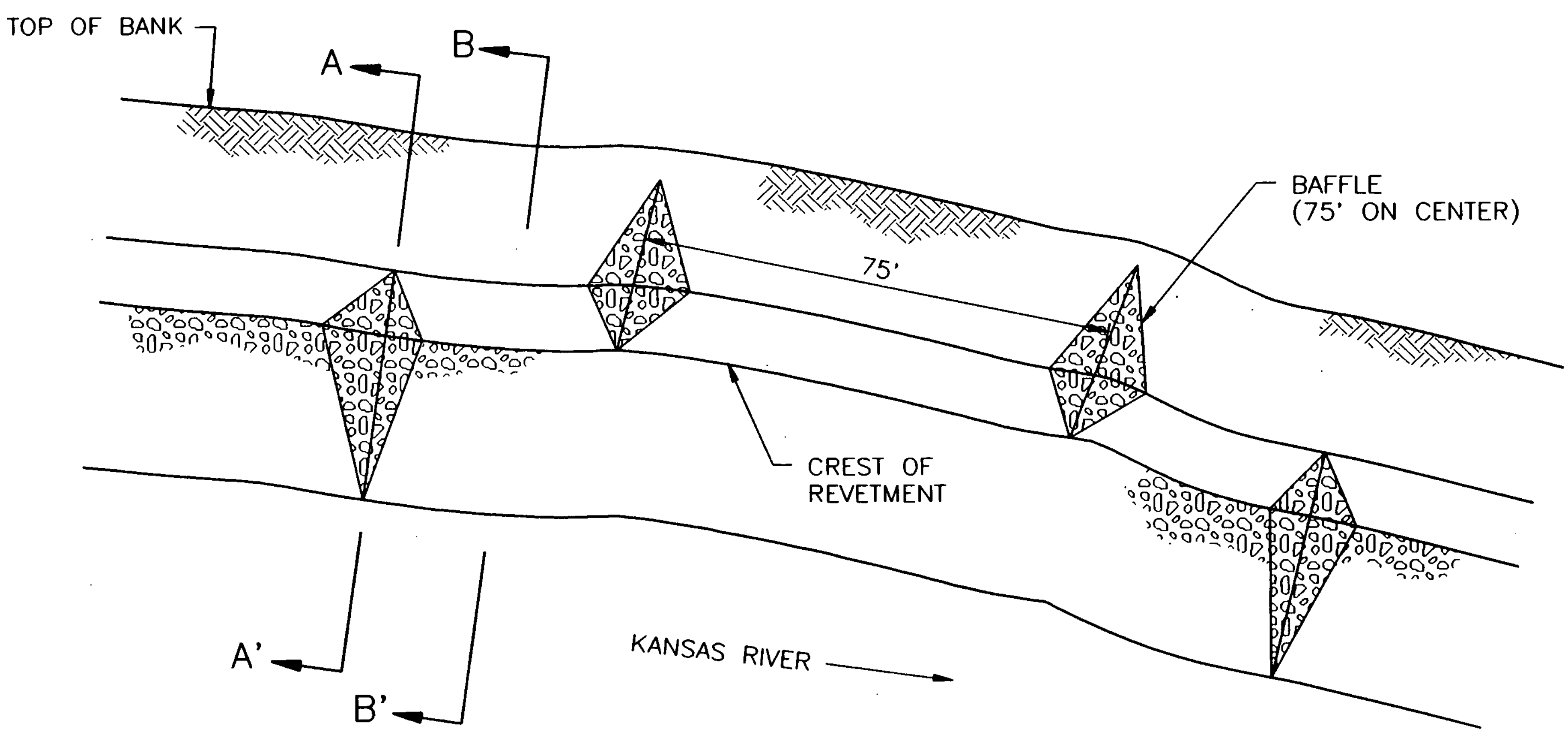
- Restrictions on the type of development at the SFL.
- Prohibition on the consumptive use of the local groundwater.
- Restrictions on future utility access and easements at the site.

Long-term groundwater monitoring is also part of this alternative.

The Kansas River bank will be stabilized using rock revetment (Figure 3-1). Construction of the rock revetment includes placement by dumping of graded quarry run stone to form a revetment parallel to the bank and placement of quarry run stone baffles perpendicular to the bank and revetment at 75-foot intervals. It is not necessary to orient the rocks during placement. The rock will be graded coarse to fine, and sized for the design velocity and erosion conditions. Shaping of the existing slope is not needed prior to rock placement.

The revetment will be placed at a 1.5 horizontal to 1 vertical slope which is steeper than the existing bank which is approximately 2.5 horizontal to 1 vertical (Figure 3-2). Baffles will be constructed perpendicular to the revetment at a spacing of 75 feet. As river sediments are gradually deposited behind the revetment between the baffles, the river bank will be filled in (Figure 3-3), increasing the stability of the revetment structure and also increasing the buffer between the landfill and the bank face. Please refer to the EE/CA for more detailed discussion of the riverbank stabilization.

FIGURE 3-1
TOE REVETMENT
PLAN VIEW
FORT RILEY, KANSAS



NOT TO SCALE

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FIGURE 3-2
TOE REVETMENT
SECTION A-A'
FORT RILEY, KANSAS

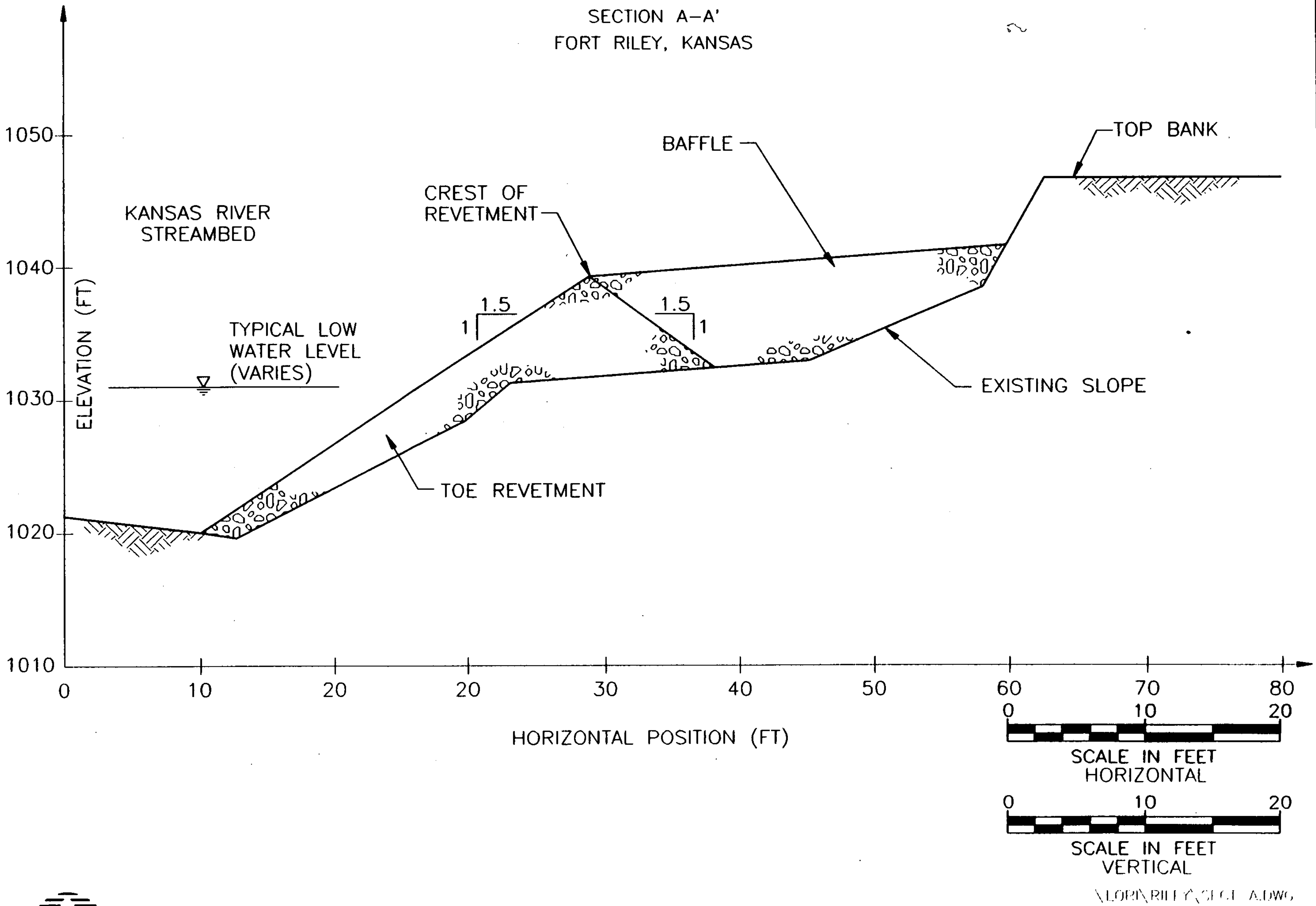

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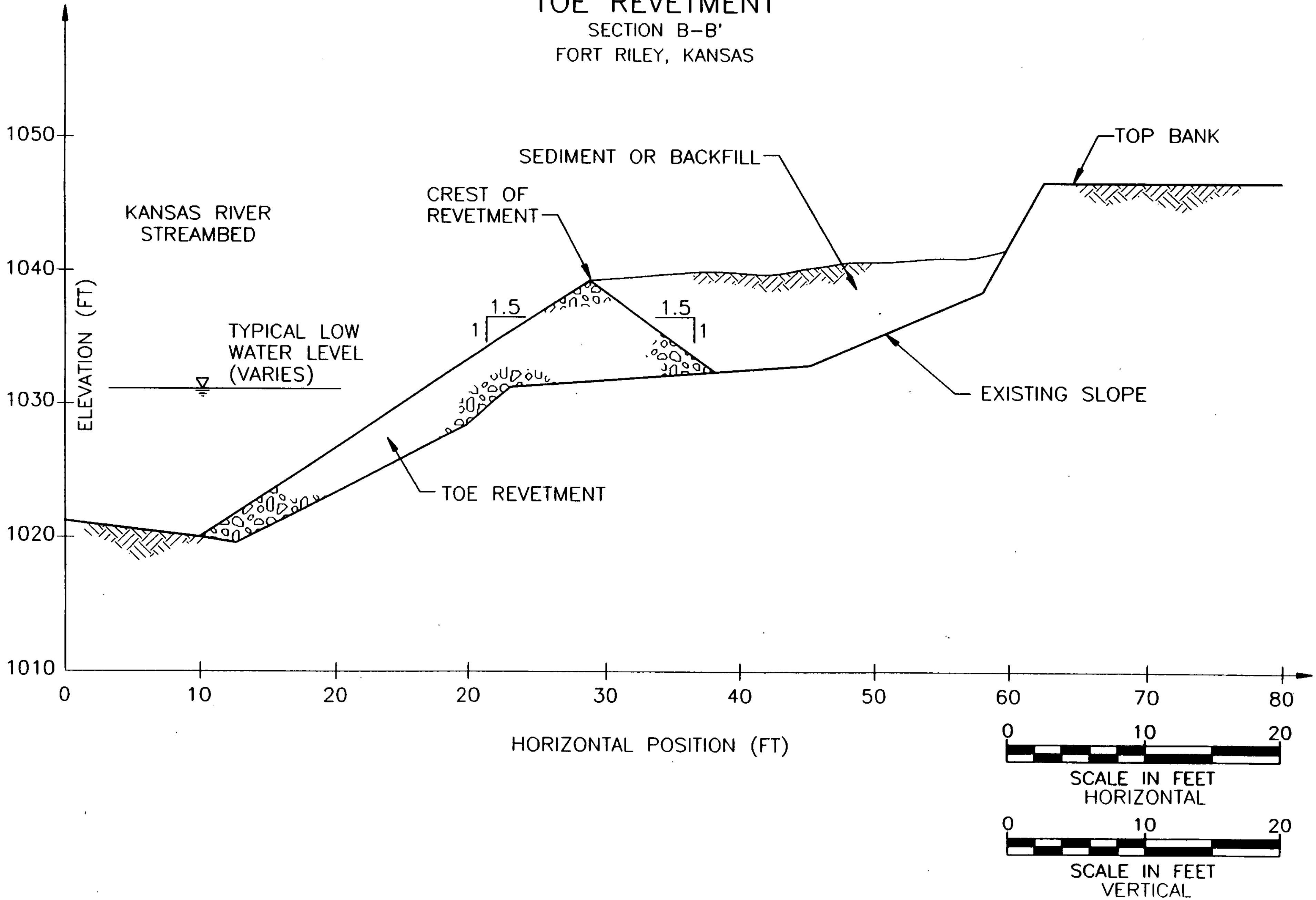
FIGURE 3-3
TOE REVETMENT
SECTION B-B'
FORT RILEY, KANSAS



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GOVERNMENT SERVICES DIVISION

As stated in section 2.5.3.4, maintenance of the rock revetment will consist of placing additional rock in areas that are undercut or washed out. Maintenance requirements should be limited because the rock will shift and fill in voids when erosion or undercutting of the revetment occurs.

Long-term monitoring of riverbank conditions is required. An annual visual inspection is adequate to observe conditions that require maintenance such as bank erosion and loss of rock revetment. Inspections would also be performed following flood events (top of bank flow or greater).

The land use restrictions would be written into the facility-wide master plan for Fort Riley and would be enforced during the review process of any proposed site development. The rules would prohibit groundwater use in the vicinity of the landfill. The master plan rules would restrict the construction of structures that involve excavation for the foundation. This would generally limit construction to slab-on-grade structures. The rules could also restrict the permanent occupancy of any structure. The rules could limit future utility easements to outside the edge of the landfill and could prohibit construction of buried utilities in the near vicinity of the landfill.

Long-term groundwater monitoring would include groundwater sampling and analysis for the constituents of concern. The objectives of the monitoring program would be to:

- Monitor for increases in contaminant concentrations in the vicinity of the SFL which would warrant additional actions at the SFL
- Determine if constituents from the SFL are migrating under Threemile Creek

Given these objectives, the most appropriate monitoring program would include:

- A background well cluster
- Well clusters with previous RG exceedances
- Well clusters which will provide information on potential migration under Threemile Creek and are not expected to be impacted by previous activities at Camp Funston

The potential wells considered for the monitoring program are:

- Background well cluster 100
- Existing well clusters 400, 500, 600, 800

- Two new well clusters, one located northeast of the 600 cluster and just east of Threemile Creek, and one west of well cluster 500 and just west of Threemile Creek. Each cluster would include a well screened at the water table and one screened at the top of bedrock.

The potential wells are shown on Figure 3-4.

The groundwater monitoring program would consist of the following elements:

- Preparation of a work plan and sampling and analysis plan. The work plan would provide the rationale and design for the program, as well as procedures for coordination and reporting.

- Semi-annual monitoring that would include (1) collection of water level measurements from all wells in the vicinity of the landfill plus the surface-water features, and (2) sampling for chemical analysis of selected wells downgradient of the SFL.

- The analyte list would consist of VOCs, antimony and lead. Antimony would be included because there is some uncertainty regarding their sources (site-related versus background) based on the RI data.

- Preparation of a semi-annual report presenting the chemical and hydrogeologic data, interpretation of data, and conclusions/recommendations. The interpretation of data would include a QA/QC evaluation, preparation of a potentiometric surface map, and a comparison of data to site historical data, other Fort Riley environmental data, and other area/regional data. The recommendations would most likely consist of (1) no-action until the next scheduled semi-annual monitoring round; (2) proposed changes to the monitoring program; or (3) a more focused assessment of an area identified as a concern based on the monitoring data. A focused assessment could be performed prior to the next scheduled semi-annual monitoring event.

- Review and comments on the semi-annual report by the regulators.

The groundwater monitoring program could be performed in conjunction with a larger-scale, area-wide monitoring program, if determined to be appropriate.

The assumed analyte list is VOCs by USEPA Method 8240 or 8010/8020. Method 8010/8020 is preferred because it provides an approximate detection limit of 2 μg/L for vinyl chloride. Antimony should also be monitored using USEPA Method 7041, which provides a detection limit of 3 μg/L. Lead should be monitored using EPA Method 7421, which provides a detection limit of 5 μg/L. The monitoring program would also include the maintenance of the monitoring wells.

FIGURE 3–4

LOCATION PLAN
POTENTIAL LONGTERM MONITORING WELLS
SOUTHWEST FUNSTON LANDFILL

FORT RILEY, KANSAS

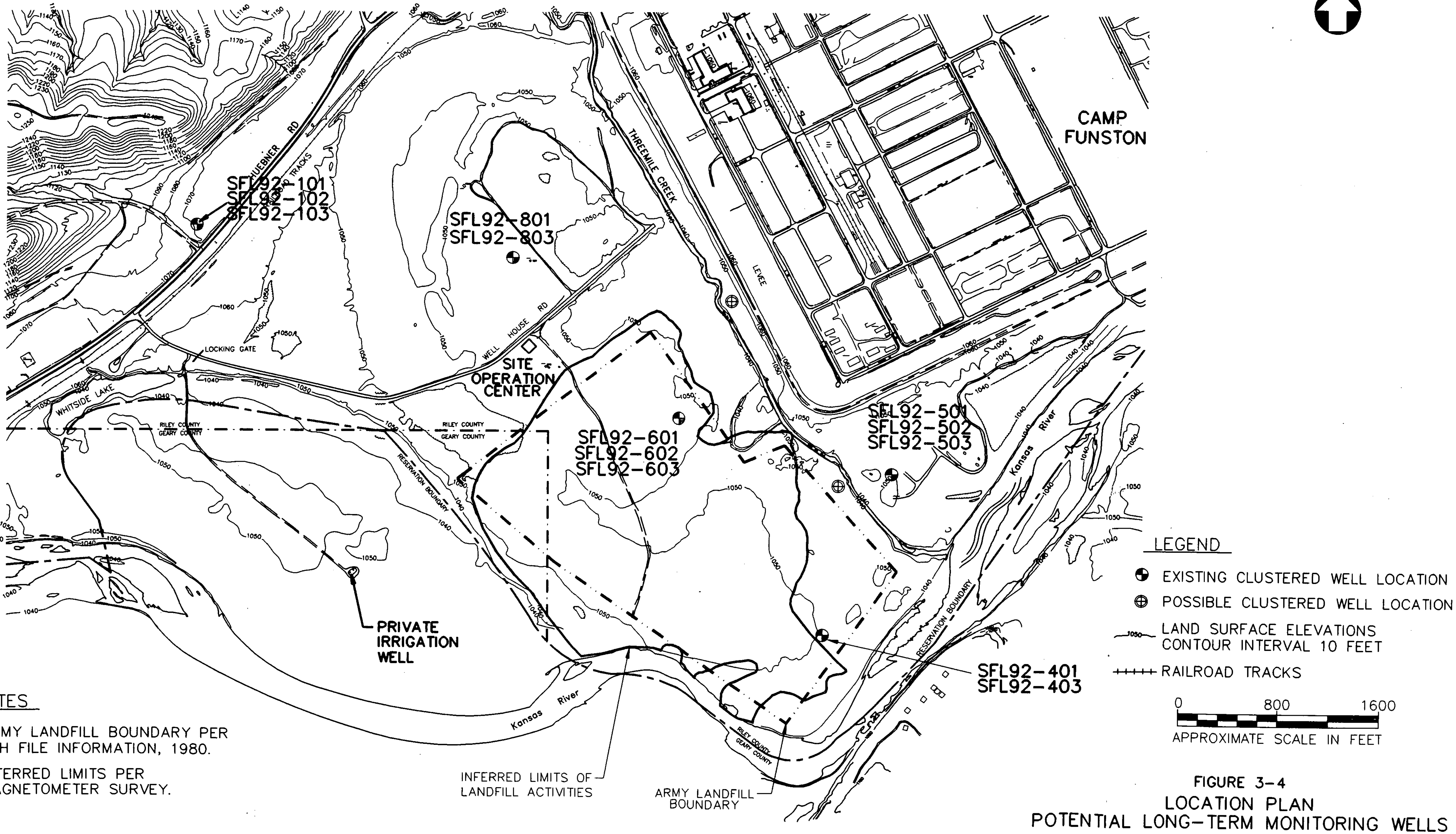

FIGURE 3–4

LOCATION PLAN
POTENTIAL LONG–TERM MONITORING WELLS

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

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3.2.2 Screening Evaluation

Effectiveness

The riverbank stabilization work will be effective in meeting the RAO of preventing the movement of the Kansas River Channel into the landfill and preventing unacceptable exposures to landfill contents along the Kansas River. This alternative is not effective in preventing the potential exposure of landfill contents on the landfill surface. The restrictions on site use provide assurances that exposure to subsurface materials and future use of groundwater at the site are prevented. Additionally, groundwater monitoring would allow tracking of groundwater conditions at the site and could provide "early warning" of significant changes in the degree or extent of contamination.

