LIBRARY COPY

Headquarters, Air Combat Command
Langley Air Force Base,
Virginia

Closure Plan

Main Base Landfill Closure Project

June 1997

49th FIGHTER WING

49 CES/CEV
Holloman Air Force Base,
New Mexico

DCN 97.640311.08

CLOSURE PLAN

MAIN BASE LANDFILL CLOSURE PROJECT
HOLLOMAN AIR FORCE BASE, NEW MEXICO

FINAL

Prepared for:

49 CES/CEV
Holloman Air Force Base, New Mexico
and
HQ ACC/CEV
Langley Air Force Base, Virginia

Prepared by:

RADIAN INTERNATIONAL

Under Contract No. F46124-94-D-8049/0011

June 1997

DOUGLAS E. BELL
NEW MEXICO
6734
REGISTERED PROFESSIONAL ENGINEER

Douglas E. Bell
6-4-97

TABLE OF CONTENTS

Page

1.0 INTRODUCTION 1-1

2.0 PHYSICAL SETTING 2-1

2.1 Location 2-1
2.2 Climate 2-1
2.3 Geology 2-1
2.4 Topography 2-1
2.5 Hydrology 2-1
2.5.1 Surface Water 2-3
2.5.2 Groundwater 2-3

3.0 SITE DESCRIPTION 3-1

3.1 Operational History 3-1
3.2 Disposal Areas 3-1
3.3 Surface Conditions 3-3
3.4 Subsurface Conditions 3-4
3.5 Historical Groundwater Monitoring 3-4
3.6 Historical Landfill Gas Monitoring 3-4

4.0 SITE CLOSURE 4-1

4.1 Technical Approach 4-1
4.2 Proposed Capping Systems 4-2
4.3 Proposed Grading Plan 4-3
4.4 Final Cover Construction 4-3
4.5 Drainage 4-4
4.6 Slope Protection and Erosion Control 4-5
4.7 Stormwater Pollution Prevention 4-5
4.8 Site Security/Access 4-5
4.9 Removal of Structures 4-5
4.10 Construction Oversight 4-5
4.11 End Use 4-6
4.12 Schedule 4-6

5.0 ENVIRONMENTAL MONITORING 5-1

5.1 Groundwater Monitoring 5-1
5.2 Gas Monitoring 5-1

TABLE OF CONTENTS
(Continued)

Page

6.0 RECORDKEEPING AND CLOSURE CERTIFICATION 6-1

7.0 POSTCLOSURE CARE 7-1

7.1 Postclosure Monitoring 7-1
7.2 Inspection and Maintenance 7-1

8.0 REFERENCES 8-1

ATTACHMENT: Revegetation Plan

APPENDIX A: Proposed Grading Plan
APPENDIX B: Groundwater Monitoring Suspension Request
APPENDIX C: Soil Investigation Technical Memorandum
APPENDIX D: Performance Demonstration for Alternate Cap Design
APPENDIX E: Erosion Rate Calculations
APPENDIX F: Construction Quality Assurance Plan

LIST OF FIGURES

Page

2-1 Holloman AFB/Main Base Landfill Location 2-2

3-1 Main Base Landfill Disposal Areas 3-2

4-1 Main Base Landfill Closure Schedule 4-7

Section 1
INTRODUCTION

The purpose of this closure plan is to present a strategy for obtaining final closure of the Holloman Air Force Base (AFB) Main Base Landfill. This closure plan was developed in accordance with Title 20 of the New Mexico Administrative Code (NMAC), Chapter 9, Part 1 (20 NMAC 9.1—Solid Waste Management).

Holloman AFB has been in military service since 1942 and has maintained an active municipal waste landfill, the Main Base Landfill, since 1958. The Main Base Landfill ceased accepting municipal waste in July 1994, but continued accepting construction and demolition debris through April 1996. Disposal of asbestos-containing material in the asbestos portion of the landfill will end in October 1996.

Representatives of Holloman AFB and the New Mexico Environment Department (NMED) met in October 1995 to discuss the proposed plans for the landfill closure. It was determined from the meeting that existing funding did not allow for soils testing necessary to meet regulatory requirements. Following the meeting, a plan for investigating the soils was prepared and funding for the testing was requested. Following the request for funding, NMED and Holloman AFB met several times to discuss the plans proposed for the landfill closure. The funding for the soil investigation was approved and the investigation was conducted in April 1996. The results of the soil investigation, in combination with historical information, have been used to develop this closure plan.

The submittal of this closure plan constitutes Holloman AFB's notice of intent to close the Main Base Landfill (as required by 20 NMAC 9.1, Section 501.D); however, as discussed and agreed upon in a November 1995 meeting between Holloman AFB and the NMED, federal funding constraints will prevent the Base from completing closure activities within the 180-day time period specified in the regulations (20 NMAC 9.1, Section 502.A.5).

Section 2
PHYSICAL SETTING

2.1 Location

Holloman AFB is located on U.S. Highway 70-82 in Otero County, seven miles southwest of Alamogordo in south-central New Mexico. The landfill, known as the Main Base Landfill, is located entirely within the boundaries of Holloman AFB (Figure 2-1). The landfill lies within Sections 1 and 12, T 17 S, R 8 E of the USGS 7.5-minute map of Holloman Quadrangle, New Mexico.

2.2 Climate

Average daily temperatures at Holloman AFB vary from the low 40s°F in the winter to the low 80s°F in the summer. According to monthly rainfall totals from 1943-1995, as reported in the *Lake Holloman Water Balance Study* (Parsons Engineering Science, 1995), rainfall in the area averages approximately 8.5 in. per year, with more than 50% of each yearly amount occurring during the months of July, August, and September. Pan evaporation data from the same sources averages 7.5 ft per year. Lake evaporation, used to approximate mean annual evapotranspiration, is generally accepted to equal approximately 75% of pan evaporation (5.7 ft per year). As a result, the net precipitation (mean annual precipitation minus mean annual evapotranspiration) for the Holloman AFB area is approximately -60 in. per year, typical of an arid environment.

2.3 Geology

Holloman AFB is situated in the central portion of the Tularosa Basin, a north-south trending basin bounded on the east by the Sacramento Mountains and on the west by the San Andres Mountains, which are actually tilted fault blocks. The basin is the central area that collapsed between fault scarps on either side of the valley. The basement rock of the basin lies thousands of feet below the ground surface, and the overlying basin fill consists largely of unconsolidated sediments originating from weathering of the surrounding mountains. Having been eroded from the mountains and transported by various means, the sediments in the central portion of the basin are heterogeneous, consisting predominantly of fine-grained sands, silts, and clays, grading out to coarser material near the mountains. Similarly, subsurface soils in the vicinity of the landfill are typically fine-grained and highly variable, consisting of sands and silty sands with interbedded lenses of clays.

2.4 Topography

The area within the Tularosa Basin is fairly flat, with surface elevations in the range of 4000 ft above mean sea level (msl). The surrounding mountains rise more than 3000 ft above the basin floor. The natural ground surface within the Main Base Landfill is fairly level, beginning at elevations of approximately 4096 ft above msl in the southernmost portion of the landfill and sloping upward toward the northernmost portion where elevations are approximately 4118 ft. The proposed grading plan (Appendix A) shows the existing site topography as of December 1994. The ground surface north of the arroyo has been elevated as a result of disposal activities and ranges from 4119 to 4125 ft above msl. Elevations of the arroyo floor within the landfill area range from 4082 to 4095 ft above msl, approximately 13 to 32 ft below the surrounding ground surface, with bank slopes ranging from 6% to 50%, with the steeper side slopes resulting from disposal operations along the arroyo banks.

2.5 Hydrology

The Tularosa Basin is a closed basin; neither groundwater nor surface water discharge to any unit outside of the basin. Water is gained through precipitation and is lost to evaporation, transpiration, and infiltration, or collects in local low points (playas).

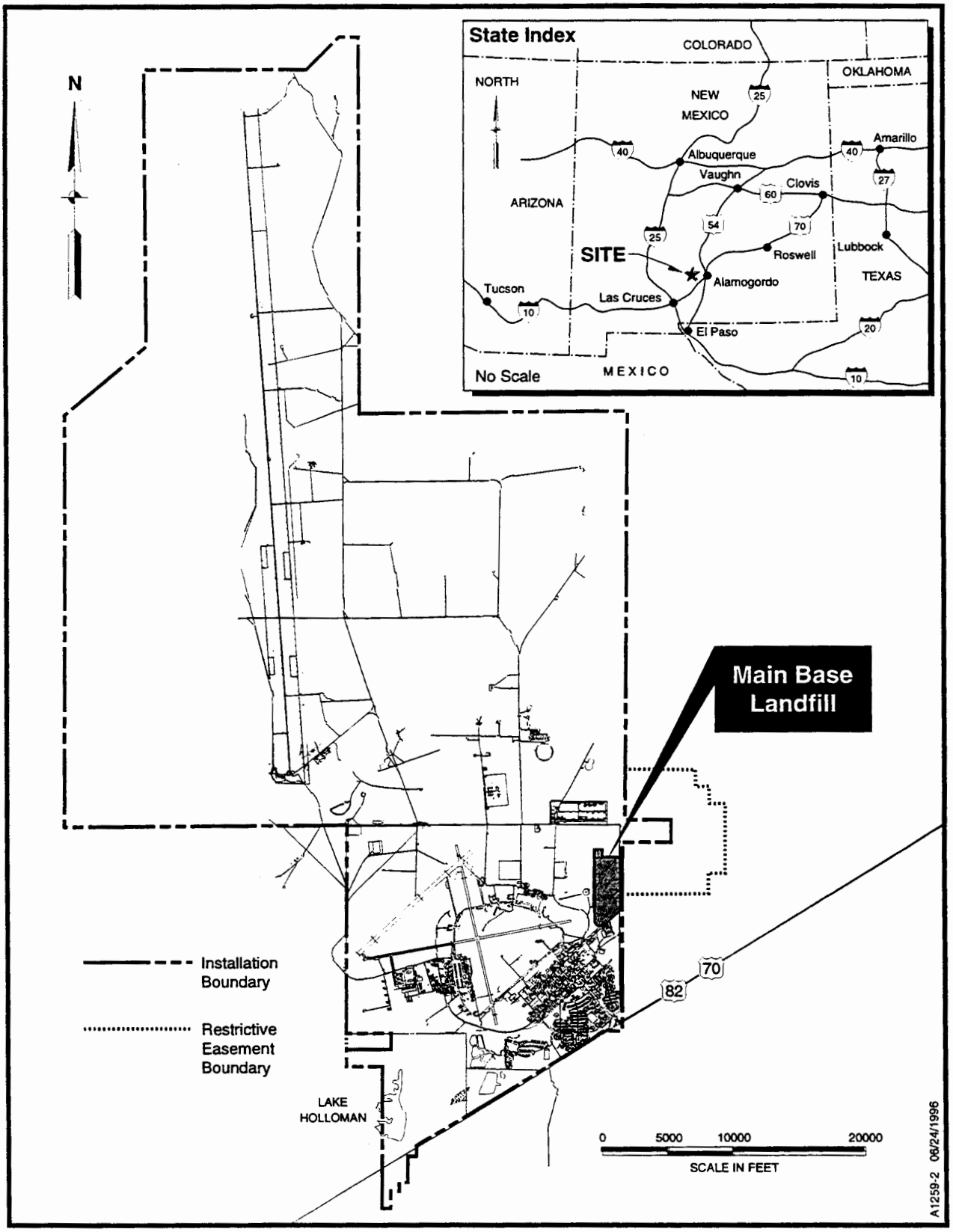


Figure 2-1. Holloman AFB/Main Base Landfill Location

2.5.1 Surface Water

No perennial streams or rivers exist within the basin; however, there are several ephemeral streams ("arroyos" or "draws"). Surface water drainage features within Holloman AFB consist of several southwest-trending arroyos, one of which runs through the Main Base Landfill area. The arroyo enters the landfill area at the northeast corner and leaves through a culvert under the railroad that crosses the arroyo and forms the southern boundary of the area. The arroyo (part of the north fork of Dillard Draw) joins the main channel of Dillard Draw approximately 1500 ft downstream (south) of the culvert. The 100-year flood water surface elevation in the arroyo has been estimated by the U.S. Army Corps of Engineers at 4098 ft above msl (Holloman AFB Master Plan, Tab F—Flooded Areas, December 1972). This water surface will submerge the construction/demolition debris disposal areas within the arroyo (see Section 4), but municipal disposal areas will not be flooded.

Surface water drainage within the landfill area flows overland and into the arroyo, where during most storm events it ponds on the arroyo bed and eventually dissipates through infiltration and/or evaporation. During some very wet years, a small pond may appear in the southern portion of the landfill upstream of the culvert. The pond may last for several months, but does not persist throughout the year.

2.5.2 Groundwater

The sediments comprising the Tularosa Basin fill are believed to be almost completely saturated from the basement rock to the near surface. The primary recharge source for the basin aquifer is percolation of rainfall through coarse alluvial fan deposits near the base of the mountains. Groundwater in the Holloman AFB area is seasonally variable and generally flows to the southwest, following surface drainage features. Within the Main Base Landfill area, groundwater is approximately 20 to 30 ft below the ground surface, and is very shallow beneath the arroyo bed (5 to 10 ft below the surface).

A small portion of the groundwater stored in the Tularosa Basin is freshwater, found mainly along the mountain ranges. Groundwater becomes progressively more mineralized toward the interior of the basin owing to slow groundwater migration from recharge to discharge areas and the presence of readily soluble minerals in the sediments. Most of the groundwater in the basin interior, including the Holloman AFB area, is not fit for human consumption, based on New Mexico Water Quality Standards (20 NMAC 6, Sections 3100 through 3103, as amended through 27 October 1995) because it exceeds Human Health Standards (HHSs) for total dissolved solids (TDS) and sulfate. For more information on local groundwater movement and quality, refer to the Groundwater Monitoring Suspension Request (Appendix B).

Section 3
SITE DESCRIPTION

The following sections describe the Main Base Landfill through summarization of pertinent operation, disposal, and monitoring information. Data used in the compilation of this section were gathered through interviews, review of past documents, review of historical maps and photographs, and field investigations.

3.1 Operational History

As stated previously, the Main Base Landfill has been in operation since 1958. Disposal of municipal waste in the landfill ceased in July 1994 and disposal of construction/ demolition debris was discontinued in April 1996. Disposal of asbestos-containing material in the asbestos portion of the landfill is anticipated to continue through October 1996.

All waste disposed of in the Main Base Landfill originated from Holloman AFB and White Sands Missile Range. Types of waste disposed of in the Main Base Landfill included nonhazardous household and industrial wastes, construction/ demolition debris, and asbestos-containing waste. Infectious and hazardous wastes generated by the Base Hospital and Primate Research Facility have not been disposed of in the landfill.

Landfill disposal has occurred entirely below grade. Waste was disposed of in long, narrow trenches, approximately 25 ft wide and varying in length. From landfill disposal records, the average depth of trenching was approximately 20 to 25 ft deep. Soil from trench excavation was stockpiled for use as cover material. Some wood debris and other construction materials have been disposed of on the surface.

3.2 Disposal Areas

The Main Base Landfill area encompasses approximately 228 acres. The landfill includes municipal waste disposal areas (approximately 100 acres), construction debris disposal areas (16 acres), and asbestos disposal areas (9 acres). Approximately 103 acres within the landfill boundary have not been used for disposal. These unused areas include the arroyo bed (40 acres, not including debris disposal areas) and other upland unused space (approximately 45 acres in the southwest portion, 12 acres surrounding disposal areas M2 and C3, and 6 acres north of Area M1).

Little information on waste disposal prior to 1974 is available; however, by reviewing available records, results of the landfill soil investigation (Appendix C), and historical aerial photography and topographic maps, the various disposal areas within the landfill were more accurately delineated and the types of waste defined. Two municipal waste disposal areas (hereafter referred to as M1 and M2) and three construction/demolition debris disposal areas (C1, C2, and C3) were identified. The known asbestos waste disposal area is named A1. These areas are shown in Figure 3-1 and are further described below.

- **Area A1** (9 acres)—The asbestos disposal area is separated from the other landfill areas by a fence. Originally occupying a portion of the northwest corner of the landfill area, the asbestos landfill was expanded in early 1990 with the addition of an 8-acre tract to the north. Prior to the establishment of an asbestos-only disposal area, some asbestos-containing debris was disposed of within the municipal areas, but the location of such material is unknown.

- **Area M1** (72 acres)—This large municipal waste disposal area lies north and northwest of the arroyo and consists of many individual disposal trenches.

Landfill disposal records indicate that material buried within this area consists mainly of household waste and construction debris. Area M1 has been divided into two areas. Area M1-A (63 acres) consists of municipal waste disposal trenches overlain by more recent construction/demolition debris and soil stockpiles on the surface. Area M1-B (9 acres) consists of older municipal waste trenches with no overlying debris; most trenches in this area have experienced some subsidence, and native vegetation has been established in the cover material. The area south of the marked southern boundary of Area M1 appeared to have been cleared in preparation for use at one time, but no municipal waste was encountered in the area during the soil investigation. A great deal of construction/ demolition debris and soil/debris stockpiles occupy the surface of Area M1 north of the arroyo.

- **Area M2** (28 acres)—This municipal waste disposal area south and east of the arroyo appeared to have been undisturbed for a long period of time. Large cacti up to 4 ft in height were growing on top of obvious trench depressions, along with a substantial amount of other native ground cover. Many trenches exhibited a noticeable amount of subsidence (ranging from approximately 6 in. to 1.5 ft). A study of aerial photography and topographic maps indicated that the area had not been used for disposal since 1986 or earlier.

- **Areas C1 and C2** (4 acres, 7 acres)—These construction/demolition debris disposal areas are located within the original banks of the arroyo and consist mainly of large pieces of concrete rubble that have been covered with soil. At certain locations, some of the cover soil had filtered through the rubble, leaving holes through which concrete rubble was visible. A review of 1988 and 1995 topographic maps indicated that material was placed and covered in these areas prior to 1986.

- **Area C3** (5 acres)—Only construction debris was found within this area adjacent to Area M2. Area C3 appears to be somewhat more recently used than Area M2; however, like Area M2, C3 appears to have been undisturbed for many years. The same observation of aerial photography and topographic maps performed for Area M2 indicated that Area C3 had not been used since at least 1986.

3.3 Surface Conditions

There are no open trenches at the Main Base Landfill; all disposal cells have been covered with soil reserved during trench excavation. Some trenches in older disposal areas have experienced up to 1.5 ft of subsidence. Older disposal areas typically have a significant amount of native vegetation; newer areas west of the arroyo are bare in some locations. Surface debris such as broken glass exists in a few isolated areas, and a number of used tires lie scattered about within the arroyo channel.

A total of 125 shallow (no deeper than 9 ft) borings were performed throughout the landfill during the landfill soil investigation in April 1996. Samples for geotechnical testing were collected at 64 of the 125 borings. Observation of soil from the borings revealed that existing cover soil consists primarily of silt or silty sand, having an average hydraulic conductivity (permeability) of 3.7×10^{-4} cm/sec. Depth-to-waste measurements made during the soil investigation indicated that most of the disposal areas have an adequate amount of cover material compared with cover material thicknesses required for closure by NMED: a total of 6 in. topsoil plus 18 in. low-permeability soil for municipal disposal areas, 30 in. compacted soil (no

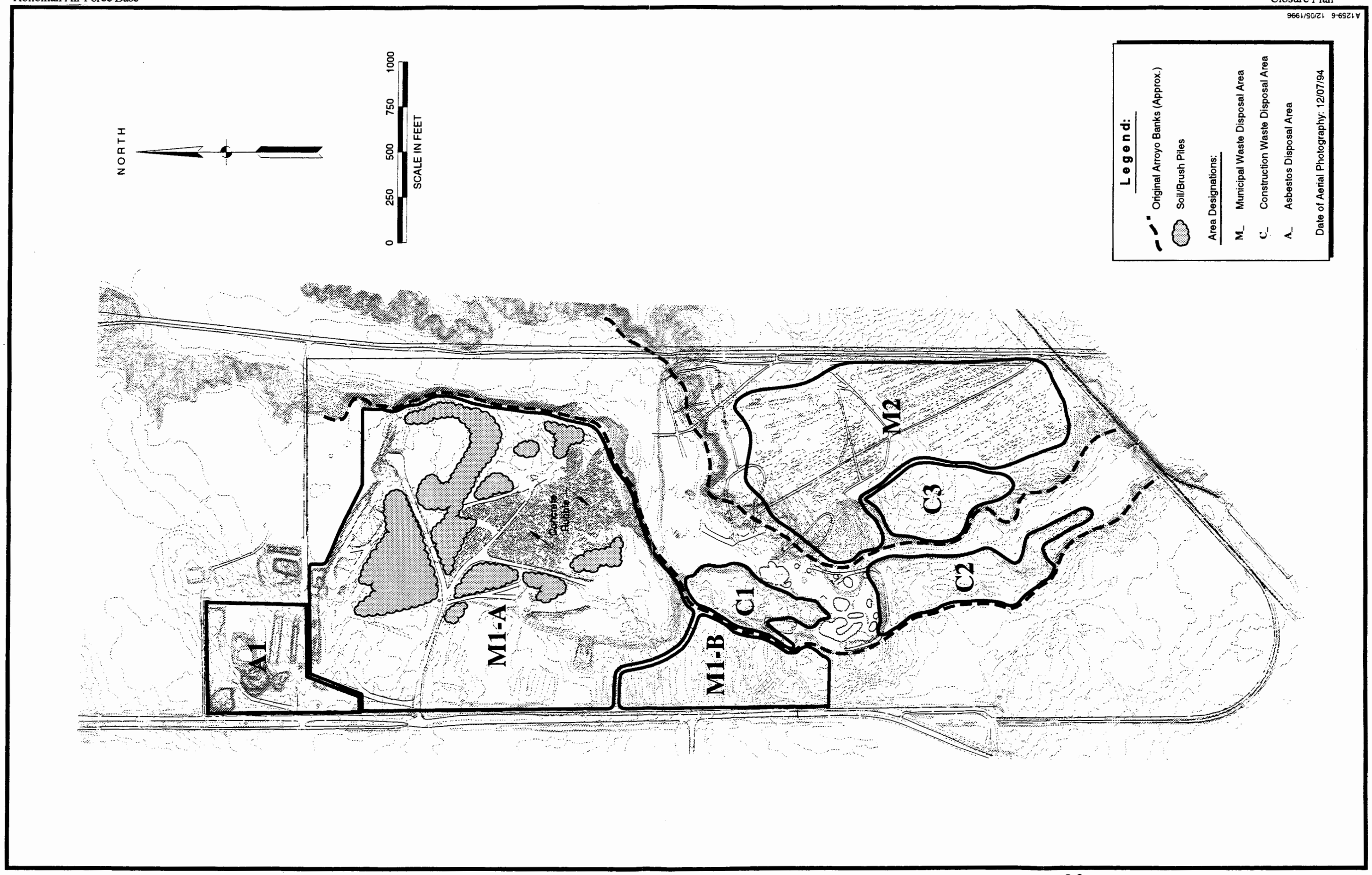


Figure 3-1. Main Base Landfill Disposal Areas

permeability requirement) for construction debris disposal areas, and 36 in. compacted soil for asbestos areas. Waste or debris was encountered at a depth less than the required depth in 20 of the 125 cover borings, including one cover boring within the asbestos landfill area (at 24 in., 6 in. less than the required 36 in.). More information on cover soils, including sample locations, cover thickness results, geotechnical results, and visual observations is contained in the Soil Investigation Technical Memorandum (Appendix C).

3.4 Subsurface Conditions

Local subsurface soil conditions at the landfill were defined through direct observation of drilling operations at nine soil borings performed during the landfill soil investigation. Six borings advanced along the landfill perimeter encountered alternating, discontinuous layers of sand, silty sand, silt, and clay. The sediments were generally very heterogeneous and could not be correlated from one boring to another. The discontinuous and variable nature of these units is common within the alluvial environment of the Tularosa Basin (described in Section 2). Units encountered in three borings advanced within the arroyo consisted mainly of finer grained, clayey material deposited within the arroyo channel that could not be accurately correlated with any unit observed in perimeter borings.

No evidence of a continuous clay or other single low-permeability unit underlying the landfill was found. Groundwater was encountered at similar elevations in perimeter (approximately 23 to 28 ft below ground surface) and arroyo (approximately 5 ft below ground surface) soil borings, trending downward toward the southwest. No evidence of water or leachate seeps was apparent along the banks of the arroyo. Detailed information on the subsurface portion of the landfill soils investigation is presented in the associated Technical Memorandum (Appendix C), including soil boring logs, cross sections, and geotechnical results.

3.5 Historical Groundwater Monitoring

Phase I and II Remedial Investigations have been conducted at the Main Base Landfill as part of the U.S. Air Force's (USAF) Installation Restoration Program (IRP). The IRP is a program that implements the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) for the USAF. The IRP investigations resulted in an NMED-approved No Further Action (NFA) recommendation for the landfill (IRP Site 1) on the basis that all constituent (i.e., volatile and semivolatile organic compounds, organochlorine pesticides/polychlorinated biphenyls, total recoverable petroleum hydrocarbons, and metals) concentrations were detected below levels that would pose an unacceptable risk to human health or the environment (Walk, Haydel, and Associates, 1989).

A long-term groundwater monitoring program is currently in place to monitor groundwater quality upgradient and downgradient of the landfill as a condition of the NFA decision. The purpose of the long-term monitoring is to detect any release or potential future release of contaminants from the landfill to the groundwater. Under the long-term monitoring program, four wells in the landfill vicinity are sampled biennially for volatile organic compounds, organochlorine pesticides, Resource Conservation and Recovery Act (RCRA) metals, iron, manganese, and water quality parameters. Results of the long-term monitoring events are submitted to the NMED Groundwater Bureau; no impact to groundwater quality has been attributed to the landfill.

3.6 Historical Landfill Gas Monitoring

Prior to 1996, several instances of informal gas sampling had occurred at the landfill. Inspection records state that during a routine landfill inspection on 7 May 1993, an NMED representative monitored for methane in six landfill cells completed during the previous year and detected no gas at any location. In 1995, Holloman AFB personnel drove sampling tubes into the soil at several locations to test for gas generation; no

methane was detected. Also, neither organic nor explosive vapors were detected during breathing zone/borehole air monitoring at the 125 shallow (less than 9 ft deep) boreholes advanced throughout the landfill disposal areas during the soil investigation in April 1996.

In response to regulatory requirements (20 NMAC 9.1, Section 402.C) for methane monitoring at the Main Base Landfill, Holloman AFB installed 32 gas monitoring probes approximately 400 ft apart around the perimeter of the landfill in February 1996, and soon afterward initiated quarterly landfill gas monitoring. No methane was detected in any sample collected from any probe during either of the first two quarterly sampling events that have occurred to date.

Section 4
SITE CLOSURE

4.1 Technical Approach

The condition and content of each landfill area have been considered in light of regulatory requirements in order to develop a technical approach to closure. The proposed method of closing the landfill in its entirety has the following goals for each area (see Figure 3-1 for area locations).

- **Area A1**—One cover boring performed within the asbestos disposal area during the soil investigation found insufficient cover thickness and other borings performed in the asbestos area proved to be inconclusive as far as overall existing cover thickness. Since the asbestos material poses the greatest potential threat to human health should exposure occur, the entire A1 area will be covered with a minimum of 24 in. of soil so that waste (assumed to be buried at least 12 in. deep) is covered by the total thickness of soil required by NMED regulations (36 in.).

- **Area M1**—Area M1-A will be capped to provide a minimum 27 in. cap over any waste layer. The final cover surface shall be graded to meet the NMED-recommended range of allowable cover slopes (minimum 2%/maximum 5%) and side slopes (equal to or less than 25%). The cover material shall be selected and installed so that the in-place permeability is equal to or less than that of the existing cover material (3.7×10^{-4} cm/sec). This proposed cover system is shown to provide equivalent protection against infiltration as that provided by the cover system prescribed by NMED regulations. The demonstration of the proposed system's performance is presented in Appendix D. The older portion of this area, Area M1-B, will not require a cap (per NMED); the existing grade across this area is approximately 2%, and a significant amount of native vegetation has been established over the years. However, trenches in this area that have subsided more than 1 ft below surrounding grade will be filled. Also, any trenches where surface sampling (see Soil Investigation Technical Memorandum, Appendix C) indicated inadequate cover depth will be filled such that the required cover thickness is achieved.

- **Area M2/C3**—Studies of aerial photographs and topographic maps indicate that the municipal disposal area M2 and adjacent construction debris disposal area C3 have not been used since 1988 or earlier. Although all of the trenches in the M2 area have experienced some degree of subsidence, extensive regrading would disturb the fragile native vegetation that has been established on the existing cover material. Also, it would be expected that if any impact to the groundwater had occurred as a result of these old areas, it would have been detected during ongoing IRP groundwater monitoring. Since no groundwater results have indicated damage to groundwater quality, since significant native vegetation has been established, and since this area was abandoned prior to the effective date of the Solid Waste Act (March 5, 1990), no action is proposed for the closure of this area other than cleanup of any surface debris, filling any trenches in Area M2 that have subsided more than 1 ft or that have inadequate cover (see Area

M1-B approach above), and filling and regrading any surface voids caused by cover material filtering into subsurface voids within the buried rubble in Area C3.

- **Areas C1 and C2**—Observations made during the landfill soil investigation along with studies of aerial photography dating back to the 1940s have shown that these areas are construction/demolition debris disposal areas placed within the arroyo banks prior to 1988. Most of the material buried in these areas appears to consist of large concrete rubble with some asphalt. Since the material disposed of in these areas is neither hazardous nor putrescible and was placed before the effective date of the Solid Waste Act, no action is proposed for the closure of these areas other than localized filling of surface voids.

In summary, only Areas A1 and M1-A will be capped as part of the closure activities. Voids caused by cover subsidence within Areas C1, C2, and C3 will be spot filled. Trenches that have subsided more than 1 ft in Areas M1-B and M2 will be filled to surrounding grade; also, any trenches in these areas where cover thickness was insufficient (see Soil Investigation Technical Memorandum, Appendix C) will receive additional cover, as necessary. In support of the closure of the entire landfill area, surface debris in any area that will not be capped will be removed. Brush piles in Area M1-A will be moved to the Base composting facility; concrete and asphalt rubble piles within Area M1-A will be crushed and used for riprap/slope armor or fill material on site or transferred to a recycling facility on Base for use as construction material. Other clean soil piles in Area M1-A will be used as fill material.

4.2 Proposed Capping Systems

The following paragraphs describe the proposed capping systems for Areas A1 and M1.

- **Area A1 Cap**—NMED regulations require a total of 36 in. of compacted soil as a final cover (no permeability requirement) over asbestos layers. It is assumed that there is a minimum of 12 in. of cover over waste layers. As a result, a minimum of 24 in. of cover will be placed over the entire area to meet the required 36 in. thickness and ensure protection of human health and the environment.

- **Area M1-A Cap**—NMED Solid Waste Regulations require a cap on all municipal disposal areas consisting of 18 in. of low-permeability material and a 6-in. erosion/topsoil layer (20 NMAC 9.1 Subpart V, Section 502.A.1). Per the regulations, the low-permeability material is required to have a saturated hydraulic conductivity (permeability) equal to or less than the permeability of the natural subsoils or, if the permeability of the subsoils is greater than 1×10^{-5} cm/sec, the low-permeability layer shall meet or exceed the default permeability requirement of 1×10^{-5} cm/sec.

No singular, continuous, low-permeability ($K < 1 \times 10^{-5}$ cm/sec) unit was encountered beneath the landfill (see the Soil Investigation Technical Memorandum, Appendix C), which would be expected within the highly variable, depositional environment of the Tularosa Basin. As a result, a cap system incorporating the default permeability of 1×10^{-5} cm/sec would normally be prescribed for the site by the regulations; however, NMED guidelines do allow for the proposal of an alternate cap system (Section 502.A.2).

An alternate cap system consisting of a minimum of 27 in. of native material is proposed for Area M1-A of the Main Base Landfill. The cap system will utilize

xisting cover material where possible, supplemented by an amount of compacted native material having a permeability equal to or less than the average permeability of the existing cover (3.7×10^{-4} cm/sec). Appendix D of this document presents a performance demonstration that uses the Hydrologic Evaluation of Landfill Performance (HELP) model to show that the proposed alternate cap system for the closure of Area M1-A provides an equivalent reduction in infiltration as that provided by the prescribed cap system.

4.3 Proposed Grading Plan

The grading plan for the A1/M1-A areas has been designed to provide adequate cover of waste, minimize erosion, and promote drainage; the proposed grading plan is presented in Appendix A. The majority of cover observations within Areas M1-A and A1 encountered an adequate thickness of existing cover material. Most of the proposed surface capping and recontouring activity results from soil applied to meet regulatory slopes requirements rather than cover thickness requirements. The grading plan uses a series of ridges and valleys within the interior of the capped area in order to minimize the amount of excess cover and meet the minimum 2% cap slope required by the New Mexico regulations (Section 502.A.1.d). The regulations also require landfill sideslopes to be no greater than 25%. Owing to past disposal activities, many portions of the Area M1-A sideslopes (the arroyo banks) exceed this slope requirement and will be regraded accordingly. Approximately 0.5 acres of the arroyo bed designated as "Waters of the U.S." by a Corps of Engineers representative will be affected by sideslope construction; associated permit needs are currently being evaluated (see grading plan, Appendix A).

4.4 Final Cover Construction

The final cover system for the closure of Areas A1 and M1-A will consist of one or more of the following layers: existing cover material; fill material, where necessary (no permeability requirement); and cap material (native soil installed to have a permeability less than or equal to 3.7×10^{-4} cm/s).

- **Area A1**—The final cover system for Area A1 will consist of a combination of existing cover (assumed to be approximately 1 ft thick over all cells within the asbestos area) supplemented by compacted fill material (no permeability requirement) placed to achieve the minimum total cover thickness for asbestos disposal areas (36 in.) and to meet slope requirements.

- **Area M1-A**—The proposed cap for Area M1-A consists of a minimum of 27 in. of native material installed to have a permeability less than or equal to the average permeability of the existing cover material (3.7×10^{-4} cm/s). Where the proposed final surface in Area M1-A is less than 27 in. above the existing surface, the upper 6 in. of the existing cover will be scarified and recompacted before placing additional cap material to achieve a total of 27 in. of cover material with a permeability of 3.7×10^{-4} cm/s or less. Where final contours in Area M1-A are more than 27 in. above the existing surface, compacted fill material (no permeability requirement) will be used to bring the surface within 27 in. of final elevations; the upper 27 in. will consist of cap material meeting the required permeability.

Fill material for Areas A1 or M1-A may be obtained from existing soil stockpiles or from crushing concrete and asphalt rubble (from on-site stockpiles or from other storage areas on Base); however, where crushed rubble is used as fill, at least one foot of soil will be placed above the rubble prior to placement of any cap material. No borrow sources for the excavation of additional fill or cap

material have been identified to date. Borrow source(s), preferably within Holloman AFB, will be located prior to construction. Borrow material to be used for capping within Area M1-A will be tested to ensure that the available material will be capable of being installed to meet cap permeability requirements.

Construction will be performed by a contractor to be chosen in accordance with federal acquisition regulations. The selected construction contractor will use equipment such as scrapers, excavators, and loaders to remove soil from the selected borrow area and load it into dump trucks for transport to the construction site. To prepare the site for cap construction, scrapers, loaders, and dozers will be used to move existing soil piles within the work area and clear vegetation. Construction rubble stockpiled within the area to be capped will be moved with loaders and trucks to an area where a concrete crusher will reduce rubble to a size appropriate for use as riprap on the completed cap. Stockpiles of asphalt and concrete rubble that are located in other areas of the base will be moved to the crusher and reduced in size for appropriate use as backfill under the soil cover. This will allow the contractor to maintain the minimum slope required by NMED regulations. Dump trucks will place cap and fill material, which will be spread with dozers and compacted.

The cap for the landfill will be constructed using 280,000 yd^3 of borrowed soil material. Before the soil cap is place, approximately 100,000 yd^3 of fill material will be placed and contoured to provide the minimum 2% slope required for the cover. The fill material may be either borrowed soil or crushed rubble. A total of approximately 380,000 yd^3 (in place) of material (including both fill and cap material) will be required for final cover construction.

4.5 Drainage

A majority of the stormwater runoff originating within the capped A1/M1-A areas will be collected in drainage channels and directed toward the arroyo. Drainage features within the capped area are shown on the proposed grading plan, Appendix A. A small amount of runoff will leave the site via sheet flow from the northern area, and some runoff will be caught by the existing ditch along the road on the western side of the Main Base Landfill. Owing to the topography of the area, very little (if any) stormwater will run onto the site from outside areas. Most of the area surrounding the Main Base Landfill is open space; the Petroleum, Oil, and Lubricants (POL) area is just beyond the southern boundary of the landfill, but would not contribute stormwater runoff to the area or receive runoff from the area.

Interior drainage channels were designed to minimize flow velocities to prevent erosion damage. Channels will be further protected from erosion by using a lining system comprised of a 4-in. thick layer of cement-stabilized soil overlain by an 6-in. thick layer of riprap (d_{50} = 3 in.). Concrete-lined chutes will be used to direct channel flow over the 4:1 sideslopes (arroyo banks) where necessary. Each chute will terminate at a concrete apron fitted with energy dissipation blocks. Stone riprap will be placed past the edge of each apron to further slow the runoff before it enters the arroyo channel.

All channels were designed to accommodate a storm with a return period of 25 years. Although EPA (EPA, 1994) guidance recommends a design storm with a duration of 24 hours for stormwater collection systems in active landfills, no particular duration requirement is specified for drainage systems serving inactive portions of the landfill. Guidance suggests that such systems should manage the collection and discharge of the uncontaminated stormwater so that erosion is controlled. For the capped area drainage system, storm durations equal to the time of concentration for each drainage area were used to size channels. The time of concentration for each area is less than 24 hours, resulting in greater storm intensity (and resulting

higher peak flow estimates) than that resulting from the use of a 25-year, 24-hour storm.

4.6 Slope Protection and Erosion Control

Erosion of soil from upper and side slopes of the capped A1/M1 areas was estimated in order to identify any areas that may experience soil loss exceeding 2 tons/acre/year (the maximum soil loss rate recommended by EPA guidance to minimize maintenance and repair). The erosion calculations for several slope and cover conditions are presented in Appendix E.

Erosion of upper cap slopes was estimated at well below 1 ton/acre/year, indicating that adequate protection would be provided by using minimal slopes (generally 2%) and native ground cover. Because of the arid environment, sufficient ground cover cannot be established and maintained to provide necessary erosion protection to the 25% sideslopes. Sideslope erosion was estimated to be less than the 2 ton/acre/year guideline because of the use of a 6-in. layer of crushed concrete rubble that will be generated through the cleanup and recycling of the concrete rubble stockpiled in Area M1. As a result, the 6-in. layer of rubble will be required on all 25% sideslopes.

Other slope/erosion protective measures applied to the site include vegetation establishment and channel riprap (vegetation will be established by the landfill closure contractor). All disturbed areas will be seeded and planted with native vegetation appropriate for the landfill area according to recommendations of the Holloman AFB Natural Resources Manager (see associated Attachment to this Closure Plan). Stone riprap will be used to line drainage channels, and will be placed at channel intersections and all channel outlets. Areas where riprap or crushed concrete will be used are shown on the proposed grading plan, Appendix A.

4.7 Stormwater Pollution Prevention

The landfill closure contractor will prepare and operate in accordance with a Stormwater Pollution Prevention Plan describing practices to be implemented to control pollution associated with construction activities.

4.8 Site Security/Access

Barbed-wire fencing is currently in place around the Main Base Landfill perimeter, except for along the southern border, which consists of elevated railroad tracks which are not accessible by unofficial personnel. 6-ft high chain-link fencing currently surrounds the asbestos disposal area. Existing fencing (except where construction disturbance requires replacement) will be maintained to restrict access to the site after closure. All gates will be locked; any existing gates will be inspected and repaired if their condition allows unauthorized access. Signs will be placed along the perimeter designating the Main Base Landfill as a restricted area. Gravel roads will be constructed within the capped area to provide access for inspection and sampling activities.

4.9 Removal of Structures

No permanent facilities exist within the Main Base Landfill perimeter; however, the small portable building in the northern portion of Area M1-A and the small domed building within Area A1 will be removed from the site prior to capping.

4.10 Construction Oversight

Several steps will be taken to ensure that the Main Base Landfill is closed as required by this plan. Such steps include supervision, inspection, and testing during construction activities. The final cover will be constructed under the supervision of a registered civil engineer or certified engineering geologist, who will be responsible for documenting that the cap and drainage systems are constructed in accordance with applicable regulations and permits.

The main construction activity associated with the Main Base Landfill closure will be placement of cap material. The Construction Quality Assurance Plan is presented in Appendix F, which discusses in detail the quality assurance

program to be implemented during borrow source selection and final cover system construction.

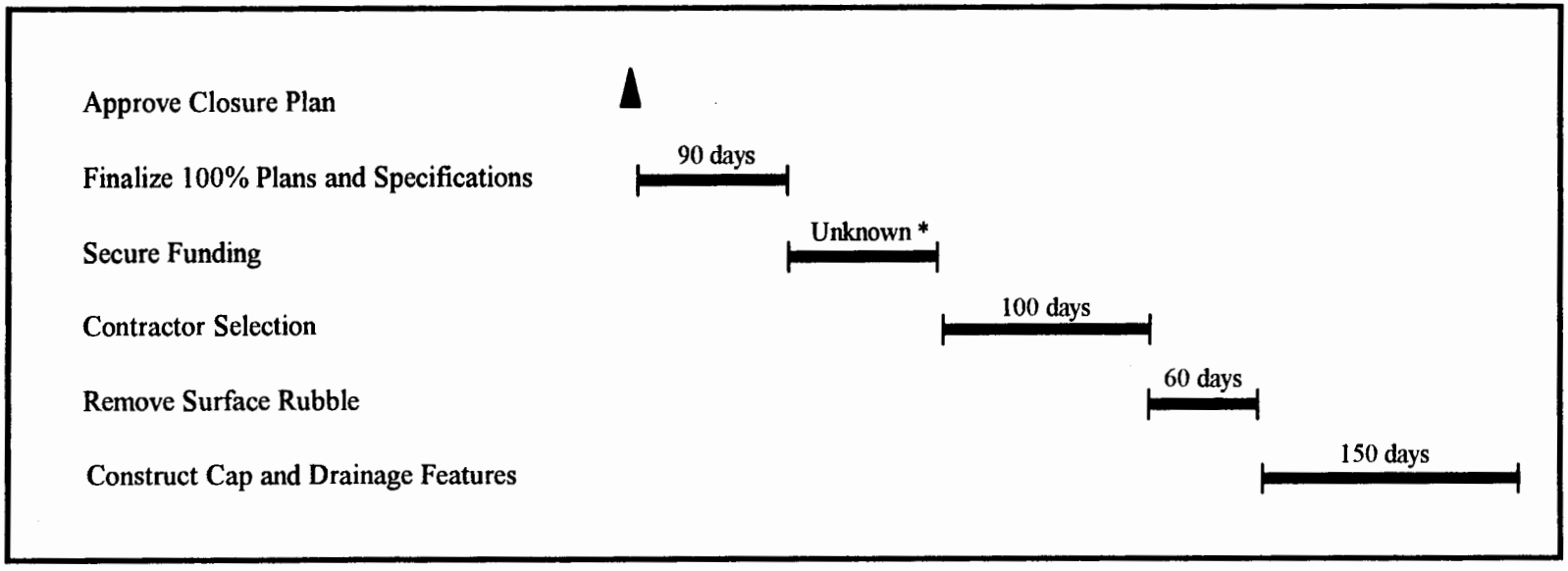
4.11 End Use

Access to the Main Base Landfill after closure will be restricted; no future use for the area is planned.

4.12 Schedule

The schedule of activities associated with the closure of the Main Base Landfill is presented in Figure 4-1. The schedule for funding of the construction activities is not known at this time; funding is scheduled for fiscal year 1997 but is contingent upon federal approval of the Appropriations Bill. This constraint may delay closure of the Main Base Landfill, as discussed in the November 1995 meeting with NMED; however, it is expected that the landfill may be closed within 310 calendar days after receipt of funding.

Figure 4-1. Main Base Landfill Closure Schedule



* The time period required for obtaining funding for closure construction cannot be accurately estimated at this time. It is anticipated that closure construction may be completed within 310 days after funding is secured.

Section 5
ENVIRONMENTAL MONITORING

5.1 Groundwater Monitoring

Groundwater monitoring is generally required for all landfills; however, the NMED Solid Waste Management Regulations (20 NMAC 9.1, Section 801.C) allow for suspension of groundwater monitoring for those facilities where it can be demonstrated that there is no potential for migration of hazardous constituents from a landfill to the uppermost aquifer during the active life of the landfill and the postclosure care period.

The primary factors that make the Holloman AFB Main Base Landfill a candidate for monitoring suspension are the absence and/or lack of a connection to a usable water supply aquifer in the area, the NFA decision applied to the Main Base Landfill by the EPA on the basis of constituents existing below risk-based levels, and the existing long-term monitoring conducted under the IRP. Fate and transport modeling has been performed, demonstrating that there is no potential for migration of hazardous constituents from the Main Base Landfill to an uppermost water supply aquifer during the active life of the landfill through the postclosure care period. The justification for suspension of groundwater monitoring requirements is presented in the Groundwater Monitoring Suspension Request (Appendix B).

5.2 Gas Monitoring

The main concern regarding the production of gases by a landfill is contamination of nearby buildings and belowgrade facilities by migrating gases. The degree to which the gas migrates vertically or horizontally depends on many factors, including the landfill design, surrounding soils, types of waste, and the type of cover. The proposed cap system for the Main Base Landfill closure will provide no significant barrier that would prevent any landfill gas from moving vertically through the cap and venting directly to the atmosphere. Additionally, there are no underground structures or utilities near the capped areas that would be at risk of having gases migrating through the subsurface accumulate within. The nearest facility, Building 1063, lies west of the Main Base Landfill; however, it is not at risk of exposure to any landfill-generated gases. The facility is positioned approximately 2000 ft from municipal disposal Area M1. Area M2 is approximately 3000 ft south of the facility; however, the two are separated by the arroyo channel. Owing to the arid environment and evidenced by previous sampling, neither Area M1 nor Area M2 is likely to be generating any appreciable amount of landfill gas.

EPA guidance suggests that methane is generated within a municipal solid waste landfill only when the moisture content of the waste exceeds 40% under anaerobic conditions (EPA, 1994). Owing to the low precipitation and high evaporation experienced at the site (see Section 2.2), relatively little water infiltrates into the Main Base Landfill; as a result, a significant amount of gas would not be expected to be generated within any portion of the Main Base Landfill. No landfill gas has been detected during historical gas sampling and monitoring (see Section 3.6 for a summary of past sampling activities). As a result of the lack of any evidence of landfill gas generation within or migration from the site and the absence of potential exposure pathways, it is determined that no risk to human health or the environment exists as a result of gas generation at the Main Base Landfill. Quarterly methane monitoring, currently ongoing, will be continued through the fourth quarterly round at a minimum (fourth quarter 1996). After that time, depending on the results of monitoring, the Base may petition the NMED to discontinue or reduce the frequency of further methane monitoring.

Section 6
RECORDKEEPING AND CLOSURE CERTIFICATION

When closure construction is completed, Holloman AFB will provide a detailed site description and map to NMED. The site description will include the date of closure completion, the boundaries of the closed areas, a location and telephone number where the current approved closure plan can be found, and a statement that future site use is restricted in accordance with the approved postclosure maintenance plan.

When closure construction is completed, Holloman AFB also will submit a certification that the Main Base Landfill has been closed in accordance with the approved specification in the current approved closure plan. This certification will include record drawings prepared by a registered professional engineer of all the environmental containment, monitoring, control, collection, and recovery systems that will remain on site during the postclosure period. The record drawings will be incorporated into the current approved postclosure maintenance plan. The certification will also include closure construction quality assurance documentation. Holloman AFB will also submit a survey plat of the landfill area (indicating that the land has been used as a landfill and its future use is restricted) to the Otero County Clerk upon closure of the landfill. A copy of the plat stamped by the County Clerk will be provided to NMED.

Section 7
POSTCLOSURE CARE

After closure construction is completed, the Main Base Landfill will enter a postclosure care period of 30 years. Holloman AFB personnel will be responsible for performing postclosure care activities, including environmental monitoring, inspection, and maintenance. Reports of postclosure activities will be submitted annually to NMED during the postclosure care period.

7.1 Postclosure Monitoring

No postclosure groundwater monitoring is proposed for the Main Base Landfill. For information supporting the request for suspension of groundwater monitoring requirements, see the associated report (Appendix B).

Quarterly methane monitoring at the Main Base Landfill, begun in January 1996, is currently ongoing. First- and second-round sampling results from 32 gas probes surrounding the Main Base Landfill did not detect methane in any probe. Previous informal sampling at the landfill had not detected landfill gases (see Section 3.6). Quarterly methane monitoring is proposed to continue through the fourth event at a minimum. If monitoring results continue to detect no methane migrating from the Main Base Landfill, the Base may petition NMED to discontinue or reduce the frequency of methane monitoring. It is believed that methane monitoring will not be necessary through the postclosure period.

Surface water sampling activities will follow protocols outlined in the National Pollutant Discharge Elimination System (NPDES) Stormwater Multi-sector Permit for Industrial Activities (29 September 1995 *Federal Register*, pp. 50804-51319).

7.2 Inspection and Maintenance

Holloman AFB personnel designated by the Base Civil Engineer will perform site inspections at least twice each year (before and after the summer wet season) and after each major rainfall event producing more than 1 in. of precipitation. Postclosure reports will present results of the inspections and a summary of maintenance performed. Site inspections will include the observation of the final cover and sideslopes, the drainage system, and vegetative cover condition.

- **Final Cover/Sideslopes**—The cover and sideslope material placed in Areas A1 and M1 will be visually inspected for excessive erosion, cracking, or slope failure. Any damage to cover material or sideslopes will be noted and repaired. Any loss of armor (concrete rubble) on the sideslopes will be repaired. During the postclosure period, capped areas experiencing subsidence will be regraded with additional soil as necessary to maintain drainage.

- **Drainage System**—During site inspections, the drainage system within the capped areas will be inspected for ponding, erosion, obstruction, excessive sedimentation, or failure. Sediment or other obstructions accumulating in drainage channels will be removed as necessary. Areas experiencing significant erosion will be repaired; areas experiencing chronic erosion problems may require lining with riprap or other preventative measures.

- **Vegetative Cover**—The vegetative cover will be inspected to identify areas of stressed vegetation or growth deficiency. Affected areas will be reseeded to establish plant growth.

Section 8
REFERENCES

Parsons Engineering Science. 1995. *Lake Holloman Water Balance Study.*

Walk, Haydel, and Associates. 1989. *Baseline Risk Assessment Report, Holloman Air Force Base, New Mexico.* U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.

U.S. Environmental Protection Agency (EPA). 1994. *Design, Operation, and Closure of Municipal Solid Waste Landfills.* EPA/625/R-94/008.

ATTACHMENT

Revegetation Plan

MEMORANDUM FOR RECORD

TO: Dr. Fred Fisher, Holloman AFB

FROM: Dr. Hildy Reiser, Base Natural Resources Manager

DATE: 29 April 1997

SUBJECT: Seeding Project - Landfill Closure Area

1. The following seed mixture would be appropriate on this project area:

Common Name	Botanical Name	lbs Pure Live Seed/Acre
Alkali sacaton (Salado variety) Sporobolus airoides	Sporobolus airoides	4.0
Four-wing Saltbush (seed from plants similar environmental conditions as HAFB)	Atriplex canescens	2.0
Sand dropseed (New Mexico seed source, or will grow in local conditions)	Sporobolus cryptandrus	1.0
Blue grama (Hachita variety)	Bouteloua gracilis	2.0
Little bluestem (Pastura variety)	Schizachyrium scoparius	3.0
	Total:	12.0 lbs PLS/acre

2. Seed mixture must be noxious weed free (see attached list). Seed sources are also supplied (see attached list.)

3. Till the soil to a depth no greater than 2 inches.

4. Sow seed uniformly at a rate of 12 pounds of PLS per acre. Seed shall be drilled to a maximum depth of 1/2 inch unless otherwise specified. Direction of seeding shall be across slopes and on the contour whenever possible. Seeding will not be permitted when wind velocity exceeds 8 miles per hour. Seeding should occur after soil has warmed up (mid-June to mid-July). Watering should occur until germination occurs or the start of monsoon season. Thus watering might be reduced if monsoon season occurs.

5. Water as necessary for germination and continued growth. Areas shall be maintained until a cover of plants is achieved.

6. Mulch shall be spread uniformly in a continuous blanket, using 2 ½ tons per acre of air dry mulch. Mulch shall be crimped into the soil. The mulch shall be spread uniformly over the area either by hand or with a mechanical mulch spreader. When spread by hand, the bales of mulch shall be torn apart and fluffed before spreading. Mulching will not be permitted when wind velocity exceeds 10 miles per hour. The mulch shall be wetted down and allowed to soften for 15 to 20 minutes prior to crimping. A heavy disc such as a mulch-tiller, with flat serrated discs at least ¼ inch in thickness, having dull edges and the disc spaced 6 inches to 8 inches apart shall be used to crimp (or anchor) the mulch into the soil to a minimum depth of 2 inches. The discs shall be of sufficient diameter to prevent the frame of the equipment from dragging the mulch. The crimping operations shall not be parallel to prevailing west/southwesterly winds.

Mulch shall be certified noxious weed free (one local source: WW Farm & Ranch Supply, Tularosa, NM, 505-585-2200, noxious weed free hay). Bermuda grass hay, cereal grain straw (such as oat or wheat), forage sorghums, including Johnson grass, will not be accepted. Hay material which has passed through a seed harvesting combine or a thresher will not be acceptable. A minimum of 50 percent of weight of the herbage making up the material shall be 10 inches in length or longer. Mulch material which contains an excessive quantity of mature seed of noxious weeds or other species, including crops which would be detrimental to the grasses planted on the mulched areas or provide a menace to surrounding rangelands, will not be acceptable. Discolored, weathered, brittle hay or any hay harvested during the dormant season will not be acceptable.

7. Current prices (as of 28 April 1997) for:

<u>Curtis & Curtis, Inc</u>
Alkali sacaton (Salado) - $8.00/lb of PLS
Four-wing saltbush - $8.00/lb of PLS
Blue grama (Hachita) - $16.00/lb of PLS
Sand dropseed - $6.00/lb of PLS
Little bluestem (Pastura) - $10.00/lb of PLS
Would provide seed mixture.
Cost: $116.00/acre
All seeds currently in stock

<u>Granite Seed Company</u>
Would provide seed mix @ $8.38/lb PLS
Cost: $100.56/acre
All seeds currently in stock

8. If African rue, Russian thistle and/or salt cedar invades area to be restored, prior to seeding, herbicide treatment following methods in Parker and Reiser (1997, in prep) will be implemented. Most effective treatment time is in the fall (between 30 Sept and 15 October). If this is not possible, herbiciding must occur between 15 April and 15 May.

9. If anyone has any questions, let me know.

SEED SOURCES

Granite Seed Company (GSC)
1697 West 2100 North
P.O. Box 177
Lehi, UT 84043
800-992-5040

Wild Seed, Inc. (WSI)
P.O. Box 27751
Tempe, AZ 85285
602-345-0669

Curtis & Curtis, Inc. (CCI)
4500 N. Prince
Clovis, NM 88101
602-762-475

Wild Seed, Inc. tends to be expensive. Granite Seed Company the most reasonable. Curtis & Curtis is variable in its pricing.

Variety of seed available and prices can be quite variable season-to-season and year-to-year.

APPENDIX A

Proposed Grading Plan

TO VIEW THE MAP AND/OR MAPS WITH THIS DOCUMENT, PLEASE CALL THE HAZARDOUS WASTE BUREAU AT 505-476-6000 TO MAKE AN APPOINTMENT

APPENDIX B

Groundwater Monitoring Suspension Request*

* *There were no agency comments on the Draft Final Groundwater Monitoring Suspension Request document; Draft Final copies included as Appendix B to the closure plan stand without revision.*

Headquarters, Air Combat Command
Langley Air Force Base,
Virginia

Draft Final

Groundwater Monitoring Suspension Request

Main Base Landfill Closure Project

June 1996

---

49 CES/CEV
Holloman Air Force Base,
New Mexico

DCN 96-640-311-02

GROUNDWATER MONITORING SUSPENSION REQUEST

MAIN BASE LANDFILL CLOSURE PROJECT
HOLLOMAN AIR FORCE BASE, NEW MEXICO

DRAFT FINAL

Prepared for:

49 CES/CEV
Holloman Air Force Base, New Mexico
and
HQ ACC/CEV
Langley Air Force Base, Virginia

Prepared by:

RADIAN INTERNATIONAL LLC

8501 North Mopac Boulevard
Austin, Texas 78720-1088

Under Contract No. F46124-94-D-80409/0011

June 1996

TABLE OF CONTENTS

Page

1 INTRODUCTION 1-1

1.1 Basis for Groundwater Monitoring Suspension Request 1-1
1.1.1 Groundwater Quality 1-1
1.1.2 Results of Remedial Investigations at the Landfill Indicate No Further Action 1-2
1.1.3 IRP Groundwater Monitoring at the Main Base Landfill 1-2
1.2 Additional Measure Conducted in Support of the GWMSR 1-2
1.2.1 Overview of Technical Approach 1-2

2 CONCEPTUAL SITE MODEL 2-1

2.1 Site Description 2-1
2.2 Climate 2-1
2.3 Site Geology 2-1
2.4 Hydrogeology 2-4
2.4.1 Surface Water 2-4
2.4.2 Groundwater 2-4
2.5 Water Quality 2-4

3 HELP MODEL INPUT PARAMETERS AND RESULTS 3-1

3.1 Overview of HELP Model 3-1
3.2 HELP Model Data Inputs and Technical Approach 3-1
3.3 Results of HELP Model 3-1

4 MULTIMED MODEL INPUT PARAMETERS AND RESULTS 4-1

4.1 Overview of MULTIMED 4-1
4.2 MULTIMED Model Data Inputs and Technical Approach 4-1
4.3 Results of MULTIMED Modeling 4-3
4.4 Summary 4-3

5 SUMMARY AND CONCLUSIONS 5-1

6 GROUNDWATER SCIENTIST CERTIFICATION 6-1

7 REFERENCES 7-1

APPENDIX A: HELP Model Inputs and Results
APPENDIX B: MULTIMED Model Inputs and Results
APPENDIX C: Results of Water Quality Sampling at the Main Base Landfill
APPENDIX D: PQLs for the NMSWMR Part VIII Groundwater Monitoring Parameters
APPENDIX E: Calculation of Infiltration and Recharge Values Used in Case II
APPENDIX F: Registered Groundwater Scientist Documentation

LIST OF FIGURES

Page

2-1 Location Map of the Holloman AFB Main Base Landfill 2-2

2-2 Conceptual Geologic Cross Section of the Main Base Landfill 2-3

2-3 Regional Groundwater Flow at Holloman AFB as Measured in 1993 2-5

2-4 Potentiometric Surface as Measured in November 1995 2-6

3-1 Conceptual Cross Section Used for HELP Model Calculations 3-2

4-1 Conceptual Models of Cases I Through III 4-4

LIST TABLES

3-1 HELP Model Input Parameters for Calculation of Leachate Infiltration Rate 3-3

3-2 HELP Model Input Parameters for Calculation of the Recharge Rate 3-4

4-1 MULTIMED Model Input Parameters 4-2

4-2 Summary of Results for Case Studies I Through III 4-5

LIST OF ACRONYMS AND ABBREVIATIONS

AFB	Air Force Base
EPA	Environmental Protection Agency
GWMSR	Groundwater Monitoring Suspension Request
HELP	Hydrologic Evaluation Landfill Performance
HHSs	Human Health Standards
IRP	Installation Restoration Program
LTM	Long-term Monitoring
MCLs	Maximum Contaminant Levels
NFA	No Further Action
NM WQCC	New Mexico Water Quality Control Commission
NMED	New Mexico Environment Department
PCBs	Polychlorinated Biphenyls
PQL	Practical Quantitation Limit
RI	Remedial Investigation
SMCLs	Secondary Maximum Contaminant Levels
SWMR-4	Solid Waste Management Regulations
TDS	Total Dissolved Solids

Section 1
INTRODUCTION

This report presents a demonstration for a Groundwater Monitoring Suspension Request (GWMSR) for the Holloman Air Force Base (AFB) Main Base Landfill (hereafter referred to as the "landfill") located in Otero County, New Mexico. The request is presented in accordance with Subpart VIII, Section 801.C of the New Mexico Solid Waste Management Regulations (20 NMAC 9.1). The regulations allow for a GWMSR for those facilities where it can be demonstrated that there is no potential for migration of hazardous constituents from a landfill to the uppermost aquifer during the active life of the landfill and the post-closure care period.

Presented below is an overview of the basis and technical approach of the GWMSR demonstration. Subsequent sections of this report present an overview of the important geologic and hydrogeologic conditions at the landfill and a summary of the results, conclusions, and recommendations of the fate and transport study conducted in support of the GWMSR demonstration.

1.1 Basis for Groundwater Monitoring Suspension Request

The primary factors that make the Holloman AFB landfill appropriate for a groundwater monitoring suspension are:

- Absence of and/or lack of connection to a usable water supply aquifer below Holloman AFB as a result of naturally high salinity and low hydraulic potential;
- The Phase I/II remedial investigation (RI) and risk assessment resulted in an approved no further action (NFA) decision for the landfill on the basis that all constituents are below levels that would pose an unacceptable risk to human health or the environment; and
- A long-term groundwater monitoring program is currently in place at the landfill to monitor the groundwater upgradient and downgradient of the landfill.

A more detailed discussion of each of the above factors is provided in the following subsections.

1.1.1 Groundwater Quality

The New Mexico Environment Department's (NMED) suspension provision applies particularly to Holloman AFB because of the naturally high salinity and low hydraulic potential of the groundwater in this area of the Tularosa Basin. According to the New Mexico Water Quality Standards (NMAC 6, Sections 3100 through 3103, as amended through 27 October 1995), groundwater in the saturated zone beneath Holloman AFB is designated as unfit for human consumption because it exceeds New Mexico Human Health Standards (HHSs) for total dissolved solids (TDS) and sulfate, and, therefore is not considered a source or potential source of drinking water.

In addition, U.S. Environmental Protection Agency (EPA) guidelines (Guidelines for Groundwater Classification Under the EPA Groundwater Protection Strategy [EPA, 1986]) classify the groundwater beneath Holloman AFB as Class III B. Class III B groundwater is groundwater with TDS concentrations greater than 10,000 mg/L that does not connect with or discharge to adjacent aquifers or groundwater of a higher class. Constituent migration from the uppermost saturated zone beneath the landfill to potential laterally or vertically adjacent water supply aquifers is, therefore, not possible.

1.1.2 Results of Remedial Investigations at the Landfill Indicate No Further Action

A Phase I/II remedial investigation (RI) was conducted at the Main Base Landfill in 1987 and 1989 under the Installation Restoration Program (IRP). The IRP is a program implemented by the Department of the Air Force to ensure that past waste management sites are identified and remediated, as necessary, to mitigated hazards to human health and the environment. The IRP follows the requirements of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the 1986 statutory amendments to CERCLA (the Superfund Amendments and Reauthorization Act [SARA]) requiring federal facilities to comply with the National Contingency Plan.

During the RI, groundwater samples were collected from several locations upgradient and downgradient of the landfill and analyzed for the following constituents: volatile and semivolatile organic compounds, organochlorine pesticides, polychlorinated biphenyls (PCBs), total recoverable petroleum hydrocarbons, acid/base/ neutral extractable organics, and metals. The Phase I/II RI resulted in a NMED approved NFA recommendation for the landfill on the basis that all constituents were below levels that would pose an unacceptable risk to human health or the environment (Walk, Haydel, and Associates, 1989b). Groundwater was determined to be the only migration pathway of any significance, and the only exposure route was determined to be potential consumption of groundwater by off-Base livestock. On the basis of a conservative modeling approach, constituent levels at potential off-Base receptor locations were calculated and their toxicological effects were evaluated. From the results of the Baseline Risk Assessment (Walk, Haydel, and Associates, 1989a), it was concluded that no significant risk to public health or the environment is present at the landfill. As a result, NFA was recommended and has been approved by EPA Region VI for the landfill.

1.1.3 IRP Groundwater Monitoring at the Landfill

A long-term groundwater monitoring program is currently in place to monitor upgradient and downgradient groundwater quality as a condition of the NFA decision at the landfill. The purpose of the long-term monitoring (LTM) program is to detect any release or potential future release of constituents from the landfill to the groundwater. Under the Installation Restoration Program (IRP), groundwater samples are collected on a biennial basis from a network of four wells (one upgradient well and three downgradient wells) and analyzed for volatile organic compounds, organochlorine pesticides, RCRA metals, iron, manganese, and water quality parameters. Results and conclusions of the sampling data are presented in a biennial LTM Report, which is submitted to the NMED Groundwater Bureau.

Should NMED accept Holloman AFB's request for groundwater suspension, a copy of the IRP biennial report will be submitted to NMED's Office of Solid Waste, Permit Section.

1.2 Additional Measure Conducted in Support of the GWMSR

In addition to the factors presented above, contaminant fate and transport predictions were conducted using site-specific field measurements and computer modeling to consider potential future impacts of the landfill on the groundwater and human health and the environment. A brief description of the technical approach of the fate and transport study is provided below.

1.2.1 Overview of Technical Approach

Specific elements of the proposed approach for the fate and transport study were developed in accordance with the results of meetings and correspondence with members of the Permit Section of NMED's Office of Solid Waste Bureau. The results of discussions with NMED included recommendations that Holloman AFB

submit a demonstration with the following elements.

- Collect and compile site-specific data to support the development of a conceptual site model for the landfill;
- Use conservative Hydrologic Evaluation of Landfill Performance (HELP) model to predict the potential infiltration rate of leachate from the landfill to the saturated zone and to calculate expected natural groundwater recharge rate for the area surrounding the landfill;
- Use Base- and site-specific data and MULTIMED model to predict the end-point concentration of a model constituent at a hypothetical receptor well located at the Base property boundary;
- Where possible, use contaminant fate and transport input assumptions and predictions that maximize contaminant migration;
- Extend the model simulation for a period of 600 years (i.e., 20 times the required 30-year postclosure care Subtitle D closure regulations) in order to account for a worst case scenario of contaminant fate and transport within the uppermost saturated zone; and
- Identify and document all assumptions and model input parameters in a formal groundwater monitoring suspension request.

The remainder of this report presents an overview of the conceptual site model and the results, conclusions, and recommendations of the Fate and Transport Study conducted in support of the GWMSR demonstration.

Section 2
CONCEPTUAL SITE MODEL

A conceptual site model was developed using site-specific data collected from investigations conducted at the landfill and the surrounding area from 1989 to 1995. The conceptual model discusses the important geologic and hydrogeologic site features that affect the evaluation of leachate migration potential from the landfill to a selected hypothetical receptor well location. The information presented in this section serves as the basis for input into HELP and MULTIMED models.

2.1 Site Description

Holloman AFB is located in south-central New Mexico, as shown in Figure 2-1. The Base is approximately 75 miles northeast of El Paso, Texas, and about 7 miles west of Alamogordo, New Mexico, in the northwest-central portion of Otero County.

The Base has been in military service since 1942 and has maintained an active municipal waste landfill (Main Base Landfill) since 1958. The landfill is located in the eastern portion of the Base, covering approximately 228 acres (Figure 2-1). As shown in the detailed drawing, the north fork of Dillard Draw occupies approximately 70 of these acres. A 20-acre portion in the southwest area and a 9-acre portion in the northeast area of the landfill are undisturbed and have not been used for waste disposal. A 1-acre asbestos disposal area was established in the northwest corner of the landfill and was expanded with the addition of an 8-acre asbestos disposal area to the north.

2.2 Climate

The climate at Holloman AFB is arid with low annual rainfall and low relative humidity. According to 53 years of rainfall data collected by the Holloman AFB weather station (1943-1995), rainfall in the area averages approximately 8.5 in. per year, with more than 50% of the precipitation falling between the months of July and September. Mean daily temperatures range from low 40s °F in the winter months to the low 80s °F in the summer months.

The mean annual lake evaporation rate, commonly used to estimate mean annual evapotranspiration, is estimated at 67 in. per year. The net precipitation (mean annual precipitation minus mean annual evapotranspiration) for the Holloman AFB area is approximately -59 in. per year.

2.3 Site Geology

The subsurface conditions at the landfill were defined by direct sampling and observation of the drilling operations of soil and/or monitor well borings drilled between 1989 and 1996. The lithologies present appear to be generally consistent across the site. A conceptual model of the subsurface conditions at the site is presented in Figure 2-2.

As shown, the near surface sediments (0-2 ft) consist of well-drained silty to sandy loam of the Holloman-Gypsum Land, Yesum Complex. Underlying the surface soil is an upper sandy-silt unit, consisting of approximately 18 ft of sand, silt, and/or silty sand. Discontinuous clay lenses are common in the upper sandy-silt unit. A semicontinuous clay unit underlies the upper sandy-silt unit. The middle clay is reddish brown with abundant gypsum crystals and ranges from 7 to 15 ft thick where present. Average thickness of this clay is 10 ft. A lower sand unit consisting of interbedded sand, clay, and silt lies beneath the middle clay. This unit is lithologically heterogeneous, consisting primarily of sand and silty sand with occasional lenses of clay. The full thickness of the lower sand was not penetrated during drilling at the site, but on the basis of borehole data from nearby sites at the Base, it is estimated to be 10 ft.

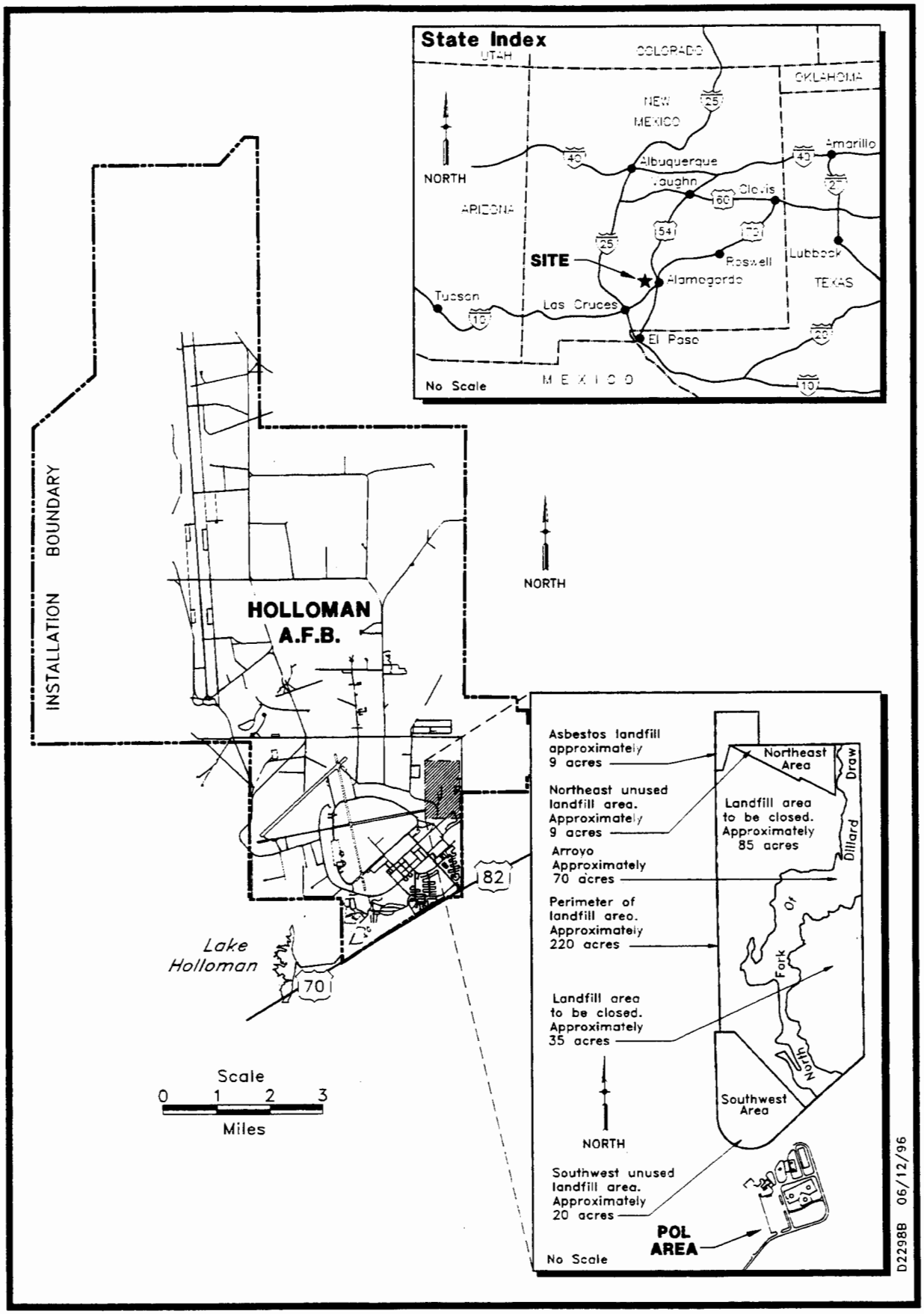


Figure 2-1. Location Map of the Holloman AFB Main Base Landfill

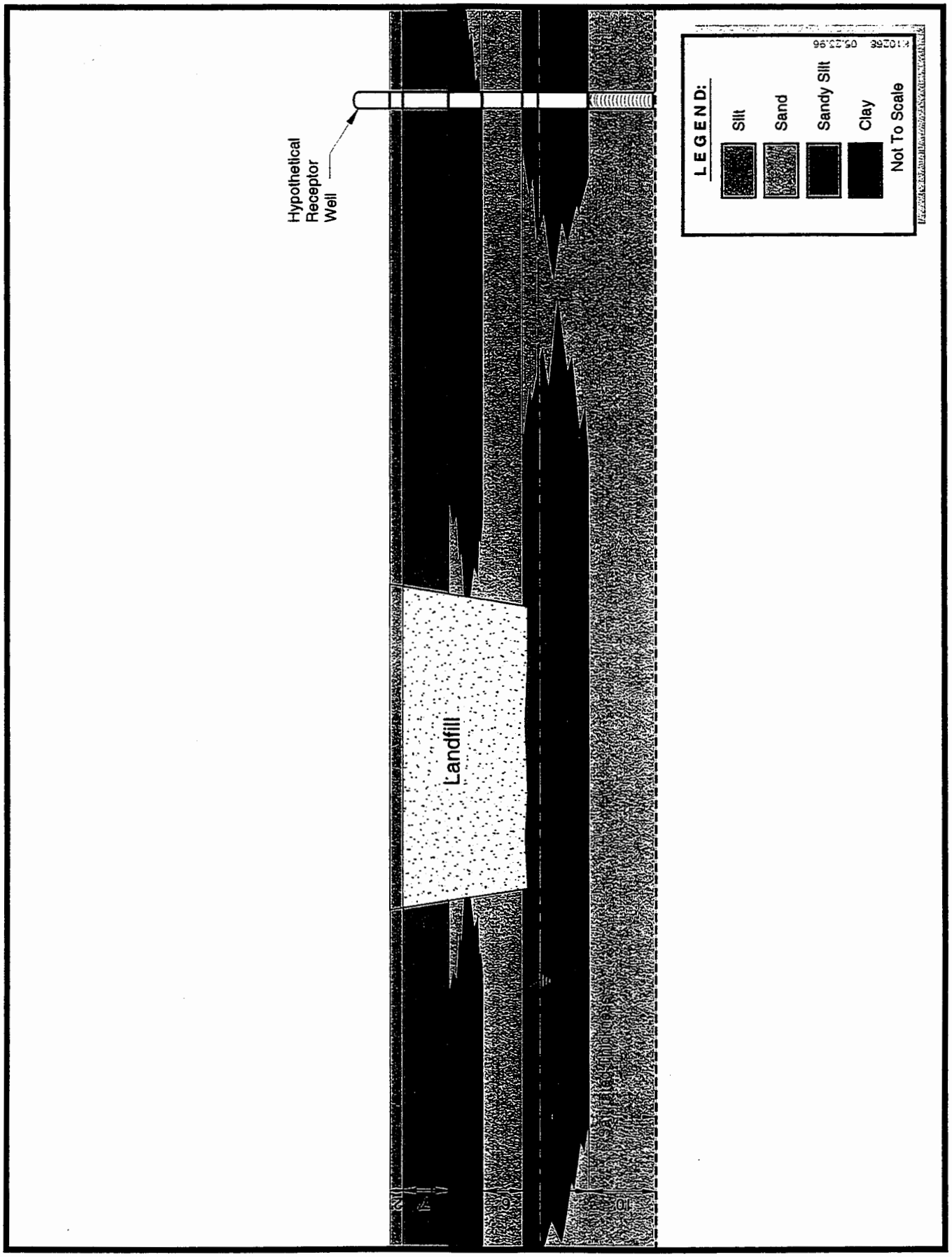


Figure 2-2. Conceptual Geological Cross Section of the Main Base Landfill

2.4 Hydrogeology

2.4.1 Surface Water

Holloman AFB is located in the Tularosa Basin, which is a closed basin with no surface water drainage. Water is lost to evaporation, transpiration, and infiltration, or collects in local playas, low points in the basin. The Base is crossed by several southwest-trending arroyos that control surface drainage in the undeveloped part of the Base. One of these arroyos, Dillard Draw, runs between the northwestern and southeastern portion of the landfill and terminates in playas south of the Base (e.g., Pond G). In addition, during periods of high precipitation, surface water may collect in the southern portion of Dillard Draw north of the railroad tracks.

2.4.2 Groundwater

Groundwater occurs under unconfined flow conditions in the unconsolidated bolson deposits beneath Holloman AFB. The primary source of recharge for groundwater in the bolson aquifer is percolation of rainfall and stream runoff through the coarse, unconsolidated alluvial fan deposits located near the base of the Sacramento Mountains upgradient of Holloman AFB. Groundwater discharge occurs either through evapotranspiration or seeps along steep-sided arroyos, into closed playa lakes such as Lake Lucero, or smaller playa lakes in the eastern parts of the Tularosa Basin.

Regional groundwater flow in the area is to the southwest (Figure 2-3). Local groundwater flow is seasonally variable and is affected by the relationship between the water table elevation and the elevation of the bottom of the local arroyo channels. In the southeastern portion of the Base, near the landfill, regional groundwater flows to the southwest, following the Dillard Draw surficial drainage system. In the northern portion of the Base, groundwater flows to the west, following the Ritas Draw, Malone Draw, and Lost River drainages.

The groundwater elevation at the landfill was surveyed in November 1995. The potentiometric surface map developed using the survey data is presented in Figure 2-4. Under an average hydraulic gradient of 0.004, the groundwater flows regionally from northeast to southwest at an average rate of 1.8×10^{-3} cm/sec. In the immediate vicinity of Dillard Draw, groundwater movement is redirected to the south-southeast and flows toward Dillard Draw. As measured in November 1995, average depth to the top of the saturated zone at the landfill is 22.5 ft below land surface.

2.5 Water Quality

Groundwater quality in the Tularosa Basin is potable at the Boles and San Andres water well fields located at the foot of the Sacramento Mountains, 14 miles southeast of Holloman AFB. Groundwater becomes progressively more mineralized as it flows downgradient toward the interior of the basin. It has been estimated that approximately 98% of the alluvial deposits in the central portion of the Tularosa Basin contains sodium chloride brines with TDS concentrations greater than 35,000 mg/L (U.S. Department of Interior, 1970). This decrease in water quality can be attributed to slow groundwater migration from recharge to discharge areas and the presence of readily soluble minerals in the bolson sediments. TDS exceed 100,000 mg/L in groundwater in some portions of the Tularosa Basin (USGS, 1985).