Since this alternative involves placing material on existing grade and minimal disturbance of the surface, this alternative should not impact on-site workers or the community during implementation. During groundwater sampling, there is the potential of groundwater exposure for the sampling team. However, with the appropriate OSHA training and personnel protective equipment, any such exposure should be controlled.

As with the no action alternative, this alternative is currently protective of human health and the environment because on-site activities are limited and site groundwater is not currently used. Groundwater monitoring and groundwater use restrictions should eliminate the potential concerns for invasive activities and use of groundwater in the future.

Since this alternative does not directly involve treatment, there is no reduction in toxicity and volume of contamination.

Because this is a containment alternative, the long-term groundwater monitoring and institutional controls are critical to the long-term protection of human health based on the potential unacceptable risk due to future groundwater exposure.

Implementability

This alternative is readily implementable. Construction of the riverbank stabilization is underway and due to be completed in Spring 1994. The groundwater monitoring has been ongoing at the site, and installation of additional wells can be readily implemented. Modifying the base master plan is a straightforward administrative process.

Cost

This alternative has a medium implementation cost consisting of construction cost of the river bank stabilization plus legal and administrative fees for enacting the institutional controls. Part of the existing monitoring well system will be used for long-term monitoring. Long-term costs for this alternative include periodic maintenance for the riverbank and groundwater monitoring costs. The monitoring costs include the long-term professional services and laboratory costs necessary to perform groundwater monitoring.

3.3 ALTERNATIVE 3 - NATIVE SOIL COVER

3.3.1 Description

This alternative includes the elements of Alternative 2 (river bank stabilization, long-term groundwater monitoring, and restrictions on land use and groundwater use) plus a native soil cover. A native soil cover provides cover over the landfill contents and supports vegetation. The vegetation controls erosion caused by stormwater runoff and promotes evapotranspiration which uses soil water that would otherwise percolate through the cover and potentially contact the landfill contents. This cover does not provide a complete hydraulic barrier to infiltration.

The existing landfill cover is a 2-foot thick (average) native soil cover but is in need of repair. This alternative would involve regrading and reseeding the existing cover. The conditions that need repair are settlement (that causes stormwater to pond), settlement cracks, and erosional rills. These conditions are characterized in Section 1.2.3.5. The repairs would include placing local borrow in settled areas to restore positive drainage and placing approximately 12 inches of additional fill over the existing cover. The regraded area would be revegetated. As discussed in Section 1.2.3.10, infiltration through the existing landfill cover is estimated at 2.59 inches per acre per year. Information obtained from laboratory analysis of potential local borrow soils was used by the Army Corps of Engineers to perform additional HELP modelling to determine the efficiency of a native soil cover versus a 1×10^{-5} cm/second cover in reducing infiltration. Table 3-1 summarizes the results of this evaluation. As indicated in Table 3-1, upon performing the proposed repairs on the existing cover, infiltration through the native soil cover is estimated at 1.52 inches per acre per year, as compared to 1.15 inches per acre per year for the 1×10^{-5} cover. Though soils from the proposed borrow area east of the landfill do not meet 1×10^{-5} hydraulic conductivity criteria, improvements to the existing landfill using this soil would provide an equivalent reduction in infiltration to that of a 1×10^{-5} cover over the existing landfill (Table 3-1).

Annual inspections would be appropriate for monitoring the cover conditions. Maintenance of the cover would include top seeding, fertilizing, and irrigation within the first few years after construction in order to establish a flourishing stand of grass. Long-term maintenance would include mowing, periodic burning, and fertilizing to maintain the grass. Filling and other earthwork might be required to correct long-term settlement or erosion. Revegetating might also be required in eroded areas, particularly after dry years.

TABLE 3-1

HELP MODEL AVERAGE ANNUAL TOTALS
COVER DESIGN EVALUATION
Southwest Funston Landfill
Fort Riley, Kansas

Description of Model	Grass Condition	Precipitation In	Runoff In	Evapotranspiration In	Infiltration In
Existing Cover - Poor Grass	Poor	33.86	1.44	29.69	2.59
Existing Cover - Good Grass	Good	33.86	0.11	32.16	1.52
1×10^{-5} - Good Grass	Good	33.86	0.31	32.35	1.15
1×10^{-5} - Cover Over Existing	Good	33.86	0.25	32.28	1.28

Source: Technical Memorandum, Cover Design Analysis and Alternatives Discussion, USACE, Kansas City District

3.3.2 Screening Evaluation

Effectiveness

This alternative would meet the RAOs for soil and would meet the groundwater RAO because the groundwater use prohibition should eliminate exposure to groundwater.

As with the no action alternative, this alternative is currently protective of human health and the environment. The riverbank stabilization and repairs to the existing cover would assure that the potential future exposure of landfill contents at the ground surface was minimized. The potential future exposure to groundwater would be prevented with a groundwater use prohibition. Groundwater characteristics would be monitored in the future with a long-term monitoring plan.

This alternative would not reduce mobility, toxicity or volume of contamination through treatment. Repair of the landfill cover would have a beneficial impact on the rate of infiltration through the cover by enhancing the vegetative cover to promote evapotranspiration and by minimizing ponding of stormwater (ponded stormwater provides a driving head to the downward movement of infiltration). Also, cracks and rills (conduits for rapid downward movement of stormwater) would be repaired. Infiltration from the landfill surface is one of three identified mechanisms of potential leachate generation. The reduction of infiltration would reduce the mobility of contaminants in the landfill and have a beneficial impact on the groundwater quality. Since the other two leachate mechanisms would not be controlled, it is unknown whether this alternative would provide a significant benefit to groundwater.

This alternative would pose minimal impacts to on-site workers and the community during implementation because construction would mostly be limited to placement of materials above the existing grade. The intent of this alternative is to minimize excavation and subsequent exposure of the landfill contents or potentially contaminated media.

Because this is a containment alternative, long-term groundwater monitoring and institutional controls are necessary to the long-term protection of human health based on the potential unacceptable risk due to future groundwater exposure.

Implementability

This alternative would be readily implementable with standard construction methods. Local borrow soil is available near the landfill.

Cost

This alternative would have a medium capital cost, consisting of the construction cost of the cover repair and river bank stabilization, plus the legal and administrative fees for enacting the institutional controls. Long-term costs would include periodic maintenance of the riverbank and landfill cover, plus the costs of the long-term groundwater monitoring program.

3.4 ALTERNATIVE 4 - SINGLE BARRIER COVER

3.4.1 Description

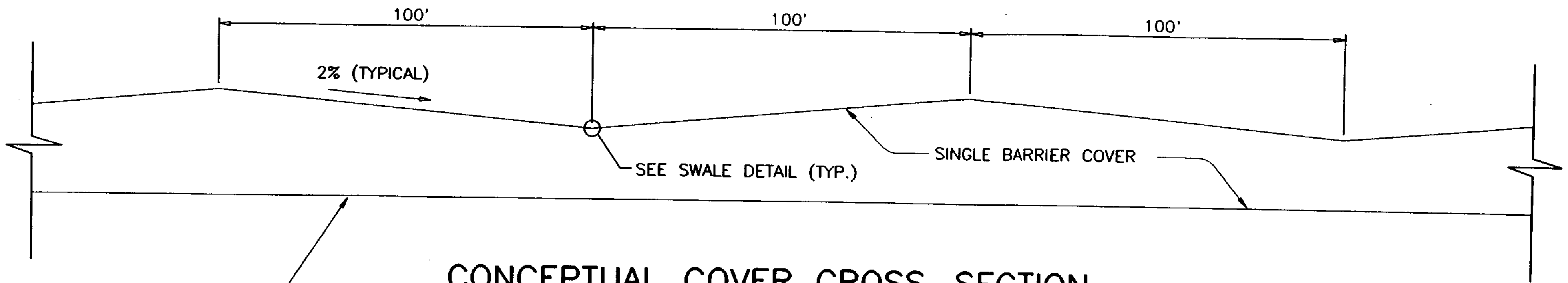
This alternative includes a single barrier cover as conceptually presented in Figures 2-1 and 3-5. For developing this alternative, a geosynthetic is used for the hydraulic barrier because preliminary evaluation for the removal action cover indicates that a local clay source may not be available. The cover includes a passive gas collection system because of the potential (although not anticipated) for landfill gas buildup under the geomembrane. Additionally, retrofitting a gas collection system would be significantly more expensive than installation during construction. This alternative also includes the riverbank stabilization, institutional controls, and long-term groundwater monitoring which were presented in Alternative 2.

This alternative would provide a cover over the open area of the landfill (see Figure 3-6) but would not provide additional soil cover over wooded areas within the inferred landfill area (based on the magnetometer survey) or the reported landfill limits (DEH files, 1982). The wooded areas are located along the edges of the landfill. The magnetometer survey interpretation states that anomalies observed at the edge of the wooded area may indicate shallow metallic debris scattered from pushing waste and soil around on the surface during closure grading and may not indicate the presence of waste cells. Furthermore, the waste that is reported to have been placed along the Kansas River bank is mostly construction debris and discarded heavy appliances apparently placed to control bank erosion. These types of materials typically present a relatively low threat of contaminating groundwater compared to other wastes believed to have been disposed at the SFL. Anomalies were not detected in the wooded area in the southeast corner of the site where incidents of isolated dumping of landfilled materials are suspected, but not confirmed. Since these wooded areas apparently account for a small fraction of the total waste volume disposed at the SFL, deforestation of the potential woodland habitats along the edge of the landfill for the purpose of capping is not warranted. Furthermore, deforestation of the Kansas River bank could potentially be counterproductive to controlling bank erosion.

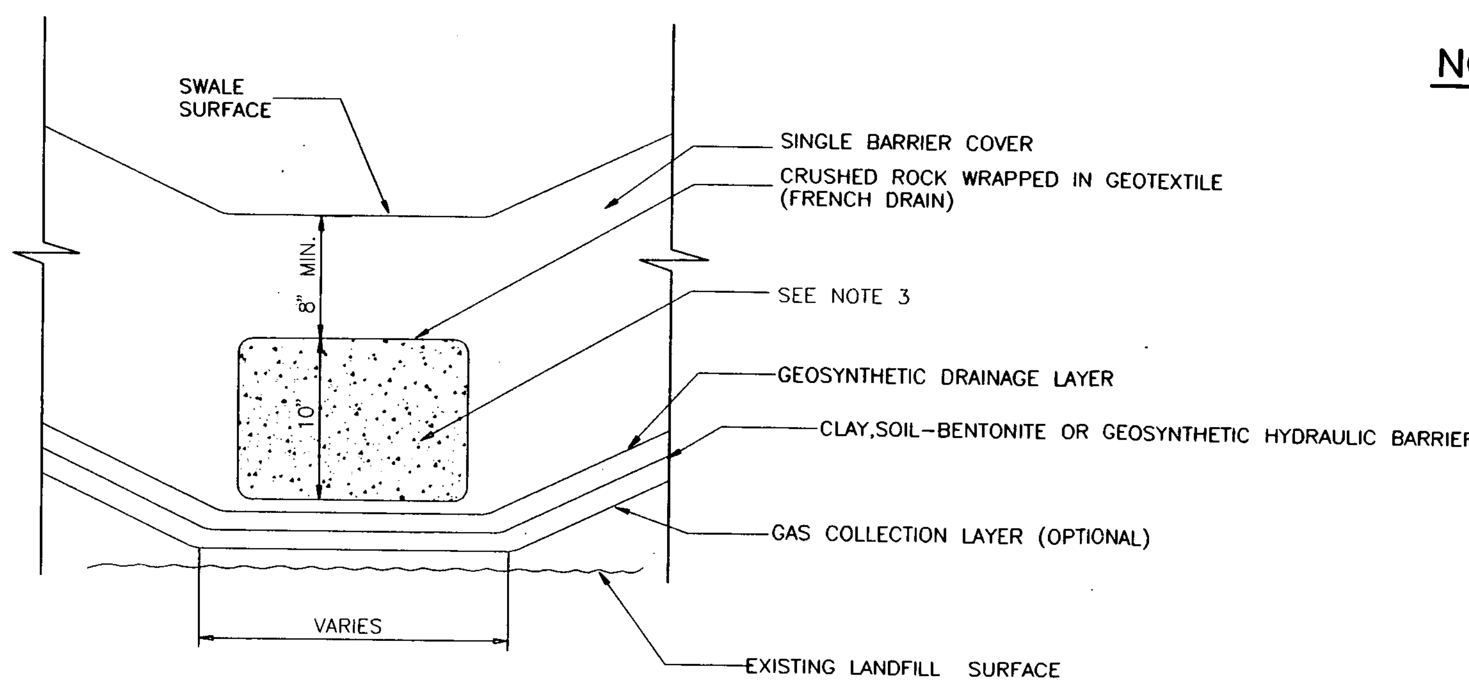
The construction process would likely proceed as follows:

- Vegetation would be cleared from the existing cover. Topsoil would not be stripped. The existing surface would be proofrolled to locate soft spots. Such soft spots would be reworked and compacted.
- Compacted soil fill (foundation fill) would be placed on the existing grade to achieve the desired cover slope. This fill work would include raising the settled areas on the existing cover to restore the topography and drainage features that were constructed during 1983 closure activities. There are no permeability

FIGURE 3-5
SINGLE BARRIER COVER
CONCEPTUAL CROSS-SECTION
FORT RILEY, KANSAS



CONCEPTUAL COVER CROSS-SECTION
NOT TO SCALE



SWALE DETAIL
NOT TO SCALE

NOTES

1. EXISTING SURFACE WOULD BE FILLED IN AREAS THAT HAVE SETTLED TO RESTORE THE TOPOGRAPHY AND DRAINAGE FEATURES CONSTRUCTED DURING THE 1983 CLOSURE ACTIVITIES.
2. SEE FIGURE 2-1 FOR A CONCEPTUAL DETAIL OF THE COVER
3. FRENCH DRAIN WOULD BE ORIENTED TO FOLLOW TOPOGRAPHY AND DRAINAGE FEATURES OF EXISTING SURFACE

FIGURE 3-5
SINGLE BARRIER COVER
CONCEPTUAL CROSS-SECTION

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FIGURE 3–6
CONCEPTUAL SURFACE AREA DELINEATION SINGLE BARRIER COVER
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

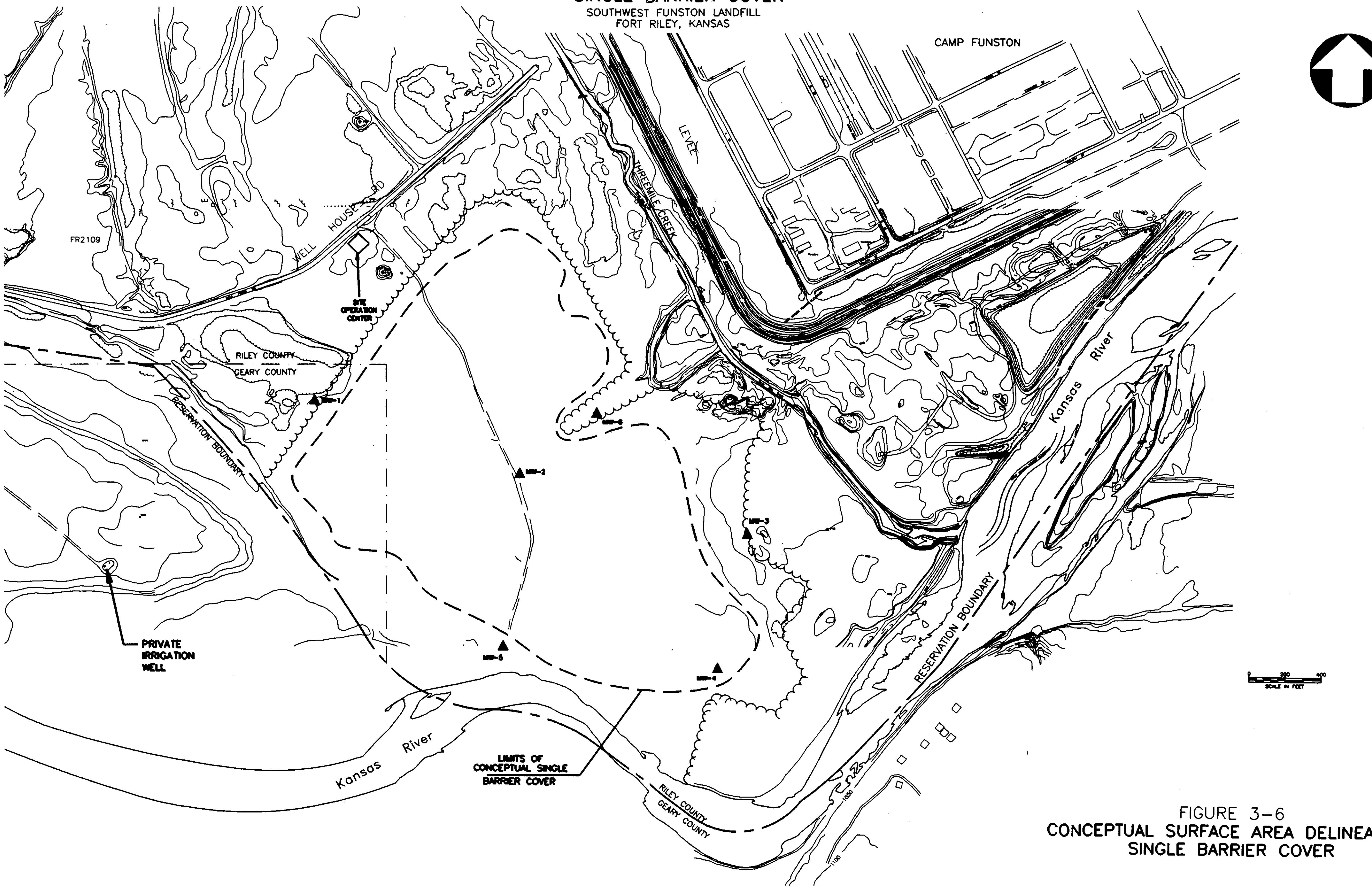

FIGURE 3–6
CONCEPTUAL SURFACE AREA DELINEATION
SINGLE BARRIER COVER

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/HOME/FT-RILRI/2537SITE

requirements and the thickness of this layer would vary. The overlying layers would parallel the top grade of the foundation fill.