The groundwater beneath Holloman AFB is designated as unfit for human consumption, based on New Mexico Water Quality Standards (20 NMAC 6, Sections 3100 through 3103, as amended through 27 October 1995) because it exceeds New Mexico HHSs for TDS and sulfate. As presented in Appendix C, TDS concentrations ranging between 28,000 and 60,000 mg/L were measured at the landfill during the 1989 RI (Walk, Haydel, and Associates (1989b). Average values of other groundwater quality parameters measured at Holloman AFB (chloride, fluoride, and nitrate-nitrite) also exceed HHSs and, except

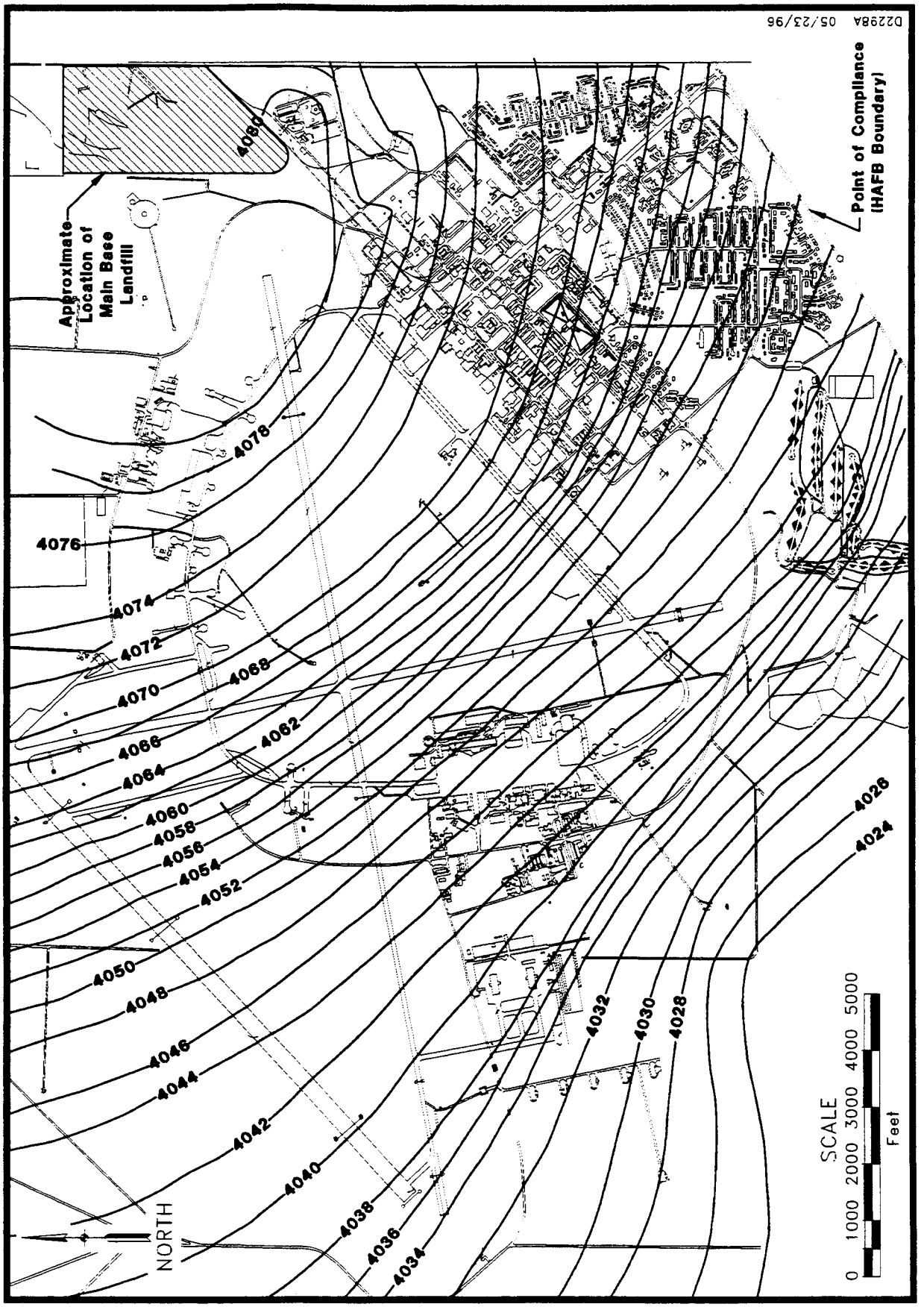


Figure 2-3. Regional Groundwater Flow at Holloman AFB as Measured in 1993

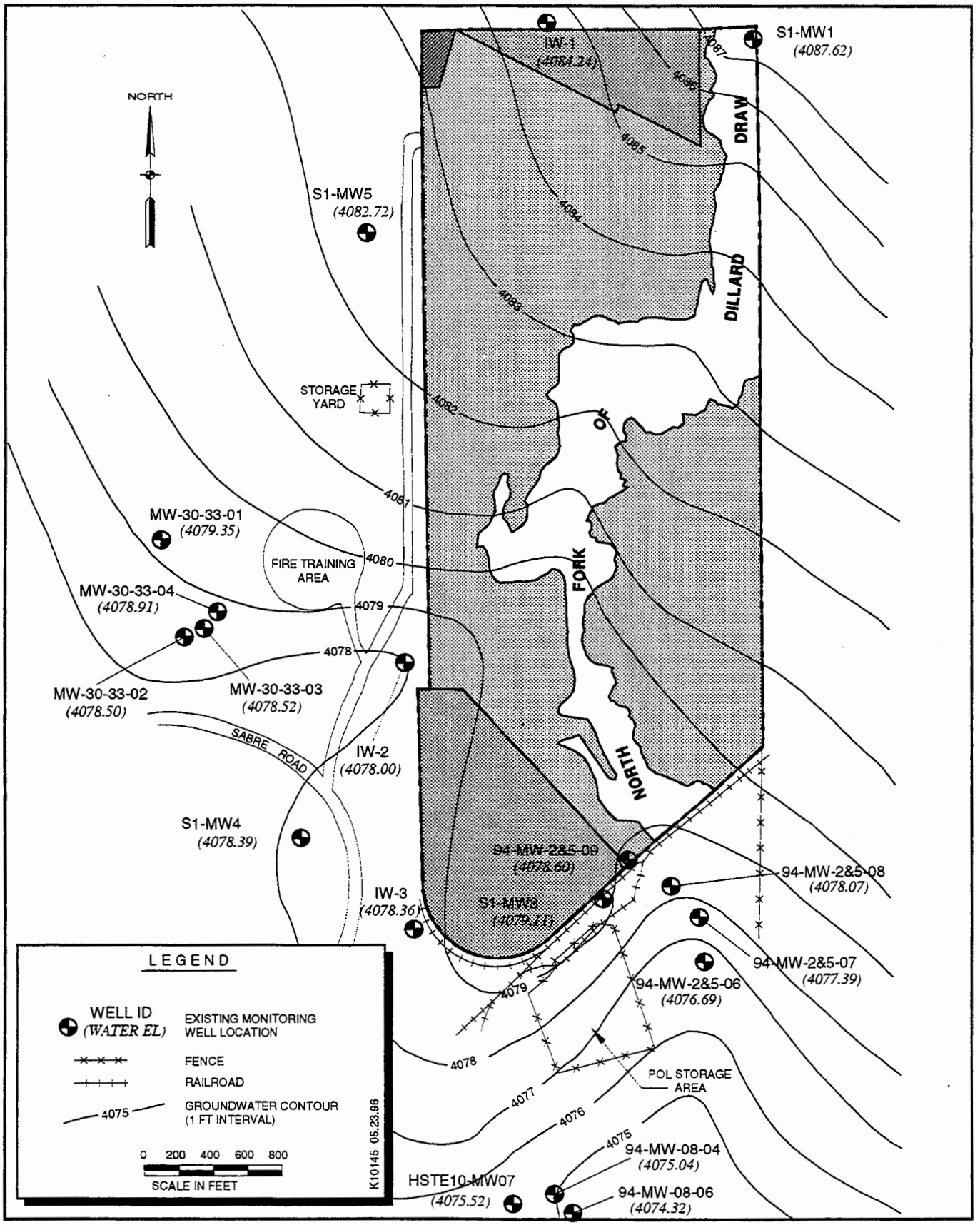


Figure 2-4. Potentiometric Surface as Measured in November 1995

for fluoride, also exceed federal primary MCLs and SMCLs. Water quality parameters reflect that the groundwater in this area is not potable under natural conditions.

Although EPA guidelines for groundwater classification are not recognized by the State of New Mexico, the EPA guidelines (*Guidelines for Groundwater Classification Under the EPA Groundwater Protection Strategy* [EPA, 1986]) classify the groundwater beneath Holloman AFB as a Class III B aquifer (i.e., TDS concentrations greater that 10,000 mg/L and no interconnection with adjacent aquifers).

Because the Tularosa Basin is a closed basin, its groundwater does not discharge or connect to any adjacent aquifers. Adjacent surface waters include groundwater surfacing in Malone Draw and Lakes Holloman and Stinky. The TDS in Lake Holloman range from a winter low of 12,400 mg/L to a summer high of 17,000 mg/L (Cole et al., 1981); therefore, groundwater at Holloman AFB is not interconnected with surface water of a higher class.

Section 3
HELP MODEL INPUT PARAMETERS AND RESULTS

The fate and transport study used two models, HELP and MULTIMED, to transpose the site conceptual model into mathematical models in order to characterize the site hydrogeologic characteristics and make contaminant fate and transport predictions. This section presents an overview of the HELP model and a summary of the input parameters and model results. An overview of the results and conclusions of the MULTIMED model is presented in Section 4.

3.1 Overview of HELP Model

The HELP model is a quasi-two-dimensional model that simulates the movement of water into, through, and out of landfills and/or natural soil layers. Using daily climatological data and soil and landfill design characteristics as input, HELP calculates a hydrologic water budget for the system that includes estimates of surface runoff, evapotranspiration, and average annual percolation through landfill and/or natural soil layers.

3.2 HELP Model Data Inputs and Technical Approach

For the purposes of the fate and transport study, the HELP model was used to calculate conservative estimates of infiltration and recharge to serve as inputs into MULTIMED. As shown conceptually in Figure 3-1, infiltration rates were predicted through the landfill (Layers 1-3), whereas recharge rates were predicted through the natural geologic units (Layers 1-5).

Data inputs used for HELP were either field-measured values or values chosen to maximize the estimation of the recharge and infiltration rates. A detailed description of field measured data and estimated data for the HELP model is presented in Tables 3-1 and 3-2.

To maximize the HELP results, an above-normal precipitation value of 9.93 in./year was used. The precipitation data used for the HELP modeling were based on rainfall data collected during the past five years (i.e., 1991 to 1995). The rainfall in 1991 and 1992 was anomalously high, which resulted in an average annual precipitation of 9.93 in. for the period between 1991 and 1995, compared with the measured 53-year, 8.4 annual average (Holloman AFB weather station).

To further maximize the predictions of infiltration calculations, the landfill was considered one large cell for modeling purposes. This assumes that the entire area of the landfill comprises municipal waste material. In reality the landfill is not as extensive, but consists of smaller individual cells (trenches) that are scattered throughout the 489,645-m^2 area.

3.3 Results of HELP Model

The results of the HELP model calculations are presented in Tables A-1 and A-2 (Appendix A). The results tables include a summary of the model input parameters, annual water balance data for each year, and overall water balance summary data (i.e., peak daily, average monthly, and average annual values of precipitation, runoff, evapotranspiration, and percolation. The information that is required by MULTIMED as input into the fate and transport calculations is the average annual percolation (i.e., infiltration, recharge) value which is contained in the overall summary section of the results tables.

As shown on pages A1-55 and A2-56 of Appendix A , the resulting average annual values for infiltration and recharge were 7.6×10^{-7} m/year and 1.0×10^{-6} m/year, respectively. These values represent the calculated average percolation rate of water through the base of the landfill into the uppermost saturated zone.

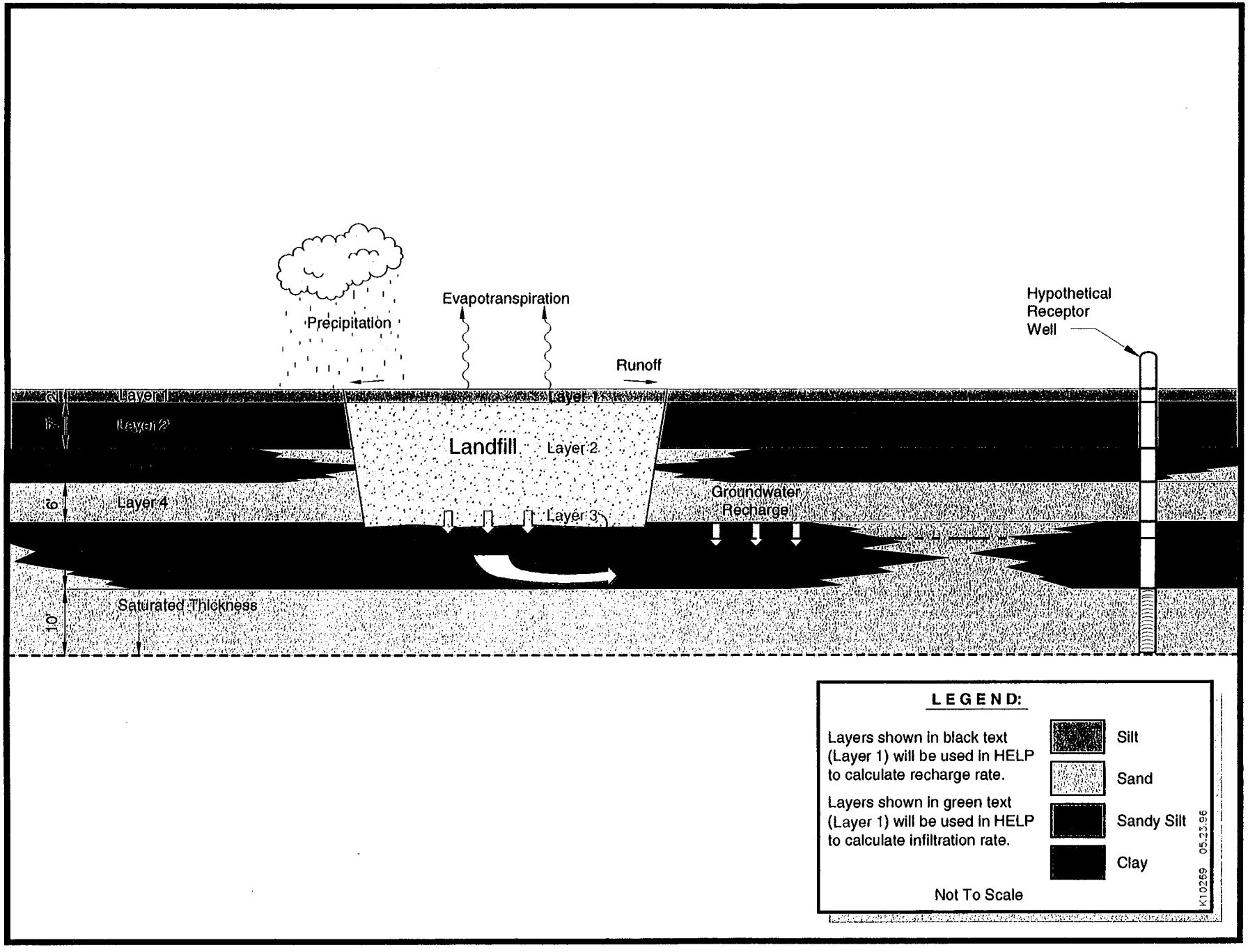


Figure 3-1. Conceptual Cross Section Used for HELP Model Calculations

Table 3-1
HELP Model Input Parameters for Calculation of Leachate Infiltration Rate

Input Parameter	Value (Layer 1)	Value (Layer 2)	Value (Layer 3)	Justification
CLIMATOLOGY DATA				
City	Holloman AFB, New Mexico			Holloman AFB Weather Station Data
Precipitation/Source of Data	Holloman AFB Weather Station			Holloman AFB Weather Station Data
Temperature/Source of Data	Holloman AFB Weather Station			Holloman AFB Weather Station Data
Maximum Leaf Area Index	1			Poor stand of native grasses
Evaporative Zone Depth	30 inches			Value based on type of vegetation
Growing Season	Start (60); End (275)			Value based on type of vegetation
LANDFILL COVER DATA				
Type of Vegetative Cover	Native Grasses and Shrubs			Based on results of site visit
SCS Runoff Curve Number	89			Lake Holloman water balance study
Active (uncovered)?	Yes			Conservative estimate
% Surface Runoff that Drain from Landfill	50			Estimate based on topography
Surface Area	121 Acres			Total area of landfill
SOIL AND DESIGN DATA				
Source of Soil Characteristics	Default HELP Values/Field Measurements			
Total Number of Layers	3	3	3	Includes upper silt unit and waste unit (Figure 3-1)
Thickness (inches)	24	216	24	Thicknesses as measured at site.
Layer Type	1	1	1	Based on known site conditions
Soil Texture	23	18	27	Drilling logs of boreholes drilled at the site.
Porosity	0.461	0.671	0.400	Default values from HELP User's Manual
Field Capacity	0.36	0.292	0.3660	Default values from HELP User's Manual
Wilting Point	0.203	0.077	0.2880	Default values from HELP User's Manual
Moisture Content	0.203	0.077	0.2880	Estimated based on wilting point values.
Saturated Hydraulic Conductivity (cm/sec)	9.0×10^{-6}	1.0×10^{-3}	7.8×10^{-7}	Default values from HELP compared with site results for accuracy
Is Layer Compacted	Yes	Yes	Yes	Assumed to be partially compacted as a result of machinery operating within landfill area.

Table 3-2
HELP Model Input Parameters for the Calculation of the Recharge Rate

Input Parameter	HELP Input Parameter Values					Justification
	Layer 1	Layer 2	Layer 3	Layer 4	Layer 5	
CLIMATOLOGY DATA						
City	Holloman AFB, New Mexico					Holloman AFB Weather Station Data
Precipitation/Source of Data	Holloman AFB Weather Station					Holloman AFB Weather Station Data
Temperature/Source of Data	Holloman AFB Weather Station					Holloman AFB Weather Station Data
Maximum Leaf Area Index	1					Poor stand of native grasses
Evaporative Zone Depth	30 in.					Value based on type of vegetation
Growing Season	Start (60); End (275)					Value based on type of vegetation
LANDFILL COVER DATA						
Type of Vegetative Cover	Native Grasses and Shrubs					Vegetative cover
SCS Runoff Curve Number	86					Lake Holloman water balance study
Active (uncovered)?	Yes					Conservative Estimate
% Surface Runoff that Drain from Landfill	50					Estimated value based on topography and soil type
Surface Area	397 Acres					Area from downgradient boundary of landfill to hypothetical receptor well
SOIL AND DESIGN DATA						
Source of Soil Characteristics	Default HELP Values/Field Measurements					
Total Number of Layers	5	5	5	5	5	Includes upper silt unit and waste unit (Figure 3-1)
Thickness (inches)	24	84	60	72	24	Thicknesses as measured at site.
Layer Type	1	1	1	1	1	Based on known site conditions
Soil Texture	8	7	10	3	11	Geotechnical results from nearby sites and excavation records
Porosity	0.463	0.473	0.398	0.457	0.464	Default values from HELP User's Manual
Field Capacity	0.232	0.222	0.244	0.083	0.310	Default values from HELP User's Manual
Wilting Point	0.116	0.104	0.136	0.033	0.187	Default values from HELP User's Manual
Moisture Content	0.116	0.104	0.136	0.033	0.187	Estimated based on wilting point values.
Saturated Hydraulic Conductivity (cm/sec)	3.7×10^{-4}	5.2×10^{-4}	1.2×10^{-4}	3.1×10^{-3}	6.4×10^{-5}	Default values from HELP compared with site results for accuracy
Is Layer Compacted	No	No	No	No	No	Recharge is assumed to occur in undisturbed and, therefore, uncompacted areas outside of the landfill boundary

SECTION 4
MULTIMED MODEL INPUT PARAMETERS AND RESULTS

This section presents an overview of the MULTIMED model and summarizes the input parameters and model results.

4.1 Overview of MULTIMED

MULTIMED is a one-dimensional, analytical model capable of evaluating contaminant concentrations for groundwater receptors at the water table beneath a landfill or at potential receptor locations in an aquifer downgradient of a landfill. Data requirements for MULTIMED include general model design, landfill design specifications, and saturated zone characteristics (USEPA, 1993). As output, the model provides a value defined as the "concentration after saturated zone model," which is the concentration of a constituent calculated by the model to be present at a selected receptor location after a specified period of time selected for the model.

4.2 MULTIMED Model Data Inputs and Technical Approach

For the purposes of the GWMSR, MULTIMED was used to evaluate the potential for a generic constituent with an initial concentration of 1 mg/l to migrate from the landfill to a hypothetical receptor well located downgradient of the site. Data inputs into MULTIMED were either field-measured data or values chosen to maximize contaminant migration and consider potential impacts on human health and the environment. A detailed description of field-measured data and estimated data used in the MULTIMED model are presented in Table 4-1.

As shown conceptually in Figure 2-2, groundwater fate and transport predictions were modeled through the uppermost saturated zone, from the base of the landfill to a hypothetical receptor well located approximately 2743 m hydraulically downgradient of the landfill, at the southernmost boundary of Holloman AFB. The southern Base boundary serves as a conservative location for the hypothetical receptor well because a water supply aquifer is not present below Holloman AFB or the immediate vicinity surrounding the Base.

The duration of the model run(s) was selected to be 600 years (20 times the required 30-year postclosure care period required by the NMSWMR). The value of 600 years was selected on the basis of the results of a case study in which the constituent modeled traveled from the landfill to a hypothetical downgradient receptor well location at a rate of 20 times faster than the transport rate predicted using modeling. This value is expected to represent the upper limit of contaminant rate predictions and is estimated to represent a worst case scenario for predicting the rate of transport of constituents within the saturated zone beneath the landfill.

Results of the modeling were evaluated by comparing the concentration output from the MULTIMED saturated zone model to the practical quantitation limit (PQL) of ethylene dibromide (i.e., 0.000025 mg/l), the lowest PQL listed for constituents required for monitoring under Part VIII of the NMSWMR (see Appendix D of this report). The PQL, as defined in the SWMR, is the lowest concentration of an analyte in the groundwater that can be reliably determined within specified limits of precision and accuracy under routine laboratory operating conditions. Therefore, if the resulting concentration of the default constituent is below the detectable limits of the lowest PQL (i.e., 0.00025 mg/l), it could not be reliably detected in the groundwater.

Table 4-1
MULTIMED Model Input Parameters

Variable Name	Units	Value Proposed	Source/Comments
General			
Run Option	-	deterministic-transient	Transient*
Active Models	-	saturated zone parameters and source parameters	Saturated zone parameters and source parameters**
Aquifer Saturated Zone Parameters			
Depth and Particle Characteristics			
-Aquifer porosity	-	0.437	Characteristics listed in model literature for loamy sand.
-Bulk density	g/cc	1.98	Estimated value for sand.
-Aquifer Thickness	m	5.49	See Figure 2-2 of conceptual site model.
Hydraulic and Dispersion Parameters			
-Hydraulic conductivity	m/yr	567.65	Characteristics listed in model literature for loamy sand (1.7×10^{-3} cm/sec).
-Hydraulic gradient	-	0.004	See Figure 2-4.
Well Related Parameters			
-Receptor distance from site	m	2743	Hypothetical receptor well located at southern boundary of Holloman AFB.
-Angle off center	degree	0	Most direct path to hypothetical receptor well.***
-Zone distance from water table	m	0	Most direct route to screened area of well.***
Source Contaminant Data			
-Initial concentration at landfill	mg/l	1	1 is used so that the model output can be easily translated to all constituents.

* The transient-state model allows for the maximization receptor concentration for a 50 year pulse over a 600 year period.

** By excluding biodegradation from the simulation, the unsaturated zone can be omitted for the steady-state case. Removing the unsaturated zone is a simpler, more conservative approach to modeling the landfill leachate.

*** Environmentally conservative estimates of the effectiveness of a landfill require the well to be located at the top of the aquifer along a line drawn parallel to the groundwater flow direction and perpendicular to the downgradient edge of the facility, intersecting that edge at its midpoint.

4.3 Results of MULTIMED Modeling

During the study, several model runs were executed to consider the impact (i.e., the resulting endpoint concentration) of different scenarios on the fate and transport of constituents in the groundwater. Figure 4-1 presents an overview of the scenarios modeled, and includes a summary of the input parameters and results for each case.

For the first model run (Case I), infiltration and recharge rate values derived from the HELP model (see Section 3.1.2) were used as input into MULTIMED. It was assumed that infiltration occurs over the entire area of the landfill (i.e., approximately 490,000 m^2) and that recharge occurs over the area between the downgradient edge of the landfill and the hypothetical receptor well (i.e., approximately 1.6×10^6 m^2). As presented in Table 4-2, the Case I model resulted in a contaminant concentration at the hypothetical receptor well after 600 years of 0.12×10^{-5} mg/L. This value is well below the PQL of 0.00025 for ethylene dibromide and, therefore, would be undetectable at this concentration in the groundwater.

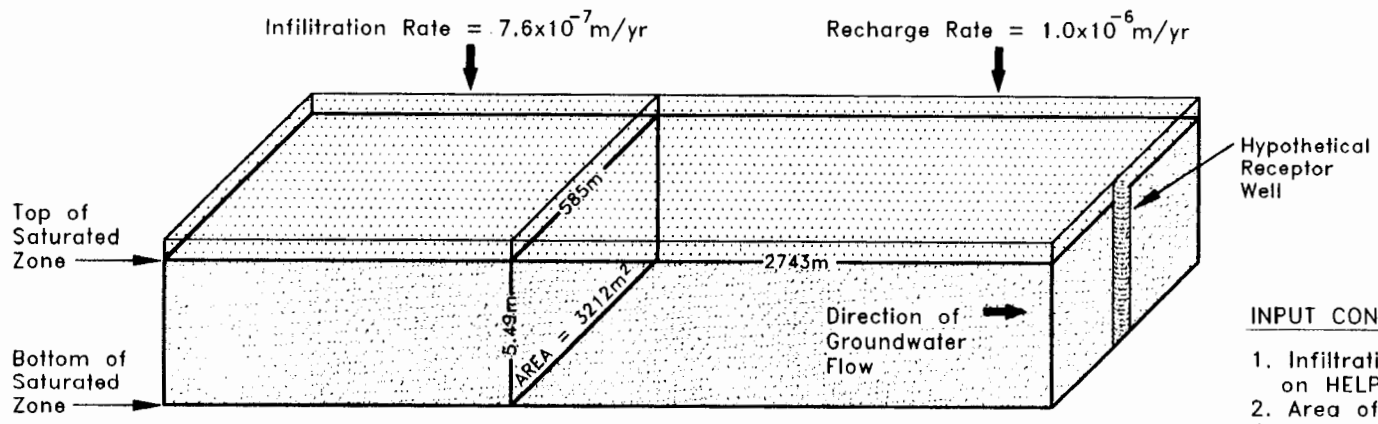
The second scenario (Case II) assumed similar areas of infiltration and recharge as used in the Case I model; however, the infiltration and recharge rates were increased to evaluate the effects of a more conservative scenario on the resulting endpoint concentration. Assuming that the hydrologic system beneath the landfill is a closed system (i.e., water enters the system only through infiltration and recharge and exits the system through horizontal flow through the upper saturated zone perpendicular to water flow), the theoretical maximum values of infiltration and recharge capable of maximizing the hydrologic properties of the uppermost saturated zone were calculated (see Appendix E). The model was then executed with the new values for infiltration and recharge (i.e., 4.1×10^{-6} m/year and 4.0×10^{-4} m/year, respectively). As presented in Table 4-2, the resulting concentration at the hypothetical receptor well was 0.57×10^{-5} mg/l, an order of magnitude lower than the lowest detectable concentration within reliable limits.

The third, and final, scenario (Case III) modeled assumed that the landfill has a clay soil liner that contains a 1-m^2 hole in the liner through which potential leachate can enter the uppermost saturated zone. A value of 1 m^2 represents the sum of the greatest number of defects, or holes, in a liner as a result of installation defects per acre, as defined by HELP user guide (USEPA, 1994). The infiltration rate and recharge rate for this case were both set equal to 1 m/yr. These values were used as inputs into MULTIMED and resulted a contaminant concentration at the hypothetical receptor well of 0.00000 mg/l.

4.4 Summary

Several conservative model runs were executed in MULTIMED to consider the impacts of different scenarios on the fate and transport of constituents in the uppermost saturated zone beneath the landfill. Even with worst case assumptions of leakage, the resulting endpoint contaminant concentration at the hypothetical receptor well for all three model runs executed was at least an order of magnitude lower than its PQL within reliable limits.

CASE I. Use of Infiltration and Recharge Rates as Determined Through HELP Model.



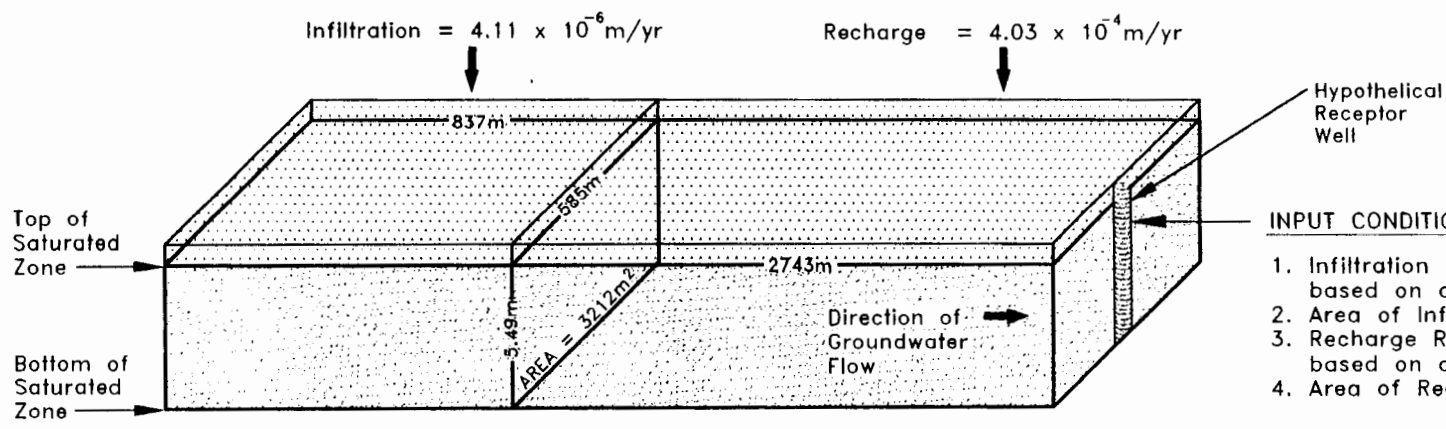
INPUT CONDITIONS

1. Infiltration Rate of 7.6x10^{-7}m/yr based on HELP modeling.
2. Area of Infiltration of 489,645 m^2
3. Recharge Rate of 1.0x10^{-6} m/yr based on HELP Modeling
4. Area of Recharge of 1,604,655 m^2

MODEL RESULTS

Successful execution of model with a resulting end point concentration of 0.116x10^{-5}mg/L after 600 years.

CASE II. Use of Infiltration and Recharge Rates Calculated to Maximize the Capacity of the Hydrologic System within the Saturated Zone



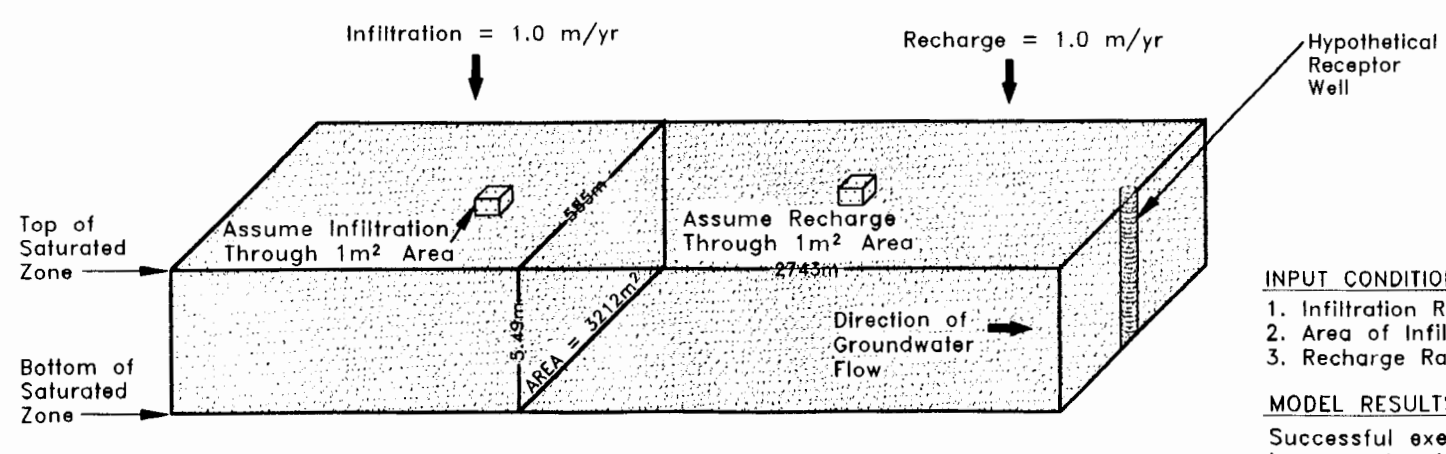
INPUT CONDITIONS

1. Infiltration Rate of 4.11x10^{-6}m/yr based on calculations (Attachment C)
2. Area of Infiltration of 489,645 m
3. Recharge Rate of 4.03x10^{-4} m/yr based on calculations (Attachment C)
4. Area of Recharge of 1,604,655 m^2

MODEL RESULTS

Successful execution of model with a resulting end point concentration of 0.570x10^{-5} mg/L after 600 years.

CASE III. Infiltration Rate of 1 meter/year Over an Area of 1 square meter Recharge Rate of 1 meter/year Over an Area of 1 square meter



INPUT CONDITIONS

1. Infiltration Rate of 1.0 m/yr
2. Area of Infiltration of 1 m^2
3. Recharge Rate of 1.0 m/yr

MODEL RESULTS

Successful execution of model resulting in an end point concentration of 0.0 mg/L after 600 years.

E13111C 04.30.96

Figure 4-1. Conceptual Model of Cases I Through III

Table 4-2
Summary of Results for Case Studies I Through III

Case	Facility Area (m^2)	Recharge Area (m^2)	Infiltration (m/yr)	Recharge (m/yr)	Concentration at Receptor Well			PQL[a] for Ethylene Dibromide (mg/L)	Conclusions
					30 years (mg/L)	120 years (mg/L)	600 years (mg/L)		
I	489,670	1,604,655	7.6×10^{-7}	1.0×10^{-6}	0.10×10^{-18}	0.85×10^{-8}	0.12×10^{-5}	0.25×10^{-4}	Hypothetical receptor well concentration is below PQL value.
II	489,670	1,604,655	4.11×10^{-6}	4.03×10^{-4}	0.55×10^{-18}	0.45×10^{-7}	0.57×10^{-5}	0.25×10^{-4}	Hypothetical receptor well concentration is below PQL value.
III	1	1	1	1	0.10×10^{-14}	0.00000	0.00000	0.25×10^{-4}	Hypothetical receptor well concentration is below PQL value.

[a] Ethylene dibromide has the lowest PQL of any of the constituents presented in Appendix A, Table A-1 of the New Mexico Solid Waste Management Regulations.

Section 5
SUMMARY AND CONCLUSIONS

The NMED groundwater monitoring suspension provision has particular applicability for the Holloman AFB landfill on the basis of the following factors:

- Groundwater in the uppermost aquifer beneath the landfill is not considered a source or potential source of drinking water and is not laterally or vertically interconnected to other water supply aquifers.
- As concluded from the RI and baseline risk assessment conducted at the landfill in 1989, no significant risk is posed by the landfill to human health or the environment. As a result, NFA has been recommended and approved for the landfill by NMED under the IRP.
- Groundwater monitoring is currently being conducted at the landfill under the IRP.

In addition, as demonstrated through contaminant fate and transport calculations conducted using site-specific field measurements and computer modeling, the Holloman AFB landfill is located in a hydrologic regime that will prevent the release of constituents from the landfill to potential groundwater receptors.

It is therefore concluded that the Holloman AFB Main Base Landfill should be granted a suspension of the groundwater monitoring requirements per Subpart VIII, Section 801.C of the New Mexico Solid Waste Management Regulations. The required groundwater scientist certification for this demonstration is presented in Section 6.

Section 6
GROUNDWATER SCIENTIST CERTIFICATION

I hereby certify that, to the best of my professional judgement, the information provided in this request for suspension of the groundwater monitoring requirements for the Holloman AFB Main Base Landfill is accurate and complete. The results of the fate and transport study conducted in support of the Groundwater Monitoring Suspension Request demonstrate that there is no potential for migration of hazardous constituents from the landfill to an uppermost water supply aquifer during the active life of the landfill and the post-closure care period.

Signature of Qualified Groundwater Scientist

06-17-96
Date

George B. Matanga
Printed Name

*See following resume which demonstrates conformity with 105.GG

Section 7
REFERENCES

CH2M Hill. 1983. *Installation Restoration Program Records Search for Holloman Air Force Base, New Mexico.*

Cole, Richard A., et al. 1981. *A Limnological Study of Lake Holloman with Management Recommendations for Multiple Use. NMSU, Las Cruces, New Mexico.*

Orr, B.R., and R.G. Meyers. 1986. *Water Resources I Basin-Fill Deposits in the Tularosa Basin, New Mexico.* U.S. Geological Survey Report 85-4219.

U.S. Department of Interior. 1970. *Saline Groundwater Resources of the Tularosa Basin, New Mexico.* Research and Development Progress Report No. 561.

U.S. Environmental Protection Agency. 1986. *Guidelines for Groundwater Classification under the EPA Groundwater Protection Strategy.*

U.S. Environmental Protection Agency, Office of Solid Waste Management. 1993. *User Manual Supplement: Using MULTIMED to Evaluate Subtitle D Landfill Designs.* U.S. EPA Contract No. 68-WO-0025.

U.S. Environmental Protection Agency, Office of Solid Waste Management. 1994. *The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3.* EPA/600/R-94/168a.

U.S. Geological Survey. 1985. *Hydrologic Data on the Shallow Bolson Fill Near the Sewage Lagoons and Lake Holloman, Holloman Air Force Base, Alamogordo, New Mexico.*

Walk, Haydel, & Associates. 1989(a). *Baseline Risk Assessment Report, Holloman Air Force Base, New Mexico. U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.*

Walk, Haydel, & Associates. 1989(b). *Installation Restoration Program Remedial Investigation Report for Holloman AFB, New Mexico.* U.S. Army Corps of Engineers, Omaha District, Omaha, Nebraska.