- A gas collection layer would be placed directly on the foundation fill. This layer could consist of a geonet placed between two layers of nonwoven geotextile. The geonet would be high-density polyethylene or a similar material. The synthetic drainage product is selected for consideration over gravel because large quantities of suitable granular material are not available in the area. The cost of hauling gravel would make a synthetic product a more economical alternative. Gas vents would be provided to tie into the gas collection layer. A gas vent is typically a vertical standpipe with a perforated pipe base. The subsurface base is connected to the gas collection system. The standpipe penetrates the ground surface and is open to the atmosphere. The opening is protected from precipitation and entry of birds and other small animals. Approximately one vent would be constructed per acre of cover.

- A geosynthetic barrier would be placed directly over the gas collection layer. This barrier could be a geosynthetic clay liner (GCL) or a polyethylene liner. The GCL typically consists of bentonite flakes or granules sandwiched between two layers of geotextile. Once the GCL becomes wet, the bentonite hydrates and swells, filling the surrounding voids, and forming a relatively impervious barrier. A polyethylene liner would be made of very low-density polyethylene (VLDPE) or a similar product. VLDPE is capable of deforming significantly prior to failure and this characteristic is desired since differential settlement could occur. The polyethylene liner would be placed under strict quality control. Field monitoring of the installation and field testing would be performed.

- A geonet and geotextile would be placed directly over the synthetic barrier. This drainage layer would be similar to the gas collection layer described above.

- Above the drainage layer, a minimum of 18 inches of soil would be placed as a vegetative layer. The initial lift of soil would be tracked in and not compacted to protect the underlying synthetic products. Above the initial lift, the soil would be placed and compacted but there would be no hydraulic conductivity requirements. The top six inches would be tracked in and prepared for seeding. This material could be top soil or soil fill enhanced to promote vegetative growth.

- The cover surface would be seeded with a hardy, indigenous grass mix.

- During each phase of the earthwork, engineering control such as silt fences, berms, and temporary siltation ponds would be used to reduce erosion and sediment load in stormwater runoff.

Because the existing grade of the landfill would be raised about three feet, the existing floodplain might be impacted resulting in a rise in flood stages. This should be evaluated in remedial design and, if necessary, controls such as a floodway around the landfill could be constructed to compensate for the loss in floodplain capacity.

Borrow soil would be required and could be taken from the area east of Threemile Creek between the Camp Funston levee and the Kansas River.

Maintenance of the single barrier cover would be similar to the native soil cover including top seeding, fertilizing, and irrigation within the first few years after construction in order to establish a flourishing stand of grass. Long-term maintenance would include mowing and periodic fertilizing to maintain the grass. Reseeding could also be required after years of severe drought. Filling and other earthwork could be required to correct long-term settlement or erosion. Revegetating could also be required in eroded areas. Maintenance of the riverbank revetment would also be required as discussed in Alternative 2. Annual visual inspections of the cover and the riverbank stabilization project would be appropriate for this alternative.

3.4.2 Screening Evaluation

Effectiveness

This alternative is effective at meeting the soil and groundwater RAOs for the same reasons stated in Alternative 3. Institutional controls provide assurances that exposure to site groundwater is prevented. Furthermore, the single barrier cover is expected to reduce infiltration because of the hydraulic barrier. The resulting infiltration through a single barrier cover would be a small fraction of that through the existing cover. Because infiltration is one of three identified mechanisms of potential generation of leachate, a reduction in infiltration may have a beneficial impact on groundwater. But, because the other two mechanisms are not controlled, the impact of infiltration reduction on the groundwater characteristics might be insignificant.

This alternative should not adversely impact on-site workers or the community because construction of the multi-layer cap is constructed mostly above the existing grade. As stated in Alternative 2, on-site sampling teams could potentially be exposed to groundwater. However, with the appropriate OSHA training and personnel protective equipment, any such exposure should be controlled. Furthermore, ingestion of groundwater by trained sampling personnel is unlikely.

This alternative would not reduce mobility, volume, or toxicity through treatment. As stated above, the reduction in infiltration might impact potential migration of contaminants in the landfill. Again, the resulting benefit to groundwater quality might be insignificant.

Because this is a containment alternative, institutional controls and long-term groundwater monitoring would be necessary to the long-term protection of human health and the environment based on the potential, unacceptable risk of future exposure to groundwater.

Implementability

This alternative should be readily implementable. The cover and riverbank stabilization could be constructed with standard construction methods.

Cost

The capital cost of this alternative would be high and the maintenance costs would be medium.

3.5 ALTERNATIVE 5 - PHYSICAL CONTAINMENT OF GROUNDWATER

3.5.1 Description

This alternative involves the construction of a soil bentonite (SB) slurry wall around the perimeter of the landfill boundary to limit the flow of groundwater under the landfill. The native soil cover (repair of existing cover), riverbank stabilization, institutional actions, and groundwater monitoring as discussed in Alternatives 2 and 3 are also included in this alternative. To construct the slurry wall, approximately 9,100 linear feet of SB wall would be installed, as shown in Figure 3-7. The SB wall would be installed by excavating to an average depth of 60 feet. This depth allows a five-foot wall key into the bedrock, which has been estimated from monitoring well soil borings to be at an average depth of 55 feet. Actual wall depth will depend on the thickness of weathered rock underlying the alluvium at the SFL. The SB wall connection with a low permeability shale or limestone formation underlying the SFL alluvium is important to achieve a low permeability barrier. In some cases, bottom key grouting may be needed to ensure a low permeability connection, if the wall is set into a fractured or weathered formation.

Consideration was given to installing a partial wall (i.e., not completely surrounding the landfill); however, this was not expected to be effective. In the portion of the landfill near the Kansas River, the groundwater flow direction may vary from southeasterly (toward the river) to northerly (away from the river) depending on the relative elevation difference in the Kansas River stage and the regional water table conditions north and west of the SFL. If a slurry wall was installed only along the Kansas River and Threemile Creek (south and east side of the landfill), then groundwater flow could build up on the landfill side of the wall when high regional water table conditions (caused by seasonal recharge) were higher than the river stage potentially saturating the waste. If a slurry wall was installed on the north and west portion of

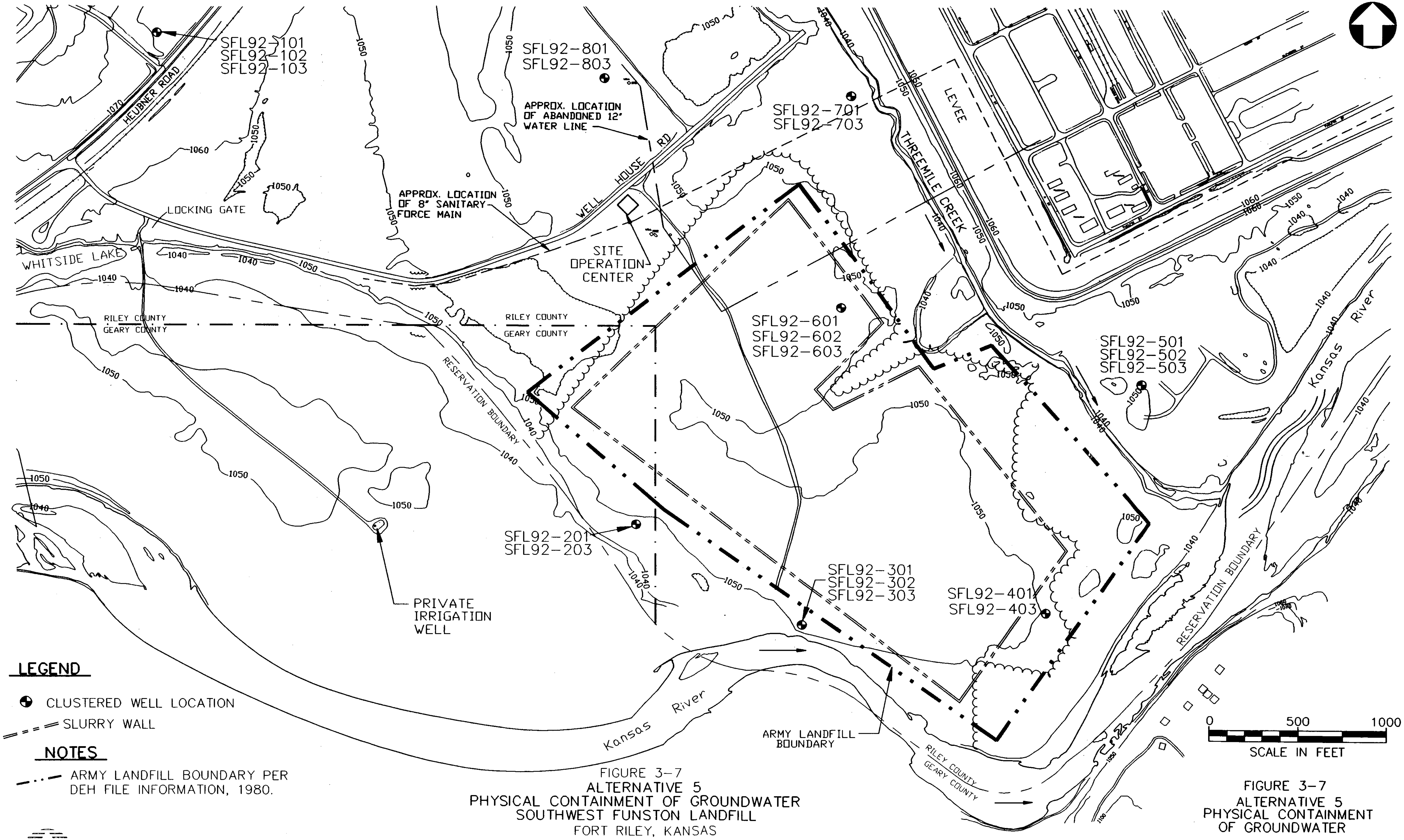

FIGURE 3-7
ALTERNATIVE 5
PHYSICAL CONTAINMENT OF GROUNDWATER
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

FIGURE 3-7
ALTERNATIVE 5
PHYSICAL CONTAINMENT OF GROUNDWATER

LAW ENVIRONMENTAL INC.
GOVERNMENT SERVICES DIVISION

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the SFL, then river influx could saturate the landfill contents. Because of the variation in groundwater flow direction, a slurry wall encompassing the landfill was considered the only effective slurry wall option for controlling groundwater movement at the landfill.

The design of a slurry wall might proceed as follows:

- Collection of additional geological information needed to design and construct the slurry wall, including rock depth and location, permeability, and the degree and depth of weathered rock. The depth to an aquiclude (low permeability shale) at the SFL should be verified along the slurry wall alignment. The top of shale is erosional and, therefore, the depth to shale would have to be determined. Structural discontinuities and changes in subsurface conditions that might interfere with wall continuity during construction or the tie-in with a low permeability formation should be identified and construction methods dealing with site discontinuities should be identified during the design phase. The composition and geology of the rock layer is necessary for designing the wall key and selecting a method of notching the bedrock for the key. Location of an existing 12-inch abandoned waterline should be verified.

- Better determination of the hydraulic conductivity should be made in design to estimate the groundwater flow rates that could be encountered during the construction of the wall. Considering the wide range estimate of hydraulic conductivity at the SFL, a pump test would likely be needed during the design phase investigation.

- Design of trench backfill, considering soil information including soil water content, permeability, soil chemical properties such as organic content, and gradation. The backfill mix design is an important factor in SB wall performance. Sufficient fines would probably be available in the excavated materials at the SFL. If sufficient fines were not present in on-site soils, an alternate borrow source could be identified within Fort Riley.

- The compatibility of the bentonite slurry used in the SB wall with the chemical constituents of the groundwater must be considered in the design. The low levels of organic contaminants detected in SFL groundwater would not be expected to significantly affect the physical or chemical properties of the bentonite slurry backfill. Bentonite hydration could be affected, however, by the presence of high concentrations of electrolytes in the groundwater used for hydration. High levels of sodium, calcium, and metals in the groundwater might affect the hydration of the bentonite, reduce the swelling and sealing properties of the bentonite after long-term contact with the groundwater, and reduce the sealing performance of the SB wall. Backfill compatibility testing with SFL groundwater should be considered during design.

- Designation of site work areas, temporary and permanent spoils disposal areas, erosion controls, and site restoration following construction. Excavation and construction methods would dictate the working areas needed for construction, and should be defined during the design phase.

- Construction of the slurry wall.

This alternative includes the institutional controls and groundwater monitoring as described in Alternative 2.

3.5.2 Screening Evaluation

Effectiveness

The removal action is being constructed prior to the implementation of this alternative and will meet the remedial action objectives discussed in Section 2.0 with the exception that the RAO to prevent future ingestion of and dermal contact with SFL groundwater is not assured. The effectiveness of institutional controls as discussed in Alternative 2 applies to this alternative. Construction of a slurry wall around the SFL will not provide effective long-term control of groundwater contaminant migration. Since the slurry wall is intended to effectively separate the dynamics of the flow regime occurring inside the wall from that occurring outside the wall, groundwater elevations inside the landfill will not equilibrate with external water levels. Therefore, upflow from the bedrock, in addition to SB wall seepage, could potentially cause groundwater levels to rise within the SFL area enclosed by the slurry wall. Over time, the rising water level inside the wall could create a positive gradient out of the containment area. Because of the aforementioned conditions, this alternative would not be effective without a mechanism for groundwater removal. Alternative 5 incldues the slurry wall with a groundwater withdrawl option.

Implementability

This alternative could be implemented, but is not retained because it does not offer long-term effectiveness.

Cost

Construction of a slurry wall around the SFL has a high capital cost and low O&M cost.

3.6 ALTERNATIVE 6 - HYDRAULIC CONTAINMENT OF GROUNDWATER

3.6.1 Description

With Alternative 6, hydraulic containment of groundwater in the SFL will be accomplished by constructing a physical barrier around the perimeter of the landfill, as in Alternative 4, and pumping groundwater collected within the landfill. This alternative also includes groundwater monitoring as discussed in Alternative 2. Alternative 6 includes a groundwater extraction system consisting of one recovery well pumping at a rate of approximately 250 gpm. Additionally, this extraction system includes a slurry wall around the perimeter of the landfill. The intent of this system is to pump from within the slurry wall in order to maintain an inward gradient towards the landfill. Additionally, this alternative includes the treatment and subsequent discharge of recovered groundwater collected within the slurry wall boundary. Details of this alternative are discussed below.

As discussed in Alternative 5, the physical barrier will consist of a slurry wall around the boundary of the landfill. The slurry wall will be constructed using a soil-bentonite slurry. The estimated depth of the slurry wall is approximately 55 feet, and the estimated length is approximately 9,100 feet. This alternative is shown in Figure 3-8.

In order for the slurry wall to form an effective hydraulic barrier, groundwater from within the landfill must be collected. With this alternative, the groundwater extraction system consists of one recovery well, located as shown in Figure 3-8, installed to a depth of approximately 70 feet to penetrate the bedrock. Well placement was based on the goal of maintaining an inward gradient across the slurry wall. The slurry wall is intended to effectively separate the dynamics of the flow regime occurring inside the wall from that occurring outside the wall, therefore pumping conditions and the groundwater gradient inside the wall should not be substantially affected by changes in the direction of groundwater gradient outside the wall. The volume of groundwater expected to be collected is approximately 360,000 gallons per day (gpd). This pumping rate was based on a hydraulic conductivity of 150 ft/day and a transmissivity of 9,000 ft^2/day. The projected drawdown along the inside perimeter of the slurry wall for the wall location shown in Figure 3-8 and the aforementioned pumping rate is approximately 0.3 feet. This projected drawdown is derived from preliminary calculations based on available hydrogeologic information. These calculations represent possible conditions and are used here as an example; the details of the example calculations are provided in Appendix B. However, some estimates of hydraulic conductivity in the alluvial aquifer system range as high as 500 ft/day, which would significantly increase the required pumping rate. Actual design and implementation of the groundwater recovery system will require a pilot aquifer test prior to design of a full scale system.

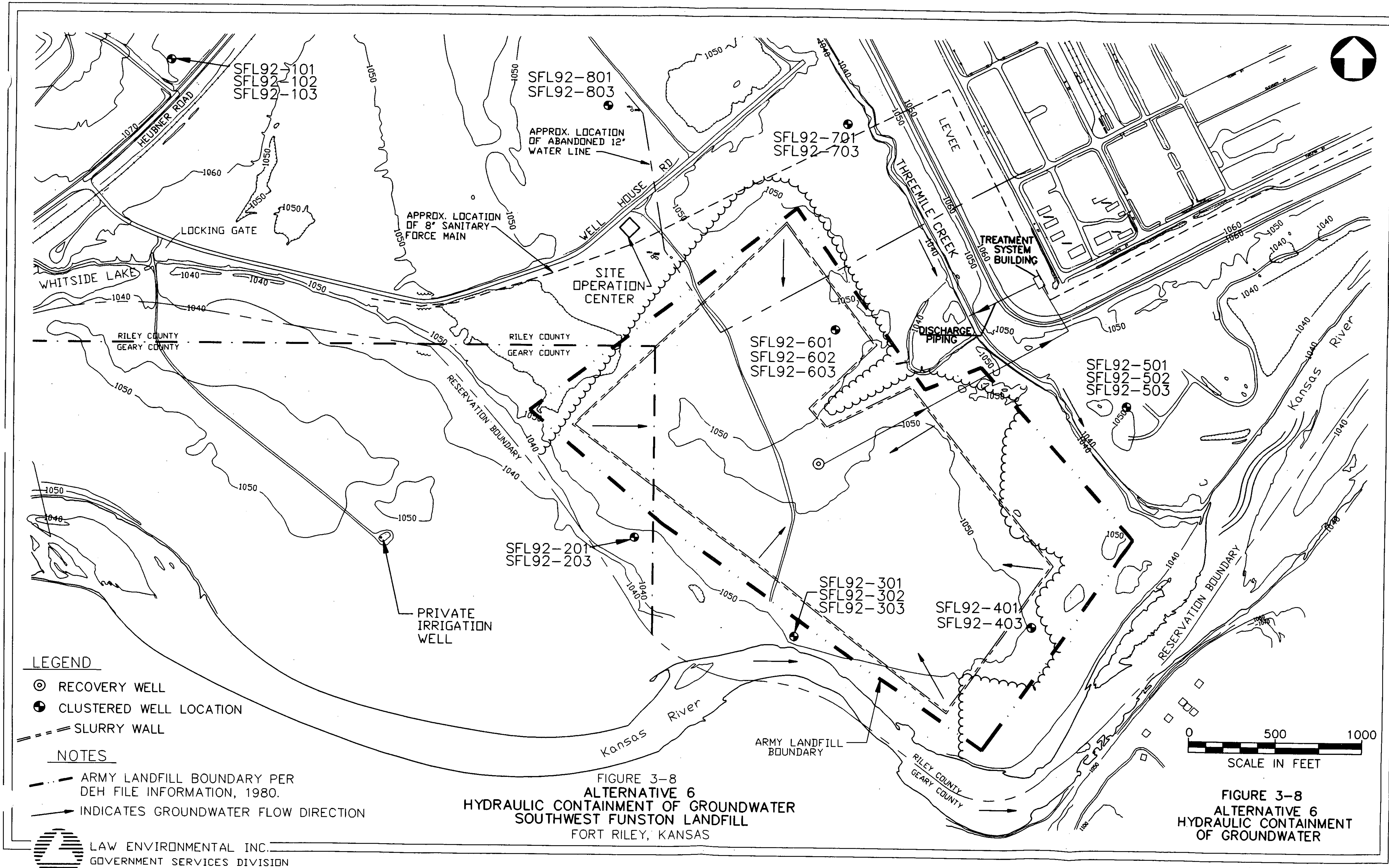

FIGURE 3-8
ALTERNATIVE 6
HYDRAULIC CONTAINMENT OF GROUNDWATER
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

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Groundwater would be pumped from the recovery well into the air stripper for removal of organics. The extracted groundwater would be treated in an on-site treatment system. The design of the treatment system considers operational requirements to remove the organic constituents, and the attainment of an effluent meeting NPDES discharge criteria allowing the effluent discharge into Threemile Creek and the Kansas River. Component technologies of this system were discussed in Section 2.5.3, and a conceptual layout for the treatment system is presented in Figure 3-9. The treatment system would consist of one low profile air stripper capable of handling up to approximately 360 gpm flow for VOC removal, a filtration system for solids/metals removal, and carbon adsorption vessels for polishing. The proposed air stripper is designed based on a total flow from the well of approximately 250 gpm. The air stripper is a stainless steel, three-tray system which contains a sump tank, blower, control panel, and associated piping, gauges, etc. The air stripper would achieve removal of benzene and vinyl chloride to less than 1 μg/L. Based upon the volume of contaminants emitted in the air stream (less than one pound per day), emissions control is not expected to be required. Considering the anticipated load of iron and other metals (Table 2-5), the trays of the low profile air stripper would require cleaning approximately monthly in order to remove the buildup caused by these inorganics. The possible location of the treatment plant is shown on Figure 3-8.

Upon treatment for organics in the air stripper, the discharge stream would be treated for removal of solids/insoluble metals prior to polishing with a carbon adsorption system. This filtration system would consist of an in-line filtration unit primarily designed for the removal of solids. In the treatment system, the backwash from the filter and the cleaning waste from the air stripper would be collected in a building sump. Solids/insoluble metals collected from the cleaning of the air stripper and the filtration system would be transferred to a filter screen for solids removal before being recirculated. The water generated from this operation would be pumped back through the air stripper. It is anticipated that the solids from this operation would be nonhazardous and therefore can be disposed in a municipal landfill.

Based upon the design of the air stripper and solids/metals removal systems, only trace amounts of volatile organics should be present in the groundwater as the water exits the filtration system. The treated groundwater would flow through an activated carbon adsorption system as a final polishing step prior to discharge. Since the air stripper and solids/metals removal systems are designed to reduce the concentration of volatile organics to meet effluent quality, minimal loading on the carbon vessels is anticipated. Treated water will discharge from the carbon adsorption system to Threemile Creek.

3.6.2 Screening Evaluation

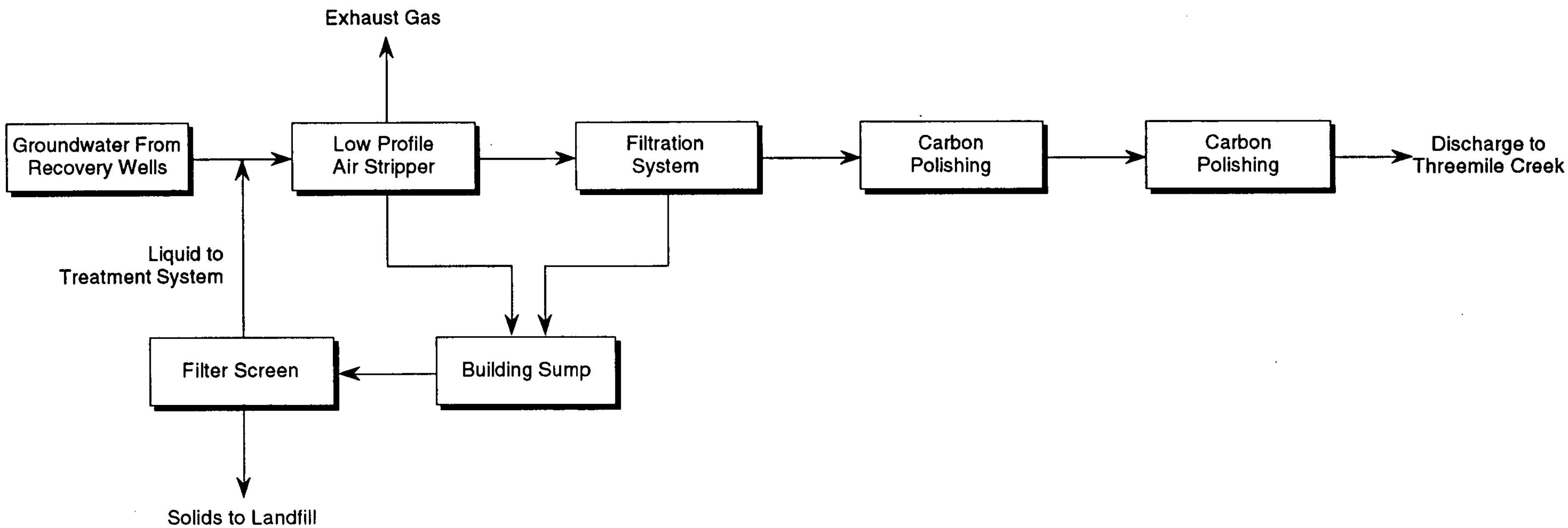
Effectiveness

The objectives of Alternative 6 are to contain groundwater within the landfill boundaries and to prevent exposure to the constituents of concern in the groundwater. Since the removal action would be constructed prior to this alternative, the effectiveness of Alternative 1 would be

FIGURE 3-9

CONCEPTUAL LAYOUT FOR TREATMENT SYSTEM - ALTERNATIVE 6

SOUTHWEST FUNSTON LANDFILL, FORT RILEY, KANSAS



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relevant to this alternative. However, if designed properly, this alternative effectively collects the contaminated groundwater from the SFL and thus reduces and controls the volume of contaminated groundwater at the site. This alternative is expected to reduce the toxicity and mobility of the groundwater by containing the groundwater within the SFL and removing contaminated groundwater for treatment, which is likely to reduce residual concentrations of organic constituents remaining in the groundwater. However, the time frame to meet remedial goals is expected to be long, and complete remediation may not be feasible. This alternative may not reduce the risk of potential future exposure to an on-site groundwater user; however, implementing groundwater access restrictions will limit potential future contact with groundwater.

Implementability

Currently, several uncertainties exist relative to design of the slurry wall and groundwater extraction system. Design of the slurry wall would require a geotechnical investigation as described in Alternative 4. The projected groundwater recovery rate is based on limited information and would need to be confirmed by an aquifer test. Results of the aquifer test could significantly change the feasibility, implementability, treatment requirements, and projected costs. Design of the groundwater treatment system would require treatability testing to evaluate metals interference, potential sludge production, and the need for and loading to the carbon adsorption system.

Installation of a recovery well should be a relatively straightforward process; care must be taken during drilling since debris is expected to be encountered in the landfill. Auger refusals during drilling may require multiple drilling attempts to obtain a suitable boring to bedrock. Installation of a slurry wall is more complicated than recovery well installation; slurry mixture and uniformity must be verified. A building must be erected for the treatment system. The SFL site is located in the 50-year floodplain, which should be considered in the building design. The building would have to be insulated and heated to prevent freezing of process equipment. In summary, this alternative can be implemented using available equipment and construction techniques.

Cost

Costs for this alternative are based upon experience with other slurry wall and groundwater treatment system installations. Manufacturer information and cost opinions were also utilized. The majority of the capital cost associated with this alternative is associated with the slurry wall. O&M costs for the slurry wall will be low, and O&M costs for the treatment system are expected to be high. This alternative is retained for detailed analysis.

3.7 ALTERNATIVE 7 - GROUNDWATER EXTRACTION, TREATMENT AND DISCHARGE

3.7.1 Description

Alternative 7 includes the institutional actions and groundwater monitoring described in Alternative 2, and a groundwater extraction system which provides a hydraulic barrier in the vicinity of monitoring wells SFL92-500, -600, and -800. This hydraulic barrier consists of three recovery wells pumping at approximately 330 gpm each, resulting in a total rate of approximately 1,000 gpm. The intent of this system is to form a hydraulic barrier in the SFL which will prevent contaminants in the groundwater from migrating. The three recovery wells are located as shown on Figure 3-10; the three wells will be installed to a depth of approximately 70 feet in order to penetrate the bedrock. The wells would be screened throughout the saturated thickness of the aquifer. Since a contaminant plume cannot be estimated with available data, well placement was based upon the projected capture zones of the recovery wells, as shown on Figure 3-10. Recovery wells were located in proximity to monitoring wells SFL92-500, -600, and -800, because organic contaminants exceeding remedial goals were detected in these wells during some of the sampling rounds. The estimated pumping rate from each recovery well is about 330 gpm. The volume of groundwater expected to be collected is approximately 1,440,000 gpd. The well locations and pumping rates have been selected using capture zone analyses based on available hydrogeologic information. The analyses are provided in Appendix B. Actual design and implementation of the groundwater recovery system would require a pilot aquifer test prior to the design of a full scale system.

After extraction, the groundwater would enter the on-site treatment system. Components of this system were discussed in Section 2.5.3, and a conceptual layout for the treatment system is presented on Figure 3-11. The treatment system will consist of three low profile air strippers (each capable of pumping up to 360 gpm) piped in parallel for VOC removal, a filtration system for solids/metals removal, and carbon adsorption vessels for polishing. The process description of the groundwater treatment system is presented below.

Groundwater would be pumped from the recovery wells into one of the three air strippers for removal of organics. The proposed air strippers are designed based on a total combined flow from the three wells of approximately 1,000 gpm. The piping from the recovery wells would be split into three streams as the groundwater enters the treatment system building. Each air stripper system would consist of a low profile air stripper capable of handling up to 360 gpm. Each air stripper is a stainless steel, three-tray system which contains a sump tank, blower, control panel, and associated piping, gauges, etc. Each air stripper would achieve removal of benzene and vinyl chloride to less than 1 ppb. Based upon the volume of contaminants emitted in the air stream, emissions control may be required. Based on the anticipated load of iron and other metals (Table 2-5), the trays of each low profile air stripper would require cleaning approximately monthly in order to remove the buildup caused by these inorganics.

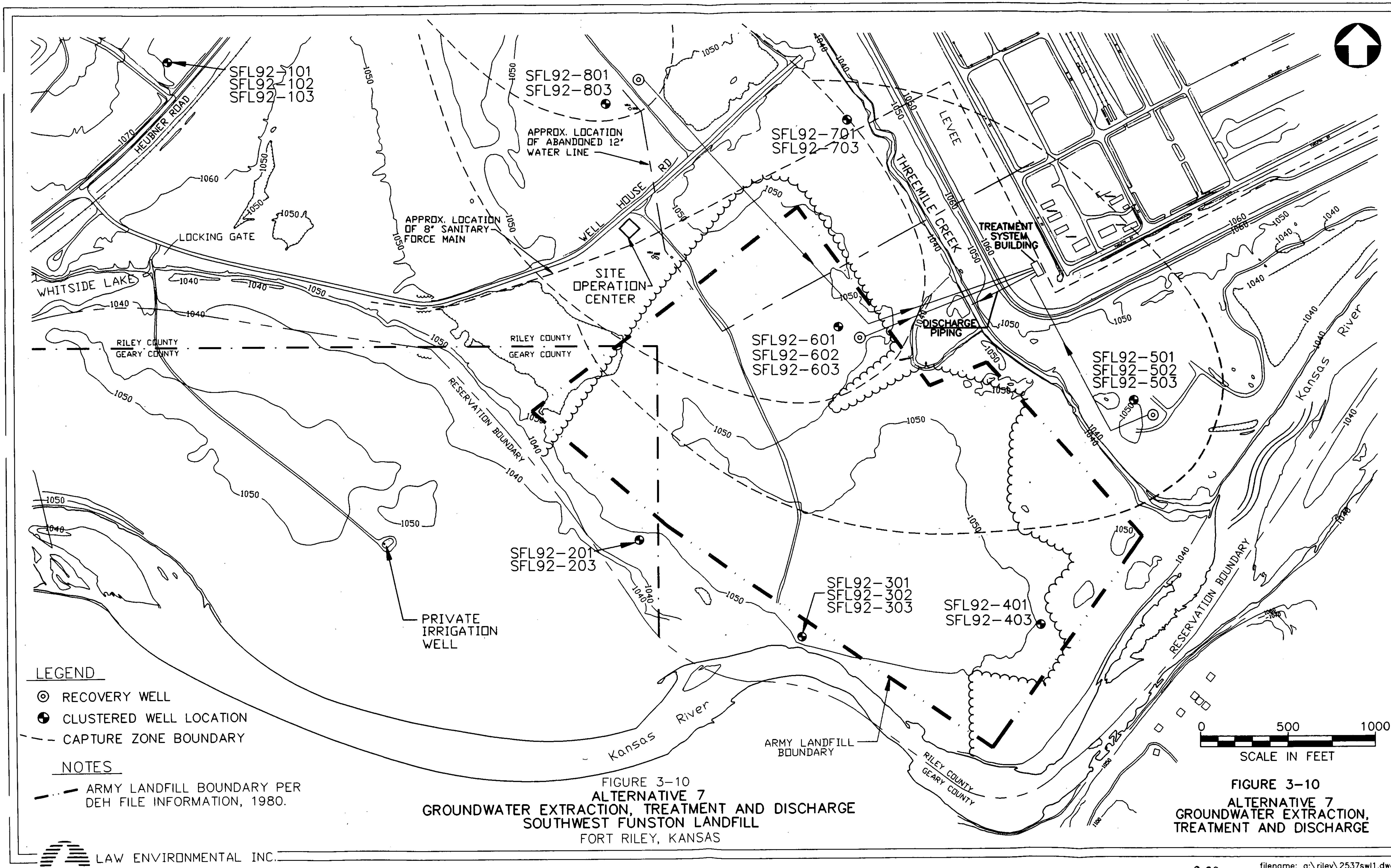

FIGURE 3-10
ALTERNATIVE 7
GROUNDWATER EXTRACTION, TREATMENT AND DISCHARGE
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

FIGURE 3-10
ALTERNATIVE 7
GROUNDWATER EXTRACTION, TREATMENT AND DISCHARGE

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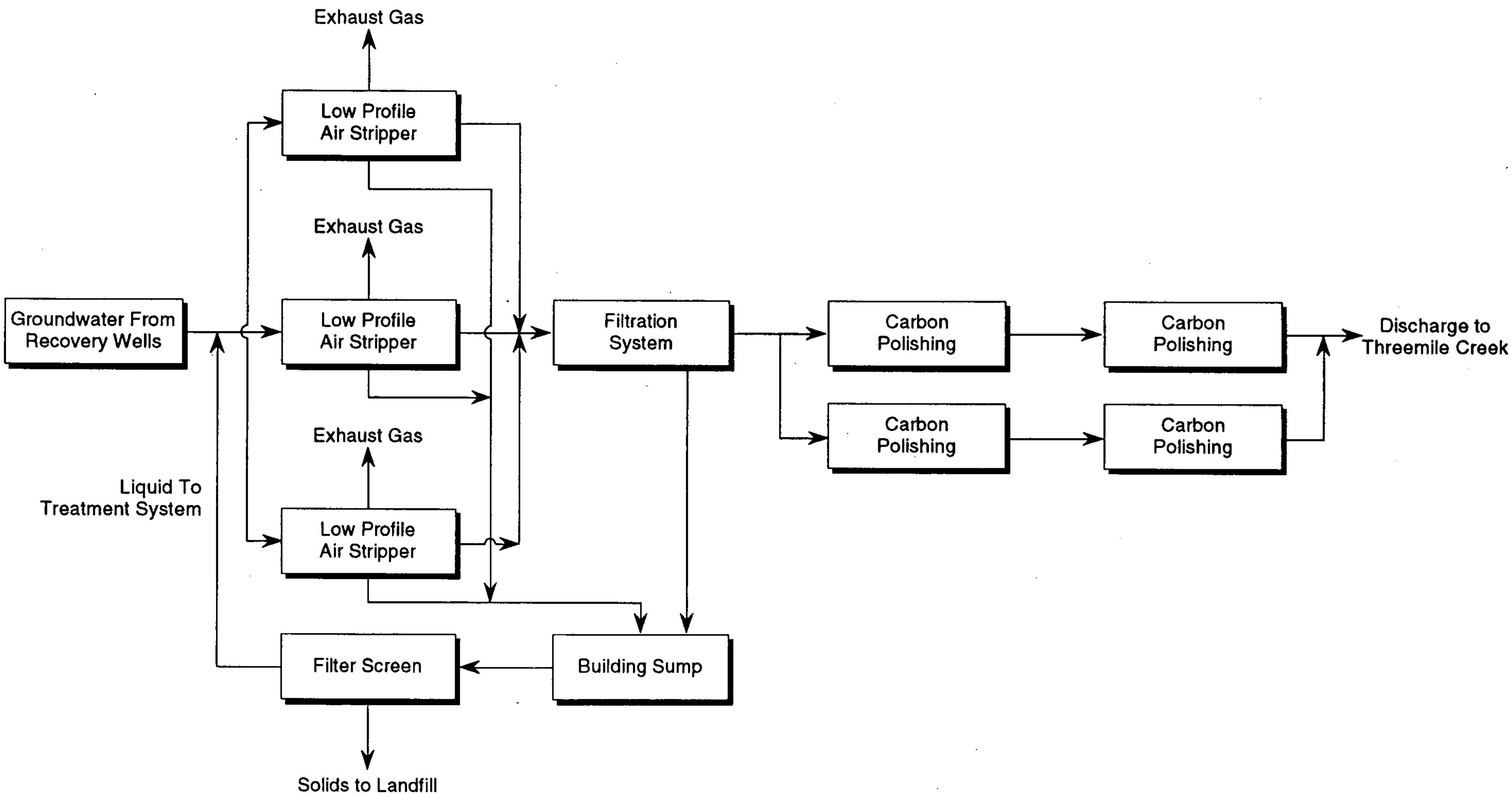
FIGURE 3-11

CONCEPTUAL LAYOUT FOR TREATMENT SYSTEM - ALTERNATIVE 7

SOUTHWEST FUNSTON LANDFILL, FORT RILEY, KANSAS



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Upon treatment for organics in the air strippers, the discharge streams from the three air strippers would be combined and treated for removal of solids/insoluble metals prior to polishing with a carbon adsorption system. As with the filtration system in Alternative 6, this filtration system would consist of an in-line filtration unit primarily designed for the removal of solids. As with Alternative 6, in the treatment system, the backwash from the filter and the cleaning waste from the air strippers would be collected in a building sump. As in Alternative 6, the solids/metals collected from the cleaning of the air strippers and the filtration system would be transferred to a sump and then pumped to a filter screen for solids removal. The water generated from this operation would be pumped back through the air stripper; the solids from this operation would be disposed in a municipal landfill.