APPENDIX A
HELP MODEL INPUT PARAMETERS AND RESULTS

Table A-1
HELP Model Input Parameters and Results for Infiltration

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\data4.D4
TEMPERATURE DATA FILE:       C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\datainf.D10
OUTPUT DATA FILE:            C:\HELP3\datad6.OUT


TIME:  14:19     DATE:   2/ 9/1996


******************************************************************************

     TITLE:  Groundwater Fate and Transport Study, Holloman AFB

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.
```

Table A-1
(Continued)

```
                    LAYER  1
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  23
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.4610 VOL/VOL
  FIELD CAPACITY               =      0.3600 VOL/VOL
  WILTING POINT                =      0.2030 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2030 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.900000032000E-05 CM/SEC
NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
        FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  18
  THICKNESS                    =    216.00   INCHES
  POROSITY                     =      0.6710 VOL/VOL
  FIELD CAPACITY               =      0.2920 VOL/VOL
  WILTING POINT                =      0.0770 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0770 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC


                    LAYER  3
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  27
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.4000 VOL/VOL
  FIELD CAPACITY               =      0.3660 VOL/VOL
  WILTING POINT                =      0.2880 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2880 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.779999993000E-06 CM/SEC
```

Table A-1
(Continued)

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	89.00	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	121.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.334	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	15.090	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	5.334	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	28.416	INCHES
TOTAL INITIAL WATER	=	28.416	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Holloman AFB New Mexico

MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	60	
END OF GROWING SEASON (JULIAN DATE)	=	275	
AVERAGE ANNUAL WIND SPEED	=	5.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	47.10	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	30.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.60	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	48.30	%

NOTE: PRECIPITATION DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.

NOTE: TEMPERATURE DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EL PASO TEXAS

STATION LATITUDE = 32.95 DEGREES

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.508	223234.562	3.59
EVAPOTRANSPIRATION	10.780	4734942.000	76.08
PERC./LEAKAGE THROUGH LAYER 3	0.000032	14.146	0.00
CHANGE IN WATER STORAGE	2.882	1265698.370	20.34
SOIL WATER AT START OF YEAR	28.416	12481151.000	
SOIL WATER AT END OF YEAR	31.298	13746850.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.323	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.571	250712.547	4.94
EVAPOTRANSPIRATION	12.207	5361512.000	105.59
PERC./LEAKAGE THROUGH LAYER 3	0.000078	34.373	0.00
CHANGE IN WATER STORAGE	-1.218	-534763.687	-10.53
SOIL WATER AT START OF YEAR	31.298	13746850.000	
SOIL WATER AT END OF YEAR	30.080	13212086.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.614	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.023	10105.007	0.25
EVAPOTRANSPIRATION	9.970	4379007.500	108.48
PERC./LEAKAGE THROUGH LAYER 3	0.000079	34.521	0.00
CHANGE IN WATER STORAGE	-0.803	-352622.719	-8.74
SOIL WATER AT START OF YEAR	30.080	13212086.000	
SOIL WATER AT END OF YEAR	29.277	12859463.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.481	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.303	133278.859	3.52
EVAPOTRANSPIRATION	7.683	3374734.750	89.03
PERC./LEAKAGE THROUGH LAYER 3	0.000078	34.333	0.00
CHANGE IN WATER STORAGE	0.643	282505.156	7.45
SOIL WATER AT START OF YEAR	29.277	12859463.000	
SOIL WATER AT END OF YEAR	29.920	13141969.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.188	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.293	128549.164	4.81
EVAPOTRANSPIRATION	6.993	3071611.250	115.02
PERC./LEAKAGE THROUGH LAYER 3	0.000078	34.402	0.00
CHANGE IN WATER STORAGE	-1.206	-529675.937	-19.83
SOIL WATER AT START OF YEAR	29.920	13141969.000	
SOIL WATER AT END OF YEAR	28.715	12612293.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.499	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.406	178353.391	2.87
EVAPOTRANSPIRATION	11.182	4911626.000	78.92
PERC./LEAKAGE THROUGH LAYER 3	0.000079	34.691	0.00
CHANGE IN WATER STORAGE	2.582	1133872.620	18.22
SOIL WATER AT START OF YEAR	28.715	12612293.000	
SOIL WATER AT END OF YEAR	31.296	13746165.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.197	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.572	251071.859	4.94
EVAPOTRANSPIRATION	11.532	5065196.000	99.76
PERC./LEAKAGE THROUGH LAYER 3	0.000079	34.817	0.00
CHANGE IN WATER STORAGE	-0.544	-238801.484	-4.70
SOIL WATER AT START OF YEAR	31.296	13746165.000	
SOIL WATER AT END OF YEAR	30.752	13507364.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.196	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.017	7273.991	0.18
EVAPOTRANSPIRATION	10.259	4506090.500	111.63
PERC./LEAKAGE THROUGH LAYER 3	0.000083	36.259	0.00
CHANGE IN WATER STORAGE	-1.086	-476878.312	-11.81
SOIL WATER AT START OF YEAR	30.752	13507364.000	
SOIL WATER AT END OF YEAR	29.667	13030486.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.343	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.295	129606.461	3.42
EVAPOTRANSPIRATION	7.521	3303525.750	87.15
PERC./LEAKAGE THROUGH LAYER 3	0.000084	36.952	0.00
CHANGE IN WATER STORAGE	0.814	357382.906	9.43
SOIL WATER AT START OF YEAR	29.667	13030486.000	
SOIL WATER AT END OF YEAR	30.480	13387868.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.405	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.313	137630.328	5.15
EVAPOTRANSPIRATION	4.886	2146249.500	80.37
PERC./LEAKAGE THROUGH LAYER 3	0.000087	38.087	0.00
CHANGE IN WATER STORAGE	0.880	386599.937	14.48
SOIL WATER AT START OF YEAR	30.480	13387868.000	
SOIL WATER AT END OF YEAR	31.360	13774468.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.411	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.447	196287.031	3.15
EVAPOTRANSPIRATION	12.485	5483952.500	88.11
PERC./LEAKAGE THROUGH LAYER 3	0.000086	37.836	0.00
CHANGE IN WATER STORAGE	1.238	543613.000	8.73
SOIL WATER AT START OF YEAR	31.360	13774468.000	
SOIL WATER AT END OF YEAR	32.598	14318081.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.406	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.574	252006.156	4.96
EVAPOTRANSPIRATION	12.538	5507237.000	108.46
PERC./LEAKAGE THROUGH LAYER 3	0.000080	35.289	0.00
CHANGE IN WATER STORAGE	-1.552	-681777.125	-13.43
SOIL WATER AT START OF YEAR	32.598	14318081.000	
SOIL WATER AT END OF YEAR	31.046	13636304.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.433	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.038	16748.639	0.41
EVAPOTRANSPIRATION	9.784	4297447.500	106.46
PERC./LEAKAGE THROUGH LAYER 3	0.000062	27.432	0.00
CHANGE IN WATER STORAGE	-0.632	-277699.750	-6.88
SOIL WATER AT START OF YEAR	31.046	13636304.000	
SOIL WATER AT END OF YEAR	30.414	13358604.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.169	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.313	137342.437	3.62
EVAPOTRANSPIRATION	7.792	3422318.750	90.29
PERC./LEAKAGE THROUGH LAYER 3	0.000052	22.799	0.00
CHANGE IN WATER STORAGE	0.526	230869.531	6.09
SOIL WATER AT START OF YEAR	30.414	13358604.000	
SOIL WATER AT END OF YEAR	30.939	13589474.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.797	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.291	127995.164	4.79
EVAPOTRANSPIRATION	6.960	3056842.500	114.47
PERC./LEAKAGE THROUGH LAYER 3	0.000045	19.901	0.00
CHANGE IN WATER STORAGE	-1.171	-514338.125	-19.26
SOIL WATER AT START OF YEAR	30.939	13589474.000	
SOIL WATER AT END OF YEAR	29.768	13075136.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.051	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.414	182019.203	2.92
EVAPOTRANSPIRATION	11.179	4910341.000	78.90
PERC./LEAKAGE THROUGH LAYER 3	0.000040	17.450	0.00
CHANGE IN WATER STORAGE	2.576	1131512.750	18.18
SOIL WATER AT START OF YEAR	29.768	13075136.000	
SOIL WATER AT END OF YEAR	32.344	14206649.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.689	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.572	251110.141	4.95
EVAPOTRANSPIRATION	11.564	5079124.500	100.03
PERC./LEAKAGE THROUGH LAYER 3	0.000032	14.192	0.00
CHANGE IN WATER STORAGE	-0.575	-252751.953	-4.98
SOIL WATER AT START OF YEAR	32.344	14206649.000	
SOIL WATER AT END OF YEAR	31.769	13953897.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.935	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.016	7041.396	0.17
EVAPOTRANSPIRATION	10.217	4487654.000	111.18
PERC./LEAKAGE THROUGH LAYER 3	0.000010	4.434	0.00
CHANGE IN WATER STORAGE	-1.043	-458176.062	-11.35
SOIL WATER AT START OF YEAR	31.769	13953897.000	
SOIL WATER AT END OF YEAR	30.726	13495721.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.190	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.295	129664.656	3.42
EVAPOTRANSPIRATION	7.554	3318088.000	87.54
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.106	0.00
CHANGE IN WATER STORAGE	0.780	342801.594	9.04
SOIL WATER AT START OF YEAR	30.726	13495721.000	
SOIL WATER AT END OF YEAR	31.506	13838522.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.111	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.313	137630.328	5.15
EVAPOTRANSPIRATION	4.877	2142328.250	80.22
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.889	390560.062	14.62
SOIL WATER AT START OF YEAR	31.506	13838522.000	
SOIL WATER AT END OF YEAR	32.396	14229082.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.249	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.448	196579.172	3.16
EVAPOTRANSPIRATION	12.479	5481084.000	88.07
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	1.244	546225.937	8.78
SOIL WATER AT START OF YEAR	32.396	14229082.000	
SOIL WATER AT END OF YEAR	33.639	14775308.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.183	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.574	252013.406	4.96
EVAPOTRANSPIRATION	12.532	5504595.000	108.41
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-1.546	-679107.187	-13.37
SOIL WATER AT START OF YEAR	33.639	14775308.000	
SOIL WATER AT END OF YEAR	32.093	14096201.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.042	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.038	16523.789	0.41
EVAPOTRANSPIRATION	9.780	4295688.500	106.42
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.107	0.00
CHANGE IN WATER STORAGE	-0.628	-275689.937	-6.83
SOIL WATER AT START OF YEAR	32.093	14096201.000	
SOIL WATER AT END OF YEAR	31.465	13820511.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.432	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.299	131265.859	3.46
EVAPOTRANSPIRATION	8.015	3520385.000	92.87
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.316	138905.578	3.66
SOIL WATER AT START OF YEAR	31.465	13820511.000	
SOIL WATER AT END OF YEAR	31.782	13959417.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.113	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.292	128451.992	4.81
EVAPOTRANSPIRATION	6.757	2967780.250	111.13
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.108	0.00
CHANGE IN WATER STORAGE	-0.969	-425715.187	-15.94
SOIL WATER AT START OF YEAR	31.782	13959417.000	
SOIL WATER AT END OF YEAR	30.812	13533701.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.109	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.414	181984.906	2.92
EVAPOTRANSPIRATION	11.168	4905391.500	78.82
PERC./LEAKAGE THROUGH LAYER 3	0.000002	1.082	0.00
CHANGE IN WATER STORAGE	2.588	1136514.120	18.26
SOIL WATER AT START OF YEAR	30.812	13533701.000	
SOIL WATER AT END OF YEAR	33.400	14670216.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.967	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.572	251310.266	4.95
EVAPOTRANSPIRATION	11.560	5077457.500	100.00
PERC./LEAKAGE THROUGH LAYER 3	0.000010	4.602	0.00
CHANGE IN WATER STORAGE	-0.572	-251274.125	-4.95
SOIL WATER AT START OF YEAR	33.400	14670216.000	
SOIL WATER AT END OF YEAR	32.828	14418942.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.739	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.016	7231.714	0.18
EVAPOTRANSPIRATION	10.199	4479808.500	110.98
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.109	0.00
CHANGE IN WATER STORAGE	-1.026	-450516.375	-11.16
SOIL WATER AT START OF YEAR	32.828	14418942.000	
SOIL WATER AT END OF YEAR	31.802	13968425.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.181	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.295	129730.367	3.42
EVAPOTRANSPIRATION	7.573	3326429.000	87.76
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.761	334395.469	8.82
SOIL WATER AT START OF YEAR	31.802	13968425.000	
SOIL WATER AT END OF YEAR	32.563	14302821.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.432	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.313	137630.328	5.15
EVAPOTRANSPIRATION	4.867	2137755.500	80.05
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.900	395131.750	14.80
SOIL WATER AT START OF YEAR	32.563	14302821.000	
SOIL WATER AT END OF YEAR	33.463	14697952.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.798	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.447	196447.844	3.16
EVAPOTRANSPIRATION	12.490	5486139.500	88.15
PERC./LEAKAGE THROUGH LAYER 3	0.000006	2.460	0.00
CHANGE IN WATER STORAGE	1.232	541296.562	8.70
SOIL WATER AT START OF YEAR	33.463	14697952.000	
SOIL WATER AT END OF YEAR	34.695	15239249.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.592	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 32

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.574	252008.797	4.96
EVAPOTRANSPIRATION	12.546	5510648.500	108.53
PERC./LEAKAGE THROUGH LAYER 3	0.000017	7.496	0.00
CHANGE IN WATER STORAGE	-1.560	-685165.875	-13.49
SOIL WATER AT START OF YEAR	34.695	15239249.000	
SOIL WATER AT END OF YEAR	33.135	14554083.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.096	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 33

	INCHES.	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.038	16771.174	0.42
EVAPOTRANSPIRATION	9.783	4296869.000	106.45
PERC./LEAKAGE THROUGH LAYER 3	0.000001	0.329	0.00
CHANGE IN WATER STORAGE	-0.631	-277115.812	-6.87
SOIL WATER AT START OF YEAR	33.135	14554083.000	
SOIL WATER AT END OF YEAR	32.505	14276967.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.710	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 34

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.313	137371.797	3.62
EVAPOTRANSPIRATION	7.816	3433214.500	90.57
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.501	219965.187	5.80
SOIL WATER AT START OF YEAR	32.505	14276967.000	
SOIL WATER AT END OF YEAR	33.005	14496932.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.822	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 35

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.295	129643.508	4.85
EVAPOTRANSPIRATION	6.916	3037676.250	113.75
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-1.131	-496801.187	-18.60
SOIL WATER AT START OF YEAR	33.005	14496932.000	
SOIL WATER AT END OF YEAR	31.874	14000131.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.249	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 36

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.411	180669.859	2.90
EVAPOTRANSPIRATION	11.196	4917594.000	79.01
PERC./LEAKAGE THROUGH LAYER 3	0.000001	0.553	0.00
CHANGE IN WATER STORAGE	2.563	1125625.750	18.09
SOIL WATER AT START OF YEAR	31.874	14000131.000	
SOIL WATER AT END OF YEAR	34.437	15125757.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.417	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 37

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.572	251203.187	4.95
EVAPOTRANSPIRATION	11.543	5070087.500	99.85
PERC./LEAKAGE THROUGH LAYER 3	0.000011	4.869	0.00
CHANGE IN WATER STORAGE	-0.555	-243799.594	-4.80
SOIL WATER AT START OF YEAR	34.437	15125757.000	
SOIL WATER AT END OF YEAR	33.882	14881957.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.828	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 38

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.018	8090.455	0.20
EVAPOTRANSPIRATION	10.194	4477407.000	110.92
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.111	0.00
CHANGE IN WATER STORAGE	-1.022	-448974.875	-11.12
SOIL WATER AT START OF YEAR	33.882	14881957.000	
SOIL WATER AT END OF YEAR	32.860	14432982.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.403	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.296	129835.523	3.43
EVAPOTRANSPIRATION	7.566	3323284.250	87.67
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.768	337434.875	8.90
SOIL WATER AT START OF YEAR	32.860	14432982.000	
SOIL WATER AT END OF YEAR	33.628	14770417.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.628	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.313	137630.344	5.15
EVAPOTRANSPIRATION	4.883	2144679.000	80.31
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.884	388210.125	14.54
SOIL WATER AT START OF YEAR	33.628	14770417.000	
SOIL WATER AT END OF YEAR	34.512	15158627.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.100	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 41

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.448	196726.328	3.16
EVAPOTRANSPIRATION	12.457	5471607.500	87.91
PERC./LEAKAGE THROUGH LAYER 3	0.000006	2.625	0.00
CHANGE IN WATER STORAGE	1.265	555551.937	8.93
SOIL WATER AT START OF YEAR	34.512	15158627.000	
SOIL WATER AT END OF YEAR	35.777	15714179.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.412	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 42

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.574	252015.469	4.96
EVAPOTRANSPIRATION	12.535	5505927.500	108.44
PERC./LEAKAGE THROUGH LAYER 3	0.000019	8.441	0.00
CHANGE IN WATER STORAGE	-1.549	-680452.625	-13.40
SOIL WATER AT START OF YEAR	35.777	15714179.000	
SOIL WATER AT END OF YEAR	34.227	15033727.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.016	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 43

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.038	16535.744	0.41
EVAPOTRANSPIRATION	9.781	4295921.000	106.43
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.112	0.00
CHANGE IN WATER STORAGE	-0.628	-275934.562	-6.84
SOIL WATER AT START OF YEAR	34.227	15033727.000	
SOIL WATER AT END OF YEAR	33.599	14757792.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.621	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.299	131276.141	3.46
EVAPOTRANSPIRATION	8.014	3520086.250	92.86
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.317	139191.266	3.67
SOIL WATER AT START OF YEAR	33.599	14757792.000	
SOIL WATER AT END OF YEAR	33.916	14896983.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.597	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.292	128453.617	4.81
EVAPOTRANSPIRATION	6.757	2967791.750	111.13
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.113	0.00
CHANGE IN WATER STORAGE	-0.969	-425725.219	-15.94
SOIL WATER AT START OF YEAR	33.916	14896983.000	
SOIL WATER AT END OF YEAR	32.947	14471258.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.985	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 46

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	6223888.500	100.00
RUNOFF	0.414	181984.766	2.92
EVAPOTRANSPIRATION	11.168	4905336.000	78.81
PERC./LEAKAGE THROUGH LAYER 3	0.000003	1.129	0.00
CHANGE IN WATER STORAGE	2.588	1136565.250	18.26
SOIL WATER AT START OF YEAR	32.947	14471258.000	
SOIL WATER AT END OF YEAR	35.535	15607824.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.319	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 47

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	5077499.000	100.00
RUNOFF	0.572	251310.047	4.95
EVAPOTRANSPIRATION	11.560	5077518.000	100.00
PERC./LEAKAGE THROUGH LAYER 3	0.000011	4.803	0.00
CHANGE IN WATER STORAGE	-0.572	-251332.766	-4.95
SOIL WATER AT START OF YEAR	35.535	15607824.000	
SOIL WATER AT END OF YEAR	34.962	15356491.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.928	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 48

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	4036524.000	100.00
RUNOFF	0.016	7231.698	0.18
EVAPOTRANSPIRATION	10.199	4479811.000	110.98
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.113	0.00
CHANGE IN WATER STORAGE	-1.026	-450521.406	-11.16
SOIL WATER AT START OF YEAR	34.962	15356491.000	
SOIL WATER AT END OF YEAR	33.937	14905969.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.287	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 49

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	3790555.250	100.00
RUNOFF	0.295	129730.445	3.42
EVAPOTRANSPIRATION	7.573	3326438.000	87.76
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.761	334387.094	8.82
SOIL WATER AT START OF YEAR	33.937	14905969.000	
SOIL WATER AT END OF YEAR	34.698	15240356.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.275	0.00

****

Table A-1
(Continued)

****

ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	2670518.250	100.00
RUNOFF	0.313	137630.328	5.15
EVAPOTRANSPIRATION	4.867	2137746.750	80.05
PERC./LEAKAGE THROUGH LAYER 3	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	0.900	395140.125	14.80
SOIL WATER AT START OF YEAR	34.698	15240356.000	
SOIL WATER AT END OF YEAR	35.598	15635497.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.217	0.00

****

Table A-1
(Continued)

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.02	0.36	0.11	0.24	0.67	0.58
	1.54	1.55	1.57	0.38	0.40	1.51
STD. DEVIATIONS	0.48	0.27	0.10	0.21	0.58	0.51
	0.73	1.28	1.23	0.24	0.34	1.21
RUNOFF						
TOTALS	0.002	0.000	0.000	0.000	0.000	0.044
	0.042	0.043	0.083	0.000	0.000	0.114
STD. DEVIATIONS	0.004	0.000	0.000	0.000	0.000	0.089
	0.078	0.077	0.117	0.000	0.000	0.143
EVAPOTRANSPIRATION						
TOTALS	0.890	0.656	0.436	0.359	0.793	1.061
	1.042	1.163	1.656	0.482	0.336	0.582
STD. DEVIATIONS	0.629	0.414	0.299	0.207	0.540	0.760
	0.580	0.762	0.827	0.437	0.190	0.319
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table A-1
(Continued)

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	9.93	(2.774)	4359797.0	100.00
RUNOFF	0.328	(0.1836)	143859.03	3.300
EVAPOTRANSPIRATION	9.455	(2.4461)	4152840.00	95.253
PERCOLATION/LEAKAGE THROUGH FROM LAYER 3	0.00003	(0.00003)	11.024	0.00025
CHANGE IN WATER STORAGE	0.144	(1.2872)	63086.91	1.447

****

Table A-1
(Continued)

```
*******************************************************************************
                PEAK DAILY VALUES FOR YEARS     1 THROUGH    50
   ---------------------------------------------------------------------------
                                                (INCHES)       (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                              1.25         549037.500

      RUNOFF                                     0.338        148433.9840

      PERCOLATION/LEAKAGE THROUGH LAYER  3       0.000000          0.21121

      SNOW WATER                                 1.80         788953.1870

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3108

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1734
*******************************************************************************
```

Table A-1
(Continued)

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	6.9644	0.2902
2	21.7142	0.1005
3	6.9190	0.2883
SNOW WATER	0.000	

****
****

Table A-2
HELP Model Input Parameters and Results for Recharge

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\data4.D4
TEMPERATURE DATA FILE:       C:\HELP3\data7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\data13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\data11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\datarec.D10
OUTPUT DATA FILE:            C:\HELP3\datad7.OUT

TIME:  12:34     DATE:   2/ 9/1996


******************************************************************************

     TITLE:  Groundwater Fate and Transport Study, Holloman AFB

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.
```

Table A-2
(Continued)

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1160	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 1.80
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 7

THICKNESS	=	84.00	INCHES
POROSITY	=	0.4730	VOL/VOL
FIELD CAPACITY	=	0.2220	VOL/VOL
WILTING POINT	=	0.1040	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1040	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.520000001000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 10

THICKNESS	=	60.00	INCHES
POROSITY	=	0.3980	VOL/VOL
FIELD CAPACITY	=	0.2440	VOL/VOL
WILTING POINT	=	0.1360	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1360	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.119999997000E-03	CM/SEC

Table A-2
(Continued)

```
                    LAYER  4
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   3
THICKNESS                    =     72.00   INCHES
POROSITY                     =      0.4570 VOL/VOL
FIELD CAPACITY               =      0.0830 VOL/VOL
WILTING POINT                =      0.0330 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0330 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.310000009000E-02 CM/SEC


                    LAYER  5
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  11
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4640 VOL/VOL
FIELD CAPACITY               =      0.3100 VOL/VOL
WILTING POINT                =      0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1870 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
```

Table A-2
(Continued)

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	86.00	
FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	397.000	ACRES
EVAPORATIVE ZONE DEPTH	=	30.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.408	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.950	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.408	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	26.544	INCHES
TOTAL INITIAL WATER	=	26.544	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Holloman AFB New Mexico

MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	60	
END OF GROWING SEASON (JULIAN DATE)	=	275	
AVERAGE ANNUAL WIND SPEED	=	5.70	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	47.10	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	30.30	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.60	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	48.30	%

NOTE: PRECIPITATION DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.

NOTE: TEMPERATURE DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EL PASO TEXAS

STATION LATITUDE = 32.95 DEGREES

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.007	10777.496	0.05
EVAPOTRANSPIRATION	12.255	17660174.000	86.48
PERC./LEAKAGE THROUGH LAYER 5	0.000014	20.842	0.00
CHANGE IN WATER STORAGE	1.908	2749559.500	13.46
SOIL WATER AT START OF YEAR	26.544	38252792.000	
SOIL WATER AT END OF YEAR	28.452	41002352.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-4.196	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39904.809	0.24
EVAPOTRANSPIRATION	12.160	17523648.000	105.19
PERC./LEAKAGE THROUGH LAYER 5	0.000033	48.273	0.00
CHANGE IN WATER STORAGE	-0.628	-904368.750	-5.43
SOIL WATER AT START OF YEAR	28.452	41002352.000	
SOIL WATER AT END OF YEAR	27.824	40097984.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.637	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.131	14600224.000	110.24
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.263	0.00
CHANGE IN WATER STORAGE	-0.941	-1356474.750	-10.24
SOIL WATER AT START OF YEAR	27.824	40097984.000	
SOIL WATER AT END OF YEAR	26.883	38741508.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.962	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.939	12882065.000	103.58
PERC./LEAKAGE THROUGH LAYER 5	0.000033	48.018	0.00
CHANGE IN WATER STORAGE	-0.315	-454442.437	-3.65
SOIL WATER AT START OF YEAR	26.883	38741508.000	
SOIL WATER AT END OF YEAR	26.568	38287064.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.829	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	5.988	8630036.000	98.49
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.232	0.00
CHANGE IN WATER STORAGE	0.074	106022.828	1.21
SOIL WATER AT START OF YEAR	26.568	38287064.000	
SOIL WATER AT END OF YEAR	26.641	38393088.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.357	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11149.279	0.05
EVAPOTRANSPIRATION	12.251	17654880.000	86.46
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.621	0.00
CHANGE IN WATER STORAGE	1.911	2754449.500	13.49
SOIL WATER AT START OF YEAR	26.641	38393088.000	
SOIL WATER AT END OF YEAR	28.553	41147536.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.300	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39847.418	0.24
EVAPOTRANSPIRATION	12.144	17500434.000	105.05
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.972	0.00
CHANGE IN WATER STORAGE	-0.611	-881109.250	-5.29
SOIL WATER AT START OF YEAR	28.553	41147536.000	
SOIL WATER AT END OF YEAR	27.941	40266428.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	10.600	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.186	14678550.000	110.83
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.760	0.00
CHANGE IN WATER STORAGE	-0.996	-1434796.250	-10.83
SOIL WATER AT START OF YEAR	27.941	40266428.000	
SOIL WATER AT END OF YEAR	26.946	38831632.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.658	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.918	12852293.000	103.34
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.086	0.00
CHANGE IN WATER STORAGE	-0.295	-424668.531	-3.41
SOIL WATER AT START OF YEAR	26.946	38831632.000	
SOIL WATER AT END OF YEAR	26.651	38406964.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.987	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8649624.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.869	0.00
CHANGE IN WATER STORAGE	0.060	86427.352	0.99
SOIL WATER AT START OF YEAR	26.651	38406964.000	
SOIL WATER AT END OF YEAR	26.711	38493392.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.564	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11145.470	0.05
EVAPOTRANSPIRATION	12.252	17657124.000	86.47
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.696	0.00
CHANGE IN WATER STORAGE	1.910	2752212.000	13.48
SOIL WATER AT START OF YEAR	26.711	38493392.000	
SOIL WATER AT END OF YEAR	28.621	41245604.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-3.837	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39819.957	0.24
EVAPOTRANSPIRATION	12.159	17521944.000	105.18
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.932	0.00
CHANGE IN WATER STORAGE	-0.626	-902593.125	-5.42
SOIL WATER AT START OF YEAR	28.621	41245604.000	
SOIL WATER AT END OF YEAR	27.994	40343008.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	11.988	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.158	14638619.000	110.53
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.917	0.00
CHANGE IN WATER STORAGE	-0.968	-1394874.120	-10.53
SOIL WATER AT START OF YEAR	27.994	40343008.000	
SOIL WATER AT END OF YEAR	27.026	38948136.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	7.431	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.931	12870005.000	103.48
PERC./LEAKAGE THROUGH LAYER 5	0.000034	48.883	0.00
CHANGE IN WATER STORAGE	-0.307	-442378.406	-3.56
SOIL WATER AT START OF YEAR	27.026	38948136.000	
SOIL WATER AT END OF YEAR	26.720	38505756.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-4.159	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8650206.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000033	48.269	0.00
CHANGE IN WATER STORAGE	0.060	85852.867	0.98
SOIL WATER AT START OF YEAR	26.720	38505756.000	
SOIL WATER AT END OF YEAR	26.779	38591612.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.394	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11151.424	0.05
EVAPOTRANSPIRATION	12.268	17680024.000	86.58
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.178	0.00
CHANGE IN WATER STORAGE	1.894	2729304.250	13.37
SOIL WATER AT START OF YEAR	26.779	38591612.000	
SOIL WATER AT END OF YEAR	28.673	41320916.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.028	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39851.961	0.24
EVAPOTRANSPIRATION	12.132	17482852.000	104.94
PERC./LEAKAGE THROUGH LAYER 5	0.000033	47.628	0.00
CHANGE IN WATER STORAGE	-0.599	-863525.812	-5.18
SOIL WATER AT START OF YEAR	28.673	41320916.000	
SOIL WATER AT END OF YEAR	28.074	40457388.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.025	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.164	14647511.000	110.60
PERC./LEAKAGE THROUGH LAYER 5	0.000033	47.290	0.00
CHANGE IN WATER STORAGE	-0.974	-1403760.620	-10.60
SOIL WATER AT START OF YEAR	28.074	40457388.000	
SOIL WATER AT END OF YEAR	27.100	39053628.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.561	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.936	12877287.000	103.54
PERC./LEAKAGE THROUGH LAYER 5	0.000033	47.573	0.00
CHANGE IN WATER STORAGE	-0.312	-449670.687	-3.62
SOIL WATER AT START OF YEAR	27.100	39053628.000	
SOIL WATER AT END OF YEAR	26.788	38603956.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.772	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.005	8653458.000	98.76
PERC./LEAKAGE THROUGH LAYER 5	0.000035	50.529	0.00
CHANGE IN WATER STORAGE	0.057	82598.414	0.94
SOIL WATER AT START OF YEAR	26.788	38603956.000	
SOIL WATER AT END OF YEAR	26.845	38686556.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.094	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11144.911	0.05
EVAPOTRANSPIRATION	12.250	17653148.000	86.45
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.455	0.00
CHANGE IN WATER STORAGE	1.913	2756184.000	13.50
SOIL WATER AT START OF YEAR	26.845	38686556.000	
SOIL WATER AT END OF YEAR	28.758	41442740.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.085	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39849.012	0.24
EVAPOTRANSPIRATION	12.144	17500846.000	105.05
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.611	0.00
CHANGE IN WATER STORAGE	-0.612	-881521.562	-5.29
SOIL WATER AT START OF YEAR	28.758	41442740.000	
SOIL WATER AT END OF YEAR	28.146	40561220.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	8.367	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.168	14653289.000	110.64
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.100	0.00
CHANGE IN WATER STORAGE	-0.978	-1409538.500	-10.64
SOIL WATER AT START OF YEAR	28.146	40561220.000	
SOIL WATER AT END OF YEAR	27.168	39151680.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.751	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.935	12876375.000	103.53
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.187	0.00
CHANGE IN WATER STORAGE	-0.311	-448752.625	-3.61
SOIL WATER AT START OF YEAR	27.168	39151680.000	
SOIL WATER AT END OF YEAR	26.856	38702928.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.340	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8649539.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000034	49.258	0.00
CHANGE IN WATER STORAGE	0.060	86512.555	0.99
SOIL WATER AT START OF YEAR	26.856	38702928.000	
SOIL WATER AT END OF YEAR	26.916	38789440.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.175	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11147.140	0.05
EVAPOTRANSPIRATION	12.252	17656798.000	86.47
PERC./LEAKAGE THROUGH LAYER 5	0.000035	50.360	0.00
CHANGE IN WATER STORAGE	1.910	2752530.750	13.48
SOIL WATER AT START OF YEAR	26.916	38789440.000	
SOIL WATER AT END OF YEAR	28.826	41541972.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.701	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39848.605	0.24
EVAPOTRANSPIRATION	12.144	17500718.000	105.05
PERC./LEAKAGE THROUGH LAYER 5	0.000035	49.738	0.00
CHANGE IN WATER STORAGE	-0.612	-881397.875	-5.29
SOIL WATER AT START OF YEAR	28.826	41541972.000	
SOIL WATER AT END OF YEAR	28.215	40660572.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	14.143	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.185	14677727.000	110.83
PERC./LEAKAGE THROUGH LAYER 5	0.000035	50.931	0.00
CHANGE IN WATER STORAGE	-0.995	-1433974.370	-10.83
SOIL WATER AT START OF YEAR	28.215	40660572.000	
SOIL WATER AT END OF YEAR	27.220	39226600.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.455	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.918	12852126.000	103.34
PERC./LEAKAGE THROUGH LAYER 5	0.000035	50.568	0.00
CHANGE IN WATER STORAGE	-0.295	-424509.094	-3.41
SOIL WATER AT START OF YEAR	27.220	39226600.000	
SOIL WATER AT END OF YEAR	26.925	38802088.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.776	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8649712.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000035	51.092	0.00
CHANGE IN WATER STORAGE	0.060	86342.141	0.99
SOIL WATER AT START OF YEAR	26.925	38802088.000	
SOIL WATER AT END OF YEAR	26.985	38888432.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.905	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 31

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11145.409	0.05
EVAPOTRANSPIRATION	12.252	17657086.000	86.47
PERC./LEAKAGE THROUGH LAYER 5	0.000036	52.274	0.00
CHANGE IN WATER STORAGE	1.910	2752250.500	13.48
SOIL WATER AT START OF YEAR	26.985	38888432.000	
SOIL WATER AT END OF YEAR	28.895	41640680.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-6.354	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 32

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39819.965	0.24
EVAPOTRANSPIRATION	12.159	17521960.000	105.18
PERC./LEAKAGE THROUGH LAYER 5	0.000036	52.233	0.00
CHANGE IN WATER STORAGE	-0.626	-902601.375	-5.42
SOIL WATER AT START OF YEAR	28.895	41640680.000	
SOIL WATER AT END OF YEAR	28.269	40738080.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.432	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 33

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.158	14638629.000	110.53
PERC./LEAKAGE THROUGH LAYER 5	0.000037	52.915	0.00
CHANGE IN WATER STORAGE	-0.968	-1394882.370	-10.53
SOIL WATER AT START OF YEAR	28.269	40738080.000	
SOIL WATER AT END OF YEAR	27.301	39343196.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.059	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 34

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.931	12869995.000	103.48
PERC./LEAKAGE THROUGH LAYER 5	0.000036	52.308	0.00
CHANGE IN WATER STORAGE	-0.307	-442381.156	-3.56
SOIL WATER AT START OF YEAR	27.301	39343196.000	
SOIL WATER AT END OF YEAR	26.994	38900816.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	4.785	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 35

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8650193.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000037	53.545	0.00
CHANGE IN WATER STORAGE	0.060	85858.367	0.98
SOIL WATER AT START OF YEAR	26.994	38900816.000	
SOIL WATER AT END OF YEAR	27.053	38986676.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.888	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 36

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11151.434	0.05
EVAPOTRANSPIRATION	12.268	17680024.000	86.58
PERC./LEAKAGE THROUGH LAYER 5	0.000038	54.294	0.00
CHANGE IN WATER STORAGE	1.894	2729298.750	13.37
SOIL WATER AT START OF YEAR	27.053	38986676.000	
SOIL WATER AT END OF YEAR	28.947	41715976.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.655	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 37

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39851.961	0.24
EVAPOTRANSPIRATION	12.132	17482854.000	104.94
PERC./LEAKAGE THROUGH LAYER 5	0.000038	54.552	0.00
CHANGE IN WATER STORAGE	-0.599	-863528.562	-5.18
SOIL WATER AT START OF YEAR	28.947	41715976.000	
SOIL WATER AT END OF YEAR	28.348	40852444.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.476	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 38

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.164	14647510.000	110.60
PERC./LEAKAGE THROUGH LAYER 5	0.000039	56.561	0.00
CHANGE IN WATER STORAGE	-0.974	-1403768.870	-10.60
SOIL WATER AT START OF YEAR	28.348	40852444.000	
SOIL WATER AT END OF YEAR	27.374	39448676.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	3.910	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 39

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.936	12877289.000	103.54
PERC./LEAKAGE THROUGH LAYER 5	0.000040	57.710	0.00
CHANGE IN WATER STORAGE	-0.312	-449681.687	-3.62
SOIL WATER AT START OF YEAR	27.374	39448676.000	
SOIL WATER AT END OF YEAR	27.062	38998996.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.254	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 40

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.005	8653458.000	98.76
PERC./LEAKAGE THROUGH LAYER 5	0.000041	58.381	0.00
CHANGE IN WATER STORAGE	0.057	82587.414	0.94
SOIL WATER AT START OF YEAR	27.062	38998996.000	
SOIL WATER AT END OF YEAR	27.119	39081584.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	2.549	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 41

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11144.911	0.05
EVAPOTRANSPIRATION	12.250	17653150.000	86.45
PERC./LEAKAGE THROUGH LAYER 5	0.000041	59.158	0.00
CHANGE IN WATER STORAGE	1.913	2756175.750	13.50
SOIL WATER AT START OF YEAR	27.119	39081584.000	
SOIL WATER AT END OF YEAR	29.032	41837756.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.746	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 42

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39849.012	0.24
EVAPOTRANSPIRATION	12.144	17500846.000	105.05
PERC./LEAKAGE THROUGH LAYER 5	0.000042	60.068	0.00
CHANGE IN WATER STORAGE	-0.612	-881529.812	-5.29
SOIL WATER AT START OF YEAR	29.032	41837756.000	
SOIL WATER AT END OF YEAR	28.420	40956228.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.156	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 43

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.168	14653289.000	110.64
PERC./LEAKAGE THROUGH LAYER 5	0.000043	61.586	0.00
CHANGE IN WATER STORAGE	-0.978	-1409554.870	-10.64
SOIL WATER AT START OF YEAR	28.420	40956228.000	
SOIL WATER AT END OF YEAR	27.442	39546672.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	5.757	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 44

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.935	12876372.000	103.53
PERC./LEAKAGE THROUGH LAYER 5	0.000043	62.205	0.00
CHANGE IN WATER STORAGE	-0.311	-448763.625	-3.61
SOIL WATER AT START OF YEAR	27.442	39546672.000	
SOIL WATER AT END OF YEAR	27.130	39097908.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.386	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 45

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8649539.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000045	64.178	0.00
CHANGE IN WATER STORAGE	0.060	86496.062	0.99
SOIL WATER AT START OF YEAR	27.130	39097908.000	
SOIL WATER AT END OF YEAR	27.190	39184404.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	7.747	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 46

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	20420528.000	100.00
RUNOFF	0.008	11147.140	0.05
EVAPOTRANSPIRATION	12.252	17656798.000	86.47
PERC./LEAKAGE THROUGH LAYER 5	0.000046	65.593	0.00
CHANGE IN WATER STORAGE	1.910	2752517.250	13.48
SOIL WATER AT START OF YEAR	27.190	39184404.000	
SOIL WATER AT END OF YEAR	29.100	41936924.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.788	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 47

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	16659232.000	100.00
RUNOFF	0.028	39848.605	0.24
EVAPOTRANSPIRATION	12.144	17500718.000	105.05
PERC./LEAKAGE THROUGH LAYER 5	0.000046	66.353	0.00
CHANGE IN WATER STORAGE	-0.612	-881414.375	-5.29
SOIL WATER AT START OF YEAR	29.100	41936924.000	
SOIL WATER AT END OF YEAR	28.489	41055508.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	14.019	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 48

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	13243802.000	100.00
RUNOFF	0.000	0.000	0.00
EVAPOTRANSPIRATION	10.185	14677728.000	110.83
PERC./LEAKAGE THROUGH LAYER 5	0.000046	66.859	0.00
CHANGE IN WATER STORAGE	-0.995	-1433990.870	-10.83
SOIL WATER AT START OF YEAR	28.489	41055508.000	
SOIL WATER AT END OF YEAR	27.494	39621516.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-2.264	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 49

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	12436781.000	100.00
RUNOFF	0.006	9109.818	0.07
EVAPOTRANSPIRATION	8.918	12852126.000	103.34
PERC./LEAKAGE THROUGH LAYER 5	0.000045	64.760	0.00
CHANGE IN WATER STORAGE	-0.295	-424520.094	-3.41
SOIL WATER AT START OF YEAR	27.494	39621516.000	
SOIL WATER AT END OF YEAR	27.199	39196996.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.579	0.00

****

Table A-2
(Continued)

****

ANNUAL TOTALS FOR YEAR 50

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	8761949.000	100.00
RUNOFF	0.018	25842.123	0.29
EVAPOTRANSPIRATION	6.002	8649711.000	98.72
PERC./LEAKAGE THROUGH LAYER 5	0.000044	63.065	0.00
CHANGE IN WATER STORAGE	0.060	86325.648	0.99
SOIL WATER AT START OF YEAR	27.199	39196996.000	
SOIL WATER AT END OF YEAR	27.259	39283324.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	6.798	0.00

****

Table A-2
(Continued)

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 50

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.02	0.36	0.11	0.24	0.67	0.58
	1.54	1.55	1.57	0.38	0.40	1.51
STD. DEVIATIONS	0.48	0.27	0.10	0.21	0.58	0.51
	0.73	1.28	1.23	0.24	0.34	1.21
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.001
	0.001	0.000	0.004	0.000	0.000	0.006
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.003
	0.003	0.000	0.007	0.000	0.000	0.008
EVAPOTRANSPIRATION						
TOTALS	1.170	0.670	0.259	0.144	0.675	0.670
	1.463	1.534	1.708	0.337	0.487	0.782
STD. DEVIATIONS	0.783	0.274	0.137	0.162	0.531	0.746
	0.724	0.985	1.017	0.211	0.346	0.532
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table A-2
(Continued)

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 50

	INCHES		CU. FEET	PERCENT
PRECIPITATION	9.93	(2.774)	14304459.0	100.00
RUNOFF	0.012	(0.0098)	17182.31	0.120
EVAPOTRANSPIRATION	9.900	(2.3388)	14266611.00	99.735
PERCOLATION/LEAKAGE THROUGH FROM LAYER 5	0.00004	(0.00001)	52.495	0.00037
CHANGE IN WATER STORAGE	0.014	(1.0167)	20610.62	0.144

****

Table A-2
(Continued)

```
*******************************************************************************

              PEAK DAILY VALUES FOR YEARS    1 THROUGH   50
   ---------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                            1.25       1801387.500

      RUNOFF                                   0.021        30041.9727

      PERCOLATION/LEAKAGE THROUGH LAYER  5     0.000000         0.27233

      SNOW WATER                               1.80       2588548.7500

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.1930

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1080

*******************************************************************************
```

Table A-2
(Continued)

****

FINAL WATER STORAGE AT END OF YEAR 50

LAYER	(INCHES)	(VOL/VOL)
1	2.7684	0.1154
2	9.4666	0.1127
3	8.1600	0.1360
4	2.3760	0.0330
5	4.4880	0.1870
SNOW WATER	0.000	

****
****

APPENDIX B
MULTIMED INPUT PARAMETERS AND RESULTS

Ta B-1
Case I Input Par eters and Results

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1
Run options
--- -------

DEFAULT

CASE
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated zone model
Run was	DETERMIN

Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1

Table B-1
(Continued)

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Distribution coefficient	--	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	-999.	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000E+00	100.
Molecular weight	g/M	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	0.000E+00	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000E+00	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.760E-06	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.490E+06	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	50.0	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	115.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.100E-05	-999.	0.000E+00	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	840.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	585.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000E+00	0.000E+00	1.00

Ta) B-1
(Co: ued)

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.98	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	5.49	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	568.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.400E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	CONSTANT	1.00	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Transverse dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Vertical dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Temperature of aquifer	C	CONSTANT	19.6	-999.	0.000E+00	100.
pH	--	CONSTANT	6.90	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	-999.	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	0.274E+04	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

1

TIME	CONCENTRATION
0.300E+02	0.10209E-18
0.600E+02	0.17647E-12
0.900E+02	0.24218E-09
0.120E+03	0.84588E-08
0.150E+03	0.67253E-07
0.180E+03	0.24609E-06
0.210E+03	0.56497E-06
0.240E+03	0.96659E-06
0.270E+03	0.13650E-05
0.300E+03	0.16932E-05
0.330E+03	0.19187E-05
0.360E+03	0.20373E-05
0.390E+03	0.20626E-05
0.420E+03	0.20148E-05
0.450E+03	0.19146E-05
0.480E+03	0.17807E-05
0.510E+03	0.16286E-05
0.540E+03	0.14697E-05
0.570E+03	0.13120E-05
0.600E+03	0.11610E-05

Table B-2
Case II Input Parameters and Results

1

U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1

Run options
--- -------

DEFAULT

CASE
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated zone model
Run was	DETERMIN

Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model

1
1

Table B-2
(Continued)

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Distribution coefficient	--	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	-999.	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000E+00	100.
Molecular weight	g/M	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	0.000E+00	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000E+00	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.411E-05	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.490E+06	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	50.0	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	115.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.403E-03	-999.	0.000E+00	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	DERIVED	840.	-999.	0.100E-08	0.100E+11
Width scale of facility	m	DERIVED	585.	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000E+00	0.000E+00	1.00

Table B-2
(Continued)

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.98	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	5.49	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	568.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.400E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	CONSTANT	1.00	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Transverse dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Vertical dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Temperature of aquifer	C	CONSTANT	19.6	-999.	0.000E+00	100.
pH	--	CONSTANT	6.90	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	-999.	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	0.274E+04	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

1

TIME	CONCENTRATION
0.300E+02	0.55210E-18
0.600E+02	0.94516E-12
0.900E+02	0.12913E-08
0.120E+03	0.44906E-07
0.150E+03	0.35551E-06
0.180E+03	0.12951E-05
0.210E+03	0.29597E-05
0.240E+03	0.50397E-05
0.270E+03	0.70827E-05
0.300E+03	0.87426E-05
0.330E+03	0.98582E-05
0.360E+03	0.10416E-04
0.390E+03	0.10493E-04
0.420E+03	0.10198E-04
0.450E+03	0.96431E-05
0.480E+03	0.89238E-05
0.510E+03	0.81210E-05
0.540E+03	0.72918E-05
0.570E+03	0.64769E-05
0.600E+03	0.57027E-05

Table B-3
Case III Input Parameters and Results

1

U. S. E N V I R O N M E N T A L P R O T E C T I O N A G E N C Y

E X P O S U R E A S S E S S M E N T

M U L T I M E D I A M O D E L

MULTIMED (Version 1.01, June 1991)

1
Run options
--- -------

DEFAULT

CASE
Chemical simulated is DEFAULT CHEMICAL

Option Chosen	Saturated zone model
Run was	DETERMIN

Infiltration input by user
Run was transient
Reject runs if Y coordinate outside plume
Do not reject runs if Z coordinate outside plume
Gaussian source used in saturated zone model
1
1

Table B-3
(Continued)

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Reference temperature	C	CONSTANT	25.0	-999.	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Distribution coefficient	--	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	-999.	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	25.0	-999.	0.000E+00	100.
Molecular weight	g/M	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	0.000E+00	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Henry`s law constant	atm-m^3/M	CONSTANT	0.000E+00	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00

SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	1.00	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	1.00	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	50.0	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	115.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	1.00	-999.	0.000E+00	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	CONSTANT	1.00	-999.	0.100E-08	0.100E+11
Width scale of facility	m	CONSTANT	1.00	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000E+00	0.000E+00	1.00

Table B-3
(Continued)

AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.200	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.437	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.98	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	5.49	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	-999.	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	568.	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.400E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	CONSTANT	1.00	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Transverse dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Vertical dispersivity	m	FUNCTION OF X	-999.	-999.	-999.	-999.
Temperature of aquifer	C	CONSTANT	19.6	-999.	0.000E+00	100.
pH	--	CONSTANT	6.90	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	-999.	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	0.274E+04	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

1

TIME	CONCENTRATION
0.300E+02	0.10000E-14
0.600E+02	0.00000E+00
0.900E+02	0.00000E+00
0.120E+03	0.00000E+00
0.150E+03	0.00000E+00
0.180E+03	0.00000E+00
0.210E+03	0.00000E+00
0.240E+03	0.00000E+00
0.270E+03	0.00000E+00
0.300E+03	0.00000E+00
0.330E+03	0.00000E+00
0.360E+03	0.00000E+00
0.390E+03	0.00000E+00
0.420E+03	0.00000E+00
0.450E+03	0.00000E+00
0.480E+03	0.00000E+00
0.510E+03	0.00000E+00
0.540E+03	0.00000E+00
0.570E+03	0.00000E+00
0.600E+03	0.00000E+00

APPENDIX C
RESULTS OF WATER QUALITY SAMPLING AT THE MAIN BASE LANDFILL

TABLE 3-3

SITE I - GROUNDWATER

COMMON ANIONS (mg/L)

TOTAL DISSOLVED SOLIDS (mg/L)

	Monitoring Wells								
	MW1	MW1-D	MW2	MW3	MW4	MW5	IW-1	IW-2	IW-3
Chlorides	10400	10200	20000	20300	1400	6300	6400	15500	21500
Fluorides	18.3	18.3	26.7	28.0	24.0	16.7	12.7	25.0	30.0
Nitrate-N	10.0	10	23.3	23.3	23.3	46.6	10.0	70.0	23.2
Nitrite-N	-	-	-	-	-	-	-	-	-
Ortho-Phosphate-P	3.3	3.3	10.0	6.7	3.3	3.3	3.3	6.7	10.0
Sulfates	7500	7500	10000	11000	10000	6000	5600	9250	11000
Total Dissolved Solids	28,193	67,621	47,982	47,444	36,212	19,284	18,318	38,522	45,391

\- Not detected
D Field duplicate

WH&A 1012 (REV.3/83)
WALK, HAYDEL & ASSOCIATES, INC.
ENGINEERS
NEW ORLEANS—MOBILE—BATON ROUGE

APPENDIX D
GROUNDWATER PQLs FOR PARAMETERS
REQUIRED FOR MONITORING UNDER PART VIII OF THE NMSWMR

FILED WITH
STATE RECORDS CENTER
1994 JUL 18 AM 8:03

APPENDIX A

GROUND WATER PARAMETERS

The standards are from the New Mexico Water Quality Control Commission Regulations or the federal Safe Drinking Water Act as they exist on the effective date of these regulations. Check with the Department to confirm the standards are still applicable.

Table I

Parameter	Standard[2] mg/l	PQL[3] mg/l	Parameter	Standard mg/l	PQL mg/l
Arsenic[1]	0.05	0.01	Barium[1]	1.0	0.02
Benzene[1]	0.005	0.001	Benzo[a]pyrene[1]	0.0002	0.0001
Cadmium[1]	0.005	0.002	Boron	0.75(i)	0.5
Carbon tetrachloride[1]	0.005	0.002	Chloride	250(a)	5.0
Chloroform[1]	0.1	0.005	Chromium[1]	0.05	0.01
Cobalt	0.05(i)	0.03	Copper	1.0(a)	0.06
Cyanide[1]	0.2	0.1	1,2-Dichloroethane (EDC)[1]	0.005	0.001
1,1-Dichloroethane[1]	0.025	0.005	1,1-Dichloroethylene (1,1-DCE)[1]	0.005	0.001
Ethylbenzene[1]	0.7	0.005	Ethylene dibromide (EDB)[1]	0.00005	0.000025
Fluoride[1]	1.6	0.4	Iron	0.3(a)	0.1
Lead[1]	0.05	0.01	Magnesium		
Manganese	0.05(a)	0.03	Mercury[1]	0.002	0.001
Methylene chloride[1]	0.005	0.001	Molybdenum	1.0(i)	0.75
Nickel[1]	0.1	0.05	Nitrate[1]	10	1.0
PAHs: Total Naphthalene plus monomethylnaphthalenes[1]	0.03	0.01	Phenols	0.005(a)	0.003
Polychlorinated biphenyls (PCB's)[1]	0.001	0.0005	Potassium		
Radioactivity: Combined Radium-226 and Radium 228[1]	5.0pCi/l	2.5pCi/l	Selenium[1]	0.01	0.005
Silver[1]	0.05	0.01	Sodium		
Sulfate	250(a)	5.0	Toluene[1]	0.75	0.005
Total Dissolved Solids	500(a)	5.0	Total Xylenes[1]	0.62	0.005
1,1,2,2-Tetrachloroethane[1]	0.01	0.005	Tetrachloroethylene[1]	0.005	0.0005
1,1,1-Trichloroethane[1]	0.06	0.005	Aluminum	5.0(i)	3.0
1,1,2-Trichloroethane[1]	0.005	0.002	Trichloroethylene[1]	0.005	0.001
Uranium[1]	5.0	2.5	Vinyl Chloride[1]	0.001	0.0004
Zinc	5.0(a)	0.05	pH (Units)	6.5-8.5(a)	0.1

FILED WITH
STATE RECORDS CENTER

1994 JUL 18 AM 8:03

Parameter	Standard[2] mg/l	PQL[3] mg/l	Parameter	Standard mg/l	PQL mg/l
Ammonia			Total Nitrogen[1]	10	1.0
Specific Conductance			Total Organic Carbon		
Temperature			Water Elevation		
Antimony[1]	0.006	0.003	Beryllium[1]	0.004	0.002
Thallium[1]	0.002	0.001	Vanadium[1]		0.08
Acetone[1]		0.1	Acrylonitrile[1]		0.2
Bromochloromethane[1]		0.002	Bromodichloromethane[1]		0.005
Bromoform[1]		0.015	Carbon disulfide[1]		0.1
Chlorobenzene[1]	0.1	0.005	Chloroethane[1]		0.01
Dibromochloromethane[1]		0.005	1,2-Dibromo-3-chloropropane[1]	0.0002	0.0001
1,2-Dichloropropane[1]	0.005	0.0005	cis-1,3-Dichloropropene[1]		0.02
2-Hexanone[1]		0.05	Methyl bromide[1]		0.02
Methyl chloride[1]		0.001	Methylene bromide[1]		0.02
Methyl ethyl ketone[1]		0.01	Methyl iodide[1]		0.04
4-Methyl-2-pentanone[1]		0.015	Styrene[1]	0.1	0.01
1,1,1,2-Tetrachloroethane[1]		0.005	Trichlorofluoromethane[1]		0.01
1,2,3-Trichloropropane[1]		0.01	Vinyl acetate[1]		0.05
o-Dichlorobenzene[1]	0.06	0.01	p-Dichlorobenzene[1]	0.075	0.015
trans-1,4-Dichloro-2-butene[1]		0.1	HCO_3		
CO_3			Total Kjeldahl Nitrogen		
Calcium			trans-1,3-Dichloropropene[1]		0.01

[1] Constituent is considered to be hazardous.

[2] Ground Water Protection Standard subject to change under the New Mexico Water Quality Control Commission Regulations or the federal Safe Drinking Water Act (see Section 806.H.1)

[3] Practical Quantitation Limits (PQL) are the lowest concentration of analytes in ground waters that can be realiably determined within specified limits of precision and accuracy under routine laboratory operating conditions.

All standards are health based except for those followed by (a) aesthetic standard or (i) irrigation standard. For those parameters without a specific standard, background standards shall be established.

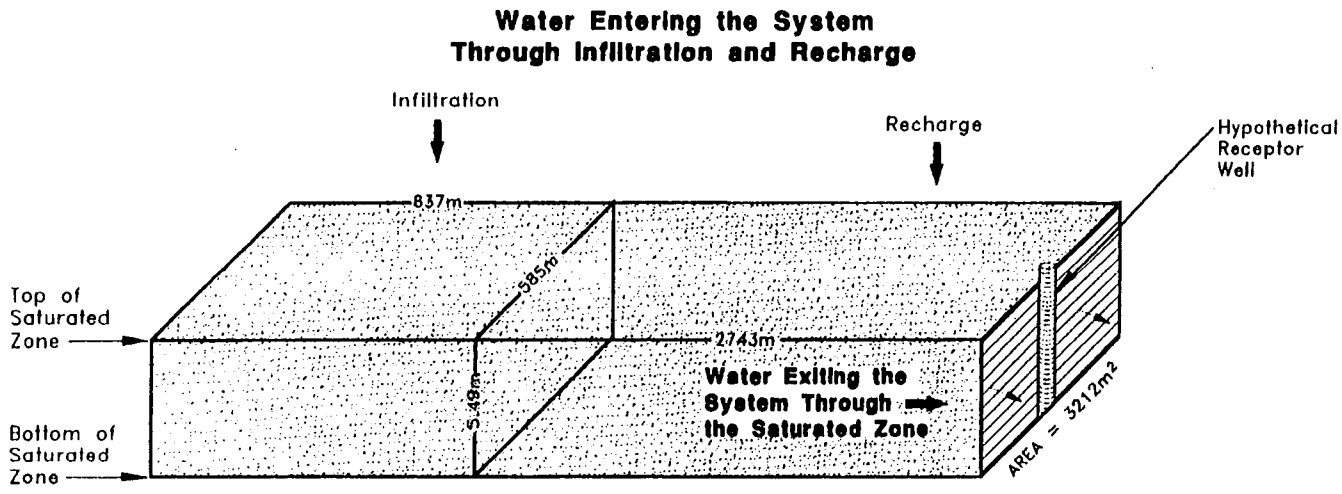
APPENDIX E
CALCULATION OF
INFILTRATION AND RECHARGE VALUES USED IN CASE II

Figure A-1 presents an overview of the hydrologic characteristics of the uppermost saturated zone. The values shown on the figure for hydraulic conductivity and hydraulic gradient (567.65 m/yr and 0.004 m/m, respectively) were obtained from measured field conditions. As shown, the annual flow rate though the aquifer at the hypothetical receptor well location may be calculated as follows:

$Q = -Kadh/dl$
where:
$K = 567.65$ m/yr
$A = (585\ m)x(5.49\ m) = 3211.65\ m^2$
$dh/dl = 0.004$

Solving for Q results in a total annual discharge of 7,292.63 m^3/year through the upper saturated zone.

Assuming the hydrologic system is a closed system, the theoretical maximum values of infiltration and recharge capable of maximizing the hydrologic properties of the uppermost saturated zone were calculated on a weighted average basis (see equations) to be $4.1x10^{-6}$ m/y, and $4.0x10^{-4}$ m/yr, respectively.



Calulated Flow Capacity of Saturated Zone

$Q = -KA\frac{dh}{dl}$

$Q = -(567.65m/yr)(585m \times 5.49m)(0.004\frac{m}{m})$

$Q = -7{,}292.3725m^3/yr$

Where:

Q = Horizontal flow through saturated zone.

K = Hydraulic conductivity of the saturated zone, as measured from pump test results.

A = Cross-sectional area of the saturated zone, perpendicular to groundwater flow.

$\frac{dh}{dl}$ = Hydraulic gradient, as determined from field measurements.

Assumptions:

The system is closed; water enters the system through infiltration and recharge only, and exits the system through the cross-sectional area of the saturated zone perpendicular to the direction of groundwater flow.

E13111B 02.20.95

Figure E-1. Hydrologic Characteristics of the Uppermost Saturated Zone

Calculation of Average Vertical Hydraulic Gradient and Hydraulic Head

1) $Q_{inf} + Q_{rec} = Q_{out}$

2) $K_{inf} A_{inf} \left(\frac{dh}{dl}\right)_v + K_{rec} A_{rec} \left(\frac{dh}{dl}\right)_v = K_{out} A_{out} \left(\frac{dh}{dl}\right)_h$

3) $\left(\frac{dh}{dl}\right)_v (K_{inf} A_{inf} + K_{rec} A_{rec}) = K_{out} A_{out} \left(\frac{dh}{dl}\right)_h$

4) $\left(\frac{dh}{dl}\right)_v$ [(2.476 m/yr) (837 m x 585 m) + (74.087 m/yr) (2743 m x 585 m)] = 568.025 m/yr) (585 m x 5.49 m) (0.004 m/m)

5) $\left(\frac{dh}{dl}\right)_v$ [120,096,436.005] = 7,297.190

6) $\left(\frac{dh}{dl}\right)_v = 6.076109 \times 10^{-5}$

7) $dh_{avg_v} = 6.076109 \times 10^{-5}$ (6.7073171 m)

8) $dh_{avg_v} = 4.075439 \times 10^{-4}$ m

where:

Q_{inf}	=	Flow from infiltration.
Q_{rec}	=	Fow from recharge.
Q_{out}	=	Flow through aquifer, out of system.
K_{inf}	=	Hydraulic conductivity through landfill.
A_{inf}	=	Areal extent of landfill.
$\left(\frac{dh}{dl}\right)_v$	=	Average vertical hydraulic gradient.
$\left(\frac{dh}{dl}\right)_h$	=	Average horizontal hydraulic gradient.
dh_{avg_v}	=	Average hydraulic head per change in length.

Contribution of Infiltration and Recharge to Average Hydraulic Head Calculated as a Weighted Average

1) $K_{inf} A_{inf} + K_{rec} A_{rec} = K_{Total} A_{Total}$

2) (2.476 m/yr) (837 m x 585 m) + (74.087 m/yr) (2,743 m x 585 m)

3) 1,212,361.02 m^3 / yr + 118,884,074.985 m^3 / yr = 120,096,436.005 m^3 / yr

4) Weighted average contribution of infiltration to total discharge = $\frac{1{,}212{,}361.02}{120{,}096{,}436.005} = 0.010095$

5) Weighted average contribution of recharge to total discharge = $\frac{118{,}884{,}074{,}985}{120{,}096{,}436.005} = 0.989905$

6) Weighted average contribution of infiltration = dh_{ave} = 0.010095 (4.075439×10^{-4})
= 4.1141557×10^{-6} m

Weighted average contribution of recharge = dh_{ave} = 0.989905 (4.075439×10^{-4} m)
= 4.0342974×10^{-4} m

where:

K_{inf}	=	Vertical hydraulic conductivity through landfill.
A_{inf}	=	Areal extent of landfill.
K_{rec}	=	Vertical hydraulic conductivity through undisturbed subsurface sediments.
A_{rec}	=	Areal extent of recharge zone.
K_{Total}	=	Total hydraulic conductivity.
A_{Total}	=	Total area.
dh_{inf}	=	Contribution of infiltration to hydraulic head.
dh_{rec}	=	Contribution of recharge to hydraulic head.

RADIAN CORPORATION

CALCULATION SHEET

CALC. NO. _____

SIGNATURE [signature] DATE 2-20-96 CHECKED [signature] DATE 2-20-96

PROJECT Holloman AFB Main Base Landfill Closure JOB NO. _____

SUBJECT Calculation of Average Vertical Conductivity SHEET 1 OF 2 SHEETS

① Calculation of average vertical conductivity in area of recharge

Layer 1	d_{m1}	$= 3.7 \times 10^{-4}$ cm/sec
Layer 2	d_{m2}	$= 5.2 \times 10^{-4}$ cm/sec
Layer 3	d_{m3}	$= 1.2 \times 10^{-4}$ cm/sec
Layer 4	d_{m4}	$= 3.1 \times 10^{-3}$ cm/sec
Layer 5	d_{m5}	$= 6.4 \times 10^{-5}$ cm/sec

$$K_{V_{Adj}} = \frac{d}{\sum \frac{d_m}{K_m}}$$

where

d = Total thickness

d_m = Thickness of each layer

K_m = Conductivity of each layer

$$K_{V_{Adj}} = \frac{6.7073171\ m}{\frac{0.6096\ m}{116.6832\ \frac{m}{yr}} + \frac{2.1336\ m}{163.9872\ \frac{m}{yr}} + \frac{1.524\ m}{37.8432\ \frac{m}{yr}} + \frac{1.8288\ m}{977.616\ \frac{m}{yr}} + \frac{0.6096\ m}{20.1864}}$$

$$= \frac{6.7073171\ m}{5.2244025 \times 10^{-3} + 1.3007 \times 10^{-2} + 4.02714 \times 10^{-2} + 1.8706731 \times 10^{-3} + 3.02035 \times 10^{-2}}$$

$$= \frac{6.7073171\ m}{0.0905807\ \frac{m}{\frac{m}{yr}}} =$$

$$= \boxed{74.047972\ m/yr}$$ = Average Vertical Hydraulic Conductivity in Recharge Area.

10-88-30702

RADIAN CORPORATION

CALCULATION SHEET

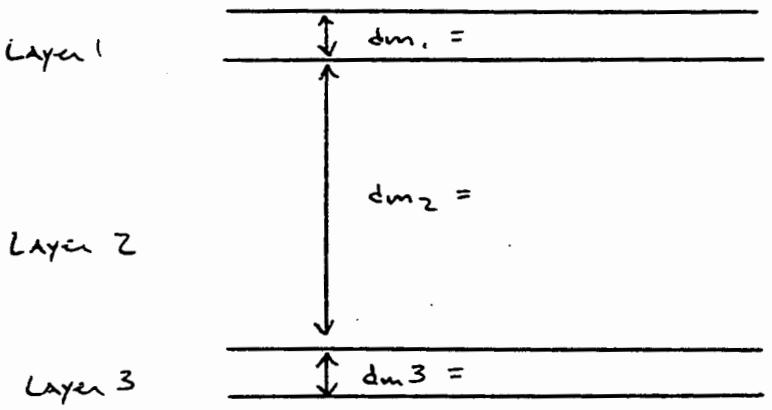
CALC. NO.

SIGNATURE [illegible] DATE 2-20-96 CHECKED [illegible] DATE 2-20-96

PROJECT Hollomon AFB Main Base Landfill Closure JOB NO.

SUBJECT Calculation of Average Vertical Hydraulic Conductivity SHEET 2 OF 2 SHEETS

② Calculation of average vertical conductivity in area of infiltration



$$K_{V_{AVG}} = \frac{d}{\sum \frac{dm}{Km}}$$

where:

d = total thickness

dm = Thickness of each layer

Km = Conductivity of each layer

$$K_{V_{AVG}} = \frac{6.7073171\ m}{\frac{0.6096\ m}{2.83924\ \frac{m}{yr}} + \frac{5.4878049\ m}{315.36\ \frac{m}{yr}} + \frac{0.6096\ m}{0.245986\ \frac{m}{yr}}}$$

$$= \frac{6.7073171}{0.214789 + 0.017407 + 2.478222}$$

$$= \frac{6.7073171\ m}{2.7104248\ \frac{m}{yr}}$$

$$= \boxed{2.4746369\ \frac{m}{yr}}$$ = Average Vertical Hydraulic Conductivity in Infiltrate Area

10-88-30702

APPENDIX E
REGISTERED GEOLOGIST CERTIFICATION

APPENDIX F
REGISTERED GROUNDWATER SCIENTIST DOCUMENTATION

GEORGE B. MATANGA

Education

Ph.D., 1978, Civil Engineering, University of California, Davis
M.S., 1973, Civil Engineering, University of California, Berkeley, California
B.S., 1971, Civil Engineering, California State University, Sacramento

Professional Registrations/Certifications

Professional Civil Engineer, California, C48432, 1991
Professional Hydrologist (GW), American Institute of Hydrology, 87-HGW-655, 1987

Experience

Senior Staff Engineer, Radian Corporation, Sacramento, California, 1991-Present
Lecturer of Civil and Environmental Engineering, Department of Civil and Environmental Engineering, University of California, Davis, California, 1995
Supervising Engineer, McLaren/Hart Environmental Engineering, Sacramento, California, 1986-1991
Visiting Assistant Professor, Department of Agricultural Engineering, Oregon State University, Corvallis, Oregon, 1984-1986
Visiting Research Scientist, Department of Land, Water and Air Resources, University of California, Davis, CA, 1983-1984
Senior Research Fellow, Department of Civil Engineering, University of Zimbabwe, Harare, Zimbabwe, 1982-1983
Post Doctoral Fellow, Department of Earth Sciences, University of Waterloo, Waterloo, Canada, 1980-1982
Civil Engineer, Ingenieuburo Dr.-Ing. Gerhard Bjornsen, Koblenz, West Germany, January 1979-December 1979
Post Graduate Research Assistant, Department of Land, Air and Water Resources, University of California, Davis, California, 1976-1978
Teaching Assistant, School of Engineering, University of Zambia, Lusaka, Zambia, 1971-1972
Junior Civil Engineer, Department of Highways, Bridge Section, City of New York, New York, June 1971-August 1971

Fields of Experience

Dr. Matanga provides technical advice to all Radian offices in groundwater flow and contaminant transport modeling. His responsibilities include directing technical staff in tasks involving groundwater modeling. He has strong experience in developing conceptual models, model calibration, model runs, and result reporting. Dr. Matanga has more than 13 years

experience in developing new numerical models, modification of existing models, and application of existing models.

Dr. Matanga is nationally and internationally recognized as a leader in application of stream functions in groundwater modeling. He co-authored with Professors John Cherry and Emil Frind the popular papers on stream functions in two-dimensional groundwater flow. Recently, Dr. Matanga developed the theory of pseudo potential functions in anisotropic porous media, and the theory of stream functions in three-dimensional groundwater flow. In both two-dimensional and three-dimensional groundwater flow, stream functions are evaluated by solution of partial differential equations. Solution of partial differential equations in groundwater flow with sinks/sources is extremely difficulty. Dr. Matanga has, therefore, developed a semigraphical method of evaluating stream functions in complex groundwater flow systems. The method is known as the method of characteristic curves. Dr. Matanga's work will lead to development of valuable tools in design of remediation systems, and visualization of groundwater flow and contaminant migration.

Dr. Matanga is also a lecturer of Civil and Environmental Engineering at University of California, Davis. He teaches graduate courses in groundwater flow and transport processes, and groundwater modeling.

Projects

- Served as groundwater modeling task leader at Pantex Plant in Amarillo, Texas. Developing the conceptual model of groundwater flow and chemical transport through the vadose and saturated zones. The flow system is complicated by existence of perched aquifers in the vadose zone.

- Served as a groundwater modeling task leader at Maxwell AFB and Gunther Annex in Montgomery, Alabama. Developed the conceptual model for groundwater flow and contaminant transport at both sites. Applied the LINX visualization software to construct the geological model.

- Served as groundwater modeling task leader at Elmendorf Air Force Base in Anchorage, Alaska. Developed conceptual model of groundwater flow and contaminant transport. Modified a finite element code SALT developed at University of Waterloo in order to account for complex geology and boundary conditions encountered on the site. The modified code is called SALT2. In addition to advection, dispersion and diffusion, SALT2 can handle adsorption and degradation of contaminants. Results from SALT2 will be used in risk assessment and evaluation of contaminant mass being discharged into Ship Creek adjacent to the aquifer.

- Provided technical advice in analysis of pump test data collected in an aquifer at Galena Air Force Base, Alaska. Applied the Neuman method.

- Developed work plan for groundwater flow and contaminant transport modeling for Gunther/Maxwell Air Force Base in Alabama.

- Applied VAPOUR-T model (developed at University Waterloo) to evaluate contaminant migration in the vadose zone at McClellan Air Force Base, Sacramento. Modified VAPOUR-T in order to handle geologic and contaminant conditions that exist at the base. Developed a data preprocessor (PREV211) for VAPOUR-T program. PREV211 resulted in a substantial reduction of the time required to prepare data for input into VAPOUR-T. In addition, PREV211 facilitates application of VAPOUR-T by users with limited knowledge of the finite element method. Results from VAPOUR-T were used in health risk assessment and in identifying areas where no action is appropriate, where immediate action is required, and where action can be delayed for a number of years. U.S. EPA is currently reviewing VAPOUR-T and PREV211.

- Developed and applied a three-dimensional finite element model (HEAD3D) in design of a groundwater remediation system at Lockheed, Beaumont consisting of extraction and recharge wells. The model was able to handle complex geologic and hydraulic conditions that exist at the site. Developed graphics software to plot head contours and velocity vectors on horizontal or vertical planes. Plots of the head contours were used to evaluate effectiveness of the remediation system to capture contaminants. Application of HEAD3D resulted in a minimal number of extraction and recharge wells, and thus saved Lockheed a substantial amount of money. Results of HEAD3D also led to redefining of the site conceptual model.

- Applied analytical models in evaluation of contamination at various sites, including Chevron site in Southern California, Reynolds Metals in Sacramento, and RhoChem in Los Angeles.

Research/Development

- Developed a new approach for evaluation of stream functions in three-dimensional groundwater flow. A spatial distribution of stream functions can be used to construct stream surfaces. Stream surfaces provide a natural platform on which to present results of simulation of contaminant transport in three-dimensional groundwater flow. The results can be interpreted accurately, because the stream surfaces are oriented in the direction of groundwater flow.

- Developed a code VISUAL3D for visualization of groundwater flow and transport processes, and evaluation of pathways of contaminant migration.

- Appointed as a Lecturer of Civil and Environmental Engineering, in the Department of Civil and Environmental Engineering, University of California, Davis, California.

Teaching graduate courses in groundwater flow and transport processes, and groundwater modeling.

- Developed a computer code known as FELT (Finite Element Line Tracing). FELT can be used to evaluate contaminant transport and design remediation systems with streamlines and stream surfaces. The stream functions used in construction of streamlines and stream surfaces can be computed by the finite element method or method of characteristic curves. A finite element approach is used to obtain nodal velocities. Therefore, a continuous velocity field is applied in simulation of contaminant transport, leading to more accurate results.

- Developed a three-dimensional finite-element model (HPS3D) for hydraulic head pseudo potential function, and stream function. The model is based on the three-dimensional stream function theory that I developed recently. Developed a graphics software (HPSPLOT3D) for plotting flow nets in three dimensions. This will facilitate generation of contaminant pathlines in three dimensions. Application of flow nets has in the past been restricted to two-dimensional flow systems. For flow systems that cannot be approximated by two-dimensional flow systems, HPS3D and HPSPLOT3D will be valuable.

- Developed a new approach to evaluate stream functions in groundwater flow systems with complex boundary conditions and extraction/recharge wells. This approach will be valuable in design of remediation systems in aquifers with partially penetrating wells and in visualization of groundwater flow and contaminant transport.

- Developed a new theory of pseudo potential functions in anisotropic porous media. Pseudo potential functions are valuable in construction of solution grids for contaminant transport modeling.

- Developed a new theory of stream functions in three-dimensional groundwater flow systems.

- Developed a finite-element program for stream functions, hydraulic head and pseudo potential functions in two-dimensional and three-dimensional groundwater flow systems.

- Developed a program based on perspective projection for plotting of iso-surfaces in three-dimensional groundwater flow systems.

As Supervising Engineer

- Evaluated groundwater flow and chemical migration in an aquifer under tidal influence for an aerospace company in Seattle, Washington.

- Applied air models for AB 2588 compliance services to a number of companies in Southern California.

- Applied numerical models in the design of well remediation system for groundwater contamination at Lockheed and Ford sites in the San Francisco Bay Area.

- Developed for the U.S. Bureau of Reclamation a finite element model for evaluation of temporal variation of chemical concentration in a well discharge. The model is being used to develop plans for use of saline water in the San Joaquin Valley of California. Training Bureau of Reclamation technical staff in application of the model to field problems. Modifying the model to account for more realistic flow conditions encountered in the San Joaquin Valley.

- Provided Proposition 65 compliance services to a confidential Southern California aerospace manufacturer. The compliance assessment involved investigating over 85 processes, involving 29 listed chemicals at 17 facilities.

- Applied a semi-analytical model to define zones of capture of chemicals for well remediation systems on sites of a number of aerospace manufacturing and electronics companies.

- Applied the Dual Theory of Potential Head and Stream Function to determine possible chemical sources in the San Gabriel Basin of Southern California.

- Evaluated hydrogeologic parameters for groundwater flow systems for two large confidential aerospace clients.

- Analyzed pumping-test data and developed zones of capture of chemicals using a finite element model for an international electronics manufacturing company.

- Reviewed reports concerning groundwater pollution at a major aerospace manufacturer's facilities in Florida and Oregon.

- Designed a well remediation system at Sacramento Metropolitan Airport.

- Applied a numerical model in the design of a well remediation system for groundwater contamination at McClellan Air Force Base, and a major aerospace manufacturing facility in Sacramento, California.

- Evaluated hydrogeology at sites of a weapon-testing company and a waste management company.

As Assistant Professor

- Taught undergraduate courses in Computer Application and Computer Modeling of Agricultural Systems, and a graduate course in Groundwater Modeling.
- Continued with research of pseudo potential functions in anisotropic porous media. The pseudo potential functions have specific application in groundwater contamination and clean-up of toxic wastes in the environment caused by chemical disposal.
- Engaged in a project with McLaren Environmental Engineering concerning the clean-up of toxic wastes at McClellan Air Force Base and Aerojet in Sacramento, and Hughes Properties in Southern California.

As Research Scientist

- Undertook research projects in numerical modeling of groundwater flow and chemical migration through porous media.
- Tested the new theory of pseudo potential functions in anisotropic porous media.

As Senior Research Fellow

- Undertook research projects and taught undergraduate courses.
- Developed a new theory of pseudo potential functions in anisotropic porous media.

As Post-Doctoral Fellow

- Participated in development of the theory of dual application of stream functions and hydraulic head.
- Applied numerical models based on stream functions and hydraulic head in analysis of chemical migration in an aquifer underlying an irrigated land in southern Alberta.
- Interfaced with Atomic Energy of Canada to evaluate contaminant migration models that could be used in studies of nuclear waste contaminants.

As Civil Engineer

- Primarily responsible for introduction of groundwater numerical models in a consulting company, Ingenieuburo, Dr. -Ing. Gerhard Bjornsen, Koblenz, Germany

- Analyzed interrelationship between surface water and groundwater in southern West Germany.

As Post-Graduate Research Assistant

- Developed a saturated-unsaturated finite element model for groundwater flow and chemical migration.

As Teaching Assistant

- Assisted in teaching courses in structural engineering, hydraulic engineering, fluid mechanics and applied mechanics.

As Junior Civil Engineer

- Participated in the development of a computer program for analysis of stress factors of beams under different loading.

Publications

Matanga, G.B., 1996. "Stream and Pseudopotential Functions in Visualization of Groundwater Flow and Transport Process," Water Resources Research, 32(4), 953-957.

Matanga, G.B., 1996. "Characteristics in Evaluating Stream Functions in Ground-Water Flow", Journal of Hydrologic Engineering, 1(1), 49-53.

Matanga, G.B., 1995. "Construction of Characteristic Curves in a Trilinear Finite Element Grid" (submitted).

Matanga, G.B. 1993. "Stream Functions in Three-Dimensional Groundwater Flow", Water Resources Research, Vol. 29, No. 9, pp 3125-3133, September.

Matanga, G.B., 1988. "Pseudo potential Functions in Construction of Flow Nets for Contaminant Transport", Water Resources Research., Vol. 24, No. 4, pp. 553-560, April.

Matanga, G.B., 1988. "A Finite Element Model for Capture Zones of Chemicals in Anisotropic-Heterogeneous Aquifers", Proc. HAZMACON Conf., April 507, Anaheim, California.

Frind, E.O. and G.B. Matanga, 1985. "The Dual Formulation of Flow for Contaminant Transport Modeling: 1. Review of Theory and Accuracy Aspects", Water Resources Research, Vol. 21, No. 2, pp. 159-169, Feb.

Frind, E.O., G.B. Matanga, and J.A. Cherry, 1985. "The Dual Formulation of Flow for Contaminant Transport Modeling: 2. The Borden Aquifer", Water Resources Research, Vol. 21, No. 2, pp. 170-182, Feb.

Matanga, G.B. and E.O. Frind, 1981. "An Evaluation of Mathematical Models for Mass Transport in Saturated-Unsaturated Porous Media", prepared for Atomic Energy of Canada, May.

Frind, E.O. and G.B. Matanga, 1981. "Groundwater Flow and Salt Transport in Irrigated Land in the Bow River Irrigation District, Alberta", prepared for Agriculture Alberta, Canada, July.

Matanga, G.B. and M.A. Marino, 1979. "Irrigation Planning: 1. Cropping Pattern", Water Resources Research, Vol. 15, No. 3, pp. 672-678, June.

Matanga, G.B. and M.A. Marino, 1979. "Irrigation Planning: 2. Water Allocation for Leaching and Irrigation Purposes", Water Resources Research, Vol. 15 No. 3, pp. 679-683, June.

Marino, M.A. and G.B. Matanga, 1978. "A Galerkin-Finite Element Simulation of Solute Transport in Subsurface Drainage Systems", proceedings of Second International Conference on Finite Elements in Water Resources, Imperial College, London.

Matanga, G.B. and M.A. Marino, 1977. "Application of Optimization and Simulation Techniques to Irrigation Management", Rep. 5003, Department of Land, Air and Water Resources, University of California, Davis.

APPENDIX C

Soil Investigation Technical Memorandum

Headquarters, Air Combat Command
Langley Air Force Base,
Virginia

Soil Investigation Technical Memorandum

Main Base Landfill Closure Project

June 1996

49 CES/CEV
Holloman Air Force Base,
New Mexico

DCN 96-640-311-04

SOIL INVESTIGATION TECHNICAL MEMORANDUM

MAIN BASE LANDFILL CLOSURE PROJECT
HOLLOMAN AIR FORCE BASE, NEW MEXICO

Prepared for:

49 CES/CEV
Holloman Air Force Base, New Mexico
and
HQ ACC/CEV
Langley Air Force Base, Virginia

Prepared by:

RADIAN INTERNATIONAL LLC

Under Contract No. F46124-94-D-8049/0011

June 1996

APPENDIX A

Site Map

TO VIEW THE MAP AND/OR MAPS WITH THIS DOCUMENT, PLEASE CALL THE HAZARDOUS WASTE BUREAU AT 505-476-6000 TO MAKE AN APPOINTMENT

APPENDIX B

Investigation Data Tables

Table B-1
Cover Investigation Data

Location	Surface/Cover Description	Total Depth (ft)	Debris	Debris Depth (ft)	Debris Description	Sample Collected?
A-05	ML, dry, soft	6.00	Municipal	4.00	Trash-grayish black rubber appearance	Yes
A-07	ML, some wood chips at 18", moist, soft	6.00	Municipal	6.00	Trash-clear plastic	Yes
A-09	SM, dry, soft	1.40	Municipal	1.40	Trash-formica	Yes
A-11	ML, loose, dry	2.50	Municipal	2.50	Trash-plastic ball with styrofoam	Yes
A-13	SM, dry, soft	1.50	Municipal	1.50	Trash-rubber tubing with glass and some metal.	Yes
A-15	SM to SC, caliche layer at 40"	9.00	None/max		Nothing found above maximum depth 9'	Yes
A-17	SM, soft, moist	9.00	None/max		Nothing found above maximum depth 9'	Yes
A-19	SM	7.00	None/refusal		Nothing found above refusal depth 7'	No
A-20	SM, soft, moist	9.00	None/max		Nothing found above maximum depth 9'	No
A-23	SM, soft, moist	7.00	None/refusal		Nothing found above refusal depth 7'	No
AS-01	SM, dry	4.50	Asbestos	2.00	Layer of bagged asbestos at 2'	Yes
AS-02	SM, soft, moist	4.50	None/max		Nothing found above maximum depth 4.5'	Yes
AS-03	SM, soft, moist	4.50	None/max		Nothing found above maximum depth 4.5'	Yes
AS-04	SM, soft, moist	7.50	None/max		Nothing found above maximum depth 7.5'	Yes
AS-05	SM, very hard at 1'	7.50	None/max		Nothing found above maximum depth 7.5'	Yes
B-01	SM, soft surface w/ glass fragments, moist w/ depth	9.00	None/max		Nothing found above maximum depth 9'	No
B-02	SM, soft at surface, dense at 2'	3.80	Municipal	3.80	Trash-Hard plastic prevents advance past 3'10"	Yes
B-03	Soft	9.00	None/max		Nothing found above maximum depth 9'	No
B-04	SM	9.00	None/max		Nothing found above maximum depth 9'	Yes
B-05	SM	9.00	Municipal	4.50	Trash-sporadic plastic and paper mixed with soil to 9'	No
B-06	SM, soft	3.00	Municipal	3.00	Trash-various	Yes
B-07	SM	6.00	Municipal	5.50	Trash-styrofoam and wood chips	No
B-09	SM, very loose	3.00	Municipal	2.00	Trash-wood chips and plastic	No
B-10	SM, very loose, moist	3.00	Municipal	2.50	Trash-plastic, cardboard, paper	Yes
B-11	SM, dry, soft	6.00	Municipal	5.00	Trash-loose glass and plastic	No
B-12	SM, dry	3.00	Municipal	1.40	Trash-glass	Yes
B-13	SM, moist, v silty at 4.5'	9.00	None/max		Nothing found above maximum depth 9'	No
B-14	SM, soft, moist	2.80	Municipal	2.80	Trash-glass and green plastic	Yes
B-16	SM to SC at 3'	5.00	None/refusal		Nothing found above refusal depth 5'	Yes
B-17	SM, denser w/ depth, soft, moist	7.50	None/refusal		Nothing found above refusal depth 7.5'	No
B-18	SM, moist	9.00	None/max		Nothing found above maximum depth 9'	Yes
B-19	SM, moist, very tight	5.00	None/refusal		Nothing found above refusal depth 5'	No
B-20	SM, moist, very dense at 3'	4.00	None/refusal		Nothing found above refusal depth 4'	Yes
B-21	SM, moist	9.00	None/max		Nothing found above maximum depth 9'	No
C-01	SM, dry, moister w/ depth	9.00	None/max		Nothing found above maximum depth 9'	Yes

Table B-1
(Continued)

Location	Surface/Cover Description	Total Depth (ft)	Debris	Debris Depth (ft)	Debris Description	Sample Collected?
C-02	SM, moist, more silt w/ depth	6.00	Municipal	5.00	Trash-Pepsi can and unknown	No
C-03	SM, dry at surface, moister w/ depth	9.00	Municipal	7.50	Trash-magazines and black, petroleum-smelling material	Yes
C-05	SM, moist, soft, gravel 4.5'-5'	6.00	Municipal	6.00	Trash-plastic	Yes
C-06	SM, cobbles 2.5'-3', moist	6.00	Municipal	5.80	Trash-plastic	No
C-07	Soil/construction material mix below 1.5'	1.50	Construction	0.00	Construction debris (brick, rubber, plywood) rmixed with soil	Yes
C-08	Construction material mixed in soil cover	3.00	Construction	0.00	Drywall	No
C-09	Gravel/cobbles mixed in soil cover	1.70	Construction	0.00	Construction material	Yes
C-10	SM, dry	2.50	Construction	2.50	Plastic-probably construction material.	No
C-11	SM with some cobbles	9.00	Construction	8.75	Concrete and asphalt material	Yes
C-12	SM, moist	2.50	Construction	2.50	Probably construction material	No
C-17	SM, moist, cobbles at 3'	9.00	None/max		Nothing found above maximum depth 9'	Yes
C-18	SM, dry, some cobbles, moister w/ depth	9.00	None/max		Nothing found above maximum depth 9'	No
C-19	SM, cobbles at 15", dense at 6'	7.50	None/refusal		Nothing found above refusal depth 7.5'	Yes
C-20	SM, dense at 4', moister w/ depth	6.00	None/refusal		Nothing found above refusal depth 6'	No
C-21	SM, dry, moister w/ depth	9.00	None/max		Nothing found above maximum depth 9'	Yes
C-25	SM, moist, sandier w/ depth	9.00	None/max		Nothing found above maximum depth 9'	No
D-01	SM, soft, moist	1.00	Municipal	1.00	Probably municipal	No
D-02	SM, sandy/moist w/ depth	9.00	None/max		Nothing found above maximum depth 9'	Yes
D-03	SM, dry	9.00	Construction	3.00	1"-2" thick layers of plastic mixed w/ soil	No
D-05	SM, soft, moist	9.00	None/max		Nothing found above maximum depth 9'	No
D-07	SM, moist	2.00	Construction	2.00	Drywall	No
D-09	SM, moist	3.00	Construction	3.00	Black rubber, concrete boulders/slabs prevent further advance	No
D-10	Gravel/debris mixed in cover soil	1.50	Construction	0.00	Construction debris (gravel) mixed with soil throughout.	Yes
D-11	At base of mound next to arroyo	9.00	Construction	3.00	Limestone cobbles, piece of metal at 3'	No
D-12	Sand/asphalt mixed with cover soil	3.00	Construction	0.00	Asphalt/plastic layer at 2.5' Asphalt mixed w/ cover soil above	Yes
D-17	Sinkholes caused by buried slabs in area	1.00	Construction	1.00	Concrete slab at 1'	No
D-18	Buried concrete slabs in area	5.50	Construction	3.00	Void 3'-4.5', lg wood fragments/conc slabs, refusal at 5.5'.	Yes
D-19	Buried concrete slabs in area	4.50	Construction	2.00	Limestone cobbles, 2" layer plastic at 2', hit large void	No
D-20	Buried concrete slabs in area, very loose cover	3.30	Construction	3.00	Loose material w/ many cobbles, refusal at 3.3'	Yes
D-21	SM, soft, moist	9.00	None/max		Nothing found above maximum depth 9'	No
D-22	SM, soft, moister w/ depth	9.00	None/max		Nothing found above maximum depth 9'	Yes
D-23	SM, dry at surface, moister w/ depth	9.00	None/max		Nothing found above maximum depth 9'	No
E-03	SM, moist	4.00	Construction	4.00	Shoe is deformed-probably hit concrete slab at 4'	Yes
E-04	SM, very plastic	2.00	Construction	2.00	Construction debris and plastic	No
E-09	Concrete, asphalt, and drywall all around on surface	1.50	Construction	0.00	Layer at 1.5'; cover soil has asph/conc mixed in throughout	No