As with Alternative 6, based upon the design of the air stripper and solids/metals removal systems, only trace amounts of any constituents of concern should be present in the groundwater as the water exits the filtration system. The treated groundwater would flow through an activated carbon adsorption system as a final polishing step prior to discharge.

Treated water would discharge from the carbon adsorption system to Threemile Creek. The anticipated piping system for this discharge is shown on Figure 3-10. As discussed in Section 2.2, the discharge stream would need to meet NPDES effluent limits.

3.7.2 Screening Evaluation

Effectiveness

The remedial action objectives for this alternative are to create a hydraulic barrier in the vicinity of wells SFL92-500, -600, and -800, which exceeded remedial goals, and to reduce the amount and toxicity of groundwater in the landfill and to prevent exposure to the constituents of concern in the groundwater. This system, if designed appropriately, effectively collects the contaminated groundwater above the RGs and thus reduces and controls the volume of contaminated groundwater at the site. With Alternative 6, the time frame in which groundwater is restored to acceptable levels (i.e., below RGs) cannot be projected based on existing information. The treatment system components for Alternatives 5 and 6 are identical except for the design flow rates and sizes of equipment units. The treatment system reduces the toxicity of the groundwater by reducing the concentrations of organic constituents of concern and by removing some of the metals and solids from the groundwater. The effectiveness of this system in addressing risks of potential future exposure to an on-site groundwater user is dependent on the time frame to reduce concentrations to the RGs. Although this cannot be directly calculated at this time, experience has shown that pump and treat for groundwater restoration is typically a long-term process (i.e., greater than 10 years) and is often unsuccessful in that RGs cannot be achieved. Since the groundwater access restrictions are also being implemented, the alternative prevents future groundwater use.

Implementability

Currently, several uncertainties exist relative to design of the groundwater extraction system. The projected groundwater recovery rate is based on limited information and would need to be confirmed by an aquifer test. Results of the aquifer test could significantly change the feasibility, implementability, treatment requirements, and projected costs. Design of the groundwater treatment system would require treatability testing to evaluate metals interference, potential sludge production, and the need for and loading to the carbon adsorption system.

Installation of recovery wells near monitoring wells SFL92-500 and -800 should be a relatively straightforward process; however, drilling near well SFL92-600 may encounter buried materials in the landfill. Auger refusal may require multiple drilling attempts to obtain a suitable boring to bedrock. A building must be erected for the treatment system associated with this alternative. This building will be larger than the one utilized for Alternative 6. The SFL site is located in the 50-year floodplain, which should be considered in building to withstand such conditions. The building would have to be insulated and heated. The discharge would be required to meet NPDES requirements; with proper design, this can be achieved and would not prevent implementing this alternative.

Cost

The capital cost of this alternative will be high, and O&M costs are expected to be high.

3.8 SUMMARY OF SCREENING EVALUATION

The following alternatives have been retained for further consideration during detailed analysis:

- Alternative 1 - No Action
- Alternative 2 - Institutional Controls, Riverbank Stabilization, and Groundwater Monitoring
- Alternative 3 - Native Soil Cover
- Alternative 4 - Single Barrier Cover
- Alternative 6 - Hydraulic Containment of Groundwater
- Alternative 7 - Groundwater Extraction and Treatment

Alternative 5, Physical Containment of Groundwater, has been eliminated from further consideration because it does not provide an effective long-term remedial action alternative.

4.0 DETAILED EVALUATION

The purpose of the detailed analysis of alternatives is to evaluate selected remedial alternatives in order to develop the rationale for selection of a remedy.

4.1 EVALUATION CRITERIA

The process options potentially applicable to the SFL were developed into alternatives and screened in Section 3.0. This section presents the results of a detailed evaluation of the remedial action alternatives retained from Section 3.0. The evaluation criteria are:

- Overall Protection of Human Health and the Environment - Addresses whether a remedy will clean up the site to within the risk range, result in any unacceptable impacts, and control the inherent hazards associated with the site.

- Compliance with ARARs - Addresses whether a remedy will meet all of the potentially applicable or relevant and appropriate requirements of other laws and regulations.

- Long-Term Effectiveness and Permanence - Refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

- Short-Term Effectiveness - Refers to the period of time needed to achieve protection, and any adverse impacts on human health and the environment that may be posed during the construction and implementation period until cleanup goals are achieved.

- Reduction in Toxicity, Mobility, or Volume of Waste through Treatment - Refers to the anticipated performance of the treatment technologies that may be employed in a remedy.

- Implementability - Describes the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement the chosen actions, and the ability to obtain regulatory approval.

- Cost - Includes the capital for materials, equipment, and related items, and the operation and maintenance costs.

- Support Agency Acceptance - Refers to USEPA's and the State of Kansas anticipated response to and acceptance of a remedy.

- Community Acceptance - Refers to the public's anticipated response to and acceptance of a remedy. Fort Riley has an existing community relations plan.

Overall protection of human health and the environment and compliance with ARARs generally serve as threshold determinations in that they must be met by any alternative in order for it to be eligible for selection. The next five criteria (long-term effectiveness and permanence; reduction in mobility, toxicity, and volume through treatment; short-term effectiveness; implementability; and cost) are the primary criteria for balancing the alternatives that meet the threshold requirements.

The final two acceptance criteria are not directly evaluated in the FS report. The agency acceptance and community acceptance criteria will be evaluated, and the final decision on the proposed plan will be selected in conjunction with the preparation of the Record of Decision (ROD). Support agency and community acceptance are significant and important. Careful planning and consideration are required to gain adequate acceptance.

The results of detailed evaluation are presented in Tables 4-1 and 4-2. Table 4-1 presents comments associated with threshold criteria and the five primary criteria are discussed in Table 4-2. The detailed evaluation has been presented in a table to provide a concise format. The alternatives and technologies are described in Section 3.0. The projected costs for the five retained alternatives are presented in Tables 4-3 through 4-7. Costs are summarized in Table 4-8.

4.2 COST ESTIMATING

The cost estimates were developed by taking quantities from the figures provided in this report and using several sources of unit costs. Unit costs were estimated from "Means Building Construction Cost Data," 51st Edition, R.S. Means Company, Inc., and compared to contractor and vendor information obtained for the removal action and other recent projects. References for documentation of cost estimates are included in Appendix C.

The cost of earthwork and slurry wall construction are particularly sensitive to site conditions. Earthwork costs are dependent on the haul distance from the borrow site and slurry wall cost may vary depending on the required method and rate of installation.

The anticipated accuracy of the cost estimates given assumed site conditions is about -30 to +50 percent because they are developed from a level of detail appropriate for a feasibility study. However, additional information gathering (i.e., aquifer test) and detailed design may substantially change the concepts on which the cost estimates are based and would substantially change actual costs. The costs include capital, engineering, operation and maintenance, and monitoring costs. The operation and maintenance and monitoring costs are presented as net present worth based on a discount rate of 7 percent, which is consistent with the Remedial Action Costing Procedures Manual (USEPA, 1987).

TABLE 4-1

EVALUATION OF THRESHOLD CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS	
	Overall Protection of Human Health and the Environment	Compliance with ARARs
Alternative 1 - No Action	• Alternative is protective of human health and the environment since groundwater is not currently used. • Exposure of landfill contents on the landfill surface or Kansas River Bank might occur since future erosion by stormwater runoff and floodwaters is not controlled. • Currently, there is no human exposure to groundwater and the RI indicates that groundwater contamination is limited. The potential risk of future groundwater exposure is not addressed by this alternative. • The RI data indicate that groundwater contamination is mostly limited to isolated, sporadic detections.	Meets ARARs considering current groundwater use. Would not meet ARARs if groundwater at the site is used for drinking water in the future.

TABLE 4-1

EVALUATION OF THRESHOLD CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS: Overall Protection of Human Health and the Environment	EVALUATION COMMENTS: Compliance with ARARs
Alternative 2 - Institutional Controls, River Stabilization, and Groundwater Monitoring	• Alternative is protective of human health and the environment since groundwater is not currently used. • The Kansas River Bank would be stabilized to control future erosion of the bank so that landfill contents would not be exposed. • Institutional Controls would provide assurances that groundwater would not be used in the future. • The RI data indicate that groundwater contamination is mostly limited to isolated, sporadic detections. Long-term groundwater monitoring would detect changes in these conditions.	Meets ARARs considering current groundwater use. Meets ARARs in the future by restricting groundwater use and site operations.
Alternative 3 - Native Soil Cover	• Same comments as Alternative 2 except potential exposure to landfill contents at the ground surface would be controlled. • By minimizing stormwater ponding, and filling cracks and erosional rills on the landfill surface, infiltration through the cover (and landfill contents) may be reduced. This can beneficially impact long-term groundwater conditions. Considering the impact of other potential leachate generation mechanisms, the benefit may be minor.	Meets ARARs considering current groundwater use. Meets ARARs in the future by restricting groundwater use and site operations.

TABLE 4-1

EVALUATION OF THRESHOLD CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS	
	Overall Protection of Human Health and the Environment	Compliance with ARARs
Alternative 4 - Single Barrier Cover	• Same comments as Alternative 2 except potential exposure to landfill contents at the ground surface would be controlled. • Infiltration through the cover and landfill contents would be reduced. This can beneficially impact long-term groundwater conditions. Considering the impact of other potential leachate generation mechanisms, the benefit may be minor.	Meets ARARs considering current groundwater use. Meets ARARs in the future by restricting groundwater use and site operations.
Alternative 6 - Hydraulic Containment of Groundwater	• Same comments as Alternative 2 except potential exposure to landfill contents at the ground surface would be controlled. • The exposure associated with the installation of the recovery system and treatment system should be minimal. The exposure associated with the slurry wall might require Level "C" protection to assure adequate protection of on-site workers. This alternative would protect human health and the environment regarding migration of contaminated groundwater off site due to the vertical barrier created by the slurry wall and the treatment of the extracted groundwater.	Meets ARARs considering current groundwater use. Would meet ARARs in the future by restricting groundwater use. Restoration of the on-site groundwater is possible but not anticipated because the landfill contents would be a potential, long-term source of groundwater contamination. With proper design and controls, location- and action-specific ARARs would be met.

TABLE 4-1

EVALUATION OF THRESHOLD CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS	
	Overall Protection of Human Health and the Environment	Compliance with ARARs
Alternative 7 - Groundwater Extraction, Treatment, and Discharge	• Same comments as Alternative 2 except potential exposure to landfill contents at the ground surface would be controlled. • The exposure associated with the installation of the recovery system and treatment system would be minimal. This alternative would protect human health and the environment regarding migration of contaminated groundwater off site due to the hydraulic barriers created by the extraction system and the treatment of the extracted groundwater.	Meets ARARs considering current groundwater use. Would meet ARARs in the future by restricting groundwater use. Restoration of the on-site groundwater is possible but not anticipated because the landfill contents would be a potential, long-term source of groundwater contamination. With proper design and controls, location- and action-specific ARARs will be met.

TABLE 4-2

EVALUATION OF PRIMARY CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS				
	Long-Term Effectiveness and Permanence	Reduction in Mobility, Toxicity, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 1 - No Action	• Potential, future groundwater exposure is not addressed in this alternative. • Potential exposure to landfill contents on the landfill surface and along the Kansas River bank is not addressed in this alternative. • A 5-year review is appropriate to assess cover and groundwater conditions. • Periodic inspections of cover conditions are appropriate to identify conditions such as excessive settlement or erosion that should be repaired. Routine inspections and timely repairs are critical to the long-term integrity of cover and rip rap revetment. Occasional repair should be expected.	• This alternative does not involve treatment.	• Currently, no human exposure to groundwater and no unacceptable risk to human health and the environment.	• Not applicable.	No additional cost.
Alternative 2 - Institutional Controls, Riverbank Stabilization, and Groundwater Monitoring	• Institutional controls would provide assurances that future groundwater exposure is prevented. • Potential exposure to landfill contents on the landfill surface is not addressed by this alternative. Future erosion and potential exposure along the riverbank is controlled. • Groundwater monitoring would detect future changes in groundwater quality, if any. • Periodic inspections of the riverbank conditions would be appropriate to identify conditions needing repair. Timely repairs are critical to long-term effectiveness of rock revetment. • A 5-year review would be appropriate to assess riverbank and groundwater conditions.	• This alternative does not involve treatment.	• Risks to on-site workers is controlled assuming adherence to OSHA requirements. The intent of the riverbank stabilization is to minimize excavation and cutting into the existing ground surface. • Risks to the community during construction is minimal. • The potential risk of groundwater exposure to groundwater sampling personnel would be controlled assuming strict adherence to OSHA requirements. • Currently, no human exposure to groundwater and no unacceptable risk to human health and the environment.	• Construction is straightforward and can be performed by most earthwork contractors. There are no anticipated problems or delays that would jeopardize the successful construction of this alternative. • Any adverse effect on the Kansas River flood hydrology due to filling in the floodplain must be evaluated.	Capital cost of $60,000 Annualized O&M of $42,000 Net present worth of $397,500

TABLE 4-2

EVALUATION OF PRIMARY CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS				
	Long-Term Effectiveness and Permanence	Reduction in Mobility, Toxicity, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost [1]
Alternative 3 - Native Soil Cover	• Institutional controls would provide assurances that future groundwater exposure is prevented. • Landfill cover and riverbank stabilization would provide controls to mitigate exposure of landfill contents at the ground surface. • Groundwater monitoring would detect future changes in groundwater quality, if any. • Periodic inspections of the landfill cover would be appropriate to identify conditions needing repair. Timely repairs are critical to long-term effectiveness of rock revetment and landfill cover. Because future settlement of the landfill is anticipated, repairs on the cover would be necessary to maintain adequate drainage.	• This alternative does not involve treatment. Because infiltration may be reduced slightly, the mobility of contaminants in the vadose zone may be reduced. Because other mechanisms of potential leachate generation are not controlled, reduction in infiltration may not have a significant beneficial impact on groundwater.	• Risks to on-site workers are controlled assuming adherence to OSHA requirements. The intent of the riverbank stabilization and landfill cover projects is to minimize excavation and cutting into the existing ground surface. • Risks to the community during construction are minimal. • The potential risk of groundwater exposure to groundwater sampling personnel would be controlled assuming strict adherence to OSHA requirements. • Currently, no human exposure to groundwater and no unacceptable risk to human health and the environment.	• Local borrow soil is available.	Capital cost of $1,630,000 Annualized O&M cost of $52,600 Net present worth of $2,125,000
Alternative 4 - Single Barrier Cover	• Same comments as Alternative 3. • Infiltration would be reduced and may reduce the potential for leaching of contaminants in the vadose zone and subsequent migration to the groundwater. Landfill contents may still come in contact with groundwater during periods of high water providing the potential for groundwater contamination. This alternative has no effect on this process.	• This alternative does not involve treatment. By reducing infiltration, the mobility of contaminants in the vadose zone may be reduced. Because other mechanisms of potential leachate generation are not controlled, reduction of infiltration may not have a significant beneficial impact on groundwater.	• Same comments as Alternative 3.	• Clay for hydraulic barrier is not available on site - would require approximately 20 mile haul.	Capital cost of $12,250,000 Annualized O&M cost of $52,600 Net present worth of $12,740,000