Table B-1
(Continued)

Location	Surface/Cover Description	Total Depth (ft)	Debris	Debris Depth (ft)	Debris Description	Sample Collected?
E-22	SM, fine grained sand at 5.5' causes refusal	5.50	None/refusal		Nothing found above refusal depth 5.5'	No
E-23	SM, moist, dense at 8'	9.00	None/max		Nothing found above maximum depth 9'	Yes
F-02	SM, moist, soft	9.00	None/max		Nothing found above maximum depth 9'	Yes
F-03	SM, moist	4.90	None/refusal		Nothing found above refusal depth 4.9'	No
F-04	SM, moist, soft	9.00	None/max		Nothing found above maximum depth 9'	Yes
F-14	SM, dry, soft	1.50	Municipal	1.20	Trash-glass, plastic, toothbrush	Yes
F-17	Asphalt mixed in with cover material below 2'	6.00	Construction	2.00	Definite asphalt layer 4.5', cover has asphalt mixed below 2'	No
F-18	Limestone cobbles mixed with dirt at surface	6.00	Construction	5.00	Concrete layer at 5' depth	Yes
F-24	SM, moist, very hard at 6'	9.00	None/max		Nothing found above maximum depth 9'	No
G-01	SM, dry, loose, dense at 2'	2.00	None/refusal		Nothing found above refusal depth 2'	No
G-03	SM, some cobbles, loose, moist	9.00	None/max		Nothing found above maximum depth 9'	Yes
G-04	SM, sandier w/ depth	5.50	Construction	5.50	Construction debris (probably) at 5.5' causes refusal	No
G-05	SM, asphalt mixed in soil 1.5'-3'	3.00	Construction	3.00	Definite wood chip/asphalt layer at 3'	Yes
G-06	SM, dry, moister w/ depth	3.00	Construction	3.00	Concrete and bricks	No
G-12	SM, dry, moister w/ depth	6.00	None/refusal	6.00	Nothing found above refusal depth 6'	No
G-13	SM, dry	3.00	Municipal	3.00	Trash-plastic and paper	Yes
G-14	SM, moist	7.50	Municipal	5.50	Trash-plastic and paper	No
G-15	SM, moister w/ depth	8.00	Municipal	6.50	Trash-plastic, paper, wood	Yes
G-16	SM, moister/siltier w/ depth, SC at 7'	10.00	None/max		Nothing found above maximum depth 10'	No
G-17	SM, moist, very dense at 5'	7.00	Construction	7.00	Rocks at 7' probably construction debris-cause refusal	Yes
G-18	SM, some concrete mixed in with cover material	2.00	Construction	2.00	Concrete, wood, asphalt at 2'	No
G-19	Concrete mixed in with loose cover, slabs showing	1.20	Construction	1.20	Concrete at 1.2'	Yes
H-02	SM, dry, moister w/ depth	4.50	Construction	4.50	Wood and concrete	No
H-03	SM, soft, loose, dry	2.80	Municipal	2.80	Fabric, wood, plastic	No
H-04	SM, moist	5.50	Municipal	5.50	Trash-rubber tire	Yes
H-05	SM, very dry	2.50	Construction	2.50	Concrete and asphalt	No
H-06	SM, soft, very dry	1.50	Construction	1.50	Asphalt	Yes
H-07	SM, loose, dry	3.00	Municipal	2.50	Wood and plastic	No
H-08	SM, some wood fragments in cover, dry	2.80	None/refusal	2.80	Nothing found above refusal depth 2.8'	Yes
H-12	SM, dry, very dense at 5'	7.50	None/refusal	7.50	Nothing found above refusal depth 7.5'	No
H-13	SM, dry	7.00	Municipal	4.00	Litter at 4', asphalt/soil mix at 6', prob conc/asph at 7'	No
H-14	SM, dry	6.00	Municipal	4.70	Trash-glass and plastic	Yes
H-15	SM, soft, dry, moister w/ depth	8.00	Municipal	7.50	Paper and plastic	No
H-16	SM, soft, silty w/ depth	6.00	Municipal	5.80	Paper, plastic, hair	Yes
H-17	SM, soft, some wood chips in cover material	5.00	Municipal	4.50	Trash-glass, plastic, paper	No

Table B-1
(Continued)

Location	Surface/Cover Description	Total Depth (ft)	Debris	Debris Depth (ft)	Debris Description	Sample Collected?
H-18	SM, soft, moister w/ depth	3.00	Municipal	3.20	Trash-paper and wood chips	Yes
H-19	SM, dry	5.00	Municipal	5.00	Trash	No
H-20	SM, dry	3.00	Municipal	2.70	Trash-paper, plastic, fabric	Yes
H-21	SM, dry	2.50	Municipal	2.50	Trash-wood and plastic	No
I-04	SM, dry	2.50	Construction	2.50	Asphalt, concrete, other construction material	No
I-13	SM, dry	1.20	Municipal	1.20	Trash-hair net, milk carton, brown bottle	Yes
I-14	SM, dry	3.00	Municipal	2.50	Trash-plastic and paper	No
I-15	SM, slightly moist	6.00	Municipal	4.00	Trash-lawnchair fibers, newspaper	Yes
I-16	SM, very soft, moist	8.00	Municipal	6.00	Trash-glass and plastic	No
I-17	SM, moist	1.50	Municipal	1.25	Trash-wood and plastic	Yes
I-18	SM, dry, loose	3.00	Municipal	2.80	Trash-plastic, wood, paper	No
I-19	SM, moist	3.20	Municipal	3.20	Trash-plastic, paper, plastic chips	Yes
I-20	SM, moist, loose	3.20	Municipal	3.20	Trash-plastic, paper	No
I-21	SM, moist	3.00	Municipal	3.00	Trash-plastic, fabric, wood	Yes
J-12	SM, dry, denser w/ depth	8.00	None/max		Nothing found above maximum depth 8'	No
J-14	SM, moist	9.00	None/max		Nothing found above maximum depth 9'	Yes
J-16	SM, dry	1.25	Municipal	1.50	Trash-glass, wood, paper	Yes
J-18	SM, dry	9.00	Municipal	4.50	Trash at 6', some glass at 4.5'	Yes
J-20	SM, dry, soft	4.00	Municipal	3.50	Trash-paper, refusal at 4'	Yes
J-21	SM, dry, soft	8.50	None/max	8.50	Nothing found above maximum depth 8.5'	No

Table B-2
Cover Sampling Geotechnical Results

Location	Sample Collected?	Permeability (cm/s)	LL	PI	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Specific Gravity	Moisture (%)	Lab Note
A-17	Yes	5.8E-05			111.7	89.4	2.438	24.9	No liquid limit/non-plastic
A-15	Yes	3.2E-04			105.9	92.8	2.373	14.2	No liquid limit/non-plastic
A-13	Yes	1.0E-04	37	13	98.6	94.5	2.429	4.4	
A-05	Yes	4.2E-05			101.1	96.3	2.308	5.1	No liquid limit/non-plastic
A-07	Yes	3.0E-04			96.2	86.8	2.335	10.8	No liquid limit/non-plastic
A-09	Yes	1.6E-04			98.6	93.6	2.394	5.4	No liquid limit/non-plastic
A-11	Yes	4.5E-04			89.1	79.5	2.317	12.1	Pieces of concrete/loosely packed
B-02	Yes	4.4E-05			115.3	110.5	2.335	4.4	No liquid limit/non-plastic
B-04	Yes	1.3E-05			114.1	106.1	2.472	7.5	No liquid limit/non-plastic
B-06	Yes	8.3E-05			104.9	91.8	2.47	14.2	No liquid limit/non-plastic
B-10	Yes	1.1E-03			100.4	85.2	2.379	17.8	No liquid limit/non-plastic
B-12	Yes	2.2E-04			107	94.4	2.553	13.3	No liquid limit/non-plastic
B-14	Yes	8.4E-05			104.4	87.8	2.435	18.9	No liquid limit/non-plastic
B-16	Yes	3.1E-03	37		113.2	87.4	2.581	29.5	Non-plastic
B-18	Yes	1.3E-04			101.4	86.8	2.37	16.9	No liquid limit/non-plastic
B-20	Yes	2.8E-05			108.8	89.9	2.633	21	No liquid limit/non-plastic
C-01	Yes	1.9E-04			105.9	100.6	2.353	5.3	No liquid limit/non-plastic
C-03	Yes	4.3E-06	28		116.8	106.8	2.445	9.4	Non-plastic
C-05	Yes	7.3E-05	31	8	108.5	102	2.306	6.3	
C-07	Yes	3.6E-03	29	7	105.6	101.5	2.511	4.1	Gravel in sample/loosely packed
C-09	Yes	1.5E-04			112.7	101	2.339	11.6	No liquid limit/non-plastic
C-11	Yes	1.3E-04			100	87	2.588	14.9	No liquid limit/non-plastic
C-17	Yes								Not cover material/sample not run
C-19	Yes								Not cover material/sample not run
C-21	Yes								Not cover material/sample not run
D-02	Yes	1.4E-04			97.7	92.4	2.344	5.7	No liquid limit/non-plastic
D-10	Yes	4.8E-02			114.6	105.6	2.506	8.5	Lg piece of gravel in sample
D-12	Yes	1.6E-04			98.2	89.1	2.532	10.2	No liquid limit/non-plastic
D-18	Yes	4.8E-03			98.6	89.5	2.66	10.1	No liquid limit/non-plastic
D-20	Yes	4.9E-04			112.5	104.9	2.535	7.3	No liquid limit/non-plastic
D-22	Yes								Not cover material/sample not run
E-03	Yes	2.8E-06	24		124.7	102.7	2.588	21.4	Non-plastic
E-23	Yes								Not cover material/sample not run
F-02	Yes	8.4E-05			103.8	85.7	2.554	21.1	No liquid limit/non-plastic
F-04	Yes	1.6E-04			115.2	99.8	2.692	15.5	No liquid limit/non-plastic

Table B-2
(Continued)

Location	Sample Collected?	Permeability (cm/s)	LL	PI	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Specific Gravity	Moisture (%)	Lab Note
F-14	Yes	1.2E-04			104	91.8	2.668	13.2	No liquid limit/non-plastic
F-18	Yes	4.6E-03			100.7	86.3	2.565	16.7	Loose sample; gravel/asphalt in sample
G-03	Yes	7.4E-05			109.4	96	2.545	14	No liquid limit/non-plastic
G-05	Yes	5.9E-04			106.5	91.4	2.707	16.6	No liquid limit/non-plastic
G-13	Yes	1.4E-04			101.6	87.7	2.661	15.8	No liquid limit/non-plastic
G-15	Yes	8.5E-06			118.5	99.6	2.627	19	No liquid limit/non-plastic
G-17	Yes	9.0E-05			109	100.8	2.588	8.1	No liquid limit/non-plastic
G-19	Yes	4.9E-04			104.1	96.9	2.664	7.4	No liquid limit/non-plastic
H-04	Yes	1.7E-05	21		121.8	101.2	2.745	20.3	Non-plastic
H-06	Yes	3.5E-04			90.2	82.3	2.524	9.5	No liquid limit/non-plastic
H-08	Yes	9.9E-05	30	7	114.6	98.8	2.61	16	
H-14	Yes	2.5E-03			113.7	93.2	2.644	22	No liquid limit/non-plastic
H-16	Yes	5.8E-06	29	8	115.7	98.2	2.67	17.9	
H-18	Yes	1.9E-04			104.1	83.3	2.636	24.9	No liquid limit/non-plastic
H-20	Yes	3.2E-04			96.8	78.4	2.65	23.5	Loose sample; roots present
I-13	Yes	4.7E-04			102.5	82.6	2.603	24.1	Loose sample; landfill debris at top
I-15	Yes	1.9E-05	30	7	114.3	95.8	2.657	19.3	
I-17	Yes	8.9E-05			103.4	85	2.52	21.8	No liquid limit/non-plastic
I-19	Yes	7.9E-05			106.5	86.7	2.449	22.8	No liquid limit/non-plastic
I-21	Yes	2.9E-04	34	3	107.5	85.4	2.68	25.9	
J-14	Yes								Not cover material/sample not run
J-16	Yes	1.6E-04			94.7	82	2.482	15.5	No liquid limit/non-plastic
J-18	Yes	1.0E-04			105.5	87.1	2.709	21.1	No liquid limit/non-plastic
J-20	Yes	7.5E-06	32		118.8	99.3	2.658	19.6	Non-plastic
AS-01	Yes	1.0E-04			107.2	91.3	2.722	17.4	No liquid limit/non-plastic
AS-02	Yes	1.1E-04			117	99.2	2.785	17.9	No liquid limit/non-plastic
AS-03	Yes	1.3E-04			117.6	101.2	2.719	16.2	No liquid limit/non-plastic
AS-04	Yes	1.5E-04			132.2	112.2	2.776	17.9	No liquid limit/non-plastic
AS-05	Yes	2.5E-03			122.7	92.3	2.596	32.9	No liquid limit/non-plastic

Table B-3
Borehole Sampling Geotechnical Results

Borehole	Location	Sample Depth	Unit Sampled	Permeability (cm/s)	LL	PI	Spec Gravity	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Moisture (%)	Void Ratio
BH-1	Perimeter	19'-19.5'	CLAY w/ silt and sand (SC)	1.6E-07	30.7	12.3	2.741	131.8	109.3	20.6	0.56
BH-2	Perimeter	5'-6'	Sandy CLAY w/ gypsum (SC)	2.7E-06			2.73	128.3	102.4	25.2	0.66
BH-3	Perimeter	20.5'-21'	CLAY (CH)	4.4E-04	29	6	2.48	89.3	74.1	20.5	1.09
BH-4	Arroyo	10.9'-12.5'	CLAY w/ minor silt and sand (CL)	1.9E-06	38	11	2.69	119.5	87.2	37.1	0.92
BH-5	Perimeter	15.5'-16'	Sandy CLAY (SC)	3.4E-07			2.53	127.4	116.9	9	0.35
BH-6	Perimeter	28.5'-29'	SILT (ML)	1.2E-06			2.73	126.7	104.9	20.8	0.62
BH-7	Perimeter	10'-10.5'	Sandy CLAY (SC)	2.4E-06			2.8	126.9	106.7	19	0.64
BH-8	Arroyo	0.5'-1'	CLAY (CH)	9.0E-08	52	20	2.78	114.5	76.8	49.2	1.26
BH-9	Arroyo	8.5'-9'	CLAY (CL)	6.0E-07	25.1	8.8	2.59	127.1	102.5	24	0.58

APPENDIX C

Soil Boring Logs

DRILLING LOG

HOLE NO.	BH-1
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1 OF 3 SHEETS	
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	2' x 2' ID split spoon; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=554392.47; Northing=676311.90
9. SURFACE ELEVATION	4099.63 ft MSL
10. DATE STARTED	10 April 1996
11. DATE COMPLETED	10 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	23 ft.
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	30.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Top soil. Silty loam, reddish brown, dry, soft, friable.		7, 23, 19, 12	
4097.6	2		SILT: very pale brown (10YR8/3), dry, friable, soft. (ML)		5, 3, 7, 11	
4095.6	4		SILT: reddish yellow (7.5YR6/6), dry, soft, friable. Contains abundant gypsum crystals near base. Brown mottled with white. (ML)		37, 35, 36, 31	
4093.6	6		Sandy CLAY with gypsum: strong brown (7.5YR5/6) low plasticity, damp, hard, mottled with white gypsum. Increasing gypsum toward base. (ML)		21, 43, 41, 50	
4091.6	8				25, 43, 50, 62	

DRILLING LOG

HOLE NO.	BH-1
1. COMPANY NAME	Radian International, LLC
2. INSPECTOR	David Robbins
SHEET 2	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			SILT: reddish yellow (7.5YR6/6), moist, soft, mottled white with gypsum. Grades to Silty SAND, very fine grained. (ML)		17 43 27 25	
4087.6	12				23 25 35 33	
4085.6	14		SAND: light brown (7.5YR6/4), fine grained, poorly graded, soft, moist, friable. (SP)			
			Silty SAND: reddish yellow (7.5YR6/6), mottled with gypsum. (SM)		21 33 78 325	
			SAND: light brownish gray (10YR6/2) moist fine grained gypsum, soft to firm. (SM)			
			Silty SAND: reddish yellow (7.5YR6/6), mottled with gypsum, moist. (SM)			
4083.6	16		SAND: light gray (10YR7/2), fine grained gypsum, soft to firm, partially cemented nodules within, moist. (SP)		235	
			Sandy CLAY: reddish yellow (7.5YR6/6) firm. (SC)			
			SAND: very pale brown (10YR8/3), gypsum, fine grained. (SP)		16 25 35 63	
4081.6	18		Silty SAND (SM) strong brown (7.5YR5/6), fine grained, becoming less silty near base, firm. (SM)			
			CLAY with minor Sand and Gypsum: yellowish red (5YR5/6) hard, medium plasticity, becoming more sandy near base. (CL)			
4079.6	20		CLAY with Silt and Sand: strong brown (7.5YR5/6), extremely hard, moist, mottled with gypsum. (SC)			Geotechnical sample
4077.6	22		SILT with minor CLAY: brownish yellow (10YR6/6), moist, soft. Grades to Silty SAND with CLAY. Water table at ~23.0 ft. (ML-SM)		45 150	
4075.6	24					
			SAND: brownish yellow (10YR6/6) wet, soft, moderately graded, primarily fine grained. Becomes slightly silty near base at 27 ft. (SP)		27 76 126 178	
4073.6	26					
					27 38 45 56	
4071.6	28					

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-1

DRILLING LOG

1. COMPANY NAME	2. INSPECTOR	HOLE NO.
Radian International, LLC	David Robbins	BH-1
		SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
					27 38 45 56	
			Sandy SILT: reddish yellow (7.5YR6/6) mottled with white gypsum, fine to medium grained sand, wet. Color change at 29.5 ft to pale yellow. (SM)		23 35	
4069.6	30		SAND with minor Silt and Clay: strong brown (7.5YR5/6) mottled with gypsum. (SP)			
			Total Depth = 30 ft			
4067.6	32					
4065.6	34					
4063.6	36					
4061.6	38					
4059.6	40					
4057.6	42					
4055.6	44					
4053.6	46					

28 30 32 34 36 38 40 42 44 46

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-1

DRILLING LOG

HOLE NO.	BH-2
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1 OF 3 SHEETS	
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler; 18" x 3" ID split spoon; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=556363.71; Northing=675511.92
9. SURFACE ELEVATION	4095.98 ft MSL
10. DATE STARTED	11 April 1996
11. DATE COMPLETED	11 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	17.5 ft.
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	30.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Top soil. Silty loam, contains abundant roots.			
			SILT: very pale brown (10YR8/3), soft, dry, friable. (ML)		6 10 16 29	
4094.0	2					
			SILT: reddish yellow (7.5YR6/6) dry, soft, friable. Contains abundant gypsum crystals, giving it a mottled appearance. Becomes slightly sandy near base. (ML)		10 23 28 22	
4092.0	4				10 22	
			Sandy CLAY with Gypsum: strong brown (7.5YR5/6) low plasticity, damp, hard, mottled with gypsum. Coarse selenite gypsum crystals up to 1-inch in length. (SC)			Geotechnical Sample
4090.0	6					
4088.0	8					

0 2 4 6 8 10

PROJECT: Holloman AFB Main Base Landfill Closure | HOLE NO.: BH-2

DRILLING LOG

HOLE NO.	BH-2

1. COMPANY NAME	2. INSPECTOR	SHEET 2
Radian International, LLC	David Robbins	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Silty SAND: reddish yellow (7.5YR7/6), damp, soft, friable. Becomes less silty and moistens with depth. Sand is very fine grained and poorly graded. (SM)			
4084.0	12					
4082.0	14					
			SAND: reddish yellow brown (7.5YR7/6), very damp, fine to medium grained, moderately graded, subrounded to subangular. (SP)			
4080.0	16					
			Silty SAND: yellowish brown (7.5YR7/6), wet at 17.0 ft, fine sand, poorly graded. (SM)			
4078.0	18					
4076.0	20		Sandy CLAY: strong brown (7.5YR4/6), firm, fairly high sand content near top, decreasing in sand with depth, fine to medium grained sand, mottled with gypsum. (SC)			
4074.0	22					
4072.0	24					
			SAND: light yellowish brown (10YR5/4) fine grained, poorly graded, hard. (SP)		50+ 50+	
4070.0	26					
4068.0	28					

PROJECT:	Holloman AFB Main Base Landfill Closure	HOLE NO.:	BH-2

DRILLING LOG

HOLE NO.	
BH-2	

1. COMPANY NAME	2. INSPECTOR	SHEET 3
Radian International, LLC	David Robbins	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			CLAY with Sand: strong brown (7.5YR4/6), low plasticity, wet, hard. Increasing gypsum content to approximately 60% near 30 ft. (CL)			
4066.0	30		Total Depth = 30 ft			
4064.0	32					
4062.0	34					
4060.0	36					
4058.0	38					
4056.0	40					
4054.0	42					
4052.0	44					
4050.0	46					

28 30 32 34 36 38 40 42 44 46

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-2

DRILLING LOG

HOLE NO.	BH-3
SHEET 1 OF 3 SHEETS	

1. COMPANY NAME: Radian International, LLC	2. DRILLING SUBCONTRACTOR: Geo-Test, Inc.
3. PROJECT: Holloman AFB Main Base Landfill Closure	4. LOCATION: Holloman AFB, NM
5. NAME OF DRILLER: Tim and Pat Byers	6. MANUFACTURERS DESIGNATION OF DRILL: CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT: 5' x 2.6" ID core barrel sampler; 18" x 3" ID split spoon; 7.25" OD Hollow Stem Auger	8. HOLE LOCATION: Easting=556395.77; Northing=676909.98
	9. SURFACE ELEVATION: 4116.18 ft MSL
	10. DATE STARTED: 11 April 1996 / 11. DATE COMPLETED: 11 April 1996
12. OVERBURDEN THICKNESS: NA	15. DEPTH GROUNDWATER ENCOUNTERED: NR
13. DEPTH DRILLED INTO ROCK: NA	16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED: NA
14. TOTAL DEPTH OF HOLE: 30.00 ft.	17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY): Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			SILT: very pale brown (10YR8/3) dry, soft, friable. (ML)		8 28 35 25	
4114.2	2		SILT with minor SAND: reddish yellow (7.5YR6/6) very fine grained, damp, soft, friable. (ML)		9 17 14 10	
4112.2	4		SAND: reddish yellow (7.5YR6/6), fine grained, poorly graded, very soft, damp, loose. (SP)		9 14 18 15	
4110.2	6			Switched to 5-ft continuous sampler.		
4108.2	8					
			Silty SAND: very pale brown (10YR8/3) damp, very fine grained, soft, friable. (SM)			

0 2 4 6 8 10

PROJECT: Holloman AFB Main Base Landfill Closure | HOLE NO.: BH-3

DRILLING LOG

1. COMPANY NAME	2. INSPECTOR	HOLE NO.
Radian International, LLC	David Robbins	BH-3
		SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
4104.2	12					
4102.2	14		SAND with minor Silt: reddish yellow (7.5YR6/6), mottled with gypsum, very hard, fine grained, damp. Grades Rapidly to silty SAND, less hard, fine grained, damp. (SP)	Interval not sampled, too hard.		
4100.2	16		SAND: strong brown (7.5YR5/6) fine grained, poorly graded, damp-moist, very hard, contains gypsum nodules. (SP)			
4098.2	18		CLAY: coarse selenite gypsum crystals, high plasticity, firm, moist. (CH)			
4096.2	20					
4094.2	22					
4092.2	24		Silty SAND: light yellowish born (10YR6/4) firm, fine to very fine, moist, mottled with white gypsum. Becomes less silty with depth. Colors alternate between very pale brown (10YR8/3) and light yellowish brown (10YR6/4) with depth. (SM)			
			Very pale brown			
4090.2	26		Light yellow brown			
			Very pale brown			
4088.2	28					

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-3

DRILLING LOG

HOLE NO.	
BH-3	

1. COMPANY NAME	2. INSPECTOR	SHEET 3
Radian International, LLC	David Robbins	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Light yellow brown			
4086.2	30		Total Depth = 30 ft			
4084.2	32					
4082.2	34					
4080.2	36					
4078.2	38					
4076.2	40					
4074.2	42					
4072.2	44					
4070.2	46					

DRILLING LOG

HOLE NO.	BH-4
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1 OF 2 SHEETS	
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=555272.44; Northing=677111.89
9. SURFACE ELEVATION	4085.00 ft MSL
10. DATE STARTED	10 April 1996
11. DATE COMPLETED	10 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	3.9 ft.
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	15.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Sandy CLAY: strong brown (7.5YR4/6), moist, fine grained, low plasticity. (SC)			
			SILT: light brownish gray (10YR6/2), moist, soft. (ML)			
4083.0	2		CLAY with minor Silt and Sand: brown (10YR4/3), becoming slightly less plastic near base, firm. Wet at 3.9 ft. (CL)			
4081.0	4					
			As above, slightly higher sand content. Slightly mottled with gypsum.			
4079.0	6					
4077.0	8					

0 2 4 6 8 10

PROJECT: Holloman AFB Main Base Landfill Closure | HOLE NO.: BH-4

DRILLING LOG

HOLE NO.	
BH-4	

1. COMPANY NAME	2. INSPECTOR	SHEET 2
Radian International, LLC	David Robbins	OF 2 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Clay, as above. Medium to high plasticity.			
4073.0	12					
4071.0	14					
			Total Depth = 15 ft			
4069.0	16					
4067.0	18					
4065.0	20					
4063.0	22					
4061.0	24					
4059.0	26					
4057.0	28					

DRILLING LOG

HOLE NO.	BH-5
SHEET 1 OF 3 SHEETS	
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler; 2' x 2" ID split spoon; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=554377.45; Northing=677511.85
9. SURFACE ELEVATION	4109.12 ft MSL
10. DATE STARTED	9 April 1996
11. DATE COMPLETED	10 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	26.5 ft.
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	30.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Top soil. Silty loam.			
			SILT: very pale brown (10YR8/3), dry, friable, occasional roots. (ML)		9 10 18 18	
4107.2	2		Silty SAND: reddish yellow (7.5YR6/6), very fine grained, poorly graded sand, damp, soft, friable. Grades to a fine-grained SAND, very poorly graded, soft, loose (SP) with depth. (SM)	Switched to continuous sampler.		
4105.2	4					
4103.2	6		Silty SAND with Gypsum: yellowish brown (10YR5/6), fine grained, hard, damp. Decreasing sand with depth; slightly clayey at 8.5 ft. (SM-ML)			
4101.2	8				39 60 60 55	

0 2 4 6 8 10

DRILLING LOG

HOLE NO. BH-5

1. COMPANY NAME: Radian International, LLC

2. INSPECTOR: David Robbins

SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Sandy CLAY: mottled with gypsum, strong brown (7.5YR5/6), low plasticity, damp, hard, minor sand near top. Slight color change at 12 ft to brownish yellow. Minor sand at 12.5 ft and 13.0 to 13.75 ft.		39 60 60 55	
4097.2	12				21 39 61 65	
4095.2	14				17 28 38 40	
			Caliche.			
4093.2	16		Sandy CLAY: (as above).		18 30 33	Geotechnical Sample
			SILT with Gypsum: intermixed, strong brown (7.5YR5/6) and very pale brown (10YR8/2), soft, friable, damp. (ML)	Interval not sampled.		
4091.2	18		SAND: very pale brown (10YR8/3), fine grained. (SP)		12 31 32 28	
			Sandy CLAY: strong brown, mottled with gypsum. (SC)			
			SAND: very pale brown (10YR8/3), fine grained. (SP)			
4089.2	20		Sandy CLAY: strong brown, mottled with gypsum. (SC)		19 21 22 25	
			SAND: light brownish gray (10YR6/2), fine to medium grained. (SP)			
			Sandy CLAY: some Clay intermixed, strong brown (7.5YR5/6) mottled with gypsum (10YR8/2), few coarse gypsum crystals present. (SC)			
4087.2	22		CLAY with coarse Gypsum crystals: low-moderate plasticity, moist, soft, strong brown. (7.5YR5/6)		13 7 6 41	
			SAND: gypsiferous, white (7.5YR8/1), very fine grained, partially cemented nodules within, damp. (SP)			
			Sandy CLAY: strong brown (7.5YR5/6), firm, damp, low plasticity. (SC)	Refusal at 23.5 and 24 ft.	260+	
4085.2	24		SAND: gypsiferous, white (7.5YR8/1), very fine grained, partially cemented nodules within, damp. Color changes at 26.0 ft to olive yellow (2.5Y6/6). Water table at 26.5 ft. (SP)			
4083.2	26				20 21 29 38	
4081.2	28		SAND: reddish yellow (7.5YR6/6), fine grained, poorly graded, moderately soft, wet. Becomes increasingly silty at depth. (SP)		26 43 73 62	

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-5

DRILLING LOG

HOLE NO.	BH-5
1. COMPANY NAME	Radian International, LLC
2. INSPECTOR	David Robbins
SHEET 3	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
					26 43 73 62	
					73 140	
4079.2	30		Total Depth = 30 ft			
4077.2	32					
4075.2	34					
4073.2	36					
4071.2	38					
4069.2	40					
4067.2	42					
4065.2	44					
4063.2	46					

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-5

DRILLING LOG

HOLE NO.	BH-6
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1	OF 3 SHEETS
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5" x 2.6" ID core barrel sampler 2" x 2" ID split spoon 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=554372.43; Northing=678712.00
9. SURFACE ELEVATION	4115.09 ft MSL
10. DATE STARTED	9 April 1996
11. DATE COMPLETED	9 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	NR
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	30.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Top soil, silty.			
			SILT: very pale brown (10YR8/3), dry, soft, friable. Becomes moist at 3.0 ft.			
4113.0	2			Switched to split spoon sampler.		
					14 17 24	
4111.0	4					
			Silty SAND: reddish yellow (7.5YR6/6), very fine grained, poorly graded, moist, soft, friable. Becomes less silty with depth. (SM)		10 12 14	
4109.0	6					
					10 23 26 28	
4107.0	8					
					16 29 30 32	

0 2 4 6 8 10

DRILLING LOG

HOLE NO. BH-6

1. COMPANY NAME: Radian International, LLC

2. INSPECTOR: David Robbins

SHEET 2 OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
					16 26 30 32	
4103.0	12		Silty SAND: mottled with Gypsum, very pale brown (10YR8/4), very fine grained, hard, moist. Increasing Silt and moisture at depth. 3-inch thick yellow (10YR8/3) layer at 15.6 ft, color changes to reddish yellow (5YR6/6) at 17 ft. (SM)		8 27 39 48	
4101.0	14				10 40 36 50	
4099.0	16				13 48 50+	
4097.0	18				20 50 36 30	
4095.0	20		SILT with Sand: mottled with gypsum, light brownish gray (2.5Y6/2), hard, moist. (SM)		14 35 40	
4093.0	22		SAND: very pale brown (10YR7/4), very fine grained, very poorly graded, moist, firm. (SP)		20 26 41	
4091.0	24		Silty SAND: very pale brown (10YR7/4) fine grained, poorly graded, moist. (SM)		30 50 50+	
4089.0	26		SAND: strong brown (7.5YR5/6), fine grained, poorly graded, moist, hard. Becomes coarser grained at depth. (SP)		19 25 17	
4087.0	28		Silty SAND: reddish yellow (7.5YR7/6), very fine grained sand, mixed with small to medium sized gypsum nodules. Becoming less silty with depth. Soft, except where there are gypsum nodules. (SM)			

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-6

DRILLING LOG

HOLE NO.	
BH-6	

1. COMPANY NAME	2. INSPECTOR	SHEET 3
Radian International, LLC	David Robbins	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			SILT: light brown (7.5YR6/4), moist, soft. Grades into fine sand with depth. (ML)		3 14 19	Geotechnical Sample
			SAND: pink (7.5YR7/4), fine grained, poorly graded, moist. (SP)			
4085.0	30		Total Depth = 30 ft			
4083.0	32					
4081.0	34					
4079.0	36					
4077.0	38					
4075.0	40					
4073.0	42					
4071.0	44					
4069.0	46					

DRILLING LOG

HOLE NO.	BH-7
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1 OF 3 SHEETS	
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler; 2' x 2' ID split spoon; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=555872.47; Northing=679512.28
9. SURFACE ELEVATION	4118.14 ft MSL
10. DATE STARTED	12 April 1996
11. DATE COMPLETED	12 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	NR
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	30.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Overburden. Silty loam, contains, abundant rootlets.			
			SILT: very pale brown (10YR8/3), soft, dry, friable. (ML)		16 28 27 19	
4116.2	2					
			Silty SAND: reddish yellow (7.5YR6/6) very fine grained sand, poorly graded, damp, soft, friable. Becomes slightly more sandy and contains mottled white gypsum. (SM)		3 5 6 5	
4114.2	4				5 10	
4112.2	6		Silty SAND: strong brown (7.5YR5/6), fine grained, moist, becoming less sandy with depth, grades to strong brown (7.5 YR5/6) sandy Clay. (SM)			
4110.2	8					

0 2 4 6 8 10

PROJECT: Holloman AFB Main Base Landfill Closure | HOLE NO.: BH-7

DRILLING LOG

HOLE NO.	BH-7
1. COMPANY NAME	Radian International, LLC
2. INSPECTOR	David Robbins
SHEET 2	OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			Sandy CLAY: strong brown (7.5YR5/6), medium to high sand content near top, decreasing sand with depth, low plasticity. From 11 to 12.75 ft, laminated layers of clay and gypsum, extremely hard. (SC)		80 52	Geotechnical Sample
4106.2	12					
			Sandy SILT: strong brown (10YR5/6), fairly high silt content near top, moist, fine grained. Becomes increasingly sandy with depth. (SM)			
4104.2	14					
				Poor recovery		
4102.2	16					
			SAND: strong brown (10YR5/6) poorly graded, fine grained, soft, loose. Becomes harder and mottled with gypsum at base. (SP)			
4100.2	18					
4098.2	20					
			Silty SAND: yellowish brown, fine grained, loose, poorly graded. Increasing silt content at 23 ft, laminated layers of silt and gypsum from 24 to 27 ft. (SM)			
				Poor recovery		
4096.2	22					
4094.2	24					
4092.2	26					
			SAND: very pale brown (10YR7/4), loose, very poorly graded, interbedded zones of pale brown (10YR8/3) gypsum. (SP)			
4090.2	28					

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-7

DRILLING LOG

HOLE NO. BH-7

1. COMPANY NAME: Radian International, LLC

2. INSPECTOR: David Robbins

SHEET 3 OF 3 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
4088.2	30		Total Depth = 30 ft			
4086.2	32					
4084.2	34					
4082.2	36					
4080.2	38					
4078.2	40					
4076.2	42					
4074.2	44					
4072.2	46					

DRILLING LOG

HOLE NO.	BH-8
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
SHEET 1	OF 2 SHEETS
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler 2' x 2" ID split spoon 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=555364.90; Northing=675700.05
9. SURFACE ELEVATION	4081.49 ft MSL
10. DATE STARTED	11 April 1996
11. DATE COMPLETED	11 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	NR
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	15.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			CLAY: strong brown (7.5YR5/6), very moist, high plasticity, soft. Black staining. (CH)	Continuous sampler could not penetrate below 1 ft.		Geotechnical Sample
4079.4	2		Clayey SILT with Gypsum: yellowish brown (10YR5/4), low plasticity, coarse white gypsum nodules. (ML)		13 24 22 18	
4077.4	4		Sandy CLAY: strong brown (7.5YR5/6), low plasticity, wet, fine grained sand, firm. Slightly sandier at depth, color change to brown (10YR5/3) at ~12 ft. (SC)		9 11 12	
4075.4	6		Saturated		4 7 9 8	
4073.4	8				2 4 5 6	

0 2 4 6 8 10

DRILLING LOG

HOLE NO.	
BH-8	

1. COMPANY NAME	2. INSPECTOR	SHEET 2
Radian International, LLC	David Robbins	OF 2 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
4069.4	12					
4067.4	14					
			Total Depth = 15 ft			
4065.4	16					
4063.4	18					
4061.4	20					
4059.4	22					
4057.4	24					
4055.4	26					
4053.4	28					

DRILLING LOG

HOLE NO.	BH-9
SHEET 1 OF 2 SHEETS	
1. COMPANY NAME	Radian International, LLC
2. DRILLING SUBCONTRACTOR	Geo-Test, Inc.
3. PROJECT	Holloman AFB Main Base Landfill Closure
4. LOCATION	Holloman AFB, NM
5. NAME OF DRILLER	Tim and Pat Byers
6. MANUFACTURERS DESIGNATION OF DRILL	CME-55 Ardco ATV
7. SIZES AND TYPES OF DRILLING AND SAMPLING EQUIPMENT	5' x 2.6" ID core barrel sampler; 7.25" OD Hollow Stem Auger
8. HOLE LOCATION	Easting=556243.44; Northing=678157.12
9. SURFACE ELEVATION	4091.91 ft MSL
10. DATE STARTED	10 April 1996
11. DATE COMPLETED	10 April 1996
12. OVERBURDEN THICKNESS	NA
15. DEPTH GROUNDWATER ENCOUNTERED	7.5 ft.
13. DEPTH DRILLED INTO ROCK	NA
16. DEPTH TO WATER AND ELAPSED TIME AFTER DRILLING COMPLETED	NA
14. TOTAL DEPTH OF HOLE	15.00 ft.
17. OTHER WATER LEVEL MEASUREMENTS (SPECIFY)	Yes

18. GEOTECHNICAL SAMPLES	DISTURBED	UNDISTURBED	19. TOTAL NUMBER OF CORE BOXES
X			NA

20. SAMPLES FOR CHEMICAL ANALYSIS	SW 8240	METALS	SW 8270	SW 8080	TCLP	21. TOTAL CORE REC.
						NA

22. DISPOSITION OF HOLE	BACKFILL	MONITORING WELL	OTHERS (SPECIFY)	23. SIGNATURE OF INSPECTOR
Grout	X			David Robbins

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
			CLAY: brown (10YR4/3), high plasticity, moist, soft, slightly sandy near base. (CH)			
4090.0	2		SAND: strong brown (7.5YR5/6), fine grained poorly graded, soft. Slightly clayey at 6 ft. Water table at 7.3 ft. (SP)			
4088.0	4					
4086.0	6					
4084.0	8		CLAY with minor Sand: strong brown (7.5YR5/6), moist, moderate to high plasticity. Coarse selenite gypsum crystals at 12 ft. (CL)			Geotechnical sample

0 2 4 6 8 10

PROJECT: Holloman AFB Main Base Landfill Closure | HOLE NO.: BH-9

DRILLING LOG

HOLE NO.	
BH-9	

1. COMPANY NAME	2. INSPECTOR	SHEET 2
Radian International, LLC	David Robbins	OF 2 SHEETS

ELEV. a	DEPTH b	GRAPHIC LOG c	DESCRIPTION OF MATERIALS d	REMARKS e	BLOW COUNTS f	SAMPLE NO. g
4080.0	12					
			SAND: strong brown (7.5YR5/6), fine grained, poorly graded, wet. (SP)			
4078.0	14					
			CLAY: strong brown (7.5YR5/6), high plasticity, firm, wet. (CL)			
			Total Depth = 15 ft			
4076.0	16					
4074.0	18					
4072.0	20					
4070.0	22					
4068.0	24					
4066.0	26					
4064.0	28					

PROJECT: Holloman AFB Main Base Landfill Closure

HOLE NO.: BH-9

APPENDIX D

Cross Sections

TO VIEW THE MAP AND/OR MAPS WITH THIS DOCUMENT, PLEASE CALL THE HAZARDOUS WASTE BUREAU AT 505-476-6000 TO MAKE AN APPOINTMENT

APPENDIX E

General Soil Permeability Table

TABLE 8–3 Hydraulic conductivity

Material	Hydraulic Conductivity	
	cm/sec	ft/day
Clay		
Unweathered	10^{-8}–10^{-9}	10^{-3}–10^{-4}
High plastic (CH)	10^{-7}–10^{-9}	10^{-2}–10^{-4}
Low plastic (CL)	10^{-6}–10^{-8}	10^{-1}–10^{-3}
Silt		
High plastic (MH)	10^{-5}–10^{-7}	1 –10^{-2}
Low plastic (ML)	10^{-4}–10^{-7}	10 –10^{-2}
Sand		
(SP)	10^{-1}–10^{-5}	10^{-4}– 1
Well sorted, fine	10^{-3}–10^{-5}	10^{-2}– 1
Well sorted, medium	10^{-2}–10^{-4}	10^{-3}–10^{-1}
Well sorted, coarse	10^{-1}–10^{-3}	10^{-4}–10^{-2}
(SW)	10^{-1}–10^{-4}	10^{-4}–10^{-1}
Poorly sorted, fine	10^{-2}–10^{-4}	10^{-3}–10^{-1}
Poorly sorted, medium	10^{-1}–10^{-3}	10^{-4}–10^{-2}
Poorly sorted, coarse	10^{-1}–10^{-3}	10^{-4}–10^{-2}
Silty sand (SM)	10^{-4}–10^{-6}	10 –10^{-1}
Clayey sand (SC)	10^{-5}–10^{-7}	1 –10^{-2}
Gravel		
(GP)	10^{-3}–1	10^{-8}–10^{-5}
Well sorted	10^{-3}–1	10^{-8}–10^{-5}
(GW)	10^{-2}–1	10^{-7}–10^{-5}
Poorly sorted	10^{-2}–1	10^{-7}–10^{-5}
Silty gravel (GM)	10^{-3}–10^{-6}	10^{-2}–10^{-1}
Clayey gravel (GC)	10^{-4}–10^{-7}	10 –10^{-2}

From: Mathewson, Christopher, *Engineering Geology*, p. 128, Bell & Howell Company, 1981.

APPENDIX D

Performance Demonstration for Alternate Cap Design

PERFORMANCE DEMONSTRATION FOR ALTERNATE CAP DESIGN
Holloman AFB Main Base Landfill

This demonstration has been prepared following procedures presented in the *Guidance Document for Performance Demonstration for an Alternative Cover Design Using the HELP Modeling Program Under the New Mexico Solid Waste Management Regulations (Draft)*, prepared by the New Mexico Environment Department (NMED) Solid Waste Bureau. Under the guidance, a Hydrologic Evaluation of Landfill Performance (HELP) model simulation is required to demonstrate that the design of any proposed alternative cover (cap) system provides equivalent reduction in infiltration as the cap system prescribed by the regulations.

Introduction

The Holloman AFB Main Base Landfill area encompasses approximately 228 acres. The landfill includes municipal waste disposal areas (approximately 100 acres), construction debris disposal areas (16 acres), and asbestos disposal areas (9 acres). Approximately 103 acres within the landfill boundary have not been used for disposal. Under New Mexico Administrative Code (NMAC) Solid Waste Management Regulations (20 NMAC 9.1), cap requirements for landfills include the following:

- Municipal waste disposal areas: 6 in. topsoil/erosion layer + 18 in. low-permeability infiltration layer (Section 502.A.1)
- Construction/demolition disposal areas: 30 in. of cover material (Section 503.A.1)
- Asbestos disposal areas: 36 in. cover material (Section 705.C.3)

Due to the arid climate, the relative unavailability of very low-permeability borrow soils in the area, and the presence of existing cover material at the landfill, an alternative cap system for the closure of municipal waste disposal areas is proposed. The purpose of this document is to compare the degree of protection against infiltration provided by the proposed cap system to that provided by the cap system prescribed by the regulations.

Prescribed Cap System

As stated above, a cap system for a municipal waste landfill designed in accordance with Section 502.A.1 of the NMED Solid Waste Management Regulations must consist of an infiltration layer (18 in.) and a topsoil/erosion layer (6 in.). Furthermore, in order to prevent a "bathtub effect" (a higher-permeability cap allowing infiltration to collect in a basin formed by a lower-permeability liner) the infiltration layer must have a saturated hydraulic conductivity equivalent to the lesser of 1) the permeability of the least conductive natural subsoils or 2) the default permeability of 1×10^{-5} cm/s.

The Holloman AFB Main Base Landfill is an existing landfill, and properties of the existing cover material and subsoils were explored during the landfill soil investigation (for results, see the *Soil Investigation Technical Memorandum*, Appendix C of the *Closure Plan*). Geotechnical results and logs from deep soil borings at the Holloman AFB landfill indicate that, although low-permeability silt and clay layers (2.7×10^{-6} to 1.6×10^{-7} cm/s) are present beneath the general bottom elevation of the trenches, these layers are not continuous across the landfill and are typically separated by higher-permeability sandy layers. The permeability of the sandy soils was not tested, but is expected to lie within the range of values typical of the material observed, which ranged from fine, poorly-graded sands to silty sands (10^{-2} to 10^{-6} cm/s). A table of permeability ranges for various soil types is presented in Attachment 1. Permeabilities measured on sandy/silty soils of the existing material averaged approximately 3.7×10^{-4} cm/s, sampled at depths of approximately 3 ft. Since there is no continuous low-permeability unit beneath the area and permeabilities of the more conductive subsoils are greater

than $1x10^{-5}$ cm/s, the default infiltration layer permeability of $1x10^{-5}$ is used for the infiltration layer of the prescribed cap system.

Proposed Alternative Cap System

The alternative cap system consists of a minimum thickness of 27 in. of native soil. The native soil cap will, in some instances, consist of a combination of existing cover material overlain by a thickness of newly placed and compacted material such that the total thickness of cover above waste material is at least 27 in. In areas where the difference between the existing surface and the proposed final surface is more than 27 in., fill material will be placed on the existing surface to raise the surface to within 27 in. of final elevations, and the final 27 in. will consist of native material installed to meet the permeability requirement.

New cap layers will be placed in a manner similar to the existing cover (no significant wetting of the soil, minimal compactive effort), and it is reasonable to assume that the resulting soil properties will be similar to those of the existing cap material. HELP default soil texture 8 (typical of minimally-compacted soil) was used to model the proposed cap since the soil type and properties measured on the existing cover (porosity, permeability) were most similar to this soil texture. This assumption is conservative, as it models the cap using the most permeable version of the native soil cap system that would result from minimal compaction (using any greater degree of compaction would result in less total percolation through the cap). Cover thickness will often be greater than the minimum 27 in. due to the construction of cap slopes to meet NMED requirements (2-5% cap slopes, Section 502.A.1.d). The construction of this capping system should be easily accomplished since the proposed permeability requirement should be easily met using native soils available in the area (potential borrow sources for cap material will be tested to ensure that the required permeability can be achieved).

HELP Modeling

Site- or area-specific data were used for the HELP modeling where applicable. Daily precipitation and temperature values from the Holloman AFB Weather Station were entered for a five-year period (using data from 1991-1995), and repeated to extend the data over the entire 30-year postclosure period. The precipitation data used provides conservative results, as 1992 and 1993 were uncommonly wet (the average yearly precipitation over the five year period is 9.9 in/yr, compared to the 53-year average of 8.5 in/yr from the Holloman AFB Weather Station). The values of other general inputs are documented in Table 1, which lists information used for both the prescribed and alternative cover HELP runs.

Site-specific geotechnical test results were used to select appropriate soil types for the modeling of the prescribed system. Specific information on soil input values for the prescribed cap are presented in Table 2; information on data used to model the proposed cover system are presented in Table 3. Results of geotechnical testing from the soil investigation are presented in Attachment 2. The results of the soil investigation are presented in the *Soil Investigation Technical Memorandum*, Radian International LLC, 1996 (Appendix C of the *Closure Plan*).

Table 1
General HELP Model Input Parameters

INPUT PARAMETER	VALUE	JUSTIFICATION
CLIMATOLOGICAL DATA		
City	Holloman AFB, NM	Site Location
Precipitation	Holloman AFB Weather Station Data	Location-specific daily data entered for years 1-5, repeated for years 5-30
Temperature	Holloman AFB Weather Station Data	Location-specific daily data entered for years 1-5, repeated for years 5-30
Maximum Leaf Area Index	1	Poor stand of native grasses
Evaporative Zone Depth	30 inches	Value based on type of vegetation
Growing Season Start/End Day	Start day 60 / End day 275	Period during which average daily temperatures are above 50-55°F.
LANDFILL COVER DATA		
Type of Vegetative Cover	Native Grasses and Shrubs	Based on site visit
SCS Runoff Curve Number	89	Lake Holloman Water Balance Study
Active (uncovered)?	No	Modeling period is post-closure
Percent of Surface Runoff Draining from Landfill	100 %	Entire closure area will be graded for drainage (2-5% cover slope)
Surface Area of Landfill	72 acres	Size of disposal area to be closed under 20 NMAC 9.1, Section 502
SOIL AND DESIGN DATA		
Source of Soil Characteristics	Default HELP Values/ Landfill Soil Investigation Results	Site-specific testing results used to select appropriate HELP default soil types for input
Number of Layers in Prescribed Cover	2	Erosion layer: 6" native material Infiltration layer: 18" $K < 1x10^{-5}$
Number of Layers in Alternative Cover	1	27" native material, $K < 3.7x10^{-4}$ cm/s (average permeability measured in existing cover soils)

Table 2
Prescribed Cover System Soil Input Parameters

INPUT PARAMETER	VALUE	JUSTIFICATION
LAYER NUMBER 1		
Layer Type	1	HELP value indicating vertical percolation
Thickness	6 inches	Required thickness of erosion/topsoil layer
Soil Texture	8	HELP default soil type having properties most similar to average values measured in on-site material during the soil investigation
Porosity	0.463 vol/vol	HELP default value for soil texture 8
Field Capacity	0.232 vol/vol	HELP default value for soil texture 8
Wilting Point	0.116 vol/vol	HELP default value for soil texture 8
Initial Moisture Content	0.220 vol/vol	Average moisture content (vol/vol) of existing cover soils measured during the soil investigation
Saturated Hydraulic Conductivity	3.70×10^{-4} cm/s	HELP default value for soil texture 8,same as average value measured during soil investigation (3.7×10^{-4})
Is Layer Compacted?	No	No significant compaction
LAYER NUMBER 2		
Layer Type	1	HELP value indicating vertical percolation
Thickness	18 inches	Required thickness of infiltration layer
Soil Texture	23	HELP default soil type most similar to the type of soil available on site (ML), except compacted to achieve lower permeability
Porosity	0.461 vol/vol	HELP default value for soil texture 23
Field Capacity	0.360 vol/vol	HELP default value for soil texture 23
Wilting Point	0.203 vol/vol	HELP default value for soil texture 23
Initial Moisture Content	0.344 vol/vol	Set at same relative position between field capacity and wilting point as that for Layer 1
Saturated Hydraulic Conductivity	9.0×10^{-6} cm/s	HELP default value for soil texture 23, slightly less permeable than that required by regulations (1×10^{-5}) (conservative)
Is Layer Compacted?	Yes	Assume moderate to heavy compaction to achieve lower permeability

Table 3
Proposed Alternative Cover System Soil Input Parameters

INPUT PARAMETER	VALUE	JUSTIFICATION
LAYER NUMBER 1		
Layer Type	1	HELP value indicating vertical percolation
Thickness	27 inches	Proposed alternate cover thickness
Soil Texture	8	HELP default soil type having properties most similar to average values measured in on-site material during the soil investigation
Porosity	0.463 vol/vol	HELP default value for soil texture 8
Field Capacity	0.232 vol/vol	HELP default value for soil texture 8
Wilting Point	0.116 vol/vol	HELP default value for soil texture 8
Initial Moisture Content	0.220 vol/vol	Average moisture content of existing cover soils measured during soil investigation
Saturated Hydraulic Conductivity	3.7×10^{-4} cm/s	HELP default value for soil texture 8, same as average value measured during soil investigation (3.7×10^{-4})
Is Layer Compacted?	Yes*	Compacted for installation integrity but not enough to achieve permeability as low as that shown in HELP default values for a similar, more heavily compacted soil (default soil 23, $K=9 \times 10^{-6}$); soil texture 8 is typical of a soil with minimal compaction.

* Since the soil tested in the soil investigation was mainly existing compacted cover material, assume that similar installation of cap (no significant moisture added, minimal compaction) using similar material will result in similar properties; therefore, use default soil texture 8. Engineering Documentation for HELP v.3 (EPA/600/R-94/168b) regarding default soil types 1-21 states that "...loam and clay soils data are considered to represent conditions typical of minimal densification efforts or low-density soils."

HELP Modeling Results

Table 4 presents the results of the HELP modeling for the prescribed and alternative cap ystems. HELP output printouts are included as Attachment 3. Results of the modeling indicate that over a five-year postclosure modeling period (recommended by the NMED guidance document), the two cap systems perform similarly, with the alternative cap preventing slightly more infiltration than the prescribed cap during the initial five years of postclosure operation. The true benefit of using the alternative cap, however, is its long-term performance. Over the entire 30-year post-closure period, the alternative cap (compared to the prescribed cap) reduced total infiltration by approximately 57%. Results indicate that the alternative cap is able to take better advantage of the high potential evapotranspiration in this arid region.

Table 4
HELP Modeling Results

YEARS AFTER CLOSURE	INFILTRATION THROUGH CAP (in./ft^2)	
	PRESCRIBED CAP 6" erosion layer 18" K=1x10^{-5} cm/s	ALTERNATIVE CAP 27" compacted native soil K=3.7x10^{-5} cm/s
1	0.539494	0.484406
2	0.078340	0.106484
3	0.008503	0.009978
4	0.001231	0.002927
5	0.000320	0.000973
Total After Year 5	0.62788	0.60477 (4% reduction)
Total After Year 30	2.61382	1.11567 (57% reduction)

The HELP model results indicate that the alternative cap system provides an equivalent reduction in infiltration as that provided by the prescribed cap over the short term, and provides a much greater reduction in infiltration over the long term. As a result, the alternative cap system consisting of a minimum thickness of 27 in. of native material is proposed for use in the closure of the Holloman AFB Main Base Landfill. The use of the alternative cap will benefit construction as the proposed permeability should be easily met using native material available in the area.

ATTACHMENT 1

General Soil Permeability Values

TABLE 8–3 Hydraulic conductivity

Material	Hydraulic Conductivity	
	cm/sec	ft/day
Clay		
Unweathered	10^{-8}–10^{-9}	10^{-3}–10^{-4}
High plastic (CH)	10^{-7}–10^{-9}	10^{-2}–10^{-4}
Low plastic (CL)	10^{-6}–10^{-8}	10^{-1}–10^{-3}
Silt		
High plastic (MH)	10^{-5}–10^{-7}	1 –10^{-2}
Low plastic (ML)	10^{-4}–10^{-7}	10 –10^{-2}
Sand		
(SP)	10^{-1}–10^{-5}	10^{-4}– 1
Well sorted, fine	10^{-3}–10^{-5}	10^{-2}– 1
Well sorted, medium	10^{-2}–10^{-4}	10^{-3}–10^{-1}
Well sorted, coarse	10^{-1}–10^{-3}	10^{-4}–10^{-2}
(SW)	10^{-1}–10^{-4}	10^{-4}–10^{-1}
Poorly sorted, fine	10^{-2}–10^{-4}	10^{-3}–10^{-1}
Poorly sorted, medium	10^{-1}–10^{-3}	10^{-4}–10^{-2}
Poorly sorted, coarse	10^{-1}–10^{-3}	10^{-4}–10^{-2}
Silty sand (SM)	10^{-4}–10^{-6}	10 –10^{-1}
Clayey sand (SC)	10^{-5}–10^{-7}	1 –10^{-2}
Gravel		
(GP)	10^{-3}–1	10^{-8}–10^{-5}
Well sorted	10^{-3}–1	10^{-8}–10^{-5}
(GW)	10^{-2}–1	10^{-7}–10^{-5}
Poorly sorted	10^{-2}–1	10^{-7}–10^{-5}
Silty gravel (GM)	10^{-3}–10^{-6}	10^{-2}–10^{-1}
Clayey gravel (GC)	10^{-4}–10^{-7}	10 –10^{-2}

From: Mathewson, Christopher, *Engineering Geology*, p. 128, Bell & Howell Company, 1981.

ATTACHMENT 2

Landfill Soil Investigation Results

Cover Samples

Location	Permeability (cm/s)	LL	PI	Sp. Gravity	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Moisture (mass/mass) %	Void Ratio	Moisture (vol/vol)
									calculated*
A-05	4.2E-05	No value	Non-plastic	2.308	101.1	96.3	5.1	0.5	0.08
A-07	3.0E-04	No value	Non-plastic	2.335	96.2	86.8	10.8	0.68	0.15
A-09	1.6E-04	No value	Non-plastic	2.394	98.6	93.6	5.4	0.6	0.08
A-13	1.0E-04	37.0	13.0	2.429	98.6	94.5	4.4	0.6	0.07
A-15	3.2E-04	No value	Non-plastic	2.373	105.9	92.8	14.2	0.6	0.21
A-17	5.8E-05	No value	Non-plastic	2.438	111.7	89.4	24.9	0.7	0.36
B-02	4.4E-05	No value	Non-plastic	2.335	115.3	110.5	4.4	0.32	0.08
B-04	1.3E-05	No value	Non-plastic	2.472	114.1	106.1	7.5	0.45	0.13
B-06	8.3E-05	No value	Non-plastic	2.47	104.9	91.8	14.2	0.68	0.21
B-10	1.1E-03	No value	Non-plastic	2.379	100.4	85.2	17.8	0.74	0.24
B-12	2.2E-04	No value	Non-plastic	2.553	107	94.4	13.3	0.69	0.20
B-14	8.5E-05	No value	Non-plastic	2.435	104.4	87.8	18.9	0.73	0.27
B-16	3.1E-03	37.0	Non-plastic	2.581	113.2	87.4	29.5	0.84	0.41
B-18	1.3E-04	No value	Non-plastic	2.37	101.4	86.8	16.9	0.7	0.23
B-20	2.8E-05	No value	Non-plastic	2.633	108.8	89.9	21	0.83	0.30
C-01	1.9E-04	No value	Non-plastic	2.353	105.9	100.6	5.3	0.46	0.08
C-03	4.3E-06	28.0	Non-plastic	2.445	116.8	106.8	9.4	0.43	0.16
C-05	7.3E-05	31.0	8.0	2.306	108.5	102	6.3	0.41	0.10
C-09	1.5E-04	No value	Non-plastic	2.339	112.7	101	11.6	0.45	0.19
C-11	1.3E-04	No value	Non-plastic	2.588	100	87	14.9	0.86	0.21
D-02	1.4E-04	No value	Non-plastic	2.344	97.7	92.4	5.7	0.58	0.08
D-12	1.6E-04	No value	Non-plastic	2.532	98.2	89.1	10.2	0.77	0.15
D-18	4.8E-03	No value	Non-plastic	2.66	98.6	89.5	10.1	0.85	0.15
D-20	4.9E-04	No value	Non-plastic	2.535	112.5	104.9	7.3	0.51	0.12
E-03	2.8E-06	24.0	Non-plastic	2.588	124.7	102.7	21.4	0.57	0.35
F-02	8.4E-05	No value	Non-plastic	2.554	103.8	85.7	21.1	0.86	0.29
F-04	1.6E-04	No value	Non-plastic	2.692	115.2	99.8	15.5	0.66	0.25
F-14	1.2E-04	No value	Non-plastic	2.668	104	91.8	13.2	0.81	0.20
G-03	7.4E-05	No value	Non-plastic	2.545	109.4	96	14	0.65	0.21
G-05	5.9E-04	No value	Non-plastic	2.707	106.5	91.4	16.6	0.85	0.24
G-13	1.4E-04	No value	Non-plastic	2.661	101.6	87.7	15.8	0.89	0.22
G-15	8.5E-06	No value	Non-plastic	2.627	118.5	99.6	19	0.65	0.30
G-17	9.0E-05	No value	Non-plastic	2.588	109	100.8	8.1	0.6	0.13
G-19	4.9E-04	No value	Non-plastic	2.664	104.1	96.9	7.4	0.72	0.12
H-04	1.7E-05	21.0	Non-plastic	2.745	121.8	101.2	20.3	0.69	0.33
H-06	3.5E-04	No value	Non-plastic	2.524	90.2	82.3	9.5	0.91	0.13
H-08	9.9E-05	30.0	7.0	2.61	114.6	98.8	16	0.65	0.25
H-14	2.5E-03	No value	Non-plastic	2.644	113.7	93.2	22	0.77	0.33
H-16	5.8E-06	29.0	8.0	2.67	115.7	98.2	17.9	0.7	0.28
H-18	1.9E-04	No value	Non-plastic	2.636	104.1	83.3	24.9	0.97	0.33
I-15	1.9E-05	30.0	7.0	2.657	114.3	95.8	19.3	0.73	0.30
I-17	8.9E-05	No value	Non-plastic	2.52	103.4	85	21.8	0.85	0.29
I-19	7.9E-05	No value	Non-plastic	2.449	106.5	86.7	22.8	0.76	0.32
I-21	2.9E-04	34.0	3.0	2.68	107.5	85.4	25.9	0.96	0.35
J-16	1.6E-04	No value	Non-plastic	2.482	94.7	82	15.5	0.89	0.20
J-18	1.0E-04	No value	Non-plastic	2.709	105.5	87.1	21.1	0.94	0.29
J-20	7.5E-06	32.0	Non-plastic	2.658	118.8	99.3	19.6	0.67	0.31
AS-01	1.0E-04	No value	Non-plastic	2.722	107.2	91.3	17.4	0.88	0.25
AS-02	1.1E-04	No value	Non-plastic	2.785	117	99.2	17.9	0.75	0.29
AS-03	1.3E-04	No value	Non-plastic	2.719	117.6	101.2	16.2	0.68	0.26
AS-04	1.5E-04	No value	Non-plastic	2.776	132.2	112.2	17.9	0.54	0.32
AS-05	2.5E-03	No value	Non-plastic	2.596	122.7	92.3	32.9	0.76	0.49
AVG.**	3.7E-04						14.85		0.22

* HELP requires volume/volume moisture for input

Volume/volume moisture content:
Assuming total volume = 1 cf
Vol/vol mc = vol water/total vol = vol water
Volume of water:
=(wet weight-dry weight)/water density
=(wet weight-dry weight)/62.43
=vol/vol moisture content

** Asbestos area (AS-_) results not included in K, moisture averages since this area will be closed separately from the rest of the landfill

Boreholes

Location	Permeability (cm/s)	LL	PI	Spec Gravity	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Mass/mass Moisture (%)	Void Ratio
BH-1	1.6E-07	30.7	12.3	2.74	131.80	109.30	20.60	0.56
BH-2	2.7E-06	No value	Non-plastic	2.73	128.30	102.40	25.20	0.66
BH-3	4.4E-04	29.0	6.0	2.48	89.30	74.10	20.50	1.09
BH-4	1.9E-06	38.0	11.0	2.69	119.60	87.20	37.10	0.92
BH-5	3.4E-07	No value	Non-plastic	2.53	127.40	116.90	9.00	0.35
BH-6	1.2E-06	No value	Non-plastic	2.73	126.70	104.90	20.80	0.62
BH-7	2.4E-06	No value	Non-plastic	2.80	126.90	106.70	19.00	0.64
BH-8	9.0E-08	52.0	20.0	2.78	114.50	76.80	49.20	1.26
BH-9	6.0E-07	25.1	8.8	2.59	127.10	102.50	24.00	0.58
AVG.*	7.5E-05							

* Arroyo borehole results not included in perm. average...soil in arroyo is depositional material in channel/not typical of landfill subsoils
Arroyo boreholes: BH-4, BH-8, BH-9

Other Samples

Loc ID	Permeability (cm/s)	LL	PI	Spec Gravity	Wet Unit Wt (pcf)	Dry Unit Wt (pcf)	Mass/mass Moisture (%)	Void Ratio	Lab Note
Samples Held (not cover material)									
C-17	Sample not run								
C-19	Sample not run								
C-21	Sample not run								
D-22	Sample not run								
E-23	Sample not run								
J-14	Sample not run								
Unsatisfactory Samples (see Lab Note Column)									
A-13	1.0E-04	37.0	13.0	2.429	98.6	94.5	4.4	0.6	Loose sample; pieces of concrete
C-07	3.6E-03	29.0	7.0	2.511	105.6	101.5	4.1	0.54	Loose sample; gravel in sample
D-10	4.8E-02	No value	Non-plastic	2.506	114.6	105.6	8.5	0.48	Large piece of gravel in sample
F-18	4.6E-03	No value	Non-plastic	2.565	100.7	86.3	16.7	0.85	Loose sample; gravel/asphalt in sample
H-20	3.2E-04	No value	Non-plastic	2.65	96.8	78.4	23.5	1.11	Loose sample; roots present
I-13	4.7E-04	No value	Non-plastic	2.603	102.5	82.6	24.1	0.97	Loose sample; landfill debris at top

ATTACHMENT 3

HELP Output

```
******************************************************************************
******************************************************************************
**                    PRESCRIPTIVE COVER 30-YR OUTPUT                       **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**            FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\HOLPRE.D10
OUTPUT DATA FILE:            C:\HELP3\prelong.OUT

TIME:  10:44     DATE:   5/30/1996

******************************************************************************
     TITLE:  Prescriptive Closure Cover, Use InSitu Moisture
******************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.

                                LAYER  1
                                --------
                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   8
        THICKNESS                    =      6.00   INCHES
        POROSITY                     =      0.4630 VOL/VOL
        FIELD CAPACITY               =      0.2320 VOL/VOL
        WILTING POINT                =      0.1160 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2200 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                                LAYER  2
                                --------
                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER  23
        THICKNESS                    =     18.00   INCHES
        POROSITY                     =      0.4610 VOL/VOL
        FIELD CAPACITY               =      0.3600 VOL/VOL
        WILTING POINT                =      0.2030 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.3440 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.900000032000E-05 CM/SEC

                 GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                 ----------------------------------------
       NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.
      SCS RUNOFF CURVE NUMBER              =     89.00
      FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
      AREA PROJECTED ON HORIZONTAL PLANE   =     72.000   ACRES
      EVAPORATIVE ZONE DEPTH               =     24.0     INCHES
      INITIAL WATER IN EVAPORATIVE ZONE    =      7.512   INCHES
      UPPER LIMIT OF EVAPORATIVE STORAGE   =     11.076   INCHES
      LOWER LIMIT OF EVAPORATIVE STORAGE   =      4.350   INCHES
      INITIAL SNOW WATER                   =      0.000   INCHES
      INITIAL WATER IN LAYER MATERIALS     =      7.512   INCHES
      TOTAL INITIAL WATER                  =      7.512   INCHES
      TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Holloman AFB New Mexico

MAXIMUM LEAF AREA INDEX	=	1.00
START OF GROWING SEASON (JULIAN DATE)	=	60
END OF GROWING SEASON (JULIAN DATE)	=	275
AVERAGE ANNUAL WIND SPEED	=	5.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	47.10 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	30.30 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	49.60 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	48.30 %

NOTE: PRECIPITATION DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.
NOTE: TEMPERATURE DATA FOR Holloman AFB New Mexico
WAS ENTERED BY THE USER.
NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR EL PASO TEXAS

STATION LATITUDE = 32.95 DEGREES

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.107	27900.654	0.75
EVAPOTRANSPIRATION	14.647	3828186.000	103.37
PERC./LEAKAGE THROUGH LAYER 2	0.539494	141002.203	3.81
CHANGE IN WATER STORAGE	-1.123	-293616.750	-7.93
SOIL WATER AT START OF YEAR	7.512	1963336.250	
SOIL WATER AT END OF YEAR	6.389	1669719.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.262	0.00

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.181	47401.961	1.57
EVAPOTRANSPIRATION	11.982	3131519.750	103.65
PERC./LEAKAGE THROUGH LAYER 2	0.078340	20475.031	0.68
CHANGE IN WATER STORAGE	-0.681	-178074.203	-5.89
SOIL WATER AT START OF YEAR	6.389	1669719.500	
SOIL WATER AT END OF YEAR	5.707	1491645.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.724	0.00

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	284.484	0.01
EVAPOTRANSPIRATION	10.234	2674637.750	111.36
PERC./LEAKAGE THROUGH LAYER 2	0.008503	2222.302	0.09
CHANGE IN WATER STORAGE	-1.053	-275246.094	-11.46
SOIL WATER AT START OF YEAR	5.707	1491645.250	
SOIL WATER AT END OF YEAR	4.654	1216399.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.193	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	18106.107	0.80
EVAPOTRANSPIRATION	8.836	2309425.500	102.39
PERC./LEAKAGE THROUGH LAYER 2	0.001231	321.823	0.01
CHANGE IN WATER STORAGE	-0.277	-72316.820	-3.21
SOIL WATER AT START OF YEAR	4.654	1216399.120	
SOIL WATER AT END OF YEAR	4.377	1144082.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.540	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.976	1561946.120	98.29
PERC./LEAKAGE THROUGH LAYER 2	0.000320	83.551	0.01
CHANGE IN WATER STORAGE	0.003	845.589	0.05
SOIL WATER AT START OF YEAR	4.377	1144082.370	
SOIL WATER AT END OF YEAR	4.381	1144928.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.184	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.109	28448.877	0.77
EVAPOTRANSPIRATION	11.862	3100308.250	83.71
PERC./LEAKAGE THROUGH LAYER 2	0.003615	944.703	0.03
CHANGE IN WATER STORAGE	2.195	573768.625	15.49
SOIL WATER AT START OF YEAR	4.381	1144928.000	
SOIL WATER AT END OF YEAR	6.576	1718696.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.497	0.00

ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.184	48022.293	1.59
EVAPOTRANSPIRATION	11.844	3095490.000	102.45
PERC./LEAKAGE THROUGH LAYER 2	0.279917	73158.984	2.42
CHANGE IN WATER STORAGE	-0.747	-195350.266	-6.47
SOIL WATER AT START OF YEAR	6.576	1718696.500	
SOIL WATER AT END OF YEAR	5.829	1523346.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.717	0.00

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	213.164	0.01
EVAPOTRANSPIRATION	10.406	2719810.750	113.24
PERC./LEAKAGE THROUGH LAYER 2	0.009703	2535.901	0.11
CHANGE IN WATER STORAGE	-1.227	-320661.000	-13.35
SOIL WATER AT START OF YEAR	5.829	1523346.250	
SOIL WATER AT END OF YEAR	4.602	1202685.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.185	0.00

ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	18084.395	0.80
EVAPOTRANSPIRATION	8.606	2249181.750	99.72
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.045	-11729.564	-0.52
SOIL WATER AT START OF YEAR	4.602	1202685.250	
SOIL WATER AT END OF YEAR	4.557	1190955.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.606	0.00

ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.102	26769.609	1.68
EVAPOTRANSPIRATION	6.163	1610752.120	101.36
PERC./LEAKAGE THROUGH LAYER 2	0.003192	834.304	0.05
CHANGE IN WATER STORAGE	-0.189	-49287.402	-3.10
SOIL WATER AT START OF YEAR	4.557	1190955.750	
SOIL WATER AT END OF YEAR	4.368	1141668.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.158	0.00

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.110	28620.078	0.77
EVAPOTRANSPIRATION	11.770	3076250.000	83.06
PERC./LEAKAGE THROUGH LAYER 2	0.002263	591.476	0.02
CHANGE IN WATER STORAGE	2.288	598008.687	16.15
SOIL WATER AT START OF YEAR	4.368	1141668.370	
SOIL WATER AT END OF YEAR	6.656	1739677.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.817	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.185	48382.254	1.60
EVAPOTRANSPIRATION	11.773	3076933.500	101.84
PERC./LEAKAGE THROUGH LAYER 2	0.431127	112679.461	3.73
CHANGE IN WATER STORAGE	-0.829	-216673.922	-7.17
SOIL WATER AT START OF YEAR	6.656	1739677.000	
SOIL WATER AT END OF YEAR	5.827	1523003.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.522	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	213.730	0.01
EVAPOTRANSPIRATION	10.390	2715428.000	113.05
PERC./LEAKAGE THROUGH LAYER 2	0.002778	726.005	0.03
CHANGE IN WATER STORAGE	-1.203	-314469.812	-13.09
SOIL WATER AT START OF YEAR	5.827	1523003.120	
SOIL WATER AT END OF YEAR	4.624	1208533.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.570	0.00

****

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.070	18307.398	0.81
EVAPOTRANSPIRATION	8.635	2256878.250	100.06
PERC./LEAKAGE THROUGH LAYER 2	0.000505	131.947	0.01
CHANGE IN WATER STORAGE	-0.076	-19779.791	-0.88
SOIL WATER AT START OF YEAR	4.624	1208533.250	
SOIL WATER AT END OF YEAR	4.548	1188753.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.780	0.00

****

ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.103	26897.754	1.69
EVAPOTRANSPIRATION	6.177	1614531.620	101.60
PERC./LEAKAGE THROUGH LAYER 2	0.002310	603.651	0.04
CHANGE IN WATER STORAGE	-0.203	-52964.375	-3.33
SOIL WATER AT START OF YEAR	4.548	1188753.500	
SOIL WATER AT END OF YEAR	4.346	1135789.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.098	0.00

****

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.110	28667.039	0.77
EVAPOTRANSPIRATION	11.800	3083941.250	83.27
PERC./LEAKAGE THROUGH LAYER 2	0.002586	675.807	0.02
CHANGE IN WATER STORAGE	2.258	590185.000	15.94
SOIL WATER AT START OF YEAR	4.346	1135789.120	
SOIL WATER AT END OF YEAR	6.604	1725974.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.754	0.00

****

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.185	48303.285	1.60
EVAPOTRANSPIRATION	11.728	3065355.750	101.46
PERC./LEAKAGE THROUGH LAYER 2	0.403393	105430.766	3.49
CHANGE IN WATER STORAGE	-0.757	-197767.625	-6.55
SOIL WATER AT START OF YEAR	6.604	1725974.120	
SOIL WATER AT END OF YEAR	5.847	1528206.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.576	0.00

****

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	214.005	0.01
EVAPOTRANSPIRATION	10.404	2719220.750	113.21
PERC./LEAKAGE THROUGH LAYER 2	0.007724	2018.636	0.08
CHANGE IN WATER STORAGE	-1.223	-319555.312	-13.30
SOIL WATER AT START OF YEAR	5.847	1528206.500	
SOIL WATER AT END OF YEAR	4.624	1208651.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.535	0.00

****

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.070	18211.012	0.81
EVAPOTRANSPIRATION	8.633	2256264.000	100.03
PERC./LEAKAGE THROUGH LAYER 2	0.000000	0.000	0.00
CHANGE IN WATER STORAGE	-0.072	-18937.693	-0.84
SOIL WATER AT START OF YEAR	4.624	1208651.120	
SOIL WATER AT END OF YEAR	4.552	1189713.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.138	0.00

****

ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.103	26864.389	1.69
EVAPOTRANSPIRATION	6.179	1614932.620	101.63
PERC./LEAKAGE THROUGH LAYER 2	0.000439	114.768	0.01
CHANGE IN WATER STORAGE	-0.202	-52842.363	-3.33
SOIL WATER AT START OF YEAR	4.552	1189713.500	
SOIL WATER AT END OF YEAR	4.350	1136871.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.584	0.00

****

ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.110	28672.113	0.77
EVAPOTRANSPIRATION	11.783	3079533.000	83.15
PERC./LEAKAGE THROUGH LAYER 2	0.002186	571.422	0.02
CHANGE IN WATER STORAGE	2.275	594694.625	16.06
SOIL WATER AT START OF YEAR	4.350	1136871.120	
SOIL WATER AT END OF YEAR	6.625	1731565.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.256	0.00

****

ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.185	48431.051	1.60
EVAPOTRANSPIRATION	11.740	3068474.500	101.56
PERC./LEAKAGE THROUGH LAYER 2	0.419745	109704.562	3.63
CHANGE IN WATER STORAGE	-0.785	-205289.687	-6.79
SOIL WATER AT START OF YEAR	6.625	1731565.750	
SOIL WATER AT END OF YEAR	5.840	1526276.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.277	0.00

****

ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	213.832	0.01
EVAPOTRANSPIRATION	10.395	2716854.750	113.11
PERC./LEAKAGE THROUGH LAYER 2	0.003086	806.615	0.03
CHANGE IN WATER STORAGE	-1.209	-315975.781	-13.16
SOIL WATER AT START OF YEAR	5.840	1526276.000	
SOIL WATER AT END OF YEAR	4.631	1210300.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.881	0.00

ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.070	18312.086	0.81
EVAPOTRANSPIRATION	8.663	2264153.250	100.38
PERC./LEAKAGE THROUGH LAYER 2	0.000030	7.759	0.00
CHANGE IN WATER STORAGE	-0.103	-26935.328	-1.19
SOIL WATER AT START OF YEAR	4.631	1210300.250	
SOIL WATER AT END OF YEAR	4.528	1183364.870	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.670	0.00

ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.103	26882.521	1.69
EVAPOTRANSPIRATION	6.154	1608445.870	101.22
PERC./LEAKAGE THROUGH LAYER 2	0.000068	17.693	0.00
CHANGE IN WATER STORAGE	-0.177	-46276.934	-2.91
SOIL WATER AT START OF YEAR	4.528	1183364.870	
SOIL WATER AT END OF YEAR	4.351	1137088.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.405	0.00

ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.110	28669.439	0.77
EVAPOTRANSPIRATION	11.795	3082758.000	83.24
PERC./LEAKAGE THROUGH LAYER 2	0.002417	631.598	0.02
CHANGE IN WATER STORAGE	2.263	591411.187	15.97
SOIL WATER AT START OF YEAR	4.351	1137088.000	
SOIL WATER AT END OF YEAR	6.613	1728499.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.815	0.00

ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.185	48419.633	1.60
EVAPOTRANSPIRATION	11.742	3068891.750	101.57
PERC./LEAKAGE THROUGH LAYER 2	0.405253	105916.953	3.51
CHANGE IN WATER STORAGE	-0.773	-201907.844	-6.68
SOIL WATER AT START OF YEAR	6.613	1728499.120	
SOIL WATER AT END OF YEAR	5.841	1526591.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.200	0.00

ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	213.931	0.01
EVAPOTRANSPIRATION	10.401	2718335.250	113.17
PERC./LEAKAGE THROUGH LAYER 2	0.003042	795.147	0.03
CHANGE IN WATER STORAGE	-1.215	-317447.250	-13.22
SOIL WATER AT START OF YEAR	5.841	1526591.370	
SOIL WATER AT END OF YEAR	4.626	1209144.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.390	0.00

****

ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.070	18315.902	0.81
EVAPOTRANSPIRATION	8.629	2255244.250	99.99
PERC./LEAKAGE THROUGH LAYER 2	0.000027	7.150	0.00
CHANGE IN WATER STORAGE	-0.069	-18031.037	-0.80
SOIL WATER AT START OF YEAR	4.626	1209144.120	
SOIL WATER AT END OF YEAR	4.557	1191113.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.857	0.00

****

ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.103	26857.828	1.69
EVAPOTRANSPIRATION	6.185	1616602.500	101.73
PERC./LEAKAGE THROUGH LAYER 2	0.000535	139.717	0.01
CHANGE IN WATER STORAGE	-0.209	-54530.926	-3.43
SOIL WATER AT START OF YEAR	4.557	1191113.000	
SOIL WATER AT END OF YEAR	4.349	1136582.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.278	0.00

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.02	0.36	0.11	0.24	0.67	0.58
	1.54	1.55	1.57	0.38	0.40	1.51
STD. DEVIATIONS	0.48	0.27	0.10	0.21	0.58	0.51
	0.73	1.29	1.23	0.24	0.34	1.22
RUNOFF						
TOTALS	0.001	0.000	0.000	0.000	0.000	0.011
	0.011	0.006	0.023	0.000	0.000	0.041
STD. DEVIATIONS	0.003	0.000	0.000	0.000	0.000	0.023
	0.022	0.011	0.041	0.000	0.000	0.052
EVAPOTRANSPIRATION						
TOTALS	0.983	0.876	0.362	0.215	0.584	0.720
	1.402	1.545	1.645	0.424	0.456	0.638
STD. DEVIATIONS	0.554	0.453	0.216	0.257	0.450	0.818
	0.735	0.980	0.926	0.201	0.297	0.409
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0019	0.0103	0.0538	0.0108	0.0091	0.0000
	0.0001	0.0010	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0070	0.0538	0.1111	0.0199	0.0208	0.0000
	0.0003	0.0016	0.0002	0.0000	0.0000	0.0002

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	9.93	(2.793)	2594259.2	100.00
RUNOFF	0.093	(0.0605)	24369.80	0.939
EVAPOTRANSPIRATION	9.851	(2.3320)	2574676.00	99.245
PERCOLATION/LEAKAGE THROUGH FROM LAYER 2	0.08713	(0.16990)	22771.668	0.87777
CHANGE IN WATER STORAGE	-0.105	(1.1547)	-27558.47	-1.062

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.25	326700.000
RUNOFF	0.121	31637.7754
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.041525	10852.87300
SNOW WATER	1.80	469459.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3130	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1738	

```
******************************************************************************
******************************************************************************
**                    PROPOSED COVER 30-YR OUTPUT                           **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**               HELP MODEL VERSION 3.01    (14 OCTOBER 1994)               **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY              **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************

PRECIPITATION DATA FILE:     C:\HELP3\DATA4.D4
TEMPERATURE DATA FILE:       C:\HELP3\DATA7.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\DATA13.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\DATA11.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\HOLALT27.D10
OUTPUT DATA FILE:            C:\HELP3\27long.OUT

TIME:  10:40     DATE:   5/30/1996

******************************************************************************
     TITLE:  27" alternative cover
******************************************************************************

     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
              WERE SPECIFIED BY THE USER.