TABLE 4-2

EVALUATION OF PRIMARY CRITERIA
DETAILED ANALYSIS OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

ALTERNATIVE	EVALUATION COMMENTS				
	Long-Term Effectiveness and Permanence	Reduction in Mobility, Toxicity, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost
Alternative 6 - Hydraulic Containment of Groundwater	• Same comments as Alternative 3. • This alternative provides physical containment of groundwater in the landfill. • This alternative could control potential future on-site groundwater exposure if RGs were achieved in the aquifer. However, restoration of the on-site groundwater is not anticipated since the landfill contents would be a long-term potential source of groundwater contamination. If restoration is possible, cleanup would probably take decades.	• A recovery well and slurry wall control groundwater migration and reduce the mobility and volume of contaminated groundwater. Treatment of collected groundwater for organics would reduce the toxicity and volume of contamination in the groundwater.	• Same comments as Alternative 3.	• The installation of the slurry wall would require a geotechnical evaluation and coordination with various regulatory agencies and contractors. • A pilot wall or flexibility by the contractor during the initial phases of construction might be needed to identify an effective method of wall construction. The duration and cost of the slurry wall installation would depend upon how successful the contractor is with excavation and the type of waste which is excavated during the installation. • Design of the groundwater recovery system would require an aquifer test to confirm effectiveness and design parameters. • Design of the groundwater treatment system would require treatability testing to confirm effectiveness and design parameters.	Capital cost of $4,980,000 Annualized O&M cost of $170,000 Net present worth of $7,470,000
Alternative 7 - Groundwater Extraction, Treatment, and Discharge	• This alternative could effectively control the potential exposure to groundwater if the remediation goals were achieved in a reasonable time frame. However, restoration of the on-site groundwater is not anticipated since the landfill contents would be a long-term potential source of groundwater contamination. If restoration is possible, cleanup would probably take decades. • Same comments as Alternative 3.	• A recovery well collection system would create a hydraulic barrier at the landfill, reducing the mobility of groundwater contaminants. The collection of groundwater would reduce the volume of contaminated groundwater at the site. With the treatment of collected groundwater for organics, the toxicity and volume of contamination in the groundwater would be reduced.	• Same comments as Alternative 3.	• This implementation of a groundwater collection and treatment system should not present any significant or administrative difficulties. A treatment building would be required to contain the treatment system. The treatment system and building would be designed to function in a 50-year floodplain. The electrical equipment would be mounted above the flood elevation. • The selected treatment system is a proven process and the equipment is available from a number of vendors. • Design of the groundwater recovery system would require an aquifer test to confirm effectiveness and design parameters. • Design of the groundwater treatment system would require treatability testing to confirm effectiveness and design parameters.	Capital cost of $2,125,000 Annualized O&M cost of $325,000 Net present worth of $6,465,000

TABLE 4-3
COST PROJECTION FOR ALTERNATIVE 2
DRAFT FINAL FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

ALTERNATIVE 2 – INSTITUTIONAL CONTROLS, RIVERBANK STABILIZATION, AND GROUND-WATER MONITORING

COST ELEMENTS	UNIT OF MEASURE	UNIT COST	NUMBER OF UNITS	DIRECT COSTS SUBTOTAL LINE TOTAL
IMPLEMENTATION COST FOR INSTITUTIONAL CONTROLS				
ADMINISTRATIVE AND LEGAL FEES	LUMP SUM	$20,000		$20,000
COST OF NEW MONITORING WELL CLUSTER				
WELL INSTALLATION – (2) – 3 WELL CLUSTERS	LUMP SUM	$30,000		$30,000
SUBTOTAL CAPITAL COST				$50,000
CONTINGENCY @ 20%				$10,000
TOTAL CAPITAL COST FOR ALTERNATIVE 2				$60,000
LONG-TERM INSPECTIONS				
ANNUAL VISUAL INSPECTION WITH SUMMARY LETTER	PER ANNUM	$1,100	1	$1,100
30-YEAR NET PRESENT WORTH OF INSPECTIONS (@ 7% INTEREST)				$13,650
GROUNDWATER MONITORING				
FIELD EFFORT (SAMPLE 12 WELLS)	$/MANHOUR	$45	72	$3,240
REPORT PREPARATION	$/MANHOUR	$75	160	$12,000
SUPPLIES	$TOTAL	$500		$500
SHIPPING	$TOTAL	$500		$500
GROUNDWATER ANALYSIS				
VOCs (METHOD 8240)	$/SAMPLE	$225	14	$3,150
ANTIMONY	$/SAMPLE	$40	14	$560
LEAD	$/SAMPLE	$40	14	$560
TOTAL PER SAMPLING EVENT				$20,510
ASSUME SEMIANNUAL MONITORING IN YEARS 1 THROUGH 5 AND ANNUAL MONITORING IN YEARS 5 THROUGH 30.				
NET PRESENT WORTH OF GROUNDWATER MONITORING (@ 7% INTEREST)				$296,928
LONG-TERM MAINTENANCE				
ROCK REVETMENT REPAIRS				
MOBILIZATION/DEMOBILIZATION	LUMP SUM	$500	1	$500
REPLACE LOST REVETMENT	$/CY	$75	300	$22,500
PER EVENT TOTAL				$23,000
ASSUME REPAIRS PERFORMED IN YEARS 10, 20, AND 30				
30-YEAR NET PRESENT WORTH OF REPAIRS (@ 7% INTEREST)				$20,657
SUBTOTAL OF INSPECTIONS, MAINTENANCE, AND GW MONITORING				$331,235
CONTINGENCY @ 20%				$66,247
PRESENT WORTH COST OF INSPECTIONS, MAINTENANCE, AND GW MONITORING FOR ALTERNATIVE 2				$397,482

TOTAL CAPITAL COST	$60,000
TOTAL ANNUALIZED INSPECTIONS, MAINTENANCE, AND OPERATING COSTS	$42,133
PRESENT WORTH COST	$397,482

NOTE: Capital Cost of Riverbank Stabilization Project is not included in the Alternative cost because the contract was awarded January 13, 1994 and the project is scheduled for completion in Spring 1994.

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TABLE 4-4
COST PROJECTION FOR ALTERNATIVE 3
DRAFT FINAL FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

ALTERNATIVE 3 – NATIVE SOIL COVER

COST ELEMENTS	UNIT OF MEASURE	UNIT COST	NUMBER OF UNITS	DIRECT COSTS SUBTOTAL LINE TOTAL
IMPLEMENTATION COST FOR INSTITUTIONAL CONTROLS				
ADMINISTRATIVE AND LEGAL FEES	LUMP SUM	$20,000		$20,000
COST OF NEW MONITORING WELL CLUSTER				
WELL INSTALLATION	LUMP SUM	$30,000		$30,000
CONSTRUCTION COST OF NATIVE SOIL COVER				
SITE PREPARATION	$/ACRE	$1,500	120	$180,000
SOIL FILL AND REGRADING	$/C.Y.	$5.50	175000	$962,500
APPLY WEED KILLER, FERTILIZER, AND SEED	$/ACRE	$1,500	110	$165,000
SUBTOTAL COVER CONSTRUCTION COST				$1,307,500
SUBTOTAL CAPITAL COST				$1,357,500
CONTINGENCY AT 20 %				$271,500
TOTAL ESTIMATED CAPITAL COST				$1,629,000
GROUNDWATER MONITORING				
NET PRESENT WORTH OF GROUNDWATER MONITORING (@ 7% INTEREST) (SEE ALTERNATIVE 2, TABLE 4-3, NOT INCLUDING CONTINGENCY)				$296,928
LONG-TERM INSPECTIONS				
ANNUAL VISUAL INSPECTION WITH SUMMARY LETTER	PER ANNUM	$1,100	1	$1,100
30-YEAR NET PRESENT WORTH OF INSPECTIONS (@ 7% INTEREST)				$13,650
LONG-TERM MAINTENANCE				
CAP MAINTENANCE				
MOWING	PER ANNUM	$3,000	1	$3,000
30-YEAR NET PRESENT WORTH OF MAINTENANCE (@ 7% INTEREST)				$37,227
CAP REPAIRS				
MOBILIZATION/DEMOBILIZATION	LUMP SUM	$400	1	$400
FILL SETTLED AND ERODED AREAS	$/C.Y.	$20	500	$10,000
TOP SEED AND FERTILIZE	$/ACRE	$400	100	$40,000
ROCK REVETMENT REPAIRS				
MOBILIZATION/DEMOBILIZATION	LUMP SUM	$500	1	$500
REPLACE LOST REVETMENT	$/C.Y.	$75	300	$22,500
PER EVENT TOTAL				$73,400
ASSUME REPAIRS PERFORMED IN YEARS 10, 20, AND 30; 30-YEAR NET PRESENT WORTH OF REPAIRS (@ 7% INTEREST)				$65,923
SUBTOTAL OF INSPECTIONS, MAINTENANCE, AND GW MONITORING				$413,728
CONTINGENCY @ 20%				$82,746
NET PRESENT WORTH COST OF INSPECTIONS, MAINTENANCE, AND GW MONITORING FOR ALTERNATIVE 3				$496,474
TOTAL ESTIMATED NET PRESENT WORTH OF ALTERNATIVE 3				$2,125,474

TOTAL CAPITAL COST	$1,629,000
TOTAL ANNUALIZED INSPECTION MAINTENANCE, AND OPERATION COSTS	$52,626
TOTAL NET PRESENT WORTH	$2,125,474

NOTE: Capital Cost of Riverbank Stabilization Project is not included in the Alternative cost because the contract was awarded January 13, 1994 and the project is scheduled for completion in Spring 1994.

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TABLE 4-5
COST PROJECTION FOR ALTERNATIVE 4
DRAFT FINAL FEASIBILITY STUDY
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

ALTERNATIVE 4 – SINGLE BARRIER COVER

COST ELEMENTS	UNIT OF MEASURE	UNIT COST	NUMBER OF UNITS	DIRECT COSTS SUBTOTAL LINE TOTAL
IMPLEMENTATION COST FOR INSTITUTIONAL CONTROLS				
ADMINISTRATIVE AND LEGAL FEES	LUMP SUM	$20,000		$20,000
COST OF NEW MONITORING WELL CLUSTER				
WELL INSTALLATION	LUMP SUM	$30,000		$30,000
CONSTRUCTION COST				
MOBILIZATION/DEMOBILIZATION	LUMP SUM	$10,000	1	$10,000
TEMPORARY SILT FENCE	$/L.F.	$5.00	1500	$7,500
SURFACE PREPARATION	$/ACRE	$250	100	$25,000
PLACE FOUNDATION FILL	$/C.Y.	$4.00	295000	$1,180,000
PLACE GAS COLLECTION GEOSYNTHETIC	$/S.Y.	$4.50	484000	$2,178,000
INSTALL GAS VENTS	EA.	$500	100	$50,000
INSTALL GEOSYNTHETIC BARRIER	$/S.Y.	$4.00	484000	$1,936,000
INSTALL DRAINAGE LAYER GEOSYNTHETIC	$/S.Y.	$4.50	484000	$2,178,000
INSTALL FRENCH DRAIN FOR DRAINAGE LAYER	$/L.F.	$7.00	6000	$42,000
PLACE VEGETATIVE LAYER	$/C.Y.	$4.00	250000	$1,000,000
SEED, FERTILIZE, AND MULCH	$/ACRE	$2,000	100	$200,000
INSTALL EROSION CONTROL MAT IN SWALES	$/S.Y.	$4	6000	$24,000
SUBTOTAL				$8,830,500
ENGINEERING AT 15%				$1,324,575
SUBTOTAL CAPITAL COST				$10,205,075
CONTINGENCY AT 20 %				$2,041,015
TOTAL ESTIMATED CAPITAL COST				$12,246,090
GROUNDWATER MONITORING				
NET PRESENT WORTH OF GROUNDWATER MONITORING (@ 7% INTEREST) (SEE ALTERNATIVE 2, TABLE 4-3, NOT INCLUDING CONTINGENCY)				$296,928
INSPECTIONS AND MAINTENANCE				
NET PRESENT WORTH OF INSPECTIONS AND MAINTENANCE (SEE ALTERNATIVE 3, TABLE 4-4, NOT INCLUDING CONTINGENCY)				$116,800
SUBTOTAL OF INSPECTIONS, MAINTENANCE, AND GW MONITORING				$413,728
CONTINGENCY @ 20%				$82,746
PRESENT WORTH COST OF INSPECTIONS, MAINTENANCE, AND GW MONITORING FOR ALTERNATIVE 4				$496,474
TOTAL ESTIMATED NET PRESENT WORTH OF ALTERNATIVE 4				$12,742,564

NOTE: Capital Cost of Riverbank Stabilization Project is not included in the Alternative cost because the contract was awarded January 13, 1994 and the project is scheduled for completion in Spring 1994.

TOTAL CAPITAL COST	$12,246,090
TOTAL ANNUALIZED INSPECTION MAINTENANCE, AND OPERATION COSTS	$52,626
TOTAL NET PRESENT WORTH	$12,742,564

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TABLE 4-6
COST PROJECTION FOR ALTERNATIVE 6
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

ALTERNATIVE 6 – HYDRAULIC CONTAINMENT OF GROUND WATER

COST ELEMENTS	UNIT OF MEASURE	UNIT COST	NUMBER OF UNITS	DIRECT COSTS LINE TOTAL
EXTRACTION OF GROUND WATER				
CAPITAL COST				
POWER CONNECTION	$/FT	$14	2100	$29,400
RECOVERY WELL	$/WELL	$14,000	1	$14,000
(includes well installation for 1 well, approximately 8 inches diameter, 70 feet deep)				
VAULT	$/WELL	$2,500	1	$2,500
PUMP	$/WELL	$10,000	1	$10,000
DISCHARGE PIPING	$/FT	$56	700	$39,200
CIP CONCRETE FOR TRENCHING	$/FT	$21	2100	$44,100
PIPING FOR WELL	$/FT	$12	2100	$25,200
PUMP TEST				$250,000
CAPITAL COST SUBTOTAL				$414,400
CONTINGENCY @ 20%				$82,880
ENG. & DESIGN @ 10%				$41,440
TOTAL CAPITAL COST				$538,720
O&M COST				
EFFLUENT MONITORING	$/YEAR			$8,400
OPERATIONAL ASSISTANCE	$/YEAR			$20,000
MAINTENANCE	$/YEAR			$10,000
TOTAL O&M COST				$38,400
PRESENT WORTH COST FOR GW EXTRACTION				$1,015,227
NET PRESENT WORTH OF GROUNDWATER MONITORING (SEE ALTERNATIVE 2, TABLE 4-3, NOT INCLUDING CONTINGENCY)				$296,928
SLURRY WALL				
CAPITAL COST				
SLURRY WALL	$/SF	$6	500500	$3,003,000
(includes installation for slurry wall approximately 9100 ft long x 55 ft deep)				
CAPITAL COST SUBTOTAL				$3,003,000
CONTINGENCY @ 20%				$600,600
ENG. & DESIGN @ 5%				$150,150
TOTAL CAPITAL COST				$3,753,750
O&M COST	$/YEAR			$10,000
PRESENT WORTH COST FOR SLURRY WALL				$3,877,840
TREATMENT OF GROUND WATER @ 250 GPM				
SOLIDS/METALS REMOVAL				
CAPITAL COST				
FILTRATION SYSTEM	TOTAL		1	$15,000
(system includes filtration vessel based on 250 gpm flow)				
FILTER SCREEN	TOTAL		1	$25,000
SUMP PUMP	TOTAL		1	$600
CAPITAL COST SUBTOTAL				$40,600
CONTINGENCY @ 20%				$8,120
ENG. & DESIGN @ 10%				$4,060
TOTAL CAPITAL COST				$52,780
O&M COST				
SLUDGE DISPOSAL	$/TON	$50	68	$3,400
OPERATIONAL ASSISTANCE	$/YEAR			$20,000
MAINTENANCE	$/YEAR			$25,000
TOTAL O&M COST				$48,400
PRESENT WORTH COST				$653,378

TABLE 4-6 (Continued)
COST PROJECTION FOR ALTERNATIVE 6
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

AIR STRIPPING				
CAPITAL COST				
AIR STRIPPER (system includes one low profile air stripper and associated piping based on 250 gpm total flow)	TOTAL	$60,000	1	$60,000
CAPITAL COST SUBTOTAL				$60,000
CONTINGENCY @ 20%				$12,000
ENG. & DESIGN @ 10%				$6,000
TOTAL CAPITAL COST				$78,000
O&M COST				
MONTHLY CLEANOUT	$/CLEANOUT	$300	12	$3,600
OPERATIONAL ASSISTANCE	$/YEAR			$10,000
MAINTENANCE	$/YEAR			$2,000
TOTAL O&M COST				$15,600
PRESENT WORTH COST				$271,581
ACTIVATED CARBON ADSORPTION				
CAPITAL COST (system includes two carbon vessels holding 20000 pounds of carbon each)	TOTAL	$82,500	2	$165,000
CAPITAL COST SUBTOTAL				$165,000
CONTINGENCY @ 20%				$33,000
ENG. & DESIGN @ 10%				$16,500
TOTAL CAPITAL COST				$214,500
O&M COST				
CARBON REPLACEMENT	$/POUND	$0.96	40000	$38,400
OPERATIONAL ASSISTANCE	$/YEAR			$15,000
MAINTENANCE	$/YEAR			$4,000
TOTAL O&M COST				$57,400
PRESENT WORTH COST				$926,779
PRESENT WORTH COST FROM INSPECTIONS AND MAINTENANCE				$91,982
IMPLEMENTATION COST FOR INSTITUTIONAL CONTROLS (FROM ALTERNATIVE 2, TABLE 4-3)				$20,000
NET PRESENT WORTH OF LONG-TERM INSPECTIONS ($1,100/YR) (FROM ALTERNATIVE 2, TABLE 4-3)				$13,650
Treatment System Building Cost (Finished Cost)	$/SF	115	2800	$322,000

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TOTAL COST FOR ALTERNATIVE 6	
TOTAL CAPITAL COST	$4,979,750
O&M COST	$170,900
PRESENT WORTH COST	$7,469,365

TABLE 4-7
COST PROJECTION FOR ALTERNATIVE 7
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

ALTERNATIVE 7 – GROUND WATER EXTRACTION, TREATMENT AND DISCHARGE

COST ELEMENTS	UNIT OF MEASURE	UNIT COST	NUMBER OF UNITS	DIRECT COSTS LINE TOTAL
EXTRACTION OF GROUND WATER				
CAPITAL COST				
POWER CONNECTION	$/FT	$14	6800	$95,200
RECOVERY WELLS	$/WELL	$14,000	3	$42,000
(includes well installation for 3 wells, approximately 8 inches diameter, 70 feet deep)				
VAULTS	$/WELL	$2,500	3	$7,500
PUMPS	$/WELL	$10,000	3	$30,000
DISCHARGE PIPING	$/FT	$56	700	$39,200
CIP CONRETE FOR TRENCHING	$/FT	$21	6800	$142,800
PIPING FOR WELLS	$/FT	$12	6800	$81,600
PUMP TEST				$250,000
CAPITAL COST SUBTOTAL				$688,300
CONTINGENCY @ 20%				$137,660
ENG. & DESIGN @ 10%				$68,830
TOTAL CAPITAL COST				$894,790
O&M COST				
EFFLUENT MONITORING	$/YEAR			$8,400
OPERATIONAL ASSISTANCE	$/YEAR			$40,000
MAINTENANCE	$/YEAR			$15,000
TOTAL O&M COST				$63,400
PRESENT WORTH COST FOR GW EXTRACTION				$1,681,523
NET PRESENT WORTH OF GROUNDWATER MONITORING (SEE ALTERNATIVE 2, TABLE 4-3, NOT INCLUDING CONTINGENCY)				$296,928
TREATMENT OF GROUND WATER @1000 GPM				
SOLIDS/METALS REMOVAL				
CAPITAL COST				
FILTRATION SYSTEM	TOTAL		1	$40,000
(system includes filtration vessel based on 1000 gpm flow)				
FILTER SCREEN	$/SCREEN	$40,000	2	$80,000
SUMP PUMP	TOTAL	$1,500	1	$1,500
CAPITAL COST SUBTOTAL				$121,500
CONTINGENCY @ 20%				$24,300
ENG. & DESIGN @ 10%				$12,150
TOTAL CAPITAL COST				$157,950
O&M COST				
SLUDGE DISPOSAL	$/TON	$50	274	$13,700
OPERATIONAL ASSISTANCE	$/YEAR			$40,000
MAINTENANCE	$/YEAR			$50,000
TOTAL O&M COST				$103,700
PRESENT WORTH COST				$1,444,768