                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   8
          THICKNESS                    =     27.00   INCHES
          POROSITY                     =      0.4630 VOL/VOL
          FIELD CAPACITY               =      0.2320 VOL/VOL
          WILTING POINT                =      0.1160 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2200 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.369999994000E-03 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  1.80
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

                   GENERAL DESIGN AND EVAPORATIVE ZONE DATA
                   ----------------------------------------

         NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

        SCS RUNOFF CURVE NUMBER              =     89.00
        FRACTION OF AREA ALLOWING RUNOFF     =    100.0     PERCENT
        AREA PROJECTED ON HORIZONTAL PLANE   =     72.000   ACRES
        EVAPORATIVE ZONE DEPTH               =     27.0     INCHES
        INITIAL WATER IN EVAPORATIVE ZONE    =      5.940   INCHES
        UPPER LIMIT OF EVAPORATIVE STORAGE   =     12.501   INCHES
        LOWER LIMIT OF EVAPORATIVE STORAGE   =      3.132   INCHES
        INITIAL SNOW WATER                   =      0.000   INCHES
        INITIAL WATER IN LAYER MATERIALS     =      5.940   INCHES
        TOTAL INITIAL WATER                  =      5.940   INCHES
        TOTAL SUBSURFACE INFLOW              =      0.00    INCHES/YEAR

                   EVAPOTRANSPIRATION AND WEATHER DATA
                   -----------------------------------

         NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
                  Holloman AFB        New Mexico
```

```
MAXIMUM LEAF AREA INDEX                    =  1.00
START OF GROWING SEASON (JULIAN DATE)      =    60
END OF GROWING SEASON (JULIAN DATE)        =   275
AVERAGE ANNUAL WIND SPEED                  =  5.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY      = 47.10 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY      = 30.30 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY      = 49.60 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY      = 48.30 %

NOTE:  PRECIPITATION DATA FOR     Holloman AFB        New Mexico
         WAS ENTERED BY THE USER.

NOTE:  TEMPERATURE DATA FOR     Holloman AFB        New Mexico
         WAS ENTERED BY THE USER.

NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR     EL PASO              TEXAS

                STATION LATITUDE  = 32.95 DEGREES
```

****

ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24803.484	0.67
EVAPOTRANSPIRATION	14.387	3760288.000	101.53
PERC./LEAKAGE THROUGH LAYER 1	0.484406	126604.359	3.42
CHANGE IN WATER STORAGE	-0.797	-208224.266	-5.62
SOIL WATER AT START OF YEAR	5.940	1552478.250	
SOIL WATER AT END OF YEAR	5.143	1344254.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.646	0.00

****

ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.171	44574.816	1.48
EVAPOTRANSPIRATION	12.033	3145036.250	104.09
PERC./LEAKAGE THROUGH LAYER 1	0.106484	27830.750	0.92
CHANGE IN WATER STORAGE	-0.750	-196119.828	-6.49
SOIL WATER AT START OF YEAR	5.143	1344254.000	
SOIL WATER AT END OF YEAR	4.393	1148134.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.386	0.00

****

ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	169.735	0.01
EVAPOTRANSPIRATION	10.182	2661184.500	110.80
PERC./LEAKAGE THROUGH LAYER 1	0.009978	2607.873	0.11
CHANGE IN WATER STORAGE	-1.003	-262063.703	-10.91
SOIL WATER AT START OF YEAR	4.393	1148134.250	
SOIL WATER AT END OF YEAR	3.390	886070.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.123	0.00

ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.829	2307547.250	102.31
PERC./LEAKAGE THROUGH LAYER 1	0.002927	764.949	0.03
CHANGE IN WATER STORAGE	-0.271	-70754.945	-3.14
SOIL WATER AT START OF YEAR	3.390	886070.500	
SOIL WATER AT END OF YEAR	3.120	815315.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.035	0.00

ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.947	1554226.000	97.81
PERC./LEAKAGE THROUGH LAYER 1	0.000973	254.386	0.02
CHANGE IN WATER STORAGE	0.032	8395.005	0.53
SOIL WATER AT START OF YEAR	3.120	815315.562	
SOIL WATER AT END OF YEAR	3.152	823710.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.024	0.00

ANNUAL TOTALS FOR YEAR 6

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24951.906	0.67
EVAPOTRANSPIRATION	12.125	3168932.500	85.57
PERC./LEAKAGE THROUGH LAYER 1	0.005489	1434.489	0.04
CHANGE IN WATER STORAGE	1.944	508152.000	13.72
SOIL WATER AT START OF YEAR	3.152	823710.562	
SOIL WATER AT END OF YEAR	5.096	1331862.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.141	0.00

ANNUAL TOTALS FOR YEAR 7

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.170	44548.988	1.47
EVAPOTRANSPIRATION	12.086	3158780.500	104.55
PERC./LEAKAGE THROUGH LAYER 1	0.090092	23546.561	0.78
CHANGE IN WATER STORAGE	-0.786	-205554.891	-6.80
SOIL WATER AT START OF YEAR	5.096	1331862.620	
SOIL WATER AT END OF YEAR	4.309	1126307.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.683	0.00

ANNUAL TOTALS FOR YEAR 8

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	165.689	0.01
EVAPOTRANSPIRATION	10.107	2641578.000	109.98
PERC./LEAKAGE THROUGH LAYER 1	0.010184	2661.709	0.11
CHANGE IN WATER STORAGE	-0.928	-242507.422	-10.10
SOIL WATER AT START OF YEAR	4.309	1126307.620	
SOIL WATER AT END OF YEAR	3.382	883800.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.494	0.00

ANNUAL TOTALS FOR YEAR 9

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.839	2310242.000	102.43
PERC./LEAKAGE THROUGH LAYER 1	0.002650	692.501	0.03
CHANGE IN WATER STORAGE	-0.281	-73377.078	-3.25
SOIL WATER AT START OF YEAR	3.382	883800.250	
SOIL WATER AT END OF YEAR	3.101	810423.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.119	0.00

ANNUAL TOTALS FOR YEAR 10

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.933	1550631.870	97.58
PERC./LEAKAGE THROUGH LAYER 1	0.001081	282.628	0.02
CHANGE IN WATER STORAGE	0.046	11960.809	0.75
SOIL WATER AT START OF YEAR	3.101	810423.187	
SOIL WATER AT END OF YEAR	3.147	822384.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.198	0.00

ANNUAL TOTALS FOR YEAR 11

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24858.105	0.67
EVAPOTRANSPIRATION	12.139	3172658.750	85.67
PERC./LEAKAGE THROUGH LAYER 1	0.005334	1394.172	0.04
CHANGE IN WATER STORAGE	1.931	504561.219	13.62
SOIL WATER AT START OF YEAR	3.147	822384.000	
SOIL WATER AT END OF YEAR	5.077	1326945.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-1.272	0.00

ANNUAL TOTALS FOR YEAR 12

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.170	44517.062	1.47
EVAPOTRANSPIRATION	12.105	3163723.000	104.71
PERC./LEAKAGE THROUGH LAYER 1	0.081524	21307.066	0.71
CHANGE IN WATER STORAGE	-0.797	-208226.516	-6.89
SOIL WATER AT START OF YEAR	5.077	1326945.250	
SOIL WATER AT END OF YEAR	4.280	1118718.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	1.040	0.00

ANNUAL TOTALS FOR YEAR 13

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	165.547	0.01
EVAPOTRANSPIRATION	10.066	2630816.250	109.53
PERC./LEAKAGE THROUGH LAYER 1	0.011117	2905.452	0.12
CHANGE IN WATER STORAGE	-0.888	-231988.297	-9.66
SOIL WATER AT START OF YEAR	4.280	1118718.620	
SOIL WATER AT END OF YEAR	3.393	886730.375	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.522	0.00

ANNUAL TOTALS FOR YEAR 14

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.857	2314990.250	102.64
PERC./LEAKAGE THROUGH LAYER 1	0.003167	827.774	0.04
CHANGE IN WATER STORAGE	-0.299	-78261.617	-3.47
SOIL WATER AT START OF YEAR	3.393	886730.375	
SOIL WATER AT END OF YEAR	3.093	808468.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.886	0.00

ANNUAL TOTALS FOR YEAR 15

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.929	1549514.500	97.51
PERC./LEAKAGE THROUGH LAYER 1	0.001054	275.563	0.02
CHANGE IN WATER STORAGE	0.050	13085.373	0.82
SOIL WATER AT START OF YEAR	3.093	808468.750	
SOIL WATER AT END OF YEAR	3.143	821554.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.028	0.00

ANNUAL TOTALS FOR YEAR 16

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24853.420	0.67
EVAPOTRANSPIRATION	12.153	3176304.250	85.77
PERC./LEAKAGE THROUGH LAYER 1	0.005521	1442.960	0.04
CHANGE IN WATER STORAGE	1.916	500870.219	13.52
SOIL WATER AT START OF YEAR	3.143	821554.125	
SOIL WATER AT END OF YEAR	5.060	1322424.370	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.052	0.00

ANNUAL TOTALS FOR YEAR 17

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.170	44519.930	1.47
EVAPOTRANSPIRATION	12.078	3156799.000	104.48
PERC./LEAKAGE THROUGH LAYER 1	0.077157	20165.625	0.67
CHANGE IN WATER STORAGE	-0.766	-200163.687	-6.63
SOIL WATER AT START OF YEAR	5.060	1322424.370	
SOIL WATER AT END OF YEAR	4.294	1122260.620	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.781	0.00

ANNUAL TOTALS FOR YEAR 18

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	165.580	0.01
EVAPOTRANSPIRATION	10.077	2633812.750	109.66
PERC./LEAKAGE THROUGH LAYER 1	0.010594	2768.771	0.12
CHANGE IN WATER STORAGE	-0.899	-234849.219	-9.78
SOIL WATER AT START OF YEAR	4.294	1122260.620	
SOIL WATER AT END OF YEAR	3.395	887411.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.533	0.00

****

ANNUAL TOTALS FOR YEAR 19

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.860	2315732.000	102.67
PERC./LEAKAGE THROUGH LAYER 1	0.002917	762.327	0.03
CHANGE IN WATER STORAGE	-0.302	-78937.273	-3.50
SOIL WATER AT START OF YEAR	3.395	887411.500	
SOIL WATER AT END OF YEAR	3.093	808474.187	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.219	0.00

****

ANNUAL TOTALS FOR YEAR 20

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.930	1549838.370	97.53
PERC./LEAKAGE THROUGH LAYER 1	0.001101	287.750	0.02
CHANGE IN WATER STORAGE	0.049	12749.381	0.80
SOIL WATER AT START OF YEAR	3.093	808474.187	
SOIL WATER AT END OF YEAR	3.142	821223.562	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.002	0.00

****

ANNUAL TOTALS FOR YEAR 21

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24850.309	0.67
EVAPOTRANSPIRATION	12.136	3171898.500	85.65
PERC./LEAKAGE THROUGH LAYER 1	0.005420	1416.628	0.04
CHANGE IN WATER STORAGE	1.933	505304.625	13.64
SOIL WATER AT START OF YEAR	3.142	821223.562	
SOIL WATER AT END OF YEAR	5.075	1326528.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.893	0.00

****

ANNUAL TOTALS FOR YEAR 22

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.170	44534.637	1.47
EVAPOTRANSPIRATION	12.089	3159600.500	104.58
PERC./LEAKAGE THROUGH LAYER 1	0.080718	21096.570	0.70
CHANGE IN WATER STORAGE	-0.780	-203909.953	-6.75
SOIL WATER AT START OF YEAR	5.075	1326528.250	
SOIL WATER AT END OF YEAR	4.295	1122618.250	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.045	0.00

****

ANNUAL TOTALS FOR YEAR 23

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	165.570	0.01
EVAPOTRANSPIRATION	10.079	2634326.000	109.68
PERC./LEAKAGE THROUGH LAYER 1	0.010585	2766.436	0.12
CHANGE IN WATER STORAGE	-0.901	-235359.562	-9.80
SOIL WATER AT START OF YEAR	4.295	1122618.250	
SOIL WATER AT END OF YEAR	3.395	887258.687	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.012	0.00

ANNUAL TOTALS FOR YEAR 24

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.861	2315789.250	102.67
PERC./LEAKAGE THROUGH LAYER 1	0.002955	772.292	0.03
CHANGE IN WATER STORAGE	-0.302	-79004.883	-3.50
SOIL WATER AT START OF YEAR	3.395	887258.687	
SOIL WATER AT END OF YEAR	3.092	808253.812	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.536	0.00

ANNUAL TOTALS FOR YEAR 25

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.927	1549193.120	97.49
PERC./LEAKAGE THROUGH LAYER 1	0.001080	282.182	0.02
CHANGE IN WATER STORAGE	0.051	13399.930	0.84
SOIL WATER AT START OF YEAR	3.092	808253.812	
SOIL WATER AT END OF YEAR	3.144	821653.750	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.207	0.00

ANNUAL TOTALS FOR YEAR 26

	INCHES	CU. FEET	PERCENT
PRECIPITATION	14.17	3703471.000	100.00
RUNOFF	0.095	24852.936	0.67
EVAPOTRANSPIRATION	12.137	3172173.000	85.65
PERC./LEAKAGE THROUGH LAYER 1	0.005499	1437.314	0.04
CHANGE IN WATER STORAGE	1.932	505007.437	13.64
SOIL WATER AT START OF YEAR	3.144	821653.750	
SOIL WATER AT END OF YEAR	5.076	1326661.120	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.324	0.00

ANNUAL TOTALS FOR YEAR 27

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.56	3021321.750	100.00
RUNOFF	0.170	44534.785	1.47
EVAPOTRANSPIRATION	12.089	3159692.500	104.58
PERC./LEAKAGE THROUGH LAYER 1	0.081045	21181.982	0.70
CHANGE IN WATER STORAGE	-0.781	-204087.672	-6.75
SOIL WATER AT START OF YEAR	5.076	1326661.120	
SOIL WATER AT END OF YEAR	4.295	1122573.500	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.228	0.00

ANNUAL TOTALS FOR YEAR 28

	INCHES	CU. FEET	PERCENT
PRECIPITATION	9.19	2401898.500	100.00
RUNOFF	0.001	165.572	0.01
EVAPOTRANSPIRATION	10.096	2638570.000	109.85
PERC./LEAKAGE THROUGH LAYER 1	0.010560	2759.856	0.11
CHANGE IN WATER STORAGE	-0.917	-239597.781	-9.98
SOIL WATER AT START OF YEAR	4.295	1122573.500	
SOIL WATER AT END OF YEAR	3.378	882975.687	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.794	0.00

****

ANNUAL TOTALS FOR YEAR 29

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.63	2255537.000	100.00
RUNOFF	0.069	17979.795	0.80
EVAPOTRANSPIRATION	8.844	2311416.500	102.48
PERC./LEAKAGE THROUGH LAYER 1	0.002963	774.382	0.03
CHANGE IN WATER STORAGE	-0.286	-74633.625	-3.31
SOIL WATER AT START OF YEAR	3.378	882975.687	
SOIL WATER AT END OF YEAR	3.093	808342.125	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.066	0.00

****

ANNUAL TOTALS FOR YEAR 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	6.08	1589068.750	100.00
RUNOFF	0.100	26193.316	1.65
EVAPOTRANSPIRATION	5.927	1549181.370	97.49
PERC./LEAKAGE THROUGH LAYER 1	0.001091	285.172	0.02
CHANGE IN WATER STORAGE	0.051	13408.902	0.84
SOIL WATER AT START OF YEAR	3.093	808342.125	
SOIL WATER AT END OF YEAR	3.144	821751.000	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.041	0.00

****

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.02	0.36	0.11	0.24	0.67	0.58
	1.54	1.55	1.57	0.38	0.40	1.51
STD. DEVIATIONS	0.48	0.27	0.10	0.21	0.58	0.51
	0.73	1.29	1.23	0.24	0.34	1.22
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.011
	0.011	0.006	0.023	0.000	0.000	0.036
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.023
	0.022	0.011	0.040	0.000	0.000	0.047
EVAPOTRANSPIRATION						
TOTALS	1.187	0.674	0.253	0.154	0.691	0.710
	1.413	1.537	1.687	0.339	0.490	0.760
STD. DEVIATIONS	0.773	0.290	0.135	0.164	0.543	0.738
	0.722	1.005	1.008	0.211	0.353	0.512
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.0004	0.0059	0.0062	0.0050	0.0170	0.0001
	0.0003	0.0013	0.0010	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0021	0.0323	0.0307	0.0185	0.0299	0.0002
	0.0005	0.0015	0.0012	0.0000	0.0000	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES		CU. FEET	PERCENT
PRECIPITATION	9.93	(2.793)	2594259.2	100.00
RUNOFF	0.087	(0.0557)	22747.89	0.877
EVAPOTRANSPIRATION	9.895	(2.4569)	2586149.50	99.687
PERCOLATION/LEAKAGE THROUGH FROM LAYER 1	0.03719	(0.09081)	9719.683	0.37466
CHANGE IN WATER STORAGE	-0.093	(0.9875)	-24357.58	-0.939

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	1.25	326700.000
RUNOFF	0.112	29391.2500
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.019277	5038.29297
SNOW WATER	1.80	469459.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2200	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1091	

APPENDIX E

Erosion Rate Calculations

EROSION RATE CALCULATIONS
Holloman AFB Main Base Landfill

The Universal Soil Loss Equation (USLE) was used to estimate average soil loss erosion rates from the upper and side slopes designed for the capping of Areas A1/M1. The principal factors influencing soil erosion caused by sheet flow of runoff are rainfall energy and intensity, soil erodibility, slope gradient, slope length, land management practices, and surface cover. The USLE does not account for soil redeposition or soil lost by gully and streambank erosion.

The USLE approximates the average annual soil loss (A, in tons/acre/year) by multiplying several factors:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

Where A = computed soil loss (tons/acre/year)
R = Rainfall/runoff factor: a measure of the average annual erosive force of rainfall.
K = Soil erodibility factor: accounts for a particular soil type's susceptibtility to erosion.
LS = Slope length/gradient factor: accounts for the relationship between the length and degree of slope to the erosion rate.
C = Cover/management factor: reflects protection against erosion provided by cropping and managment practices.
P = Erosion control practice factor: reflects protection afforded by contouring, terracing, or other protective measures.

Page 2 of this document presents a spreadsheet in which erosion rates are estimated for a number of the conditions seen on the final cap. The cap sideslopes are analyzed, assuming that crushed concrete rubble (similar to a gravel cover) will be placed on the surface of the 25% slopes. Other slopes (upper cap) are analyzed assuming that a maximum of approximately 10% ground cover may be established on site due to the arid climate.

The Environmental Protection Agency recommends limiting soil erosion from landfills to less than 2 tons/acre/year to minimize long-term maintenance. The analysis of the Holloman Main Base Landfill capped areas shows that use of the crushed concrete cover will protect the sideslope soils from excessive erosion, and use of minimal slopes and native ground cover will provide sufficient protection to the upper cap slopes.

USLE Erosion Analysis

USLE Factors for all options
R= 10
P= 1

Cover System	Height (ft)	Slope (ft/ft)	Slope Length (ft)	C	K	m	LS	Soil Loss Rate (t/ac/yr)
Side Slopes / gravel cover	30	0.25	123.69	0.05	0.35	0.50	6.55	1.15
Side Slopes / gravel cover	8	0.25	32.98	0.05	0.35	0.50	3.38	0.59
Side Slopes / vegetative cover	10	0.10	100.50	0.33	0.35	0.50	1.37	1.58
Cap Slopes / vegetative cover	8	0.05	160.20	0.33	0.35	0.50	0.68	0.78
Cap Slopes / vegetative cover	12	0.02	600.12	0.33	0.35	0.30	0.34	0.40
Cap Slopes / vegetative cover	10	0.03	333.48	0.33	0.35	0.30	0.41	0.48
Cap Slopes / vegetative cover	10	0.04	250.20	0.33	0.35	0.40	0.58	0.67

R = 10 for Holloman AFB location, taken from Isoerodent map for Western U.S. (page E-3)
P = 1 due to no terracing or contouring practices
C = 0.05 for crushed concrete cover (similar to gravel cover)(page E-4), 0.33 for approximately 10% max. achievable vegetative ground cover (page E-5)
K = 0.35 for fine sandy loams (page E-6) typical of area soils that may be used as fill
m = 0.3 for 1% to 3% slopes; 0.4 for 3.5% to 4.5% slopes; 0.5 for slopes greater than 5%
LS = slope length factor; calculated or read from LS chart (page E-7)

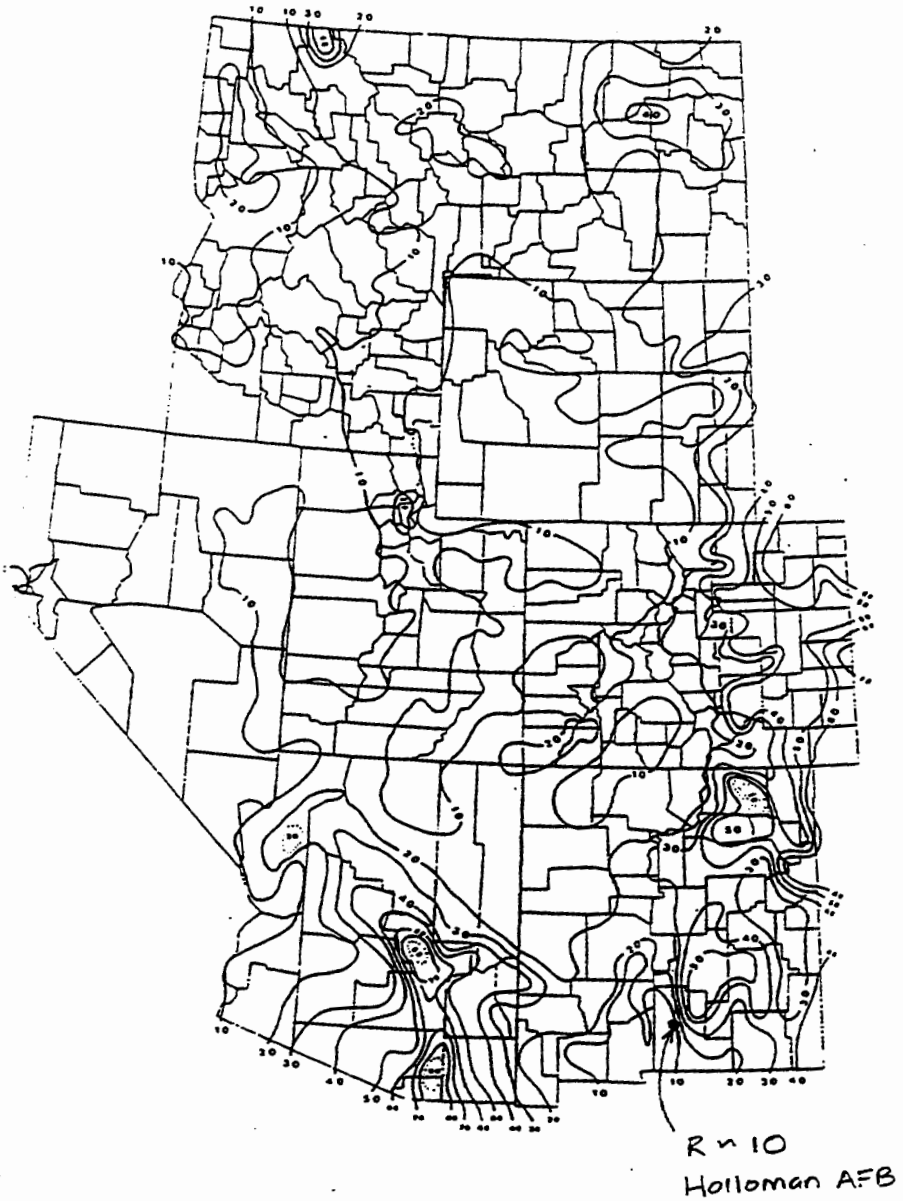


Figure 5.1 Western U.S. isoerodent map.

Table 1: C-Factor and P-Factor Values for Rainfall Erosion Control Measures (from HDI, December, 1992).

Treatment	C-Factor	P-Factor
BARE SOIL		
Packed and Smooth	1.00	1.00
Freshly Disked	1.00	0.90
Rough Irregular Surface	1.00	0.90
SEDIMENT BASIN/TRAP	1.00	0.50[A]
STRAW BALE BARRIER, GRAVEL FILTER, SAND BAGS	1.00	0.80
SILT FENCE BARRIER	1.00	0.50
ASPHALT/CONCRETE PAVEMENT	0.01	1.00
▷ GRAVEL (1/4" TO 1 1/2") @ 135 TONS/ACRE	0.05	1.00
ESTABLISHED NATIVE GRASS	Fig 4	1.00
SOD GRASS	0.01	1.00
TEMPORARY VEGETATION/COVER CROP	0.45[B]	1.00
HYDRAULIC MULCH @ 2 TONS/ACRE	0.10[C]	1.00
SOIL SEALANT	0.10-0.60[D]	1.00
EROSION CONTROL MATS/BLANKETS	0.10	1.00
HAY OR STRAW DRY MULCH @ 2 TONS/ACRE & ANCHORED		
Assumes planting of grass seed has occurred prior to application, otherwise C-Factor = 1.00.		
Slope (%)		
1 to 10	0.06	1.00
11 to 15	0.07	1.00
16 to 20	0.11	1.00
21 to 25	0.14	1.00
25 to 33	0.17	1.00
> 33	0.20	1.00
CONTOUR FURROWED SURFACE		
Must be maintained throughout construction activities, otherwise P-Factor = 1.00. Maximum length refers to down slope length.		
Slope (%) Max Length (feet)		
1 to 2 400	1.00	0.60
3 to 5 300	1.00	0.50
6 to 8 200	1.00	0.50
9 to 12 120	1.00	0.60
13 to 16 80	1.00	0.70
17 to 20 60	1.00	0.80
> 20 50	1.00	0.80

NOTE: Use of other C-Factor of P-Factor values reported in this table should be substantiated by documentation

A: Should be constructed as the first step in over lot grading
B: Assumes planting occurs within optimal climatic conditions
C: Some limitation on use in arid and semi-arid climates
D: Value used must be substantiated by documentation

Table 2 Factor C for permanent pasture, range, and idle land[1]

Vegetative Canopy		Cover that contacts the soil surface						
Type and height[2]	Percent cover[3]	Percent ground cover						
		0	20	40	60	70	80	90
No Appreciable Canopy		0.45	0.20	0.10	0.042	.028	0.013	0.006
Tall weeds or short brush with average drop fall height of 20 in.								
	50	0.26	0.13	0.07	0.035	.023	0.012	0.006
	75	0.17	0.10	0.06	0.032	.022	0.011	0.005

Extracted from:
United States Department of Agriculture, AGRICULTURE HANDBOOK NUMBER 537

Table 1 Approximate Values of Factor K for USDA Textural Classes

TABLE 1

Texture Class	Organic Matter Content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine Sand	0.16	0.14	0.10
Very Fine Sand	0.42	0.36	0.28
Loamy Sand	0.12	0.10	0.08
Loamy Fine Sand	0.24	0.20	0.16
Loamy Very Fine Sand	0.44	0.38	0.30
Sandy Loam	0.27	0.24	0.19
Fine Sandy Loam	0.35	0.30	0.24
Very Fine Sandy Loam	0.47	0.41	0.33
Loam	0.38	0.32	0.29
Silt Loam	0.48	0.42	0.33
Silt	0.60	0.52	0.42
Sandy Clay Loam	0.27	0.25	0.21
Clay Loam	0.28	0.25	0.21
Silty Clay Loam	0.37	0.32	0.26
Sandy Clay	0.14	0.13	0.12
Silty Clay	0.25	0.23	0.19
Clay	0.13 - 0.29		

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

FIGURE 4.—Slope-effect chart (topographic factor, LS), LS = $(\lambda/72.6)^m$ (65.41 $\sin^2\theta$ + 4.56 $\sin\theta$ + 0.065) where λ = slope length in feet; θ = angle of slope; and m = 0.2 for gradients < 1 percent, 0.3 for 1 to 3 percent slopes, 0.4 for 3.5 to 4.5 percent slopes, and 0.5 for slopes of 5 percent or steeper.

APPENDIX F

Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN

HOLLOMAN AIR FORCE BASE MAIN BASE LANDFILL CLOSURE

TABLE OF CONTENTS

Page

1 INTRODUCTION 1

2 MEETINGS 2

2.1 Design Review Meeting 2
2.2 Preconstruction Meeting 2
2.3 Progress Meetings 2
2.4 Unscheduled Meetings 2

3 EARTHWORK QUALITY ASSURANCE 3

3.1 Material Evaluation 3
3.2 Construction Testing 3
3.3 Construction Surveys 4
3.4 Special Testing 4
3.5 Low Permeability Layer Perforations 5
3.6 Deficiencies 5

4 DOCUMENTATION 6

4.1 Daily Record Keeping 6
4.2 Report of Field Change 6
4.3 Photographs 6
4.4 Design and Specification Changes 6
4.5 Weekly Progress Reports 6
4.6 Record Drawings 7

ATTACHMENT: General Records and Reports

LIST OF TABLES

Page

3-1 Borrow Source Testing 3

3-2 Soil Construction Testing Frequency Per Source 4

DEFINITIONS

ASTM: American Society for Testing and Materials.

Borrow Excavation: Borrow excavation will include excavation of materials from borrow areas identified on the Construction Drawings or approved by the Engineer for obtaining fill materials. The process may required exclusion of unsuitable materials and minor manipulation of materials.

Cap Layer: Cohesive native material, homogeneously moisture-conditioned and compacted as necessary to achieve a maximum permeability defined in the construction plans and specifications.

Construction Quality Assurance Monitor (Monitor): The firm or individual responsible for observing and documenting activities related to quality assurance.

Construction Testing: Testing that occurs during material placement.

Engineer: The individual or firm responsible for the design and preparation of the project Construction Drawings and Specifications.

Earthwork: Any activity involving the use of soil or rock materials as defined in the Construction Specifications.

Earthwork Contractor (Contractor): The person or firm responsible for earthwork-related activities. This definition applies to any party performing work defined as earthwork even if it is not the Contractor's primary function. This work could be activities such as backfilling anchor trenches or placing drain materials.

Gradation: Gradation of materials will be determined in accordance with ASTM C 136, D 422, or D 1140.

Material Evaluation: Activities that take place prior to material placement, such as borrow investigation.

Monitor: Person(s) reviewing the construction closure activities who is reporting those activities to the Engineer.

Owner: Holloman Air Force Base and Air Force Center for Environmental Excellence.

Project Construction Drawings and Specifications: Includes all project related Drawings and Specifications including design modifications and Record Drawings.

Project Documents: Construction Drawings, Record Drawings, Specifications, Shop Drawings, CQA Manual, Safety Plan, and Project Schedule.

Project Surveyor: The party responsible for verifying all lines and grades.

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

CONTACT REPORT

DATE _____ **ORIGINATOR** _____

CONTACT BY: [ ] TELEPHONE [ ] MEETING OTHER _____

NAME, TITLE & ORGANIZATION
ADDRESS & TELEPHONE NUMBER
PURPOSE OR SUBJECT (Give project number if appropriate)

SUMMARY

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

DAILY CONSTRUCTION REPORT

DATE _____

DAY	S	M	T	W	TH	F	S

PROJECT _____

PROJECT NO. _____

CONTRACTOR _____

WEATHER	Bright Sun	Clear	Overcast	Rain	Snow
TEMP.	To 32	32-50	50-70	70-85	85 up
WIND	Still	Moderate	High	Report No.	
HUMIDITY	Dry	Moderate	Humid		

VISITORS			
Time	Representing	Representing	Remarks

EQUIPMENT AT THE SITE

CONTRACTOR'S WORK FORCE (Indicate classification, include subcontractor personnel)

MATERIALS OR EQUIPMENT DELIVERED:

SUMMARY OF CONSTRUCTION ACTIVITIES

FIELD PROBLEMS (which could result in delay)

DISTRIBUTION:
1. Project Director
2. Design Engineer
3. File

PAGE 1 OF _____ PAGES

BY _____
RESIDENT REPRESENTATIVE

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

MEETING REPORT

Project Number: _____ Date: _____

Project Name: _____ Distribution:

Purpose of Meeting: _____

Location of Meeting: _____

Attendees: _____

_____

SUMMARY OF MEETING

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature _____

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

REPORT OF FIELD CHANGE

SPECIAL REPORT NO. _____

PROJECT _____ PAGE ___ OF ___ PAGES

LOCATION _____ PROJECT NO. _____ DATE _____

SUBCONTRACTOR _____ CROSS REFERENCE TO DAILY REPORT NO. _____

REFERENCE DATA

SPECIFICATION SECTION No. _____ PAGE No. _____ PARAGRAPH No. _____

DRAWING No. _____ ENTITLED _____

SKETCH No. _____ DATED _____ ENTITLED _____

DESCRIPTION

1. DETAILED IDENTIFICATION OF THE PROBLEM _____

2. DETAILED SOLUTION PROPOSED OR ACCOMPLISHED _____

3. IS THE PROBLEM AN ISOLATED CASE OR GENERAL? _____

4. SUBMIT SKETCHES AS NECESSARY

(Attach extra sheets as necessary)

DISTRIBUTION:
1. Radian Design Engineer
2. Radian Project Director
3. File
4. Subcontracts

BY _____
Radian Representative

11-90-33082

- Observing the effect of compaction equipment on the material placed (pad penetration, pumping, cracking, etc.);
- Observing placement for material segregation and uniformity of moisture content;
- Observing the cap layer for excessive desiccation cracking;
- Observing that materials are placed to the lines and grades shown on the Construction Drawings; and
- Observing construction surveys.

Testing frequencies are shown in Table 3-2.

3.3 Construction Surveys

All measurements will be to the tolerances shown in the Specifications. Elevations will be determined on centers acceptable to the Engineer to allow accurate representation of the following:

- Top of existing cover or fill layer; and
- Top of cap layer.

3.4 Special Testing

Testing frequencies provided in the preceding sections can be increased at the discretion of the Monitor with concurrence from the Engineer when observations indicate a potential problem. Examples of conditions that may warrant additional tests include:

- Compactors slip while compacting;
- Excessive pumping or fill cracking;
- Lift thickness greater than specified;
- Excessive soil build-up on compactor wheels;
- Improperly ballasted compactor;
- Adverse weather;
- Equipment breakdown;
- Work conducted in difficult areas;
- High frequency of failed tests; and
- Using other than industry-standard equipment.

Table 3-2
Soil Construction Testing Frequency Per Source

ASTM Test Designation[a]	Existing Cover and Fill (cy)	Cap Layer
D1557 (Compaction)	10,000	10,000
D422 (Particle Size)	10,000	10,000
D4318 (Atterburg Limits)	–	10,000
D2992 (Nuclear Density)	500 [b]	500
D2216 (Moisture Content)	500 [b]	500
EPA 9100 (Permeability)	–	10,000
Density/Moisture Content (Nuclear ASTM D2992)[c]	4/acre/lift	4/acre/lift
Density/Moisture Content (ASTM D1556 or ASTM D2167)	1/20 tests performed by ASTM D2992	1/20 tests performed by ASTM D2992
Hydraulic Conductivity (ASTM D5084)	1 per 2 acres per lift	1 per 2 acres per lift
Total Thickness (by survey)[d]	1/acre (on grid)	1/acre (on grid)

[a] Minimum one test per material type.
[b] Tests to be performed only in areas of the existing cover layer which is disturbed.
[c] Minimum one compaction test per acre per lift.
[d] Thickness of entire layer (multiple lifts).

3.5 Low Permeability Layer Perforations

All perforations in the cap layer will be repaired, including those resulting from nuclear density testing, sand-cone tests, permeability tests, and grab sample holes. Perforations will be repaired by backfilling with a soil-bentonite mixture containing at least 50 percent bentonite by volume. The bentonite mixture will be tamped in place with a tamping rod, a modified proctor hammer, or a mechanical tamper depending on the performation size.

3.6 Deficiencies

When deficiencies (items that do not meet specified values) are discovered, the Monitor will immediately determine the nature and extent of the problem, notify the Contractor, and complete required documentation. In all cases, the Monitor will notify the Contractor within ½ hour of discovering the deficiency. If the deficiency will cause construction delays of more than 1 hour or will necessitate substantial rework, the Monitor will also notify the Owner and Engineer.

The Contractor will correct the deficiency to the satisfaction of the Monitor. If the Contractor is unable to correct the problem, the Monitor will develop and present to the Engineer and Owner suggested solutions for his approval.

Where field density or moisture contents fail to meet specified values or a homogeneous fill has not been achieved, either the area should be reworked, or the material should be removed; the choice will be at the Contractor's discretion. If the Contractor chooses to rework areas that do not meet moisture content requirements, the area will be scarified, moisture-conditioned, and recompacted. Alternately, at the Engineer's discretion, undisturbed samples of the in-place material can be obtained and permeability tests, strength test, or both, conducted. Density and moisture content requirements may be waived if the permeability and strength test results are acceptable.

The corrected deficiency will be retested before additional work is performed. All retests and steps taken to correct the problem will be documented by the Monitor.

Section 4
DOCUMENTATION

This manual requires thorough monitoring and documentation of all construction activities. The Monitor is responsible for ensuring that all quality assurance requirements have been addressed and documented. Documentation will consist of daily record keeping, construction problem resolutions, photographic records, design and specification revisions, weekly progress reports, and a Summary Report. Forms typical for use in documenting construction quality assurance are shown in Attachment 1 of this document.

4.1 Daily Record Keeping

At a minimum, daily construction reports (DCR) will be prepared and submitted to the Owner and the Engineer for their review. These DCRs will consist of field notes, a summary of the daily meeting with the Contractor, and observation and data sheets. Sample forms are provided in the Forms Section.

A Meeting Report form will be completed each day, summarizing discussions held with the Contractor. At a minimum, the report will include the following:

- Date, project name, project number, and location;
- Names of parties involved in discussions;
- Items discussed;
- Scheduled activities;
- Action items defined in daily meetings;
- Weather data;
- Site plan showing work areas, including sample and test locations;
- Description of ongoing construction;
- Summary of all test results;
- A summary of both the decisions regarding acceptance of the work and corrective actions taken for construction deficiencies or defects; and
- The signature of the Monitor.

4.2 Report of Field Change

This report, which identifies and documents construction problems and resolutions, is intended to document, problems requiring significant rework. It is not intended to document items easily corrected, unless the problems are recurring. At a minimum this report will include:

- Date, project name, project number, and location;
- Date and time the problem/change occurred;
- A detailed problem/change identification;
- How the problem/change was resolved; and
- Personnel involved.

4.3 Photographs

Construction activities will be photographed, including significant problems and remedial actions. A duplicate of each photograph will be available to the Owner.

4.4 Design and Specification Changes

Design and specification changes may be required during construction. In such cases, the Monitor will notify the Engineer. Design and specification changes will only be made with written agreement from the Owner and Engineer.

4.5 Weekly Progress Reports

The Monitor will prepare weekly progress reports summarizing construction and quality assurance activities. This report will be submitted to the Owner and Engineer and will contain, at a minimum, the following information:

- The report date, project name, project number, and location;

- Work activities summary;
- Deficiencies, defects, or both, and a summary of their resolutions; and
- The Monitor's signature.

4.6 Record Drawings

The Record Drawings will accurately locate all relevant construction items, subgrade elevations of all excavations, and final grades of all layers of fill materials. All surveying and base maps required for the Record Drawings development will be prepared by the project surveyor.

ATTACHMENT

General Records and Reports

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

CONTACT REPORT

DATE _____ **ORIGINATOR** _____

CONTACT BY: [ ] TELEPHONE [ ] MEETING OTHER _____

NAME, TITLE & ORGANIZATION
ADDRESS & TELEPHONE NUMBER
PURPOSE OR SUBJECT (Give project number if appropriate)

SUMMARY

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

DAILY CONSTRUCTION REPORT

DATE _____

DAY	S	M	T	W	TH	F	S

PROJECT _____

PROJECT NO. _____

CONTRACTOR _____

WEATHER	Brite Sun	Clear	Overcast	Rain	Snow
TEMP.	To 32	32-50	50-70	70-85	85 up
WIND	Still	Mader	High	Report No.	
HUMIDITY	Dry	Mader	Humid		

VISITORS			
Time	Representing	Representing	Remarks

EQUIPMENT AT THE SITE

CONTRACTOR'S WORK FORCE (Indicate classification, include subcontractor personnel)

MATERIALS OR EQUIPMENT DELIVERED:

SUMMARY OF CONSTRUCTION ACTIVITIES

FIELD PROBLEMS (which could result in delay)

PAGE 1 OF _____ PAGES

DISTRIBUTION:
1. Project Director
2. Design Engineer
3. File

BY _____
RESIDENT REPRESENTATIVE

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

MEETING REPORT

Project Number: _____ Date: _____

Project Name: _____ Distribution:

Purpose of Meeting: _____

Location of Meeting: _____

Attendees: _____

_____

SUMMARY OF MEETING

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Signature _____

RADIAN INTERNATIONAL LLC
8501 Mopac Blvd.
P.O. Box 201088
Austin, Texas 78720-1088
(512) 454-4797

REPORT OF FIELD CHANGE

SPECIAL REPORT NO. _____

PROJECT _____ PAGE ___ OF ___ PAGES

LOCATION _____ PROJECT NO. _____ DATE _____

SUBCONTRACTOR _____ CROSS REFERENCE TO DAILY REPORT NO. _____

REFERENCE DATA

SPECIFICATION SECTION No. _____ PAGE No. _____ PARAGRAPH No. _____

DRAWING No. _____ ENTITLED _____

SKETCH No. _____ DATED _____ ENTITLED _____

DESCRIPTION

1. DETAILED IDENTIFICATION OF THE PROBLEM _____

2. DETAILED SOLUTION PROPOSED OR ACCOMPLISHED _____

3. IS THE PROBLEM AN ISOLATED CASE OR GENERAL? _____

4. SUBMIT SKETCHES AS NECESSARY

(Attach extra sheets as necessary)

DISTRIBUTION:
1. Radian Design Engineer
2. Radian Project Director
3. File
4. Subcontracts

BY _____
Radian Representative

11-90-33082