TABLE 4-7 (Continued)
COST PROJECTION FOR ALTERNATIVE 7
SOUTHWEST FUNSTON LANDFILL
FORT RILEY, KANSAS

AIR STRIPPING				
CAPITAL COST				
AIR STRIPPER (system includes three low profile air strippers and associated piping based on 1000 gpm total flow)	TOTAL	$60,000	3	$180,000
CAPITAL COST SUBTOTAL				$180,000
CONTINGENCY @ 20%				$36,000
ENG. & DESIGN @ 10%				$18,000
TOTAL CAPITAL COST				$234,000
O&M COST				
MONTHLY CLEANOUT	$/CLEANOUT	700	12	$8,400
OPERATIONAL ASSISTANCE	$/YEAR			$30,000
MAINTENANCE	$/YEAR			$6,000
TOTAL O&M				$44,400
PRESENT WORTH COST				$784,961
ACTIVATED CARBON ADSORPTION				
CAPITAL COST (system includes four carbon vessels holding 20000 pounds of carbon each)	TOTAL	$82,500	4	$330,000
CAPITAL COST SUBTOTAL				$330,000
CONTINGENCY @ 20%				$66,000
ENG. & DESIGN @ 10%				$33,000
TOTAL CAPITAL COST				$429,000
O&M COST				
CARBON REPLACEMENT	$/POUND	$0.96	80000	$76,800
OPERATIONAL ASSISTANCE	$/YEAR			$30,000
MAINTENANCE	$/YEAR			$8,000
TOTAL O&M COST				$114,800
PRESENT WORTH COST				$1,853,558
IMPLEMENTATION COST FOR INSTITUTIONAL CONTROLS (FROM ALTERNATIVE 2, TABLE 4-3)				$20,000
NET PRESENT WORTH OF LONG-TERM INSPECTIONS ($1,100/YR) (FROM ALTERNATIVE 2, TABLE 4-3)				$13,650
Treatment System Building Cost (Finished Cost)	$/SF	$115	3400	$391,000

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TOTAL COST FOR ALTERNATIVE 7	
TOTAL CAPITAL COST	$2,126,740
O&M COST	$327,400
PRESENT WORTH COST	$6,466,388

TABLE 4-8

COST PROJECTION SUMMARY
Southwest Funston Landfill
Fort Riley, Kansas

	Net Present Worth[1]
Alternative 1 — No Action	0
Alternative 2 — Institutional Controls, Bank Stabilization and Groundwater Monitoring	$395,000
Alternative 3 — Native Soil Cover	$2,125,000
Alternative 4 — Single Barrier Cover	$12,740,000
Alternative 6 — Hydraulic Containment	$7,470,000
Alternative 7 — Pump and Treat	$6,465,000

Note: [1] Cost rounded to nearest $5,000

5.0 COMPARATIVE EVALUATION

In this section, the results of the detailed evaluation (Section 4.0) are used to compare each alternative against the others based on the seven criteria. The first part of this section is a description of the evaluation system used in the comparative analysis. The remainder of the section is organized by each of the evaluation criteria. A summary matrix of the comparative analysis is provided in Table 5-1.

5.1 EVALUATION SYSTEM FOR COMPARATIVE ANALYSIS

This section describes the evaluation system used in the comparative analysis. The alternatives are scored on a pass/fail basis for the threshold criteria (protection of human health and environment, and compliance with ARARs). Those alternatives passing the threshold criteria are then evaluated on the basis of incremental differences between alternatives.

Some of the alternatives provide only slightly incremental benefit relative to a more easily implemented or less expensive alternative. Therefore, the comparative analysis considers the relative incremental differences between the alternatives. To meet this objective, a numerical system which utilizes a points system from -2 to +2 is used to compare incremental benefits in each criterion. The numerical criteria are summarized below.

- -2 Alternative has significant concerns, problems with implementability, site disturbance requirements, questions on effectiveness or significantly greater cost relative to other alternatives.
- -1 Has less desirable aspects relative to similar alternatives.
- 0 Is consistent with criteria, but does not provide added benefits or safety factors.
- +1 Provides identifiable benefits to alternatives which are consistent with criteria.
- +2 Has significant benefits relative to other alternatives.

The evaluations are summarized on Table 5-1. The totals column provided summarizes the competitive evaluation assuming each of the five criteria are weighted equally. It is understood that several factors influence the relative importance of each criteria and therefore the totals column should be viewed considering this aspect.

TABLE 5-1

COMPARATIVE EVALUATION OF ALTERNATIVES
Southwest Funston Landfill
Fort Riley, Kansas

Alternative	Overall Protection of Human Health and Environment[1]	Compliance with ARARs[1]	Long-Term Effectiveness and Permanence	Short-Term Effectiveness	Reduction of Mobility, Toxicity and Volume Through Treatment	Implementability	Cost	Total[3]
1	P/F[2]	P/F[2]	N/E	N/E	N/E	N/E	N/E	N/E
2	P	P	-1	+1	-1	+2	+2	+3
3	P	P	0	0	-1	+1	+1	+1
4	P	P	0	0	-1	0	-2	-3
6	P	P	+1	-1	0	-2	-2	-4
7	P	P	+1	-1	0	-1	-2	-3

(1) These are threshold criteria and are evaluated as either passing the criteria (P) or failing the criteria (F).

(2) The No Action Alternative is protective of human health and the environment and is in compliance with ARARs considering current site use. The No Action Alternative fails these criteria considering potential future groundwater use.

(3) The totals column is provided summarizing the competitive evaluation assuming each of the five criteria are weighted equally. It is understood that several factors influence the relative importance of each criterion and therefore the totals column should be viewed considering this aspect.

N/E - Not Evaluated

5.2 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The existing conditions are currently protective of human health and the environment because groundwater at the site is not currently used for drinking water and there is no unacceptable human exposure to the site. The no action alternative (Alternative 1) is not protective of human health and the environment considering a potential, future exposure from using the groundwater as drinking water.

The remaining alternatives provide protection against the potential exposure scenarios discussed above and therefore pass this criterion. For these alternatives, protection of human health is achieved with institutional controls that would prohibit the use of site groundwater.

5.3 COMPLIANCE WITH ARARs

The RI indicates that groundwater is the only environmental media at the site that has constituent levels above their corresponding chemical-specific ARARs. All the alternatives are currently in compliance with ARARs because use of groundwater with concentrations above MCLs is not occurring. Alternative 1 (no-action) does not, however, comply with ARARs considering a potential, future groundwater use scenario. Because the other alternatives include institutional controls prohibiting future groundwater use, compliance with ARARs is achieved. With appropriate design, all the alternatives would comply with location- and action-specific ARARs.

5.4 LONG-TERM EFFECTIVENESS AND PERMANENCE

Alternative 7 receives the highest ranking (+1) because the intent of the alternative is to eventually remove the groundwater contaminants from the aquifer.

Alternative 6 also involves groundwater recovery and therefore, also includes active restoration of the aquifer. Therefore, Alternative 6 receives a similar ranking. However, it is currently unknown how long the restoration of the aquifers to MCLs would require. Also, whether or not this restoration is technically feasible to the degree to which the alternatives would be effective in meeting the restoration objective is questionable. Several references indicate that restoration of contaminated groundwater to low concentration levels (ppb) may not be technically practicable or feasible.

Alternatives 3 and 4 are ranked similarly (0) because each alternative relies on institutional actions to prevent future groundwater use. Additionally, both alternatives include actions to prevent ponding and cover erosion which could potentially expose waste materials in the future. Alternative 4 does include a single barrier cover which minimizes or eliminates infiltration through the cover. However, since three leachate generation mechanisms exist at the Southwest Funston Landfill and the single barrier cover only addresses 1 of 3 mechanisms, the single barrier cover is expected to have similar long-term effectiveness to a native soil cover.

Alternative 2 received the lowest ranking (-1) because it relies on institutional controls to address future groundwater use and also does not involve actions which would address proper drainage and erosion on the existing cover.

5.5 SHORT-TERM EFFECTIVENESS

Alternative 2 is ranked highest (+1) because it does not involve on-site activities or disturbances of the cover.

Alternatives 3 and 4 are ranked similarly (0) because there would be no anticipated significant adverse impacts to the on-site workers, environment or community associated with their implementation. However, these alternatives do involve on-site work.

Since Alternatives 6 and 7 involve intrusive activity (i.e, drilling or slurry wall construction) and these alternatives would require conducting aquifer tests to confirm design, these alternatives are ranked lowest (-1) for short-term effectiveness.

5.6 REDUCTION OF MOBILITY, TOXICITY, AND VOLUME THROUGH TREATMENT

Alternatives 6 and 7 are ranked highest (0) because they involve recovery and treatment of groundwater and therefore provide some reduction of mobility, toxicity and volume through treatment. However, since groundwater contamination is characterized as isolated sporadic exceedances of RGs and because complete restoration of groundwater is expected to require long-term operation and may not be practical or feasible, the actual benefit of groundwater recovery and treatment may not be significant.

5.7 IMPLEMENTABILITY

Alternative 2 is ranked highest (+2) for implementability because the institutional controls are implemented readily.

Alternative 3 is ranked next highest (+1) because the removal action is currently under design and planned for construction. Additionally, native soil is readily available from a nearby borrow source.

Alternative 4 is ranked lower in implementability (0) than Alternative 3 because a local source of clay is not available. Implementing Alternative 4 would require use of an FML or hauling a significant distance from a clay borrow source.

Alternative 7 is ranked next (-1) because there are several issues that would require study if this alternative were pursued. The first issue is the pumping rate required to meet the alternative's objectives. An aquifer pumping test is required to address this issue. The pumping rate may be so high that treatment is impractical or cost prohibitive. The second issue is surface water discharge. The required flow rates would be excessive and may be difficult to discharge to the receiving stream. The third issue is the requirement for a treatability test for groundwater to confirm the treatment design and project costs.

Alternative 6 is ranked last (-2) because implementation of this alternative would involve aquifer testing as described above as well as further evaluation of site conditions which could make the construction of a slurry wall difficult.

5.8 COST

Alternative 2 is ranked the highest (+2) because this alternative involves minimum costs ($419,200) for implementation of institutional actions.

Alternative 3 is ranked next highest (+1) because the costs of this alternative ($1,120,000) are greater than alternative 2, but are significantly lower than alternatives 4, 6 and 7.

Alternatives 4, 6 and 7 are ranked the lowest (-2) because these alternatives are significantly greater in cost (i.e, in order of magnitude) than other alternatives.

5.9 SUMMARY

Alternative 2 is ranked higher in short-term effectiveness, implementability, and cost because it is easily implemented with minimal site disturbance and therefore is less costly. Alternative 2 is ranked lower in long-term effectiveness and reduction of mobility, toxicity, and volume through treatment since it does not improve the landfill cover or directly treat materials.

Alternative 3 is ranked higher than Alternative 2 for long-term effectiveness and permanence since it includes a native soil cover to improve landfill drainage and evapotranspiration. Because Alternative 3 includes some site disturbance for the cover placement at additional cost it is ranked lower than Alternative 2 in short-term effectiveness, implementability, and cost. Alternative 3 does not directly include treatment, therefore Alternative 3 is ranked similar to Alternative 2.

Alternative 4 is ranked similar to Alternative 3 in long-term effectiveness and permanence, short-term effectiveness and reduction of mobility, toxicity, and volume through treatment since these involve somewhat similar site activities and the use of a single barrier cover is not expected to significantly improve the long-term effectiveness. Alternative 4 is ranked lower than Alternative 3 in implementability and cost because a local clay source is not available and the use of a single barrier cover significantly increases the cost.

Alternative 6 is ranked higher in long-term effectiveness and permanence and reduction of mobility, toxicity, and volume through treatment because the alternative involves groundwater recovery and treatment. However, it is uncertain whether this will provide significant benefit. Alternative 6 is rated lower in short-term effectiveness, implementability, and cost because it involves additional design evaluation, potentially intrusive activities at the landfill and is significantly greater in cost than other alternatives.

Alternative 7 is ranked similar to Alternative 6 in each category except implementability, where Alternative 7 is ranked higher than 6 because it involves less design and potentially intrusive activities.

In summary, Alternatives 2 and 3 comply with ARARs, protect human health and the environment, are more easily implemented and therefore are lower in cost. Alternatives 4, 5, and 6 may provide limited additional benefit for more difficult implementation, greater short-term impacts and substantially greater cost.

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APPENDIX A

REMEDIATION GOAL CALCULATIONS

TABLE A-1

RISK-BASED REMEDIATION GOALS
Southwest Funston Landfill
Fort Riley, Kansas

CALCULATION OF RESIDENTIAL GROUNDWATER EXPOSURES
NONCARCINOGENIC EFFECTS FOR ADULTS
Ingestion, Inhalation, and Dermal Contact

$$THI = \frac{C \cdot IR_w \cdot EF \cdot ED_a}{RfD_o \cdot BW_a \cdot AT \cdot 365\ days/yr} + \frac{C \cdot K \cdot IR_a \cdot EF \cdot ED_a}{RfD_i \cdot BW_a \cdot AT \cdot 365\ days/yr} + \frac{C \cdot EF \cdot ED_a \cdot ET \cdot SA_a \cdot PC \cdot CF}{RfD_o \cdot BW_a \cdot AT \cdot 365\ days/yr}$$

$$+ \frac{C \cdot IR_w \cdot EF \cdot ED_c}{RfD_o \cdot BW_c \cdot AT \cdot 365\ days/yr} + \frac{C \cdot K \cdot IR_a \cdot EF \cdot ED_c}{RfD_i \cdot BW_c \cdot AT \cdot 365\ days/yr} + \frac{C \cdot EF \cdot ED_c \cdot ET \cdot SA_c \cdot PC \cdot CF}{RfD_o \cdot BW_c \cdot AT \cdot 365\ days/yr}$$

$$C\ (mg/L)_{risk\text{-}based} = THI \cdot AT \cdot 365\ days/yr \cdot \left[\frac{IR_w \cdot EF \cdot ED_a}{RfD_o \cdot BW_a} + \frac{K \cdot IR_a \cdot EF \cdot ED_a}{RfD_i \cdot BW_a} + \frac{EF \cdot ED_a \cdot ET \cdot SA_a \cdot PC \cdot CF}{RfD_o \cdot BW_a} + \frac{IR_w \cdot EF \cdot ED_c}{RfD_o \cdot BW_c} + \frac{K \cdot IR_c \cdot EF \cdot ED_c}{RfD_i \cdot BW_c} + \frac{EF \cdot ED_c \cdot ET \cdot SA_c \cdot PC \cdot CF}{RfD_o \cdot BW_c} \right]^{-1}$$

where:

Parameter		Definition	Adult	Child
TR	=	target risk (unitless)	1	1
C	=	chemical concentration in groundwater (mg/L)		
RfD_o	=	oral chronic reference dose (mg/kg-day)	chemical specific	
RfD_i	=	inhalation chronic reference does (mg/kg-day)	chemical specific	
IR_w	=	daily water ingestion rate (L/day)	2	2
IR_a	=	daily air inhalation rate (m^3/day)	20	20
SA	=	surface area of exposed skin (cm^2)	19,400	8,660
PC	=	permeability constant (cm/hr)	chemical specific	
K	=	volatilization factor (L/m^3)	0.5	0.5
EF	=	exposure frequency (days/yr)	350	350
ET	=	exposure time (hrs/day)	0.2	0.2
ED	=	exposure duration (yrs)	24	6
BW	=	body weight (kg)	70	15
AT	=	averaging time (yrs)	30	
CF	=	conversion factor (L/cm^3)	10^{-3}	

TABLE A-2

RISK-BASED REMEDIATION GOALS
Southwest Funston Landfill
Fort Riley, Kansas

CALCULATION OF RESIDENTIAL GROUNDWATER EXPOSURES
CARCINOGENIC EFFECTS FOR ADULTS
Ingestion, Inhalation, and Dermal Contact

$$TR = \frac{CSF_o \cdot C \cdot IR_w \cdot EF \cdot ED_a}{BW_a \cdot AT \cdot 365\ \text{days/yr}} + \frac{CSF_i \cdot C \cdot K \cdot IR_a \cdot EF \cdot ED_a}{BW_a \cdot AT \cdot 365\ \text{days/yr}} + \frac{CSF_o \cdot C \cdot EF \cdot ED_a \cdot ET \cdot SA_a \cdot PC \cdot CF}{BW_a \cdot AT \cdot 365\ \text{days/yr}}$$

$$+ \frac{CSF_o \cdot C \cdot IR_w \cdot EF \cdot ED_c}{BW_c \cdot AT \cdot 365\ \text{days/yr}} + \frac{CSF_i \cdot C \cdot K \cdot IR_c \cdot EF \cdot ED_c}{BW_c \cdot AT \cdot 365\ \text{days/yr}} + \frac{CSF_o \cdot C \cdot EF \cdot ED_c \cdot ET \cdot SA_c \cdot PC \cdot CF}{BW_c \cdot AT \cdot 365\ \text{days/yr}}$$

$$C\ (\text{mg/L})_{\text{risk-based}} = TR \cdot AT \cdot 365\ \text{days/yr} \div \left[\frac{CSF_o \cdot IR_w \cdot EF \cdot ED_a}{BW_a} + \frac{CSF_i \cdot K \cdot IR_a \cdot EF \cdot ED_a}{BW_a} + \frac{CSF_o \cdot EF \cdot ED_a \cdot ET \cdot SA_a \cdot PC \cdot CF}{BW_a} + \frac{CSF_o \cdot IR_w \cdot EF \cdot ED_c}{BW_c} + \frac{CSF_i \cdot K \cdot IR_c \cdot EF \cdot ED_c}{BW_c} + \frac{CSF_o \cdot EF \cdot ED_c \cdot ET \cdot SA_c \cdot PC \cdot CF}{BW_c} \right]$$

where:

Parameter		Definition	Adult	Child
TR	=	target risk (unitless)	1.0E-06	
C	=	chemical concentration in groundwater (mg/L)		
RfD_o	=	oral chronic reference dose (mg/kg-day)	chemical specific	
RfD_i	=	inhalation chronic reference does (mg/kg-day)	chemical specific	
IR_w	=	daily water ingestion rate (L/day)	2	2
IR_a	=	daily air inhalation rate (m^3/day)	20	20
SA	=	surface area of exposed skin (cm^2)	19,400	8,660
PC	=	permeability constant (cm/hr)	chemical specific	
K	=	volatilization factor (L/m^3)	0.5	0.5
EF	=	exposure frequency (days/yr)	350	350
ET	=	exposure time (hrs/day)	0.2	0.2
ED	=	exposure duration (yrs)	24	6
BW	=	body weight (kg)	70	15
AT	=	averaging time (yrs)	70	
CF	=	conversion factor (L/cm^3)	10^{-3}	

TABLE A-3

RISK-BASED REMEDIATION GOALS
Southwest Funston Landfill
Fort Riley, Kansas

CALCULATION OF RESIDENTIAL GROUNDWATER EXPOSURES NONCARCINOGENIC EFFECTS FOR CHILDREN
Ingestion, Inhalation, and Dermal Exposures

$$THI = \frac{C \cdot IR_w \cdot EF \cdot ED}{RfD_o \cdot BW \cdot AT \cdot 365\ days/yr} + \frac{C \cdot IR_a \cdot EF \cdot ED \cdot K}{RfD_i \cdot BW \cdot AT \cdot 365\ days/yr} + \frac{C \cdot PC \cdot SA \cdot ET \cdot EF \cdot ED \cdot CF}{RfD_o \cdot BW \cdot AT \cdot 365\ days/yr}$$

$$\underset{risk\text{-}based}{C\ (mg/L)} = THI \cdot AT \cdot 365\ days/yr \cdot \left[\frac{IR_w \cdot EF \cdot ED}{RfD_o \cdot BW} + \frac{IR_a \cdot EF \cdot ED \cdot K}{RfD_i \cdot BW} + \frac{PC \cdot SA \cdot ET \cdot EF \cdot ED \cdot CF}{RfD_o \cdot BW}\right]^{-1}$$

Where:

Parameter		Definition	Parameter Value (Child)
THI	=	target hazard index (unitless)	1
C	=	chemical concentration in surface water (mg/L)	
IR_w	=	daily water ingestion rate	2
IR_a	=	daily air inhalation rate (m^3/day)	20
SA	=	surface area of exposed skin (cm^2)	8,660
PC	=	permeability constant (cm/hr)	chemical specific
EF	=	exposure frequency (days/yr)	350
ET	=	exposure time (hrs/day)	0.2
ED	=	exposure duration (yrs)	6
K	=	volatilization factor (L/m^3)	0.5
RfD_o	=	oral chronic reference dose (mg/kg-day)	chemical specific
RfD_i	=	chronic inhalation reference dose (mg/kg-day)	chemical specific
BW	=	body weight (kg)	15
AT	=	averaging time (yrs)	6
CF	=	conversion factor (L/cm^3)	10^{-3}

REDUCED EQUATION: RECREATIONAL GROUNDWATER EXPOSURES FOR CHILDREN (NONCARCINOGENS)

$$\underset{risk\text{-}based}{C\ (mg/L)} = 1 \cdot 6\ years \cdot 365\ days/yr \cdot$$

$$\left[\frac{2\ L/day \cdot 350\ days/yr \cdot 6\ years}{RfD_o \cdot 15\ kg} + \frac{20\ m^3/day \cdot 350\ days/yr \cdot 6\ years \cdot 0.5\ L/m^3}{RfD_i \cdot 15\ kg} + \frac{PC \cdot 8{,}660\ cm^2 \cdot 0.2\ hrs/day \cdot 350\ days/yr \cdot 6\ years \cdot 10^{-3}\ L/cm^3}{RfD_o \cdot 15\ kg}\right]^{-1}$$

$$= \frac{2{,}190}{\dfrac{280 + (242.5 \cdot PC)}{RfD_o} + \dfrac{1{,}400}{RfD_i}}$$

APPENDIX B

PUMPING WELL ANALYSES

Analysis of Pumping Wells

The influence of a pumping well inside an area surrounded by a slurry wall was investigated using methods for analysis of drawdown in a finite aquifer (Bear, 1979). The simplifing assumptions used for the analysis were:

- negligible recharge through the landfill cap; and
- that pumping conditions and the groundwater gradient inside the slurry wall would be effectively seperated from changes in the direction of groundwater gradient outside the wall.

As the approximate landfill area is 120 acres, a circle with a circumference equal to the circumference of an 120-acre square was used as the conceptual model. A transmissivity value of 9,000 square feet per day (ft^2/day) and a pumping rate of 250 gallons per minute (gpm) were used during the analysis. These values, and the values used for the conductivity of the underlying bedrock, are based on the limited available data, and further study is necessary before final remedial system design can be performed. Recommended studies include aquifer testing of the alluvial deposits, packer testing of the underlying bedrock, and long-term monitoring of ground-water levels in the SFL area.

The capture zones of three recovery wells located in the areas of existing monitoring wells SFL92-501, SFL92-601, and SFL92-801 were investigated using the U.S. EPA WHPA computer program. The WHPA program is a modular semi-analytical flow model designed to assist in wellhead protection area delineation. The model's output displays flowlines which delineate capture zones. Capture zones are the zones surrounding the pumping well which will supply ground-water recharge to the well.

The simplifying assumptions used for the WHPA analyses were:

- unconfined aquifer conditions;
- an average ground-water gradient of 0.0005 feet/foot towards either the Kansas River (Figure 1), or towards Threemile Creek (Figure 2);
- a linear, fully penetrating stream boundary on the bottom edge of the model domain.

The scenarios considered during the WHPA analyses included discharge rates of 330 gpm, transmissivities of 9,000 ft^2/day, and simulation periods of ten years.

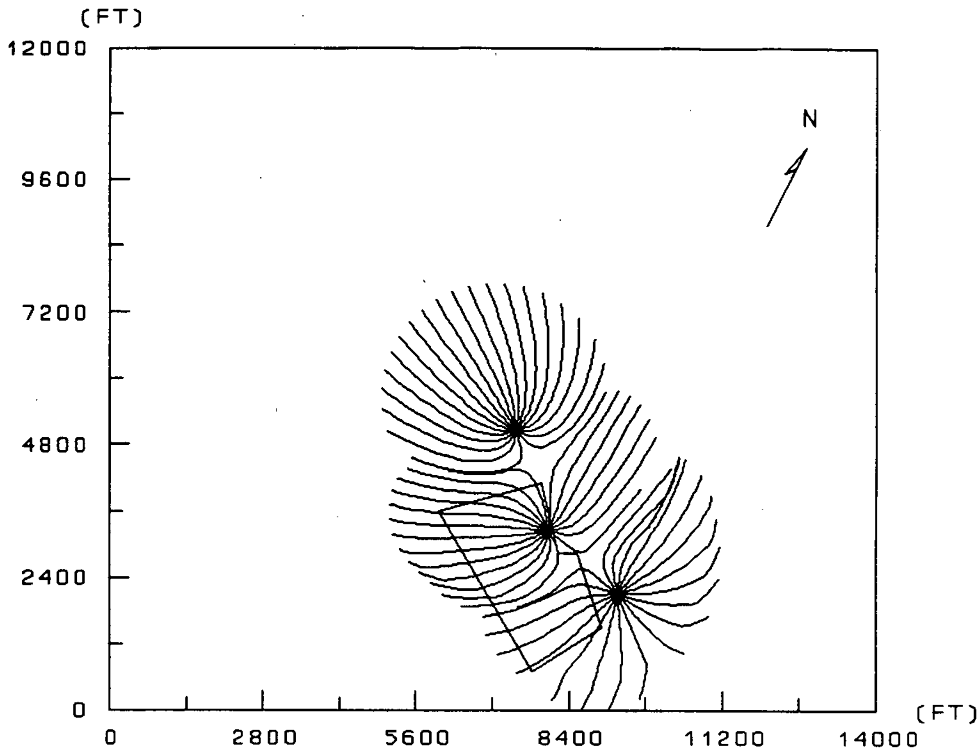

Figure 1 Flow Lines to Recovery Wells at SFL92-501, 601, and 801. Length of line illustrates distance ground-water will travel in ten years.

Number of Recovery (pumping) Wells 3
Average Aquifer Porosity 0.3
Water-table Aquifer Transmissivity (ft^2/day) 9,000
Saturated Aquifer Thickness (feet) 60
Average Water-table Gradient, rate (feet/foot) 0.0005
Average Water-table Gradient Orientation (degrees) 303
Flowline Simulation Period (years) 10

Fort Riley SFL
11-2537 .050
J. Quinn
12-10-1993

WELL NO.	APPROXIMATE WELL LOCATION		WELL RADIUS (FT)	EXTRACTION RATE (GPM)	RADIUS OF INF. (FT)
	X (FT)	Y (FT)			
501	9300	2100	0.25	330	3000.0
601	8200	3260	0.25	330	3000.0
801	7420	5080	0.25	330	3000.0

Results based on approximate locations of recovery wells at site.
Landfill, North arrow are approximate (for orientation and reference only).
Coordinate system is arbitrary.

Reference: U.S. EPA WHPA (Well Head Protection Area Delineation Code) GPTRAC Module (Semi-Analytical Option), T. N. Blandford and P.S. Huyakorn, International Ground Water Modeling Center, IGWMC-FOS 41 PC, Version 2.01, August 1991.

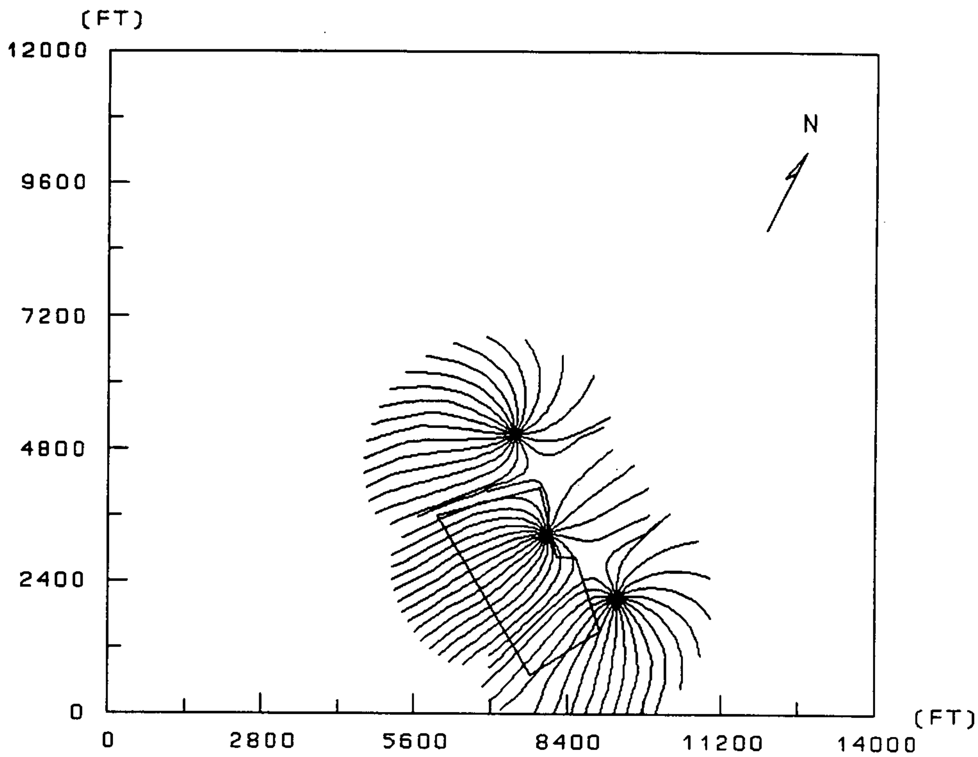

Figure 2 Flow Lines to Recovery Wells at SFL92-501, 601, and 801. Length of line illustrates distance ground-water will travel in ten years.

Number of Recovery (pumping) Wells 3
Average Aquifer Porosity 0.3
Water-table Aquifer Transmissivity (ft^2/day) 9,000
Saturated Aquifer Thickness (feet) 60
Average Water-table Gradient, rate (feet/foot) 0.0005
Average Water-table Gradient Orientation (degrees) 33
Flowline Simulation Period (years) 10

Fort Riley SFL
11-2537 .050
J. Quinn
3-16-1994

WELL NO.	APPROXIMATE WELL LOCATION		WELL RADIUS (FT)	EXTRACTION RATE (GPM)	RADIUS OF INF. (FT)
	X (FT)	Y (FT)			
501	9300	2100	0.25	330	3000.0
601	8200	3260	0.25	330	3000.0
801	7420	5080	0.25	330	3000.0

Results based on approximate locations of recovery wells at site.
Landfill, North arrow are approximate (for orientation and reference only).
Coordinate system is arbitrary.

Reference: U.S. EPA WHPA (Well Head Protection Area Delineation Code) GPTRAC Module (Semi-Analytical Option), T. N. Blandford and P.S. Huyakorn, International Ground Water Modeling Center, IGWMC-FOS 41 PC, Version 2.01, August 1991.

LAW ENVIRONMENTAL, INC.
a professional engineering and earth science consulting firm

JOB NO. 11-2537 SHEET 1 OF 1

JOB NAME Fort Riley SFL FS

BY J. Quinn DATE 3/16/94

CHECKED BY D. Polmann DATE 3/16/94

Fort Riley SFL Feasibility Study
Drawdown in a Finite Aquifer (from Bear, 1979)

Scenario: $r = 1450'$, $Q_w = 250$ gpm (48,128 ft³/day), $T = 9000$ ft²/day
$\lambda = 775$ ft, $R = 1455.5$ ft

where: r = radial distance, from pumped well, at which drawdown is calculated
Q_w = discharge of pumped well
T = transmissivity
λ = leakage factor
R = radius of circle with impervious boundary

Assuming a pumped well at the center of a circle with radius R, the solution is given by (from Bear, 1979)

$$s(r) = \frac{Q_w}{2\pi T}\left[K_o(r/\lambda) + I_o(r/\lambda)\frac{K_1(R/\lambda)}{I_1(R/\lambda)}\right]$$

where s = drawdown
K_o, I_o, K_1, I_1 = Modified Bessell Functions

$$s(r) = \frac{48{,}128 \text{ ft}^3/\text{d}}{(2)(\pi)(9{,}000 \text{ ft}^2/\text{d})}\left[K_o(1.9) + I_o(1.9)\frac{K_1(1.9)}{I_1(1.9)}\right]$$

$$s(r) = 0.85\text{ft}\left[0.1339 + 2.15\frac{0.1674}{1.4688}\right]$$ (from the table in Bear, 1979)

$$s(r) = 0.85\text{ft}[0.3789]$$

$$s(r) = 0.32 \text{ feet}$$

∴, the calculated drawdown at $r = 1{,}450$ ft (i.e, 5.5 feet inside impervious boundary with a radius of 1455.5 feet) is <u>0.32 feet</u>.

Notes: (a) The analysis was conducted assumming a system with an area of 120 acres. A square with this area would have a circumference of 9,144 feet. A circle with an equivalent circumference will have a diameter of 2911 feet, and a radius of 1455.5 feet. Therefore, the analysis was conducted using a circle with a radius of 1,455.5 feet.

(b) The leakage factor (λ) is given by

$\lambda^2 = \frac{B'BK}{K'}$ (assuming a B' of 200 ft and a K' of 10 ft/day)

where: B' = thickness of underlying semipervious layer
K' = conductivity of semipervious layer
B = assumed as 60 feet in the SFL area
K = 150 ft/day, assumed in the SFL area

APPENDIX C

REFERENCES FOR COST DOCUMENTATION

APPENDIX C

REFERENCES FOR DOCUMENTATION OF COST ALTERNATIVES 2, 3, AND 4 (TABLES 4-3, 4-4 AND 4-5) DRAFT FINAL FS REPORT, APRIL 1994

Costs for Alternative 2 are based on previous experience on similar projects

Alternatives 3 and 4 (Cover Construction)

Item	Quantity Basis	Unit Cost Basis
Mob/Demob	NA	Assumed (Previous Experience)
Temp. Silt Fence	Assumed	Assumed (Previous Experience)
Surface Preparation	Assumed	Assumed (Previous Experience)
Foundation Fill	USACE Preliminary Design Evaluation of Removal Action Cover	MEANS, large scraper, 5000 ft. haul (also compared to local contractor's rough estimate).
Gas Collection Geosynthetics	100 Ac (EE/CA)	Vendor's budgetary estimates
Gas Vents	1/Ac	Assumed (Previous Experience)
Geosynthetic Barrier	100 Ac (EE/CA)	Vendor's budgetary estimates
Drainage Layer Geosynthetics	100 Ac (EE/CA)	Vendor's budgetary estimates
French Drain for Drainage Layer & Swale	Estimated from Figure 3-2 of EE/CA	MEANS (inc. geotextile lining)
Vegetative Layer	100 Ac (EE/CA) x 1.5 feet thick	Same as foundation fill
Seed Fertilizer and Mulch	EE/CA Report	EE/CA Report
Erosion Control Mat in Swales	Same as French Drain (estimated from Figure 3-2 of EE/CA)	Vendor's budgetary quote

APPENDIX C

REFERENCES FOR DOCUMENTATION OF COST ALTERNATIVES 6 AND 7 (TABLES 4-6 AND 4-7) DRAFT FINAL FS REPORT, APRIL 1994

Ground Water Extraction

Power Connection Factor	-	Interpreted from CORA (Cost of Remedial Action, Version 3.0, USEPA)
Recovery Well	-	Law Environmental Estimate from Previous Well Installation Project
Vault	-	Law Environmental Estimate from Previous Well Installation Project
Pump	-	Law Environmental Estimate from Previous Well Installation Project
Discharge Piping Cost	-	Means Building and Construction Cost Data
CIP Concrete	-	Law Environmental Estimate from Previous Well Installation Project and Means Building and Construction Cost Data
Piping for Wells	-	Previous well installation and Means Building and Construction Cost Data
Pump Test	-	From Previous test performed

Slurry Wall (Alternative 6)

Slurry Wall	-	Previous project experience and estimate from slurry wall contractor

Solids/Metals Removal

Filtration System	-	Vendor Information
Filtration Screen	-	Vendor Information
Sump Pump	-	Previous procured pump
Air Stripper	-	Vendor Information
Activated Carbon System	-	Vendor Information
Carbon Cost	-	Supplier Information
Treatment System Building	-	Average Price from bid received on a recent building installation for a wastewater treatment system.
Operational Assistance	-	Based upon one person making $20,000 per year for extensive operating assistance equipment. $15,000 for less extensive operating equipment
Sludge Disposal Cost	-	Average disposal cost for non-hazardous sludge based upon current operating facilities